INTRODUCTION TO PHYSICS

Physics is a branch of science which deals with the study of matter in relation to energy

Matter is anything that occupies space and has mass

Energy is the ability to do work

BRANCHES OF PHYSICS

1. Mechanics
2. Heat
3. Light
4. Waves
5. Electricity
6. Magnetism
7. Modern physics

PHYSICS EXAMINATION

Physics has a code 535

It has three papers

1. $535/1$ paper one
2. $535/2$ paper two
3. $535/3$ or $535/4$ Physics practicals

MEASUREMENTS

To measure is to find the value of a quantity

Measurement is a number that shows the size (magnitude) of a quantity

Quantity that can be measured is called $\boldsymbol{physical\ quantity}$

Physical quantities include; time length, mass, speed, volume, density, etc.

Physical quantities are divided into

1. Fundamental (basic) quantities
2. Derived quantities

FUNDAMENTAL (BASIC) QUANTITIES

Are quantities that cannot be expressed in terms of other quantities

The three basic quantities used in mechanics are; mass, time and length

Other basic quantities are

- Temperature
- Electric current
- Amount of a substance
- Luminous intensity

DERIVED QUANTITIES

Are quantities which can be got from fundamental quantities

They include;

- Volume $= l \times w \times h$
- area $= l \times w$
- density $= \frac{m}{V}$
- speed $= \frac{d}{t}$
- pressure $= \frac{F}{A}$

INTERNATIONAL SYSTEM OF UNITS ($\boldsymbol{S.I\ UNITS}$)

To distinguish one quantity measured from the other, we attach units

The metric system of units which is agreed to be used internationally is the $S.I$ units

S.I units comes from French words *Systeme International (d'unites)*

For example

Basic quantities

Quantity	Symbol	Unit	Symbol
Mass	M	kilogram	kg
Time	T	seconds	s
Length	L	metre	m
Temperature	T	kelvin	K
Electric current	I	ampere	A
Amount of substance		mole	mol
Luminous intensity		candela	cd

Derived quantities

Quantity	Symbol	Formulae	$S.I$ unit	symbol
Area	A	$l \times w$	metre squared	m^2
Volume	V	$l \times w \times h$	metres cubed	m^3
Density	ρ	$\frac{m}{l \times w \times h}$	kilogram per cubic metre	kgm^{-3}
Speed	V	$\frac{d}{t}$	metres per second	ms^{-2}
Pressure	P	$\frac{F}{A}$	newton per metre squared	Nm^{-2}
Work	W	$F \times d$	newton metre	Nm

LENGTH

Is the distance between two fixed points

The $S.I$ unit is $\boldsymbol{metre(m)}$

Other units are

- $kilometre\ (km)$
- $centimetre\ (cm)$
- $millimetre\ (mm)$
- $yard$
- $inches$ etc.

CONVERSION OF UNITS OF LENGTH

We use $K \quad H \quad D \quad m \quad d \quad c \quad m$

. 1 0 0 0 0 0 0

Examples

Convert the following

(a) $20m$ to cm
(b) $120km$ to m
(c) $5km$ to mm
(d) $2km$ to cm
(e) $102m$ to km
(f) $500mm$ to cm

MEASUREMENTS OF LENGTH

The following instruments are used in the measurement of length

1. **Tape measure**
- It measure length of greater than $1m$ e.g. $length$ of a wall, length of a football pitch

2. **Metre rule**
- It measures small lengths less than $1m$ e.g. length of a book, length of a bicycle spoke etc.
- It has a length of $1m = 100c$

DENSITY

Is the mass per unit volume

$$density = \frac{mass}{volume}$$

$$\boxed{\boldsymbol{\rho = \frac{M}{V}}}$$

From

$$\rho = \frac{M(kg)}{V(m^3)}$$

The $S.I$ unit of density is
$\boldsymbol{kilogram\ per\ cubic\ metre\ (kgm^{-3})}$

Other unit is
$gram\ per\ cubic\ centimetre\ (gcm^{-3})$

Where $1gcm^{-3} = 1000kgm^{-3}$

CONVERSION OF UNITS

Convert the following

(a) $5.4gcm^{-3}$ to kgm^{-3}
(b) $43gcm^{-3}$ to kgm^{-3}
(c) $21000kgm^{-3}$ to gcm^{-3}
(d) $13600kgm^{-3}$ to gcm^{-3}

Examples

1. The density of water is $1000kgm^{-3}$. What does this mean?

2. An object of mass $1000kg$ has a volume of $25m^3$. Find its density in
   (a) kgm^{-3}
   (b) gcm^{-3}

3. A box with dimensions $4m\ by\ 2m\ by\ 1m$ weighs $48kg$. Calculate its density

4. An object of mass $500g$ has a volume of $200cm^3$. Find its density in;
   (a) gcm^{-3}
   (b) kgm^{-3}

5. Calculate the mass of air in the room of dimensions $1000cm\ by\ 500cm\ by\ 200cm$ if the density of air is $1.25kgm^{-3}$

6. A piece of mineral has a density of $0.6gcm^{-3}$
   (a) What does this mean?
   (b) If its mass is $6g$, find its volume

Density of some substances

Water	$1000kgm^{-3}$
Mercury	$13600kgm^{-3}$
Air	$1.25kgm^{-3}$

Why do we study density

1. To test for purity of substances
2. To identify materials
3. To choose light gases for filling balloons
4. To choose the right materials for construction

DETERMINATION OF DENSITY OF A LIQUID

- An empty measuring cylinder is weighed and its mass M_1 is noted
- A liquid is poured in a measuring cylinder
- The measuring cylinder is weighed again and its mass M_2 is noted
- Mass of the liquid $M = M_2 - M_1$
- Volume, V of the liquid in the measuring cylinder is noted
- Density of the liquid is calculated from $\rho = \frac{M}{V}$

DETERMINATION OF DENSITY OF A REGULAR OBJECT

- The object is weighed using a beam balance and its mass, m is noted
- The dimensions of the object are measured
- The volume, V of the object is calculated using a formula
- Density is obtained from $\rho = \frac{m}{V}$

DETERMINATION OF DENSITY OF AN IRREGULAR OBJECT

- The object is weighed using a beam balance and its mass, M is noted
- A measuring cylinder is filled with water and its volume, V_1 is noted
- The object is tied on a thread
- The object is carefully lowered into the water and the new volume, V_2 of the water is noted
- Volume of the object is obtained from
  $V = V_2 - V_1$
- Density of the object is got from $\rho = \frac{M}{V}$

Examples

1. A measuring cylinder contains water up to a level of $100cm^3$. A piece of a stone of mass $50g$ is dropped into a measuring cylinder to $350cm^3$. Calculate the
(a) Volume of the stone
(b) Density of the stone in gcm^{-3} and kgm^{-3}

DENSITY OF A MIXTURE

If a liquid of mass, M_1 and volume, V_1 is mixed with a liquid of mass, M_2 and volume, V_2

Then

Total mass $= M_1 + M_2$

Total volume $= V_1 + V_2$

$$\boldsymbol{Density = \frac{M_1 + M_2}{V_1 + V_2}}$$

Examples

1. A $40g$ of water of volume $60cm^3$ is mixed with alcohol of mass $80g$ having a volume of $140cm^3$. Calculate the density of the mixture

2. Two liquids P and Q are mixed together. If P has a density of $800kgm^{-3}$ and volume $200cm^3$ while Q has a density of $400kgm^{-3}$ and a volume of $800cm^3$. Calculate the density of the mixture

3. $4cm^3$ of milk has a mass of $5g$ and it is mixed with $6cm^3$ of water of mass $6g$. What is the density of the mixture

4. $4g$ of oil of density $0.8gcm^{-3}$ is mixed with $1g$ of alcohol of density $1.2gcm^{-3}$. Find the density of the mixture

5. $An\ alloy\ is\ made$ by mixing $40cm^3$ of metal X whose density is $2gcm^{-3}$ and another metal Y of density $3gcm^{-3}$ and volume $20cm^3$. Determine the density of the alloy

6. $1800cm^3$ of fresh water of density $1000kgm^{-3}$ is mixed with $2200cm^3$ of sea water of density $1025kgm^{-3}$. calculate the density of the mixture

$\boldsymbol{FACTORS\ THAT\ AFFECT\ DENSITY}$

1. **Temperature**
Density of a substance decreases with increase in temperature
Increase in temperature increases the volume of a substance but the mass remains constant, this decreases the density

2. **Pressure**
This affect the density of gases
For a fixed mass of a gas, increase in pressure increases the density of the gas

RELATIVE DENSITY, $R.D$

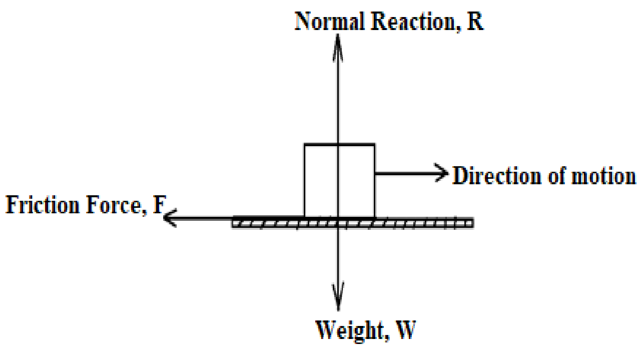
Is the ratio of mass of a substance to the mass of an equal volume of water

(a) Find the magnitude of the resultant force
(b) Find the acceleration acting on the body

FRICTION FORCE

Is a force that opposes the relative motion of two surfaces in contact

Friction acts in opposite direction to that of a force that causes motion



TYPES OF FRICTION

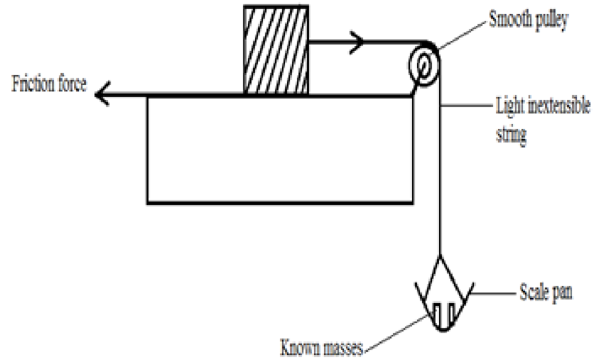
1. Static friction
2. Sliding or dynamic friction
3. Viscosity

STATIC FRICTION

Is a friction which opposes motion of two surfaces in contact at rest

It prevents motion

EXPERIMENT TO MEASURE STATIC FRICTION



- Small known masses are slowly added to the scale pan until the block just starts to slide
- Total weight of the scale pan and added masses is obtained
- The total weight is the static friction

LIMITING FRICTION

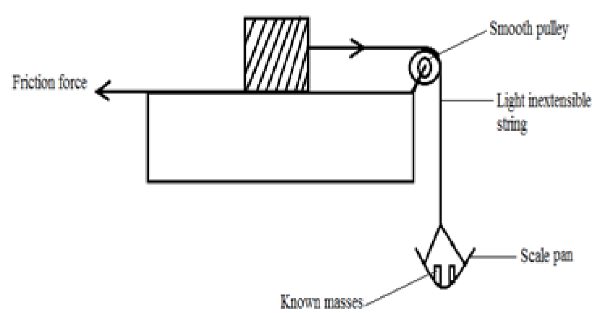
Is the maximum friction between two surfaces

SLIDING OR DYNAMIC FRICTION (KINETIC FRICTION)

Is the friction that opposes relative motion between two surfaces in contact in motion

It slows down motion

EXPERIMENT TO MEASURE DYNAMIC FRICTION



- Small known masses are slowly added to the scale pan and each time the block is given a small push until the block moves with uniform speed

TEMPERATURE SCALE

Is one which can measure the degree of hotness of a substance.

They include

1. Celsius scale
2. Kelvin scale

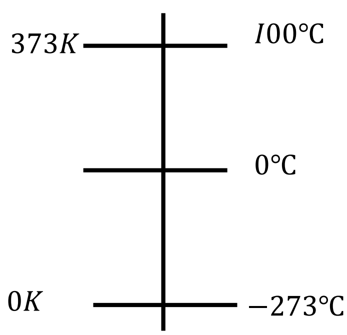
CELSIUS SCALE

- It records temperature in ℃
- It has the ice point at 0℃ and the steam point at 100℃
- The distance between 0℃ and 100℃ is divided into 100 small divisions called degrees

KELVIN SCALE

- It records temperature in $kelvin(K)$
- $\boldsymbol{T(K) = t(^0C) + 273}$

KELVIN SCALE AND CELSIUS SCALE



THE FIXED TEMPERATURE POINTS

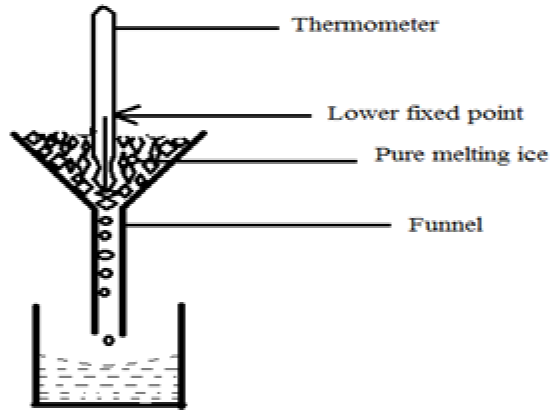
There are two fixed points namely

1. Lower fixed point
2. Upper fixed point

LOWER FIXED POINT (ICE POINT)

- Is the temperature of pure melting ice at standard atmospheric pressure
- It is 0℃
- The ice must be pure, since presence of impurities lower the melting point

DETERMINING LOWER FIXED POINT



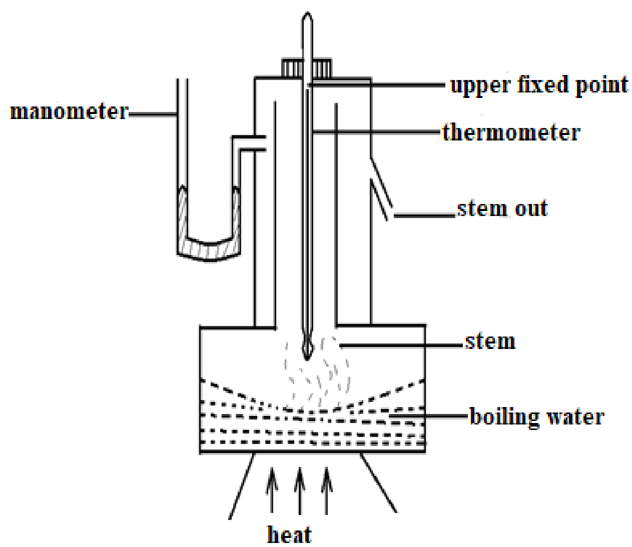
- The bulb is surrounded by pure melting ice
- The mercury thread falls readily and then becomes constant
- The top of the mercury thread is marked as lower fixed point

UPPER FIXED POINT

Is the temperature of steam from boiling water at standard atmospheric pressure

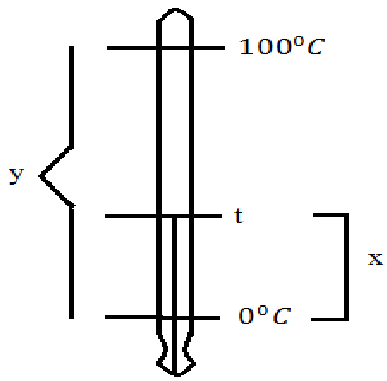
- It is 100℃
- *Steam is used because water may be containing impurities that may affect the boiling point of water*

DETERMINING UPPER FIXED POINT



- The thermometer is kept in the steam above boiling water
- The mercury thread rise up steadily and then becomes constant
- The top of the mercury thread is marked as the upper fixed point

TO MEASURE TEMPERATURE USING UN-CALIBRATED THERMOMETER



- The fixed points are obtained
- The distance, y between the upper fixed point and the lower fixed point **(fundamental interval)** is obtained
- The distance, x between the lower fixed point and the unknown temperature is obtained
- Unknown temperature, t is obtained from

$$\boldsymbol{t = \frac{x}{y} \times 100℃}$$

Examples

1. The ice point and steam point are found to be $100mm$ apart on an un-graduated thermometer. The distance above the $L.F.P$ is $50mm$.what is the temperature corresponding to this distance in ℃
2. The ice point and steam point are found to be $192mm$ apart on un-graduated thermometer. What is the temperature recorded in ℃ when the length of the mercury thread is $67.2mm$ above the ice point
3. The fundamental interval on a thermometer is $20cm$. If the mercury level falls to $12cm$ below the ice point when the thermometer is dipped in a solution, find the temperature of the solution
4. The length of a mercury thread at a lower fixed point and the upper fixed point are $2cm$ and $8cm$ respectively for a certain liquid X. Given that the length of the mercury thread at unknown temperature, t is $6cm$, determine the value of t

THE THERMOMETER

Is an instrument used to measure temperature

TYPES OF THERMOMETER

1. Liquid in glass thermometer
2. Electrical resistance thermometer
3. Constant volume gas thermometer
4. Thermoelectric thermometer

THERMOMETRIC PROPERTY

Is the one which varies continuously with temperature and constant at constant temperature

For example

1. Length of a liquid column
2. The electrical resistance of a metal
3. Pressure of a fixed mass of a gas
4. Thermoelectric $e.m.f$
5. Volume of a fixed mass of a gas

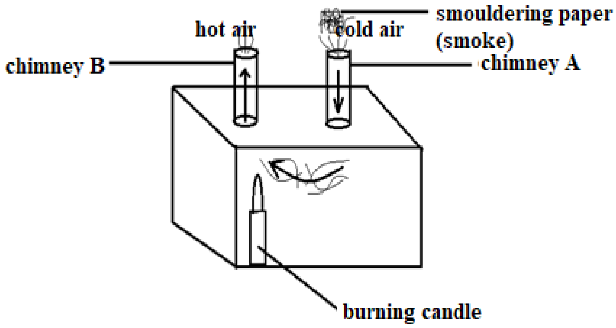
PHYSICAL PROPERTIES OF MATTER THAT CHANGES WITH TEMPERATURE

1. Length of rod
2. Volume of a liquid
3. Volume of a gas at constant pressure
4. Color of a substance
5. State of matter
6. Pressure of a gas at constant volume
7. Electrical resistance

THERMOMETRIC LIQUIDS

Is a liquid that can be used in a thermometer

The commonly used liquids are



- Cold dense air (smoke) flows down through chimney A
- It circulates inside and passes over the burning candle where it is heated
- The air molecules expand, become less dense and rises up through chimney B
- Cold air comes down to replace the warm rising air forming convectional current

APPLICATION OF CONVECTION

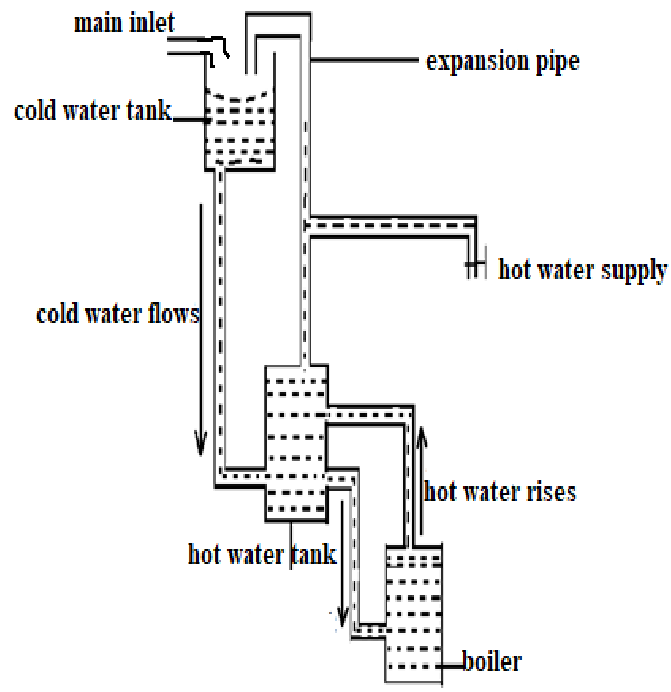
1. **Liquids**

- Domestic hot water supply system

2. **Gases**

- Chimneys in kitchen and factories
- Ventilation pipes in VIP latrines
- Ventilations in houses
- Land and sea breeze

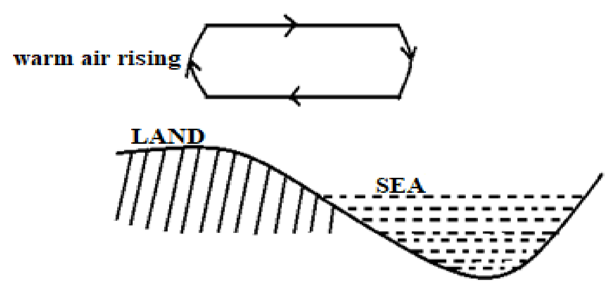
DOMESTIC HOT WATER SUPPLY SYSTEM



- Cold water runs down to the bottom of the hot water tank and continues to the boiler
- Water is heated, becomes less dense and it rises
- The cold water displaces the hot water in the boiler and it rises to the hot water tank and supplied to the water taps
- The expansion pipe allows steam and dissolved air to escape from the hot water

SEA BREEZE

This occurs during day time



- During day time, land heats up readily to higher temperature than the sea
- ***Penumbra*** is a region of a shadow which receives some light

ECLIPSE

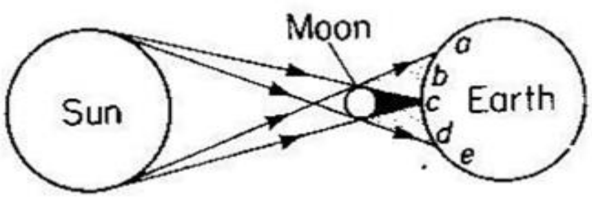
Is an obstruction of the light from the sun by either the moon or earth

It occurs when the sun, moon and the earth are in a straight line

ECLIPSE OF THE SUN (SOLAR ECLIPSE)

This is formed when light reaching the earth from the sun is obstructed by the moon

It occurs during day time, when the moon is between the sun and the earth



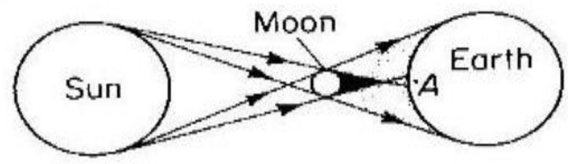
- Region $\boldsymbol{a}$ receives total darkness (umbra), the sun is not visible
- Regions $\boldsymbol{b}$ and $\boldsymbol{d}$ has partial darkness (penumbra). It receives some light but not as region $\boldsymbol{a}$ and $\boldsymbol{e}$

ANNULAR ECLIPSE

It occurs when the moon is far away from the earth

This occurs when the shadow of the moon fails to reach the earth

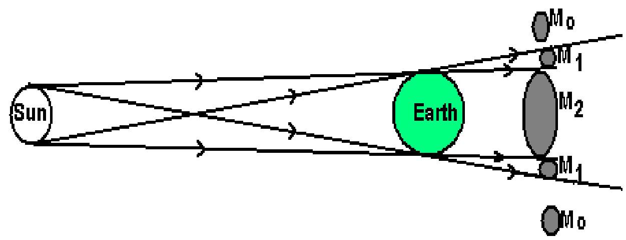
The sun appears as a thin bright ring around a black circle (an annulus)



LUNAR ECLIPSE (ELIPSE OF THE MOON)

This is formed when light from the sun reaching the moon is obstructed by the earth

It occurs at night, when the earth is between the sun and moon



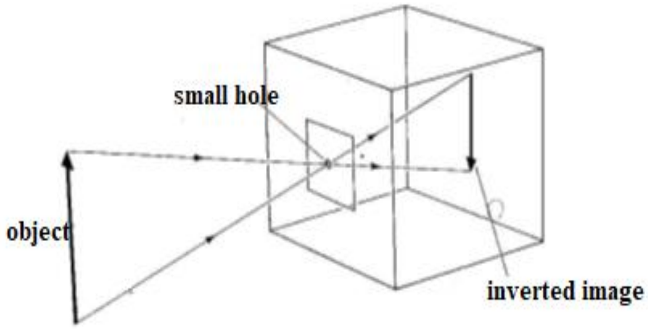
- In region M_2, the moon receives total darkness from the earth
- In region M_1, the moon receives partial darkness, it receives some light but not as much as regions M_0

THE PINHOLE CAMERA

It is made of a light tight box with a small hole in a metal plate at one end and a screen of tracing paper at the other end

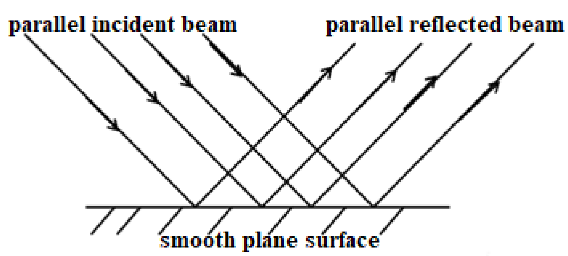
It works on the principle that light travels in a straight line

A small hole faces the object and a real, diminished and inverted image is formed on the screen



Is a reflection where a parallel beam of incidence is reflected parallel

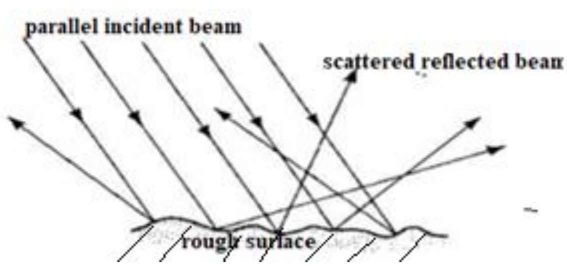
It occurs on highly smooth surfaces like plane mirrors, calm water surface etc.



1. **DIFFUSE (IRREGULAR) REFLECTION**

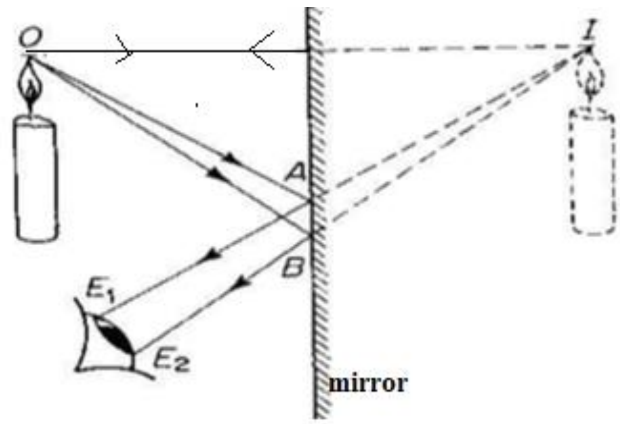
Is a reflection where a parallel beam of incidence is reflected in different direction (scattered)

It occurs on rough surfaces for examples; rough walls



REFLECTION OF LIGHT AT PLANE SURFACES

Image formation by a plane mirror



PROPERTIES OF IMAGE FORMED BY A PLANE MIRROR

1. The image has the same size as the object
2. The image distance is equal to object distance. (same distance behind the mirror as the object is in-front)
3. The image is laterally inverted (inverted sideways)
4. The image is virtual
5. It is upright (erect)

A virtual image is the image formed by apparent intersection of light rays. It cannot be formed on the screen

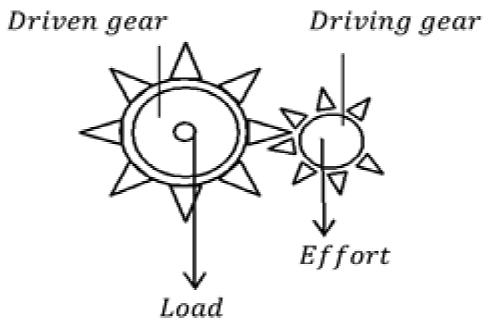
A real image is the image formed by actual intersection of light rays. It is formed on the screen

IMAGES FORMED BY TWO MIRRORS AT AN ANGLE

When two mirrors are placed at an angle x between them, the number of the images formed

$$\boldsymbol{n = \left(\frac{360}{x}\right) - 1}$$

The toothed wheels engage each other to produce a turning force



- The load and the effort are applied to the shaft connected to the gear wheels
- To use little effort to carry a heavy load $(high\ M.A)$, the wheel must turn to a low speed. The driving wheel must be smaller than driven wheel
- To use much effort to carry a small load $(low\ M.A)$, the wheel must turn to a high speed. The driving wheel must be bigger than driven wheel
- The number of rotations depends on the ratio of number of teeth and radii of the wheels
- $\boldsymbol{V.R = \frac{Number\ of\ teeth\ on\ driven\ wheel}{Number\ of\ teeth\ on\ driving\ wheel}}$

Examples

1. In a gear system, the number of teeth on the driving wheel is 10 and the teeth on the driven wheel are 40. If the system is able to lift a load of $300N$ with an effort of $100N$, calculate the;

(i) Efficiency

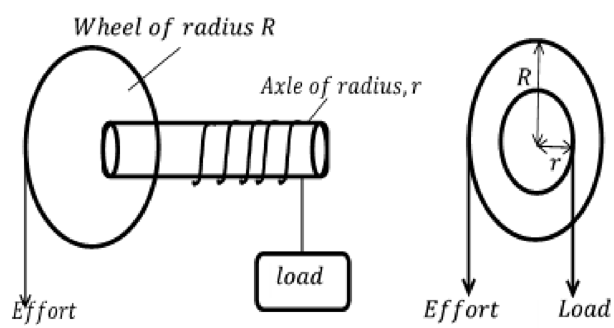
(ii) Distance moved by the effort if the distance moved by the load is $5m$

2. A driving force of $200N$ drives a wheel which overcomes a force of $350N$. Given that the driven wheel and driving wheel have 24 and 8 teeth respectively. Calculate the efficiency of the system

WHEEL AND AXLE

This is made of a large wheel attached to a pole called an **axle**

The effort is applied to the wheel and the load is raised by a string attached to the axle



For one complete turn, the load moves through a distance equal to circumference of the axle and the effort moves a distance equal to the circumference of the wheel

$$V.R = \frac{circumference\ of\ wheel}{circumference\ of\ axle}$$

$$V.R = \frac{2\pi R}{2\pi r}$$

$$\boldsymbol{V.R = \frac{R}{r}}$$

Examples

1. The figure below shows a wheel and axle system

- The tension in each string is equal to effort
- If there is no friction force and both the lower block and the rope have no weight

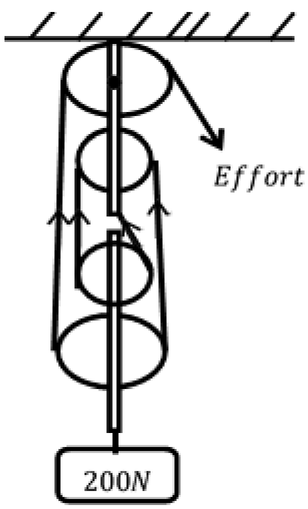
$$\textbf{Sum of upward forces} = \textbf{downward force}$$

- In reality, the movable block and the rope have weight and there is friction force. These act down ward and become part of the load ($down\ ward\ force$)

$\textbf{Total dowwn ward force} = \textbf{Load} + \textbf{weight} + \textbf{Friction}$

Examples

1. Below is a pulley system of mass $0.5kg$ and there is a friction of $5N$



Calculate

(i) Effort required to lift the load

(ii) $M.A$

(iii) $V.R$

(iv) Efficiency of the machine

(a) Give the reasons why the efficiency above is less than 100%

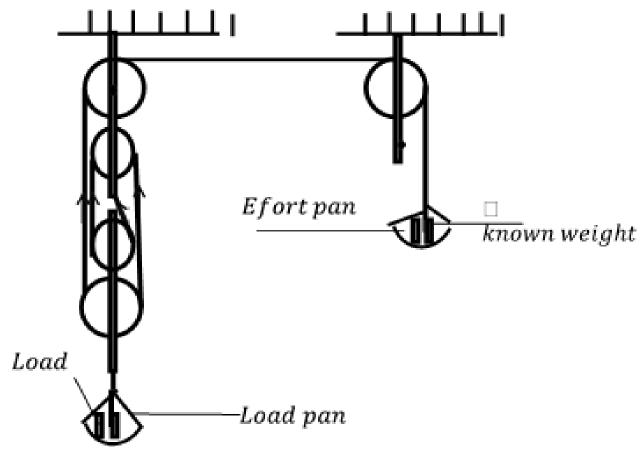
(b) Suggest ways of increasing that efficiency

2. Calculate the efficiency of a pulley system of $V.R = 6$ if a force of $1000N$ is required to raise a load of $4500N$
3. A block and tackle pulley system is used to raise a load of $400N$ steadily through a height of $15m$. If the work done against friction and useless load is $1000J$, calculate the;

(i) Work input

(ii) Efficiency of the machine

VARIATION OF $M.A$ WITH THE LOAD



- A load of known weight is placed on the load pan
- Known weights are slowly added on the effort pan until the load just rises steadily
- The experiment is repeated using different loads
- The results are tabulated including values of $M.A$
- A graph of $M.A$ against $load$ is plotted and it gives a shape below

MAGNETISM

Is a form of energy found in magnets

Magnet

A magnet is a material which can attract magnetic materials e.g. iron, steel, Nickel etc.

It always points in north and south directions if it is freely suspended.

MAGNETIC AND NON MAGNETIC MATERIALS

Magnetic materials are materials or substances that can be attracted by magnet e.g. iron, steel, Nickel, cobalt

Non- magnetic materials are materials that cannot be attracted by a magnet e.g. wood, copper, rubber

FERROMAGNETIC AND PARAMAGNETIC MATERIALS

Ferromagnetic materials are materials that are strongly attracted by the magnet. e.g. steel and iron, Cobalt, Nickel

Paramagnetic materials are materials that are slightly attracted by a magnet. e.g. aluminum, platinum, magnesium, lithium etc.

PROPERTIES OF MAGNETS

1. Magnets possess two poles North pole and South Pole
2. Unlike poles of magnet attract while like poles repel
3. When freely suspended, a magnet rests in North-South direction
4. Magnetic forces of attraction and repulsion are greatest at the poles

POLES OF A MAGNET

The ends of a magnet are called ***poles***

Every magnet has a north (N) and south (S) pole

When a magnet is freely suspended on a string, it comes to rest with its north pole facing the geographical north and its south pole pointing the geographical south

A pole is a point (part) of a magnet where the forces of attraction are strongest

LAWS OF MAGNETISM

Like poles repel each other and unlike poles attract each other

EXPERIMENT TO VERIFY THE LAW OF MAGNETISM

A magnet of known poles is freely suspended using a string

When it is at rest, a N-pole of another magnet is put towards the N-pole of a suspended magnet, the magnet swings away

This shows that N-pole repels N-pole

A S-pole is also put towards the N-pole of a suspended magnet, the N-pole is attracted

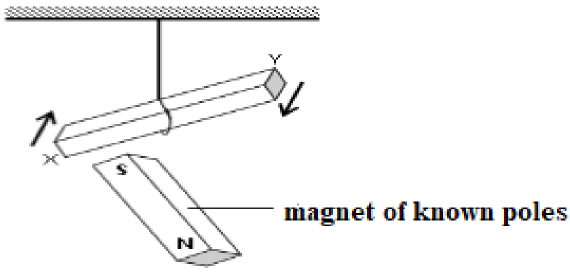
This shows that N-pole attracts S-pole

This verifies the laws of magnetism that like pole repel and unlike poles attract each other

POLARITY OF A MAGNET

Is to the nature of the poles of a magnet either $N-pole$ or $S-pole$

DETERMINATION OF THE POLARITY OF A MAGNET (IDENTIFYING THE POLES OF A MAGNET)



A magnet with known poles is freely suspended

The poles of the test magnet are brought near the poles of the suspended magnet

If repulsion occurs, the test poles are similar to that of a suspended magnet

If attraction occurs, the test poles are opposite to that of the suspended magnet

NOTE;

Repulsion is the only sure test for the polarity of a magnet since attraction may be for the piece of a magnetic material

MAGNETISATION

Is a process of making a magnet

It is a process of making a magnet material magnetized

THEORY OF MAGNETISM

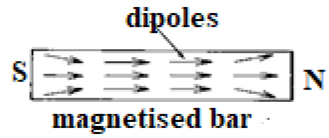
(DOMAIN THEORY)

This states that ***"a magnet is made up of very tiny magnets with their north poles pointing in the same direction"***

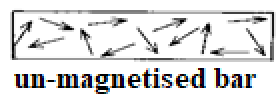
These tiny magnets are called *dipoles*

In a magnetized state, the dipoles face the same direction in groups called *domains*

At the end, the free poles of the tiny magnets repel each other and spread



In un-magnetized state, the dipoles point in all directions. The $N-pole$ of one neutralizes the $S-pole$ of the other



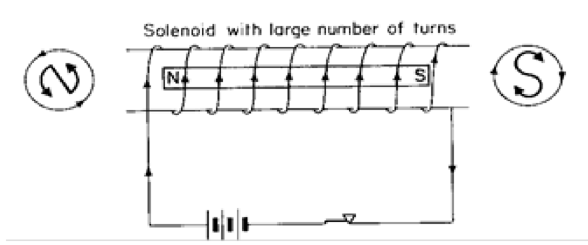
MAGNETISATION OF A FERROMAGNETIC MATERIAL

Ways in which a materials can be magnetized include

1. Electrical method
2. Stroke method
3. Induction method.

ELECTRICAL METHOD

This is the best method of making a permanent magnet



A magnetic material (bar) is placed inside a cylindrical coil having many turns (solenoid)

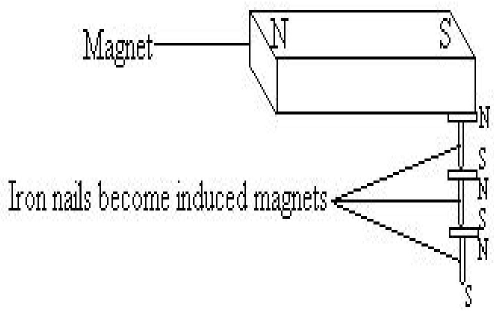
The current is switched on for a short time and then off

When the bar is removed, it will be magnetized

MAGNETIC SATURATION

Is the limit beyond which the strength of a magnet cannot be increased

INDUCTION METHOD



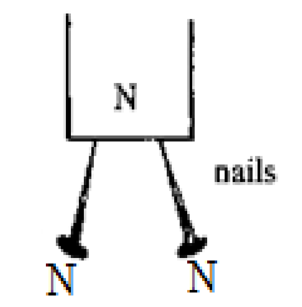
Iron nail is placed in contact with a permanent magnet for some time.

The magnetic material (iron nail) acquires temporary magnetism and could be seen attracting other iron nails or small pieces of razorblades.

The part of the magnetic material in contact with the pole of the magnet is induced with opposite poles.

Question

Figure below shows two iron nails picked up by a magnet.



Why are the nails attracted by the magnet?

The North pole of the magnet induces opposite poles on the nails such that the end close to the North Pole becomes the South Pole. Since they are unlike poles they attract each other.

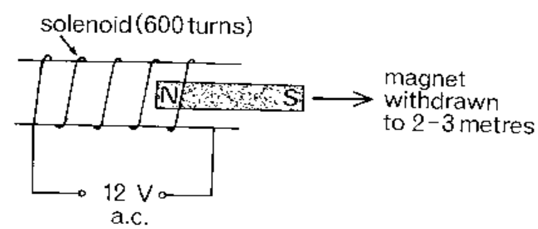
DE-MAGNETIZATION OF A MAGNET.

Is a process by which magnetism of a magnet is destroyed

This is the method by which the magnetism of a magnet is weakened and finally destroyed.

METHODS OF DE-MAGNETISING A MAGNET

1. **By hammering or hitting**; hammering the magnet while lying in the $E-W$ direction destroys its molecular arrangement.
2. **By heating**; the magnet is heated strongly while facing in the $E-W$ direction
3. **By using alternating current**.



The magnet is placed in a solenoid connected to alternating current $(a.c)$ facing in the $E-W$ direction

The magnet is removed to a long distance from the solenoid

N.B

During demagnetization by heating or hammering, the atoms of the magnet vibrate vigorously and this disturbs the arrangement of the tiny particles

Question

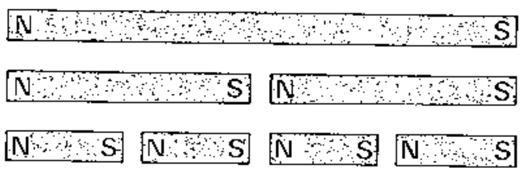
Explain why increase in temperature destroys the magnetism of a magnet?

When a substance is heated, molecules vibrate with greater energy, these increased vibrations destroy alignment of tiny magnets in the domain and the magnetism is decreased.

BREAKING A MAGNET

If a magnet is broken into smaller pieces, each piece is a magnet with a $N-pole$ and a $S-pole$

Therefore the North Pole and the South pole of a magnet cannot be separated instead more magnets are formed with reduced strength



SOFT AND HARD MAGNETIC MATERIALS

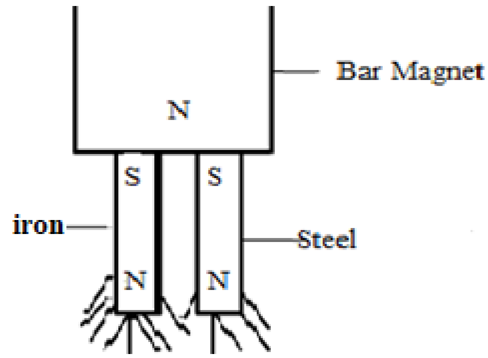
Soft magnetic materials are substances that can easily be magnetized and also lose their magnetism easily. e.g. iron
The magnetism induced is temporary and the magnets formed are temporary

They are used in,
- Electric bells
- Transformer cores
- Magnetic lens relays
- Magnetic separators

Hard magnetic materials are substances that are not magnetized easily but take long to lose their magnetism e.g. steel.

They are used in dynamos, loud speakers etc.

EXPERIMENT TO DISTINGISH BETWEEN HARD AND SOFT MAGNETIC MATERIALS.



Two similar un-magnetized pieces of iron and steel are placed side by side in contact with the pole of a magnet

They become magnetized by induction

The ends are dipped into the iron fillings

More iron fillings cling on the iron than on steel, indicating that iron is easily magnetized than steel

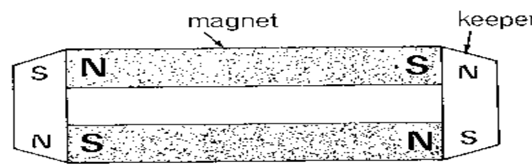
The strips are removed from the magnet and held firmly

Few fillings fall from steel while practically all fall from the iron, indicating that steel retain its magnetism while iron loses its magnetism easily

STORING MAGNETS

Magnetic keepers are soft iron bars used to keep magnets from losing their magnetism

Magnets are laid side by side with opposite poles. The magnet keepers are placed at the poles



EXPLANATION

How magnetic keepers are used to store magnets

The keepers become induced with magnetism. The opposite poles produced become neutralized with the poles of the magnets so that magnetic dipoles in the domains are kept aligned in one direction or in closed loop.

MAGNETIC FIELD PATTERNS

Magnetic field

Is the space or region around the magnet where the magnetic force is felt (experienced)

A magnetic field is represented by lines of magnetic force called ***magnetic flux***

Properties of magnetic field lines

1. They run from the north to south pole
2. They are in a state of tension
3. They repel each other side ways
4. They don't cross each other

The number of magnetic field lines per unit area is called ***magnetic flux density***

The strength of the magnetic force depends on the magnetic flux density

In a magnetic field, there is a region where magnetic flux density is zero, this is a ***neutral point***

A ***neutral point*** is a region in a magnetic field where magnetic force is zero

Field patterns can be mapped using 2 methods

i) Using iron filings
ii) Using a plotting compass or needle.

USING IRON FILINGS

A paper is put over a bar magnet on a bench and iron filings are sprinkled lightly over the paper

The paper is touched gently, the iron filings line up into a magnetic field pattern

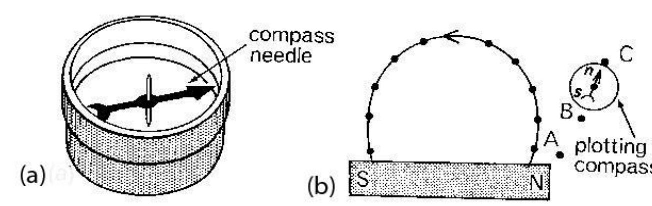
Note

Each iron filling magnetizes by induction and lines up in the direction of the field

Disadvantages

1. It does not show the direction of the field
2. It is not good for weak magnets

USING A PLOTTING COMPASS.



A magnet is placed on a flat surface and then a piece of paper is placed on top of the magnet.

A plotting compass is placed near one pole of the magnet

The position of the North Pole of the compass needle using a pencil dot is noted and marked.

The compass needle is moved onto the dot marked on the paper and a second dot is made. The process is continued until the south pole of the magnet is reached.
The dots are joined to give a line of force and show the direction of the force using an arrow.

Advantages of using a plotting compass

1. It is good for weak magnets

ENERGY

Is the ability to do work

OR

Is the capacity to do work

The $S.I$ unit of energy is $\boldsymbol{joule(J)}$

It is a scalar quantity

SOURCES OF ENERGY

1. Renewable sources

Are sources that can be re-used

They can never get exhausted (used up)

For example

1. Solar energy (sun)
2. Wind
3. Running water
4. Geothermal

2. Non-renewable sources

Are sources that cannot be re-used

They can be exhausted

For example

1. Fuel like petrol
2. Fossil
3. Nuclear energy

FORMS OF ENERGY

1. Chemical energy
Is energy obtained as a result of chemical reactions
It is the energy stored in food and fuel

2. Radiant energy
Is the energy from the sun

3. Heat energy
Is the energy from fire sources

4. Nuclear energy
Is the energy created by nuclear reactions

5. Electric energy
Is the energy due to the flow of charges

6. Light energy
Is the energy that enables us to see

7. Sound energy
Is the energy that enables us to hear

8. Mechanical energy
Is the sum of kinetic energy and potential energy

KINETIC ENERGY

Is the energy possessed by a body by virtue (reason) of its motion

$$\boldsymbol{K.E = \frac{1}{2}mv^2}$$

Where m =mass in kg

v = Velocity (speed) in ms^{-1}

POTENTIAL ENERGY

Is the energy possessed by a body by virtue (reason) of its position or state or condition

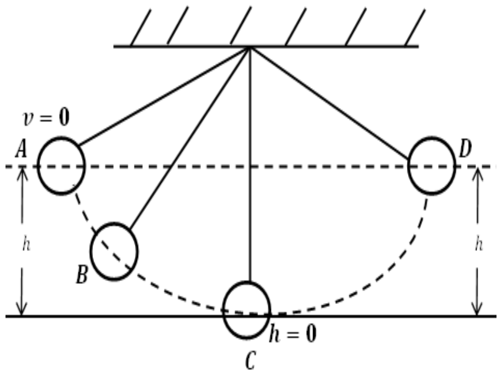
$$\boldsymbol{P.E = mgh}$$

Where

$\boldsymbol{m}$ = mass of the body in $\boldsymbol{kg}$

$\boldsymbol{g = 10ms^{-2}}$ (acceleration due to gravity)

$\boldsymbol{h}$ = Vertical height in $\boldsymbol{metres}$



POSITION	ENERGY
A	$K.E = 0$, $P.E = maximum$ $P.E = mgh$
B	$P.E$ changes to $K.E$ $M.E = P.E_B + K.E_B$
C	All $P.E$ changes to $K.E$ $K.E$ is maximum, $P.E = 0$ $K.E = \frac{1}{2}mv^2$ $the\ ball\ has\ maximum\ speed$
D	The ball is at height, h All $K.E_c$ changes to $P.E_D$ $P.E$ is maximum

Examples

1. A pendulum bob of mass, $m = 0.1kg$ is raised to a height of 0.4 above its lowest point. It is then released, calculate
   (a) $P.E$ at this height
   (b) K.E at its lowest height
   (c) The maximum velocity

2. A ball of mass $500g$ is dropped from a high wall and it strikes the ground with a velocity $10ms^{-1}$
   (a) What is the $K.E$ of the ball as it is just about to strike the ground
   (b) What was its $P.E$ before it was dropped
   (c) From what height was the ball dropped

3. A $200g$ ball falls from a height of $0.5m$. calculate its $K.E$ just before hitting the ground

4. A block of mass $2kg$ falls freely from rest through a distance of $3m$. Find the
   (a) $K.E$ of the block before it hits the ground
   (b) $velocity$ with which the body hits the ground

POWER

Is the rate of transfer of energy

OR

Is the rate of doing work

$$\boldsymbol{Power = \frac{work\ done}{time\ taken}}$$

$$Power = \frac{energy\ transfered}{time\ taken}$$

It is a scalar quantity

$$Power = \frac{work(J)}{time(s)}$$

The $S.I$ unit of power is $\boldsymbol{Js^{-1}}$ $\boldsymbol{(joules\ per\ second)}$

But $1Js^{-1} = 1W(watt)$

Therefore the $S.I$ unit of power is $\boldsymbol{watt(W)}$

A watt is the rate of transfer of energy of $1 joule\ per\ second$

Larger units are

- The smoke particles are seen as bright specks moving in a continuous random motion

Conclusion

- This demonstrates Brownian motion

Explanation

- The random motion of the smoke particles is due to collision between smoke particles and invisible air molecules which are in a state of constant random motion

EFFECTS OF TEMPERATURE ON BROWNIAN MOTION

When the temperature of the smoke cell is increased, the particles are seen to move faster

An increase in temperature increases the kinetic energy of the molecules hence the speed of the molecules also increases

When the temperature of the smoke cell is reduced by placing it on a block of ice, the smoke particles are seen to move slowly

Decrease in temperature reduces the kinetic energy of the molecules thus reducing the speed of the molecules

USING POLLEN GRAINS TO DEMONSTRATE BROWNIAN MOTION

- Pollen grains are introduced in a container with water and viewed under a microscope
- The pollen grains are seen moving a continuous random motion

Explanation

- The continuous random motion is due to the collision of pollen grains with water molecules that are in a constant random motion

DIFFUSION

Is the spreading of molecules of matter from a region of high concentration to a region of low concentration

Diffusion is extremely slow in solids, average in liquids and very fast in gases

FACTORS THAT AFFECT THE RATE OF DIFFUSION

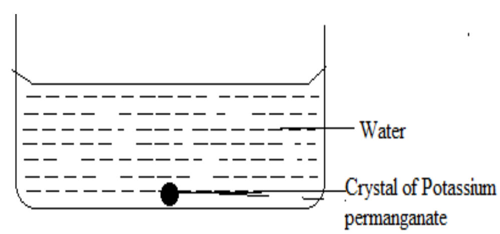
1. **Temperature**
   The rate of diffusion increases with increase in temperature and decreases with decrease in temperature

2. **Molecular mass**
   Light molecules diffuse faster than heavy molecules

3. **Size of particles**
   Small particles diffuse faster than larger molecules

4. **Pressure**
   The rate of diffusion of a gas increases with an increase in pressure

EXPERIMENT TO SHOW DIFFUSION IN LIQUIDS



- A crystal of potassium permanganate is placed at the bottom of a beaker containing water
- The crystal dissolves and spreads throughout forming a purple solution
- The spreading of a purple solution demonstrates diffusion

APPLICATION OF CAPILLARITY

1. Absorption of water by a towel
2. The action of a blotting paper
3. Rise of oil (paraffin) in a lamp wick
4. Rise of water and mineral salts in plants

DISADVATAGES OF CAPILLARITY

1. Absorption of water by building makes walls weak and they collapse

SOLUTION

1. A damp proof course ($polythene\ or\ cncrete\ slab$) prevents capillarity from the ground

SURFACE TENSION

Is a force on a liquid surface that causes it to behave as if it is covered with an elastic skin

EFFECTS OF SURFACE TENSION

1. A steel needle or pin can float on water surface
2. Some insects can walk on water surface
3. Water drops from a tap form spherical droplets

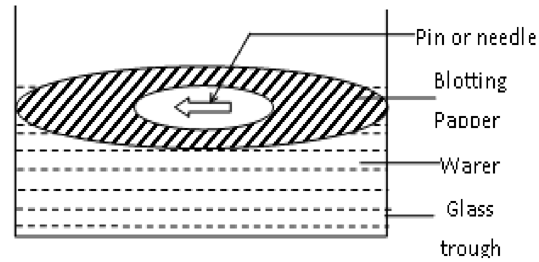
FACTORS AFFECTING SURFACE TENSION

1. **Temperature**
   Increase in temperature reduces surface tension

2. **Impurities**
   Addition of impurities like soap solution weakens surface tension

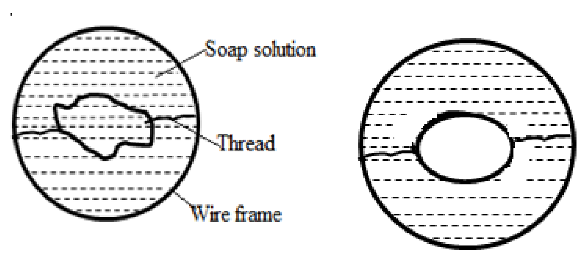
EXPERIMENT TO DEMONSTRATE SURFACE TENSION

METHOD 1



- A clean beaker is filled with clean water
- A blotting paper is placed on the water surface
- A pin slightly greased is gently placed on the blotting paper
- After sometime, the blotting paper sinks and the needle remains floating due to surface tension

METHOD 2



- A thread is tied to form a loop across a wire frame
- The frame is first dipped into soapy water so that a thin film stretches across the wire frame
- The film inside a thread is broken
- The tread is pulled into a circle due to surface tension

CENTRE OF GRAVITY

Is the point through which the total weight of a body acts

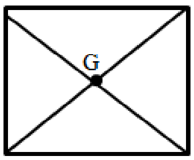
The $C.O.G$ coincides with centre of mass

Centre of mass is a point through which the total mass of a body concentrate

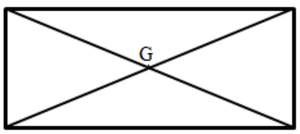
For regular bodies, their centre of gravity is exactly in their centres

For example

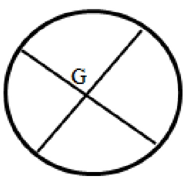
1. **Square**



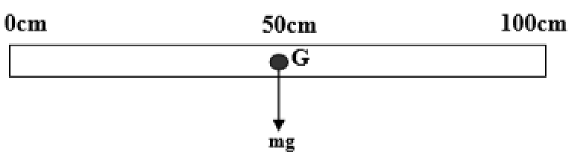
2. **Rectangle**



3. **Circle**



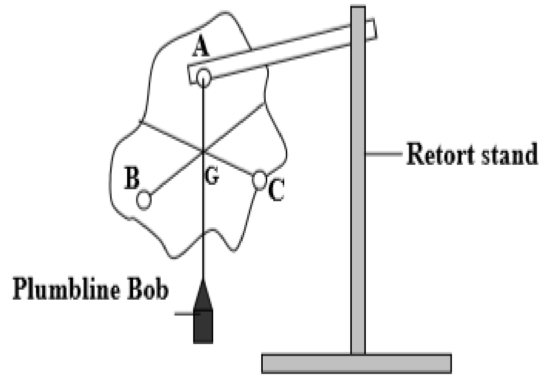
4. Uniform metre rule



DETERMINATION OF CENTRE OF GRAVITY

Using a plumbine

A plumbline is a string with a weight attached to it



- Three holes A, B and C are made at spaced intervals around the edge of the lamina
- The lamina is suspended through hole A on a nail attached on the retort stand so that it swings freely
- The plumbline is suspended on the nail
- The vertical line through hole A is drawn using a pencil
- The procedures are repeated using hole B and line drawn
- The point of intersection of the lines is the centre of gravity

  Research;

  Describe an experiment to determine $C.O.G$ of an irregular lamina using balancing method

STABILITY OF A BODY

The stability of a body depends on two factors

1. Position of the centre of gravity
2. Size of the base area

How to increase the stability of a body

1. Increasing the base area
2. Lower the centre of gravity by making the base heavier

EQUILIBRIUM

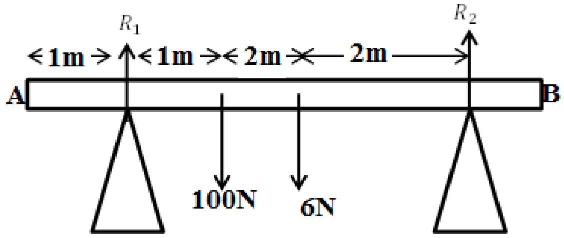
Is the state of balance of a body

OR

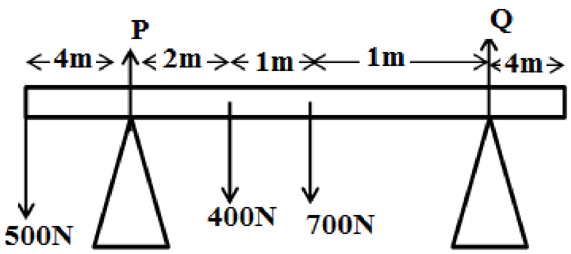
The resultant moment about any given point must be zero

More examples

1. Find the reactions R_1 and R_2, if the rod is in equilibrium



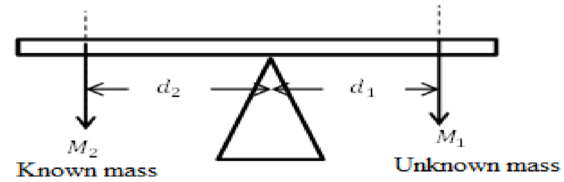
2. Calculate the forces P and Q if the beam is balancing



APPLICATIONS OF THE PRINCIPLE OF MOMENTS

1. Action of a beam balance
2. Action of a sea saw
3. Determination of mass of a uniform beam
4. Determination of mass of an object
5. Determination of relative density of a solid

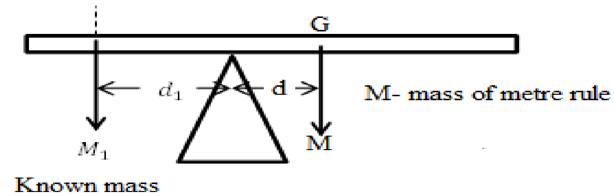
DETERMINATION OF MASS OF AN OBJECT USING THE PRINCIPLE OF MOMENTS



- A metre rule is balanced horizontally on a knife edge
- The balancing point G is noted
- A known mass m_2 and the unknown mass m_1 are suspended on either sides of the metre rule
- The distances d_1 and d_2 are adjusted until the metre rule balances again
- The distances d_1 and d_2 are noted
- Using the principle of moments

$$m_1 \times d_1 = m_2 \times d_2$$
$$m_1 = \frac{m_2 \times d_2}{d_1}$$

DETERMINATION OF MASS OF A UNIFORM METRE RULE USING THE PRINCIPLE OF MOMENTS



- A metre rule is balanced horizontally on a knife edge
- The balancing point, G is noted
- A known mass m_1 is suspended on one side of the metre rule
- The position of the knife edge is adjusted until the metre rule balances again
- The distances d_1 and d are noted
- Using the principle of moments

$$m = \frac{m_1 \times d_1}{d}$$

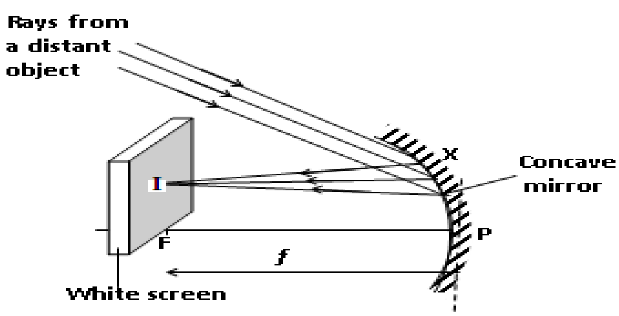
Examples

DISADVANTAGES OF CONVEX MIRROR

1. It forms diminished images
2. It gives a false impression of the distance of an object. This makes it difficult for the driver to judge the distance while reversing the car

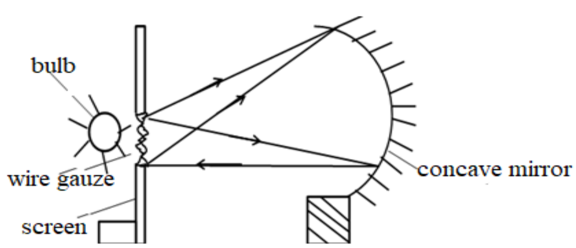
DETERMINING THE FOCAL LENGTH OF A CONCAVE MIRROR

1. Focusing a distant object (approximate method)



- The position of the mirror is adjusted until a clear sharp image of a distant object is focused on the mirror
- The distance, f between the mirror and the screen is measured
- This is the focal length of the mirror

2. Using the illuminated object



- The position of the mirror is adjusted until a clear image of the wire gauze is formed on the screen
- The distance, r between the mirror and the screen is measured
- The focal length of the mirror is obtained from $f = \frac{r}{2}$

PRESSURE

Is the force acting normally on an area of $1m^2$

$$pressure = \frac{force}{area}$$

It is a scalar quantity

The $S.I$ unit

$$pressure = \frac{force\ (N)}{area(m^2)}$$

$$= Nm^{-2}$$

$but\ 1Nm^{-2} = 1\ pascal$

Therefore the $S.I$ unit of pressure is $\boldsymbol{pascal}(\boldsymbol{Pa})$ OR $\boldsymbol{newton\ per\ square\ metre}\ (\boldsymbol{Nm^{-2}})$

A $\underline{\boldsymbol{pascal}}$ is the pressure exerted when a force of $1N$ acts normally on an area of $1m^2$

Other units of pressure

- Atmosphere (atm)
- Millimeter of mercury $(mmHg)$

Examples

1. A block of metal produces a pressure of $1000\ Nm^{-2}$ when resting on a flat surface of area $0.5m^2$. calculate the force exerted on the surface

2. A car piston exerts a force of $200N$ on a cross sectional area of $40cm^2$. Find the pressure exerted by the piston

3. A man of mass $48kg$ stands upright on a floor. If the area of contact of his shoe and the floor is $420cm^2$. Find the pressure exerted on the floor by the man

PRESSURE IN SOLIDS

Pressure in solids depends on

1. Weight of the solid
2. Area of contact

Pressure increases when the area of contact is reduced and it reduces when the area of contact increases

MAXIMUM AND MINIMUM PRESSURE

Pressure increases when the area of contact decreases and pressure decreases when the area of contact increases

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

$$P_{max} = \frac{Force}{Area_{min}}$$

$$Minimum\ pressure = \frac{force}{maximum\ area}$$

$$P_{min} = \frac{Force}{Area_{max}}$$

Examples

1. A box measures $5m$ by $1m$ by $2m$ and has a weight of $60N$, while resting on the horizontal surface, calculate the maximum and minimum pressure it exerts.
Maximum area = biggest $\times$ bigger
(biggest area) length length

Minimum area = smallest $\times$ smaller
(smallest area) length length

2. The dimensions of a cuboid are $5cm \times 10cm \times 20cm$ and the mass of the cuboid is $6kg$. Calculate the maximum and minimum pressure the cuboid exerts on the ground

3. A rectangular block of mass $48kg$ measures $4m \times 3m \times 2m$, what is the least pressure it can exert on a given surface

4. A rectangular block of metal weighs $3N$ measures $(2 \times 3 \times 4)cm^3$. What is the greatest pressure it can exert on a horizontal surface

5. A rectangular block of metal $2cm$ by $10cm$ by $10cm$ weighs $5kg$. Calcultate the maximum and minimum pressure

EXPLAIN THE FOLLOWING OBSERVATIONS

1. A hippotamus is able to walk on a muddy ground unlike a goat
A hippo has a large feet therefore it exerts less pressure while a goat has small feet and it exerts a greater pressure thus sinking in mud

2. High heeled shoes of ladies dig the ground
They have pointed soles and therefore exert a very high pressure on the ground

3. When the same force is applied at the end of the needle and the nail, one tends to feel more pain from the needle than the nail
The needle has a very small area of contact and therefore exerts a large pressure while a nail has a large area of contact and therefore exerts a less pressure

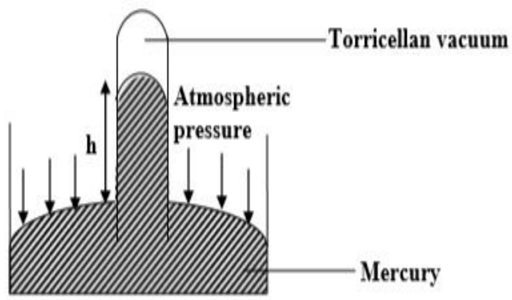
4. A wooden bed can easily be broken when standing on it than when lying on it
When standing, feet have a small area of contact and therefore exert a high pressure while lying, the area of contact is large and thus a small pressure is exerted

5. A sharp knife cuts well than a blunt one
A sharp knife has a small area of the cutting edge thus exerting a high pressure while a blunt knife has a larger area of the cutting edge hence exerting a small pressure

MEASUREMENT OF ATMOSPHERIC PRESSURE

Atmospheric pressure is measured using a ***barometer***

HOW A SIMPLE BAROMETER IS MADE IN THE LABORATORY



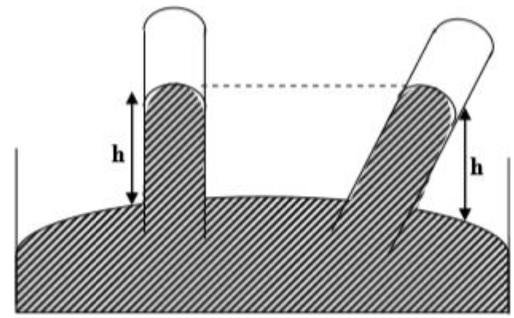
- A $1m$ long thick walled tube is filled with mercury
- The tube is inverted several times with the finger at the other end *(This expels air bubbles in the mercury).*
- After inverting several times, the tube is refilled with mercury.
- With a finger on the open end, the filled tube is inverted into a bowl of mercury.
- The finger is removed;
- The mercury falls up to a height $h = 76cmHg$
- The height h is the atmospheric pressure

Atmospheric pressure = barometric height × density of mercury × acceleration due to gravity

$$\boldsymbol{atmospheric\ pressure = h \times \rho \times g}$$

NOTE

- The torricellian vacuum is not a real vacuum because it contains some mercury vapour
- The vertical height, h of the mercury column remains the same even if the tube is tilted to an angle as shown below

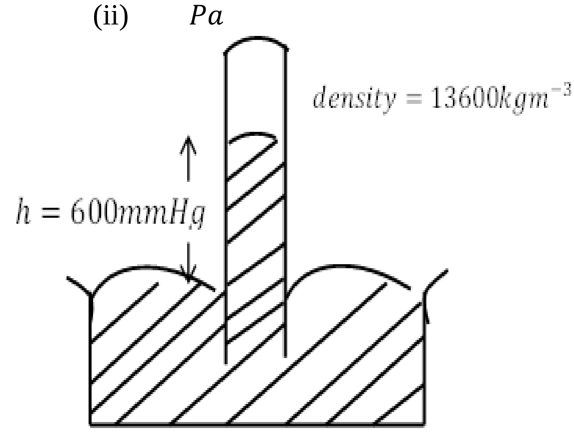


Other types of barometer are

1. Fortin barometer
2. Aneroid barometer

Examples

1. Determine the atmospheric pressure in;
   (i) $cmHg$
   (ii) Pa



2. Express;
   (i) $900mmHg$ in Nm^{-2}
   (ii) $540nnHg$ in Pa

Calculating the height of the reading of the mercury barometer at high altitude:

$$h_a\rho_a g = h_{atm}\rho_m g - h_m\rho_m g$$

Where

h_a = Height of the mountain

h_{atm} = Atmospheric pressure at the bottom of the mountain

h_m = Mercury column barometer at top of the mountain

Examples

1. A mercury barometer reads a pressure of $75cmHg$ at the bottom of a mountain and $73.5cmHg$ at the top. If the density of mercury is $13600kgm^{-3}$ and that of air is $1.25kgm^{-3}$, calculate the height of the mountain

2. A barometer is taken to the top of a mountain $440cm$ high. If the atmospheric pressure is $76cmHg$ at sea level, the average density of air $= 1.2kgm^{-3}$ and mercury is $13600kgm^{-3}$ Calculate the barometer reading

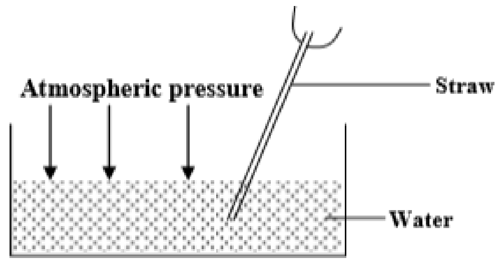
3. The pressure difference between the top and the bottom of a mountain is $1.0 \times 10^4 Nm^{-2}$. If the density of air is $1.25kgm^{-3}$. Find the height of the mountain. [Ans: 800m]

4. A barometer reads 780mmHg at the foot of the mountain which is 450m high. What is the barometer reading at the top of the mountain.(Density of air is $1.25kgm^{-3}$. and that of mercury is$13600kgm^{-3}$). [Ans: 738.9mmHg]

APPLICATIONS OF ATMOSPHERIC PRESSURE

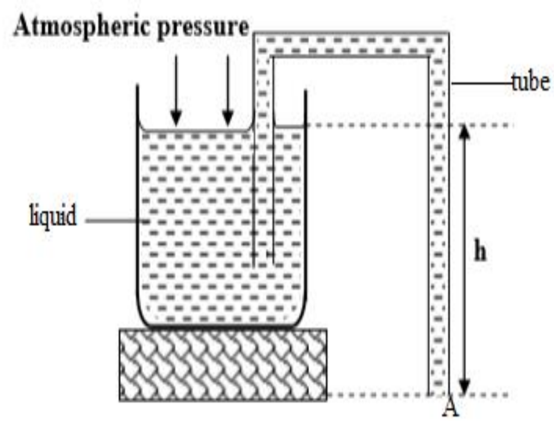
1. Siphon
2. Bicycle pump
3. Drinking straw
4. Lift pump
5. Force pump
6. Rubber sucker

THE DRINKING STRAW



- When drinking using a straw, air is sucked and this leaves a partial vacuum in the straw.
- The atmospheric pressure forces the liquid to rise through the straw

THE SIPHON

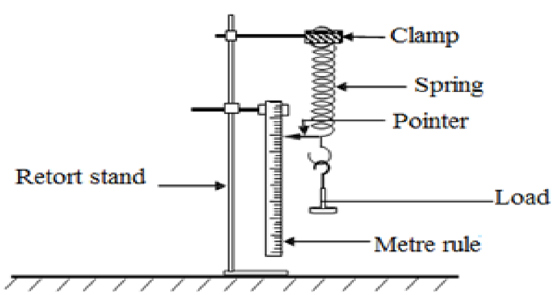


- It is used to empty tanks
- The end A must be below the liquid level in the tank
- The air inside the tube is sucked out and the tube is filled with the liquid
- Sucking reduces the pressure inside the tube and atmospheric pressure forces the liquid into the tube and it flows out continuously

Examples

1. A force of $50N$ causes an extension of $0.25m$. calculate the spring constant
2. A spring is stretched from $80cm$ to $82cm$ by a weight of $4.4N$. calculate
   (i) Extension produced
   (ii) Force constant k of the spring
3. A spring stretches by $6cm$ when supporting a load of $15N$. By how much would it stretch when supporting a load of $5kg$
4. A force of $40N$ causes an extension of $5cm$ on a spring. Find the force that will cause an extension of $8cm$

EXPERIMENT TO VERIFY HOOKE'S LAW



- The initial position, P_0 of the pointer is noted
- A known weight W is suspended from the free end of the spring
- The new position P_1 of the pointer is noted
- The extension $e = P_1 - P_o$ is calculated
- The procedures are repeated for increasing values of W
- The results are tabulated
- A graph of W against e is plotted
- A straight line through the origin is obtained
- This means that extension is directly proportional to the load hence Hooke's law is verified

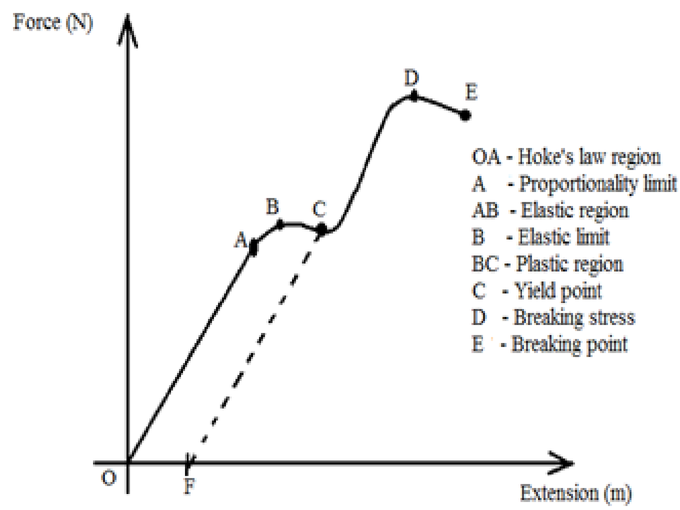
STRETCHING A WIRE

When weights are added on a thin long wire, the wire extends. The extension is proportional to the applied force

Since the wire is elastic, if the weights are removed, the wire returns to the original length

If we continue to add more masses, at a certain point, the wire will not return to exact original position (plastic deformation)

A graph of force (weight) against extension takes the shape below



REGIONS OF THE GRAPH

Region OA

- This is the ***Hooke's law region***
- The force increases proportionally with extension
- Point A is called the ***proportionality limit***
- ***<u>Proportionality limit</u>*** is the maximum load applied on a material beyond which Hooke's law is not obeyed

Region AB

- This is called the ***elastic region***

- When the applied force is removed, the body recovers its original shape and size
- Point B is called the ***elastic limit***
- ***Elastic limit*** is the maximum load applied on a material beyond which the material cannot recover its original shape and size

Region BC

- This is the ***plastic region***
- Point C is the yield point
- When the load is removed, the material does not recover its original shape and size

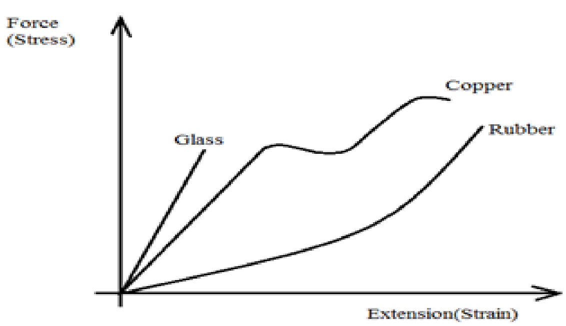
Point *D*

- This is the **breaking load**
- It is the maximum load the material can support

Point *E*

- This is the **breaking point**
- Without any further increase in weights, the wire develops cracks and the wire undergo physical changes

FORCE AGAINST EXTENSION TO SHOW THE COMPARISSION BETWEEN GLASS, COPPER AND RUBBER



GLASS

It is brittle and has a small elastic region and breaks suddenly when a force is applied

COPPER

It undergoes both elastic and plastic deformation

RUBBER

It is elastic and has a greater region of elastic deformation. It breaks suddenly when it reaches elastic limit, it does not undergo plastic deformation

STRESS, STRAIN AND YOUNG'S MODULUS

STRESS (TENSILE STRESS)

Is the force per unit cross sectional area of the material

$$\boldsymbol{stress = \frac{force}{area}}$$

The $S.I$ unit of stress is Nm^{-2} or Pa

STRAIN

Is the ration of extension of a material to its original length

$$\boldsymbol{strain = \frac{extension}{original\ length}}$$

It has no units since it's a ratio of similar quantities

YOUNG'S MODULUS

Is the ratio of tensile stress to tensile strain

$$\boldsymbol{young's\ modulus = \frac{tensile\ stess}{tensile\ strain}}$$

The $S.I$ unit is Nm^{-2}

Examples

1. A wire of length $0.1m$ is subjected to a force of $2N$. If the cross sectional area of the wire is

$5 \times 10^{-4} m^2$ and the force of $2N$ causes an extension of $0.002m$. calculate

(i) Tensile stress

(ii) Tensile strain

(iii) Young's modulus

2. A wire of length $10cm$ is subjected to a force of $2N$. If the tensile strain is 0.5 and the tensile stress is $20Nm^{-2}$. Calculate the

(i) The extension caused

(ii) Young's modulus

(iii) Cross sectional area of the wire

STEEL

It an alloy made from iron and carbon

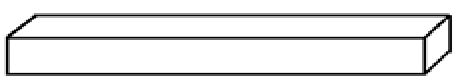
PROPERTIES OF STEEL

- It is stiff
- It ductile
- It is elastic
- It is strong

STRUCTURES AND BEAMS

BEAMS

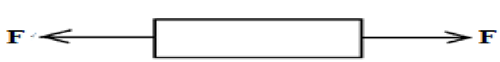
A beam is a long, large and straight material with a uniform cross sectional area



Effects of stress on a beam

1. **Tension**

Are two forces acting in opposite directions away from each other stretching its particles apart



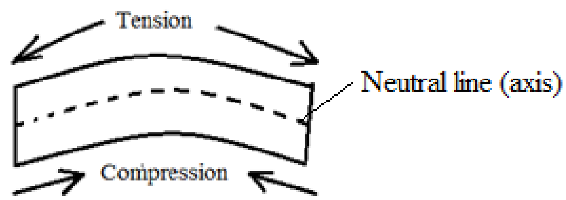
2. **Compression**

Are two forces that act towards each other making particles push together

BENDING A BEAM

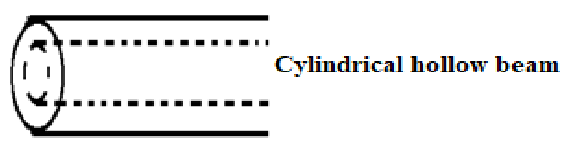
When a beam is bent, one side experiences compression force and the other side experiences tension force

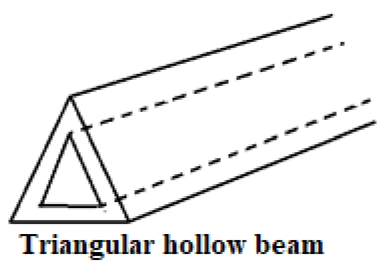
The centre of the beam is neither under tension nor compression i.e. it forms a ***neutral axis***

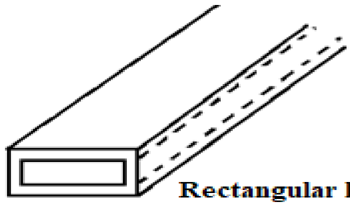


The material can be removed from the central region without breaking or weakening the beam. This is a hollow beam

Examples of a hollow beam







Rectangular hollow beam

Advantages of hollow beams

1. Makes the structure light
2. It is economical because less material is used
3. It can withstand both tension and compression
4. Cracks do not spread easily

Uses of beams

1. Used in building bridges and roofs
2. Used in making table and chair stands
3. Used in making bicycle frame
4. Used in making window and door frames

STRUCTURE

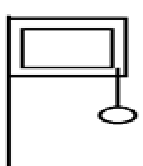
Is a rigid construction that can support a load e.g. houses, bridges, platforms etc.

Structures are made of beams

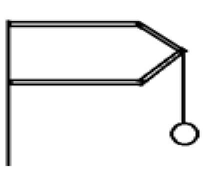
A structure is strengthened by materials called ***girders***

Triangular structures are said to be stronger compared to other shapes

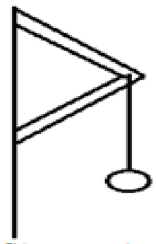
Below are certain structures of different shapes subjected to the same load



Weak

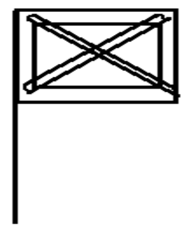


Stronger



Strongest

Rectangular structures can be made stronger (stiffer) by fixing more girders as shown below



These are materials used to strengthen a structure

Types of girders

1. **Ties;** are girders under tension forces
2. **Struts;** are girders under compression forces

IDENTIFYING TIES AND STRUTS

TIES

- When a tie is removed from the structure, the points it joins separate
- When a tie is replaced by a rope, the rope becomes tight

STRUT

- When a strut is removed from the structure, the points it joins comes closer
- When a strut is replaced by a rope, it becomes loose

EXAMPLES

Identify ties and struts from the structures below

From

$$v = u + at$$
$$S = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Using $a = g$

$$\boldsymbol{v = u + gt}$$
$$\boldsymbol{S = ut + \frac{1}{2}gt^2}$$
$$\boldsymbol{v^2 = u^2 + 2gs}$$

NOTE

For bodies falling freely (dropped), $g = 10ms^{-1}$

Examples

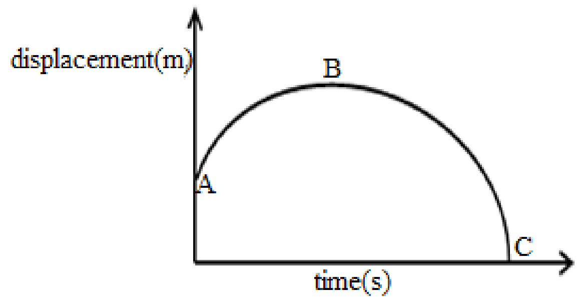
1. A small solid sphere falls freely. How far does it fall in $5s$
2. Calculate the time taken by a body dropped to attain a velocity of $100ms^{-1}$
3. A small ball is dropped from the top of a vertical cliff and takes $2.5s$ to reach the ground. Calculate the height of the cliff

BODES PROJECTED UPWARDS

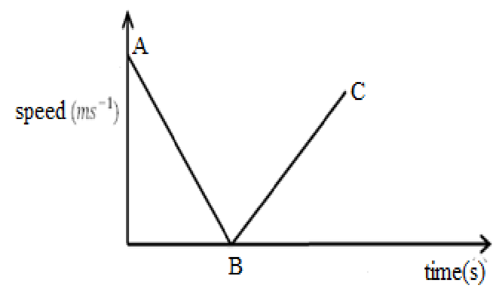
- When a body is thrown vertically upwards, $a = -g$
- The velocity reduces by $10ms^{-1}$ every second
- It decelerates until it reaches a maximum height when velocity is $zero$
- The acceleration is negative because motion is acting against gravity

GRAPHS OF MOTION

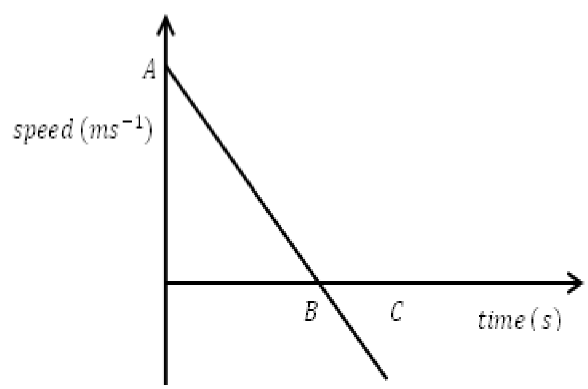
(a) Displacement – time graph



(b) Speed – time graph



(c) Velocity – time graph



From

$$v = u + at$$
$$S = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Using $a = -g$

$$\boldsymbol{v = u - gt}$$
$$\boldsymbol{S = ut - \frac{1}{2}gt^2}$$
$$\boldsymbol{v^2 = u^2 - 2gs}$$

At maximum height, $v = 0$

From; $v^2 = u^2 - 2gs$

. $0 = u^2 - 2gs$

. $\frac{2gs}{2g} = \frac{u^2}{2g}$

$$\boldsymbol{H_{max} = \frac{u^2}{2g}}$$

Examples

1. A body is thrown vertically upwards and reaches a height of $125m$. Find the velocity with which it was thrown upwards

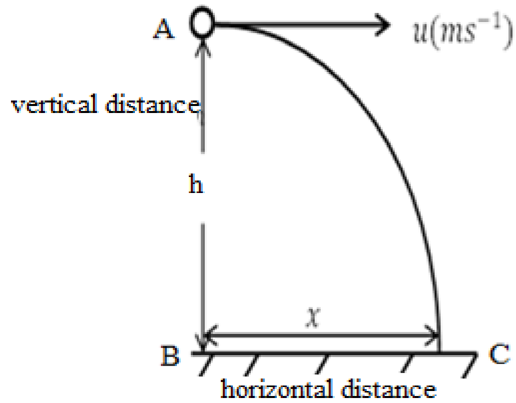
2. A ball is thrown vertically upwards with an initial speed of $2ms^{-1}$, calculate the;
   (a) Time taken to return to the receiver
   (b) Maximum height reached

3. A stone is thrown vertically upwards with an initial velocity of $30ms^{-1}$. Calculate
   (a) The time taken to reach maximum height
   (b) Maximum height

4. A bullet is fired vertically upwards and takes $4s$ to reach the maximum height, calculate
   (a) Initial velocity of the bullet
   (b) Maximum height

5. A stone is thrown vertically upwards with an initial velocity of $60ms^{-1}$, calculate the;
   (a) Time taken to reach maximum height
   (b) Total distance the stone travels to return to the hands of the sender

HORIZONTAL PROJECTION



The horizontal motion takes the same time as the vertical motion

The time taken to hit B = time taken to hit C

Stage1;Vertical motion to determine time to fall

$$S = ut + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2$$

$$\boldsymbol{t = \sqrt{\frac{2h}{g}}}$$

Stage2; Horizontal motion to determine horizontal distance

$$from; speed = \frac{distance}{time}$$

$$u = \frac{x}{t}$$

$$\boldsymbol{x = u \times t}$$

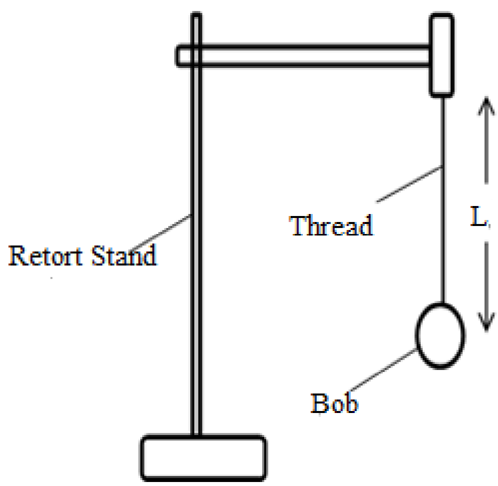
Examples

1. A ball is thrown forward horizontally from the top of a cliff with a velocity of $10ms^{-1}$, the height of a cliff above the ground is $45m$. Calculate the;
   (a) Time taken to reach the ground

(b) Distance from the cliff where the ball hits the ground

2. An object is released from an aircraft travelling horizontally with a velocity of $200ms^{-1}$ at a height of $500m$, find;
   (a) How long it takes the object to reach the ground
   (b) The horizontal distance covered by the object

EXPERIMENT TO DETERMINE ACCELERATION DUE TO GRAVITY USING A SIMPLE PENDULUM



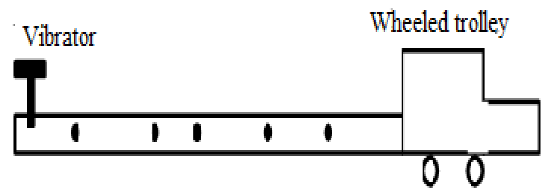
- A pendulum bob is tied at the end of a long piece of thread of length, l
- The thread is clamped on a retort stand
- The bob is slightly displaced and released to oscillate
- The time, t, for 20 oscillations is measured and recorded
- The period, T is calculated
- The procedures are repeated for different values of l
- The results are tabulated including values of, T^2
- A graph of T^2 against l is plotted, a straight line is obtained and the slope, $\boldsymbol{s}$ is calculated
- Acceleration due to gravity, g is calculated from

$$\boldsymbol{g = \frac{4\pi^2}{s}}$$

THE TICKER TIMER

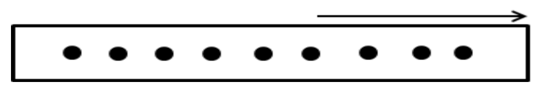
Is a device used to determine speed, velocity and acceleration of a body

It consists of a wheeled trolley which pulls a paper tape behind it and a fixed vibrator having a pricking end

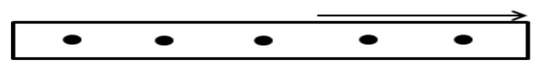


The vibrator makes dots on a piece of a paper tape that is being pulled by a wheeled trolley

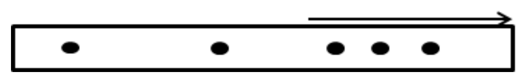
1. If the trolley moves slowly, dots are close together



2. If the trolley moves faster, the dots are far apart



3. If the trolley is accelerating, dots get apart



4. If the trolley is decelerating, dots gets closer

5. If the trolley is moving with uniform velocity, dots are uniformly spaced

TERMS USED

1. **Period,** $(\boldsymbol{T})$; Is the time taken to print any two successive dots
   $S.I$ unit is $\boldsymbol{seconds}$ $(\boldsymbol{s})$

2. **Frequency** $(\boldsymbol{f})$**;** Is the number of dots made in one second

$S.I$ unit is $\boldsymbol{hertz}$ $(\boldsymbol{Hz})$

For example $50Hz$ means 50 dots per second

50 Dots are made in 1 second

1 dot is made in $\frac{1}{50}$ seconds

1 dot is made in $\frac{1}{f}$ s

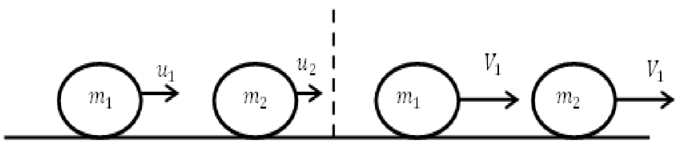
But time for 1 dot = period (T)

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

ELASTIC COLLISION

Is a type of collision where kinetic energy is conserved

- In this collision, the bodies separate after collision
- Momentum is also conserved



From the principle of conservation of momentum

$$\boldsymbol{m_1u_1 + m_2u_2 = m_1V_1 + m_2V_2}$$

Examples

1. A trolley P of mass $150g$ moving with a velocity of $20ms^{-1}$ collides with another stationary trolley Q of mass $100g$. If the two trolleys move together after collision. Calculate their common velocity

2. Two bodies of masses $3kg$ and $5kg$ are moving in opposite direction on a horizontal surface. If their velocities are $6ms^{-1}$ and $5ms^{-1}$ respectively. After collision, the bodies move in the same direction, calculate
   (a) The speed of the $3kg$ mass after collision
   (b) The loss n $K.E$
   (c) The percentage loss in $K.E$

3. A body of mass $20kg$ travelling at $5ms^{-1}$ collides with another stationary body of mass $10kg$ and they move separately in the same direction. If the velocity of the $20kg$ ma after collision is $3ms^{-1}$. Calculate the velocity with which the $10kg$ mass moves with

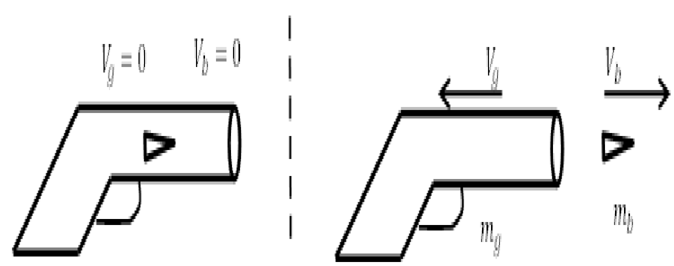
4. Two particles of masses $0.2kg$ and $0.4kg$ are approaching each other with velocities $4ms^{-1}$ and $3ms^{-1}$ respectively. On collision, the first particle reverses its direction and moves with a velocity of $2.5ms^{-1}$. Find the velocity of the second particle after collision

MOMENTUM AND EXPLOSIVES

When a bullet is fired from a gun, an explosion occurs

The bullet moves forward with a velocity called $\boldsymbol{muzzle\ velocity}$ and exerts an equal and opposite force to the gun which makes it move backwards with a velocity called $\boldsymbol{Recoil\ Velocity}$

$\boldsymbol{Recoil\ velocity}$ is the velocity of the gun after firing a bullet



$Momentum\ before\ explosion = momentum\ after\ explosion$

$m_gu_g + m_bu_b = -m_gV_g + m_bV_b$

$0 = -m_gV_g + m_bV_b$

$\boldsymbol{m_gV_g = m_bV_b}$

Examples

1. A bullet of mas $50g$ is fired with a velocity of $400ms^{-1}$ from a gun of mass $5kg$. Calculate the recoil velocity

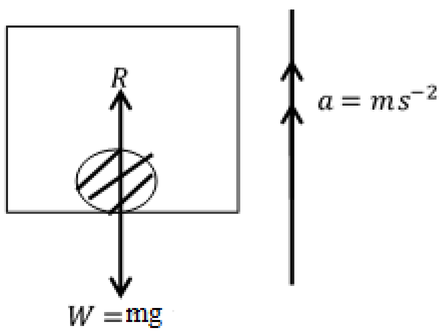
2. A bullet is fired from a gun with a horizontal velocity of $400ms^{-1}$. The mass of the gun is $3kg$ and the bullet is $60g$. Find the;
(a) The initial speed of the recoil of the gun
(b) Gain in $K.E$ of the system

MOTION IN A LIFT

When a body of mass m is placed inside a lift, it experiences two forces

1. Weight of the body (W)
2. Normal Reaction (R)

LIFT MOVING UPWARDS



$from\ F = ma$

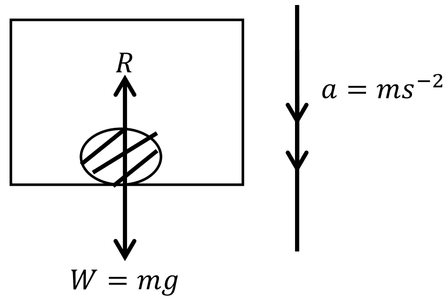
$R - W = ma$

$R - mg = ma$

$\boldsymbol{R = mg + ma}$

The person in a lift feels heavier due to the extra force, ***ma***

LIFT MOVING DOWNWARDS



$from\ F = ma$

$W - R = ma$

$mg - R = ma$

$\boldsymbol{R = mg - ma}$

The person the lift feels lighter due to the decrease of the accelerating force, ***ma***

WEIGHTLESNES

Is a condition in which a body falls at an acceleration equal to the acceleration due to gravity and the normal reaction between the surface and the body is zero

$from\ \ R = m(g - a)$

$$R = m(g - g)$$

$$\boldsymbol{R = 0N}$$

Examples

1. A man of mass $80kg$ is in the lift which is moving with an acceleration of $2ms^{-2}$. Calculate the force between the man and the lift when the;
(i) Lift moves upwards
(ii) Lift moves downwards

2. A girl of mass $60kg$ sits in a lift accelerating at a rate of $7.5ms^{-2}$. Calculate the normal reaction on a girl when the lift;
(i) Acceleration downwards

SINKING AND FLOATATION

When an object is immersed or submerged in a fluid ($liquid\ or\ air$), its weight appears to be reduced because it experiences an upward force from the fluid called $Upthrust$

$\boldsymbol{Upthrust}$ is the upward force acting on a body immersed in a fluid

A cork held under water rises to the surface when released because it experiences an up-thrust greater than its weight

The weight of a body when immersed in a fluid is called $Apparent\ weight$

$\boldsymbol{Upthrust = weight\ in\ air - weight\ in\ a\ fluid}$

$\boldsymbol{Upthrust = apparent\ loss\ in\ weight}$

Examples

1. A glass block weighs $25N$. When fully immersed in water, it weighs $15N$. Calculate its up-thrust

2. A body weighs $1N$ in air, $0.8N$ when wholly immersed in a fluid. Calculate its up-thrust

ARCHIMEDES PRINCIPLE

"When a body is fully or partially immersed in a fluid, it experiences an up-thrust equal to the weight of the fluid displaced"

$\text{Upthrust} = \text{weight of the fluid displaced}$

Also

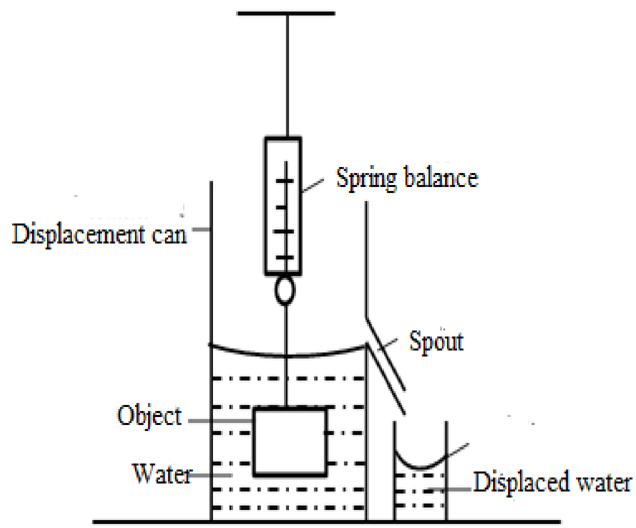
$\boldsymbol{Volume\ of\ displaced\ fluid = Volume\ of\ the\ body\ submerged}$

Examples

1. A metal weighs $20N$ in air and $15N$ when fully immersed in water. Calculate the
   (i) Up-thrust
   (ii) Weight of the displaced water
   (iii) Volume of the displaced water

2. An object weighs $7N$ in air and $3N$ when immersed in oil of density $800kgm^{-3}$. Find the;
   (i) Up-thrust
   (ii) Volume of the oil displaced
   (iii) Density of the object

EXPERIMENT TO VERIFY ARCHIMEDES PRINCIPLE



- Water is poured in the displacement can until it runs from the spout
- When the water stop dripping, an empty beaker of weight W_1 is placed below the spout
- The weight, W_a of an object in air is measured using a spring balance
- The object is carefully immersed in water and its weight, W_w is noted
- The weight, W_2 of the beaker and the displaced water is determined
- Weight of the displaced water $= W_2 - W_1$
- Up-thrust $= W_a - W_w$
- It is found out *that up-thrust= weight of water displaced* hence verifying Archimedes principle

APPLICATION OF ARCHIMEDES PRINCIPLE

1. Measurement of relative densities of solids
2. Measurement of relative densities of liquids

TO MEASURE $R.D$ OF SOLIDS

- Weight, W_a of the object in air is noted
- The weight, W_w of the object when fully immersed in water is noted
- $Upthrust = W_a - W_w$
- $R.D = \frac{Weight\ in\ air}{upthrust}$

$$\boldsymbol{R.D = \frac{W_a}{W_a - W_w}}$$

TO MEASURE $R.D$ OF A LIQUID

- Weight, W_a of the object in air is noted
- Weight, W_w of the object when fully immersed in water is noted
- Weight, W_l of the object when fully immersed in a liquid is noted

$$Relative\ Density = \frac{Upthrust\ in\ liquid}{Upthrust\ in\ water}$$

$$\boldsymbol{R.D = \frac{W_a - W_l}{W_a - W_w}}$$

$Also$

$$\boldsymbol{R.D = \frac{\rho_s}{\rho_w}}$$

Examples

1. An object weighs $5.6N$ in air and $4.8N$ in water. Find the $R.D$ and density of the solid
2. An object weighs $4.92N$ in air and $4.87N$ when immersed in water. Calculate the density of the object
3. An object weighs $100N$ in air and $84N$ in water. If it weighs $60N$ in a liquid X, find the $R.D$ of liquid X
4. A piece of iron weighs $555N$ in air. When completely immersed in water, it weighs $530N$ and weighs $535N$ when completely immersed in alcohol. Calculate the $R.D$ of alcohol and density of the alcohol
5. A glass block weighs $25N$ in air. When completely immersed in water, the block weighs $15N$. Calculate the density of the glass block

FLOATING OBJECTS

If $W < U$, the object rises up

If $W > U$, the object sinks

If $W = U$, the object floats

From the Archimedes principle

$$Upthrust = weight\ of\ the\ fluid\ displaced$$

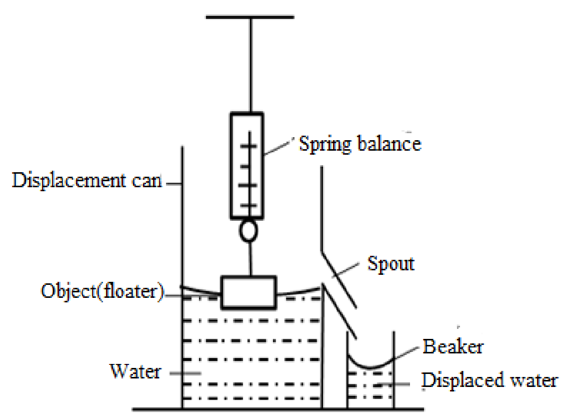
Therefore for a body to float

$$\boldsymbol{Weight\ of\ the\ object = Weight\ of\ the\ fluid\ displaced}$$

LAW OF FLOATATION

"A floating body displaces its own weight of the fluid in which it floats"

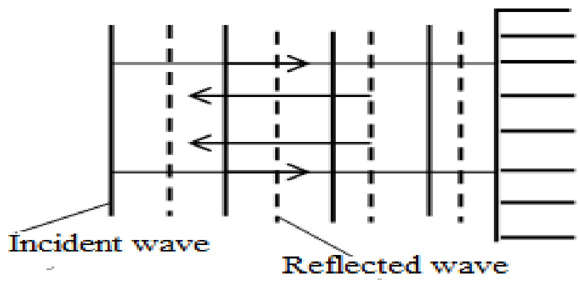
EXPERIMENT TO VERIFY THE LAW OF FLOATATION



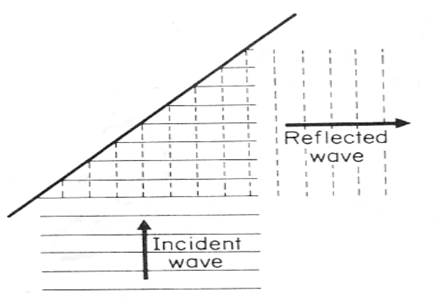
- A floater is weighed in air and its weight is noted
- Water is poured in an overflow can until it runs out of the spout
- When the water stop dripping, an empty beaker of weight, W_1 is placed below the spout

(a) plane reflector

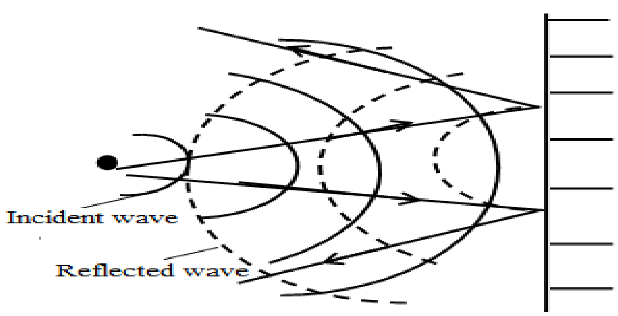
(i) plane wave fronts



(ii) plane wave fronts on inclined plane reflector

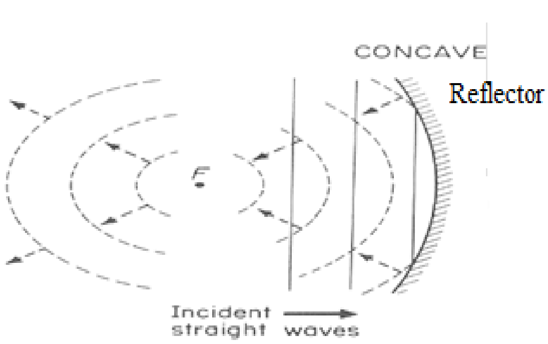


(iii) circular wave front on plane reflector

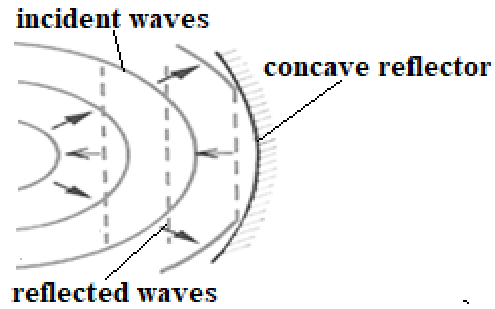


(b) concave reflector

(i) plane waves

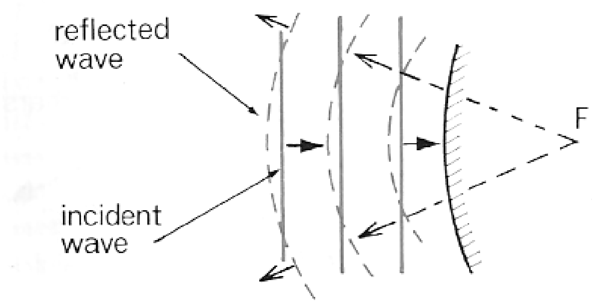


(ii) circular waves

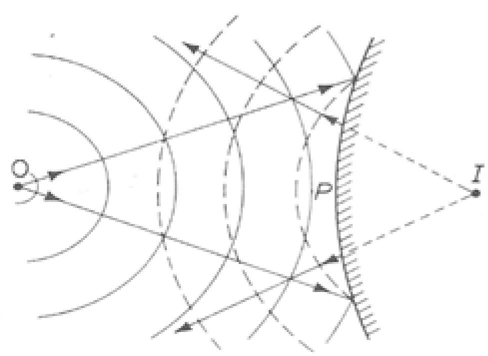


(c) convex reflector

(i) plane waves



(ii) circular waves

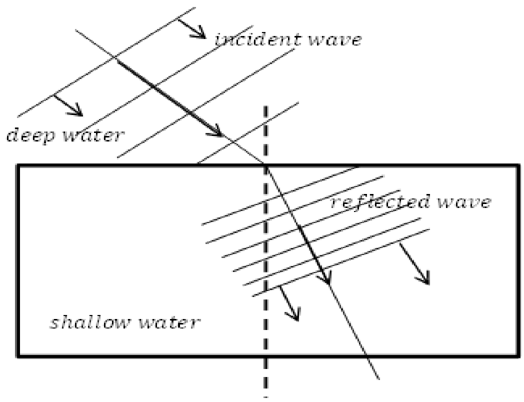


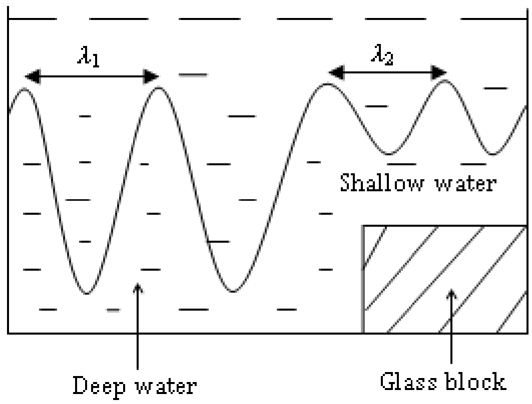
REFRACTION OF WAVES

Is the bending of a wave as it travels from one medium to another of different optical densities

It is caused due to change in wavelength and velocity of the wave. However the frequency and the period are not affected

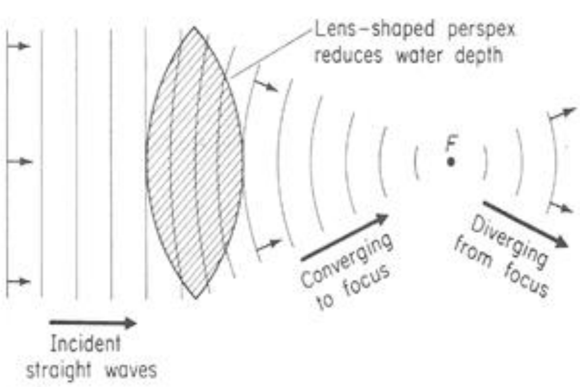
In a ripple tank, refraction is brought about by change in water depth



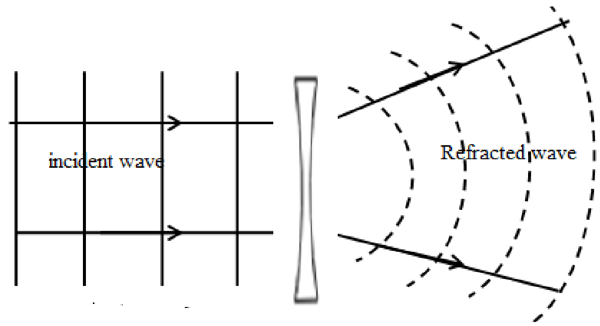


Wavelength (λ_1) in deep water is greater than wavelength (λ_2) in shallow water therefore a wave travels faster in deep water than in shallow water

Refraction on convex lens



Refraction on concave lens

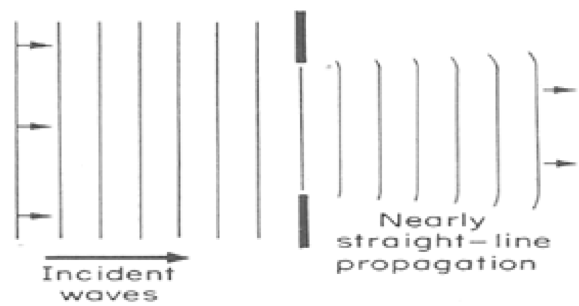


DIFFRACTION OF WAVES

Is the spreading of waves around obstacles or as they pass through gaps

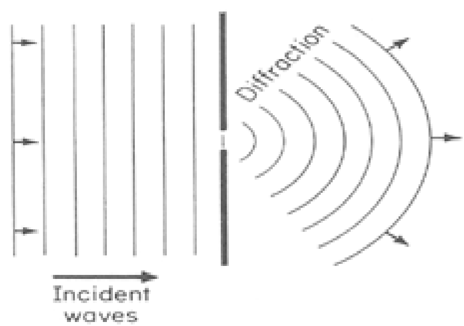
The smaller the gap, the greater the degree of diffraction

(a) wide gap



When the width of the gap is large, the straight waves pass through as nearly straight waves

(b) narrow gap



When the width of the gap is smaller, the waves pass through as circular waves

INTERFERENCE OF WAVES

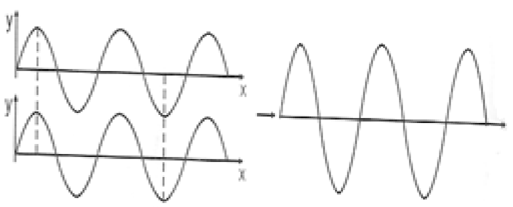
Is the superposition of two waves travelling in the same direction having the same amplitude, frequency and wavelength

If two waves have the same amplitude, wavelength and frequency, they are said to be identical and the waves are in phase.

TYPES OF INTERFERENCE

1. **Constructive interference**

Is a type of interference in which the interfering waves have a displacement in the same direction e.g. a crest meeting a crest or a trough meeting a trough

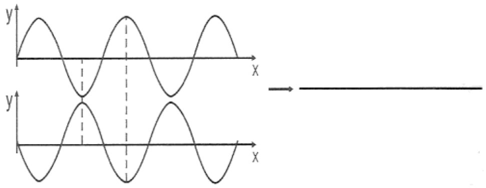


If two waves are light waves, much brighter light is obtained.

If the two waves are sound waves, a louder sound is heard

2. **Destructive interference**

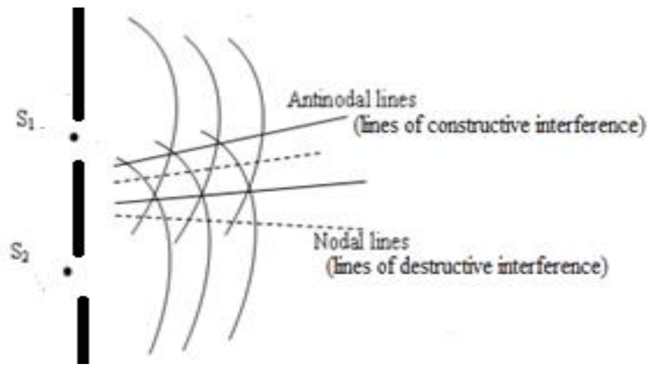
Is a type of interference in which the interfering waves have a displacement in opposite direction. E.g a crest meeting a trough



If the two waves are light waves, darkness is observed

If the two waves are sound waves, no sound is heard

Consider wave fronts passing in two narrow gaps as shown below



THE ELECTROMAGNETIC WAVES

Are waves which consists of electric and magnetic fields of high frequency

They don't require a material medium for their transmission

Examples are;

1. gamma rays
2. X-rays
3. Ultra-violet rays
4. Visible light
5. Infra-red
6. Radio waves

Properties of electromagnetic waves

1. They can travel in vacuum
2. They travel at speed of light in a vacuum
3. They travel in a straight line
4. They are transverse
5. They possess energy
6. They are reflected, refracted, diffracted, and interfered

The electromagnetic spectrum

Increasing wavelength (decreasing frequency)

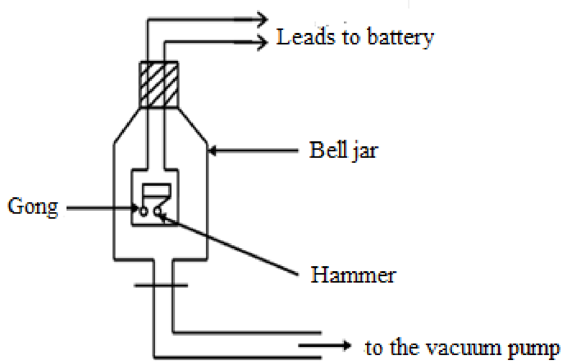
Gamma rays	X-rays	Ultra-violet	Visible light	Infra-red	Radio waves

This can be remembered well using $GaXUVIRa$

Transmission of sound

Sound requires a material medium for transmission. It travels faster in solids followed by liquids than air.

Experiment to show that sound requires a material medium for transmission



An electric bell is placed in air tight bell jar connected to a vacuum pump

When the bell is switched on, a loud sound is heard

When the air is gradually reduced from the bell jar using a vacuum pump.

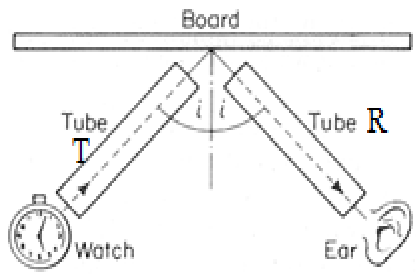
The loudness of sound reduces gradually until no sound is heard when all air is removed but the hammer is seen hitting the gong

This shows that sound requires a material medium for its transmission

NB, When air is allowed back, sound is heard again

Reflection of sound

Experiment to verify the laws of reflection of sound



A ticking watch is placed near the $tube\ T$ and the tube is made to face a hard plane surface

The ear is placed at the end of the $tube\ R$

Tube R is moved until a loud sound of the ticking watch is heard

Angles i and r are measured which are the angles of incidence and reflection

Angle $i =$ angle r and the tubes lie along the same plane, this verifies the laws of reflection

Refraction of sound

Is the bending of sound as it travels from one medium to another of different optical densities

Refraction occurs due to the change in the speed of sound which is also affected by temperature

Question

Explain why it is easier to hear sound at night than during day

During day, the ground is hot and this makes the air near it to be hot while above air is cool. Sound from the source is refracted away from the ground and makes it not clear.

At night, the ground is cool and this makes the air near the ground to be cool while above to be warm. Sound from the source is refracted towards the ground making it easier to hear sound.

Diffraction of sound waves

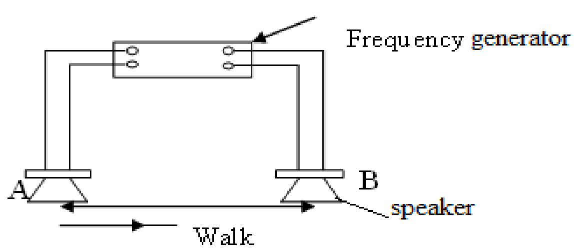
Is spreading of sound waves around corners or in gaps.

This enables a person behind a house to hear sound from inside the house

Interference of sound waves

When two sound waves of the same frequency, amplitude and wave length moving in the same direction overlap, they produce regions of loud sound (constructive interference) and regions of quiet sound (destructive interference)

Experiment to show interference of sound



When you move along AB, regions of loud sound and quiet sound are experienced, this demonstrates interference.

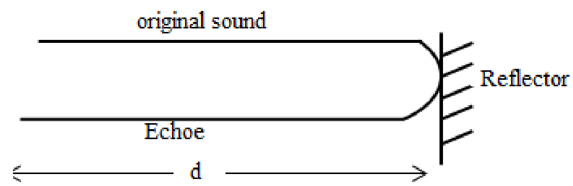
Loud sound means constructive interference where as quiet sound means destructive interference

ECHOES

Is a reflected sound

An echo is produced when sound waves strike a reflecting surface

Echoes are not heard in small rooms because the reflected sound waves return very quickly and mix up with the original sound



$.\ total\ distance = d + d = 2d$

$.from\ speed = \frac{distance}{tme}$

$.speed\ of\ sound, v = \frac{2d}{t}$

Examples

1. A girl stands at $34m$ away from a reflecting wall. She makes sound and hears an echo after $0.2s$ find the velocity of sound

2. A gun was fired. An echo from a cliff is heard $8s$ later. If the velocity of sound is $330ms^{-1}$, how far was the gun from the cliff
3. A student is standing between two walls and makes a clap. He hears the first echo after $2s$and anther after a further $3s$. If the velocity of sound is $330ms^{-1}$. Find the distance between the walls

4. A man is standing midway between two cliffs. He claps his hands and hears an echo after $3s$. Find the distance between the two cliffs ($velocity = 330ms^{-1}$)

5. Sound of frequency $250Hz$ is produced $120m$ from a cliff. Calculate the
   (i) Time taken for the sound to travel to the wall and back
   (ii) The wavelength of the sound
   ($velocity = 330ms^{-1}$)

Experiment to determine the speed of sound using the echo method

$.\frac{2L}{3} = 2Lf_0$

.from $V = \lambda f$

$.V = \frac{2L}{3} f_2$

$. f_2 = 3f_0$

A string forms both odd and even harmonics i.e $1f_0, 2f_0, 3f_0, 4f_0, 5f_0$ etc

Example

1. A string of length $0.5m$ vibrates to give a sound of a velocity $320ms^{-1}$. Find its
   (i) 3^{rd} overtone
   (ii) 3^{rd} harmonic
   (iii) 6^{th} harmonic

FACTORS THAT AFFECT THE FREQUENCY OF A STRING

1. Tension; frequency increases with tension, $f\alpha\sqrt{T}$
2. Length; frequency decreases with length, $f\alpha\frac{1}{L}$
3. Thickness (mass per unit length); frequency decreases with thickness $f\alpha\frac{1}{\sqrt{m}}$

Example

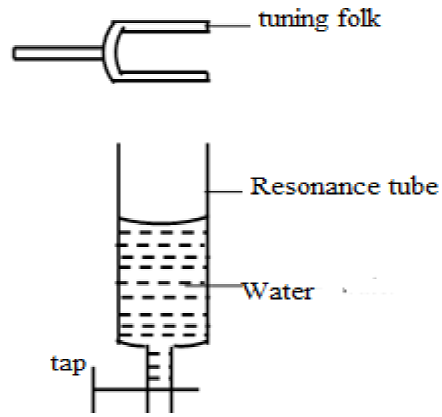
The frequency of a wave produced by a vibrating string is $320Hz$when the tension is $330N$. Calculate the frequency of the wave that is produced when the tension is increased by $120N$

RESONANCE

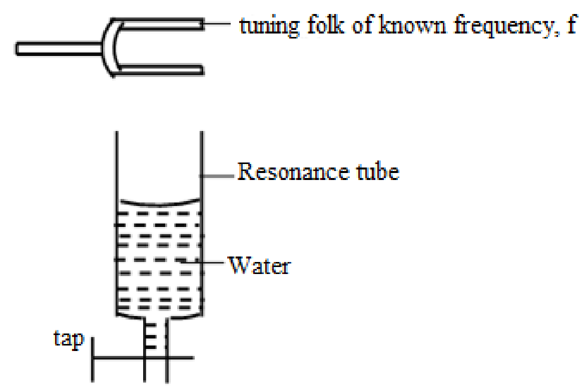
Is where a system is set into vibration at its own natural frequency as a result of a neighboring system vibrating with the same frequency

The resonance tube

It is a glass tube containing water and a tap at the bottom



Experiment to demonstrate resonance using a resonance tube

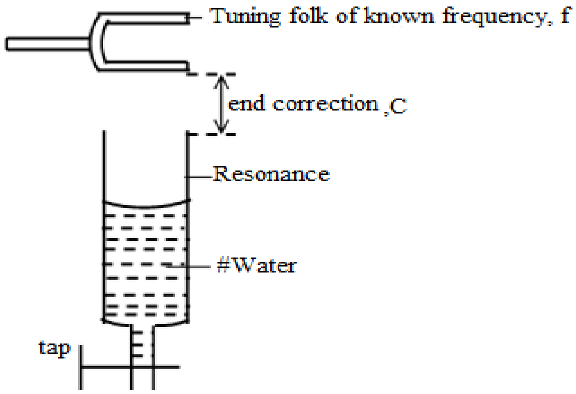


A vibrating tuning fork is placed above the resonance tube

The tap is opened to lower the water level which increases the air column

A time is reached when a loud sound is heard. This demonstrates resonance

Determining the speed of sound in air using the resonance method



A resonance tube is filled with water

A vibrating tuning fork of a known frequency is held above air in the tube

The length of the air column is adjusted by opening the tap until a loud sound is heard

The length of the air column L_1 is noted

$L_1 + c = \frac{\lambda}{4}$.........................(i)

The length of the air column is further increased utill a second loud sound is heard

The new length of the air column L_2 is noted

$L_2 + c = \frac{3\lambda}{4}$..........................(ii)

$(ii) - (i)$

Then the speed of sound $\boldsymbol{V = 2f(L_2 - L_2)}$

Examples

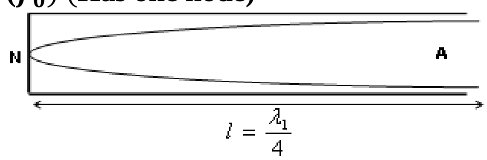
1. The tuning fork of frequency $256Hz$ produced resonance in the tube of length $32.5cm$ and one of length $95.0cm$. Calculate the speed of sound in air
2. A tube closed at one end resonates first at the length of $17.5cm$ and again at $51.5cm$. find the frequency of the vibration (speed of sound in air $= 340ms^{-1}$)

VIBRATIONS IN PIPES

1. CLOSED PIPES

Is one with one end closed and the other open eg a long drum

(a) First position or fundamental frequency ($\boldsymbol{f_0}$) (Has one node)



. $L = \frac{\lambda}{4}$

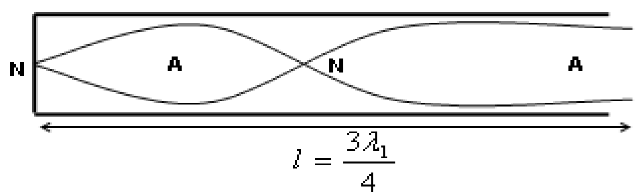
.$\lambda = 4L$

. from $v = \lambda f$

. $V = 4Lf_0$

.$f_0 = \frac{V}{4L}$

(b) Second resonance, $\boldsymbol{1^{st}\ overtone\ f_1}$ (Has 2 nodes)



.$\lambda = \frac{4L}{3}$

From $V = \lambda f$

. $V = \frac{4L}{3} f_1$

. $\frac{4L}{3} f_1 = 4Lf_0$

ELECTROSTATICS

THE STRUCTURE OF AN ATOM

An atom consists of a central part called the $nucleus$

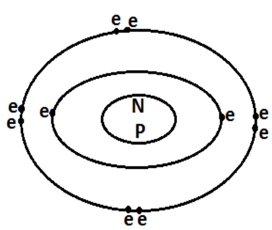
A nucleus contain $protons$ that are positively charged and $neutons$ that are not charged $neutral$

Outside the nucleus, there are $electrons$ that are negatively charged and they revolve around the nucleus

On a neutral atom, the number of electrons is equal to the number of protons

When an atom loses an electron, it will contain more positive charges than negative charges and it is said to be positively charged

When an atom gains an electron, it will contain more negative charges than positive charges and it is said to be negatively charged



Summary

Particle	Charge	Location
neutron (n)	No charge	In the nucleus
Proton (P)	Positive ($+$)	In the nucleus
Electron (e)	Negative ($-$)	Outside the nucleus

Electrostatics is the study of charges at rest

It is the study of the force between two charged bodies at rest

ELECTRIFICATION

Is a process of producing electric charges on a body that are either negative or positive

METHODS OF ELECTRIFICATION

1. By friction (rubbing); it is good for insulators
2. By contact (conduction); it is good for conductors
3. By induction; it is good for conductors

INSULATORS

Is a material without free electrons and cannot allow flow of charge through it

OR

Is a material that cannot allow electricity to flow through it

For example; Wood, Rubber, Wool

Insulators are charged by rubbing

CHARGING AN INSULATOR

- When two insulators are rubbed together, one loses electrons and becomes positively charged while another gains electrons and becomes negatively charged
- When a plastic material is rubbed against dry hair and then brought near small pieces of papers, it will attract the small pieces of paper
- When a glass rod is rubbed on silk, glass is ready to attract small pieces of paper

Summary

CHARGING AN ELECTROSCOPE

There are two methods of charging an electroscope

1. Contact method
2. **Electrostatic induction**

CONTACT METHOD

- A charged rod is rubbed on the metal cap of the $G.L.E$ to be charged. After sometimes, the rod is removed
- The $G.L.E$ diverge, this means that it is now charged

NOTE

- If the rod is negatively charged, the $G.L.E$ is charged negative and if the rod is positively charged, the $G.L.E$ is charged positive

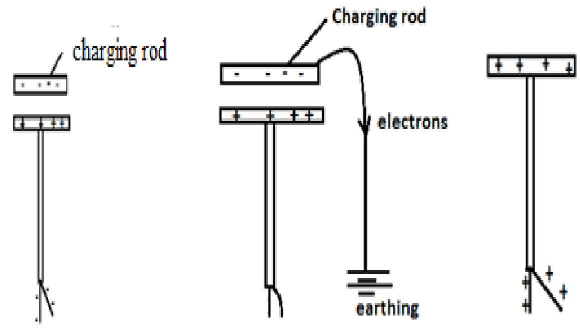
Explanation

- The charged rod induces on opposite charge on the cap and repels the charge of its kind to the leaf just before it comes into contact the cap
- When the rod touches the cap, its charges are neutralized by the charge on the cap
- The charge on the leaf distributes making the electroscope charged

CHARGING BY INDUCTION

(i) POSITIVELY

- A negatively charged rod is brought near the cap of electroscope
- The cap is then earthed by touching with the charging rod still in place
- The earthing is broken and then charging rod removed
- This leaves the electroscope positively charged

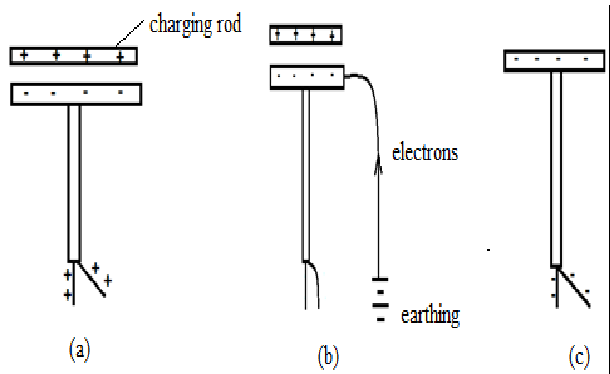


Explanation

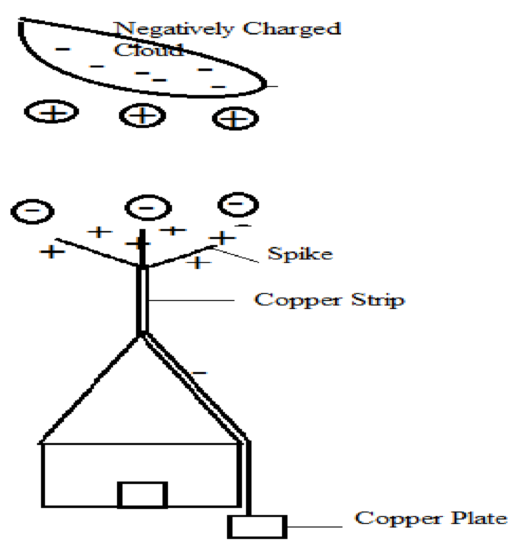
- The charged rod induces a positive charge on the cap and repels negative charges to the leaf and the leaf repels
- Earthing is done and negative charges flow to the ground
- When the charged rod is removed, the charge on the cap distributes leaving the electroscope positively charged

(ii) NEGATIVELY

- A positively charged rod is brought near the cap of the electroscope
- With the charging rod still in place, the cap is earthed by touching
- The earthing is broken and the charging rod removed
- This leaves the electroscope negatively charged



THE LIGHTNING CONDUCTOR



- When a negatively charged cloud passes over the spikes, it induces a positive charge on the spike and repels negative charges to the earth
- Ionization of air around the spikes occurs forming positive and negative ions
- Positive ions are attracted to the cloud and partly neutralize the negative charges there
- Negative ions are attracted to the spikes and neutralize the positive charges on the spike
- The excess negative charges are driven to the earth through the copper strip which reduces the possibility of lightning

NOTE

- It is not advisable to touch the copper strip of the lightning conductor
  During a thunderstorm, a current may pass through the conductor and when one touches the strip, current flows through the body and this causes an electric shock

DANGERS OF LIGHTNING

During lightning, a very large current flows between the cloud and the earth. This may lead to;

1. Death of people and animals
2. Destruction of properties like building
3. Causes power surge
4. Destroys electrical gadgets

ELECTRIC FIELD

Is a region around an electric charge in which electric force is felt

OR

Is a region around a charged conductor where electric force is experienced

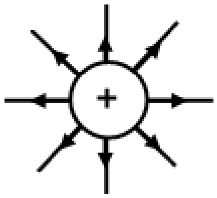
In electric fields, there are electric lines of force called **electric field lines**

PROPERTIES OF ELECTRIC FIELD LINES

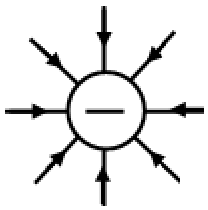
1. They originate from positive charge to negative charge
2. They are in a state of tension
3. They do not cross or touch each other
4. They repel each other sideways

ELECTRIC FIELD PATTERNS

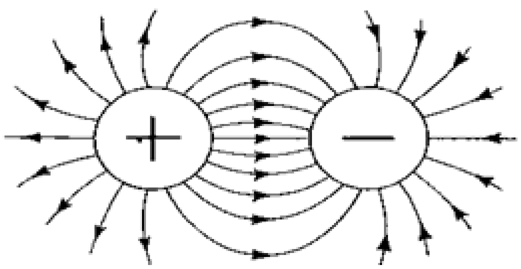
1. Isolated positive charge



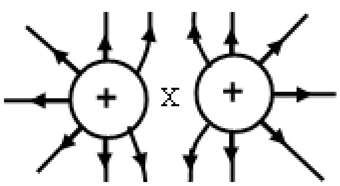
2. **Isolated negative charge**



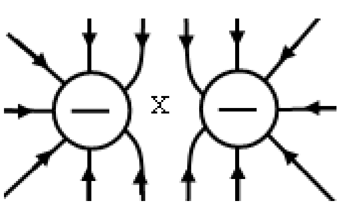
3. **Two opposite charges**



Two positive charges

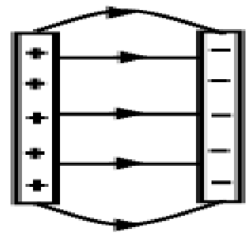


Two negative charges

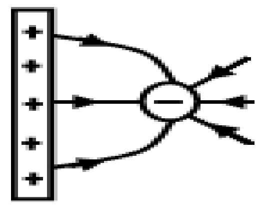


A neutral point is a region in an electric field where electric force is not felt (experienced)

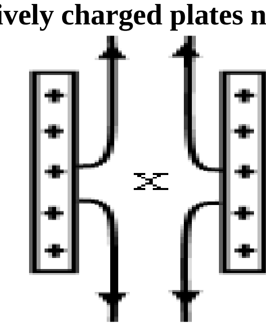
4. **Two opposite plates**



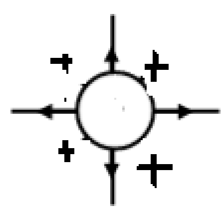
5. **A positive charge and a negative plate**



6. **Positively charged plates near each other**



7. **Hollow sphere (positive)**



ELECTRIC CELLS

Is a device which directly changes chemical energy to electrical energy

TYPES OF ELECTRIC CELLS

1. Primary cell
2. Secondary cell

PRIMARY CELLS

Are cells that cannot be recharged

In primary cells, electric current is produced as a result of non-reversible chemical reaction

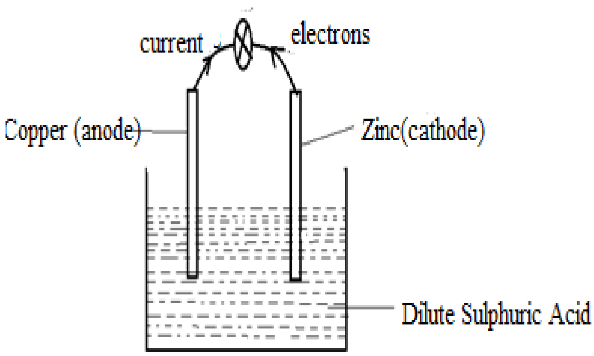
Examples

- Dry cell
- Simple cell
- Wet laclanche cell

A SIMPLE CELL

This consists of copper and zinc plates joined with a conductor and placed in electrolyte

The electrolyte used is $dilute\ sulphuric\ acid\ (H_2SO_4)$



The more reactive metal ($Zinc$) is the cathode and a less reactive metal ($copper$) is the anode

Dilute sulphuric acid ionizes as follows

$$H_2SO_{4(aq)} \rightarrow 2H^+_{(aq)} + SO^{2-}_{4(aq)}$$

When the circuit is complete, the $zinc$ goes into solution to form $zinc\ ions$, Zn^{2+} each leaving two electrons behind

$$Zn_{(s)} \rightarrow Zn^{2+} + 2e$$

The electrons produced flow through the wire to the copper plate and current flows from the positive ($copper$) towards the negative ($Zinc$)

The electrons which flow to the positive plate ($copper$) combines with $hydrogen\ ions$ to form $hydrogen\ gas$ which is given off at the $anode$

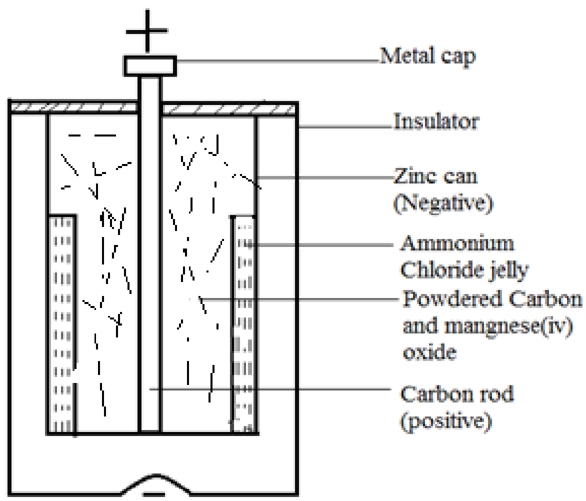
$$2H^+_{(aq)} + 2e \rightarrow H_{2(g)}$$

DEFECTS OF A SIMPLE CELL

A defect is the one that reduces the amount of current produced by a simple cell

DEFECT	HOW TO MINIMISE
1. POLARIZATION • This is the formation of hydrogen bubbles on the copper plate. • This insulates the anode and weakens the current • Polarization increases internal resistance	It is reduced by adding a depolarizer like $potassium\ dichromat$ This oxidizes the $hydrogen$ to form water
2. LOCAL ACTION • This is due to the impurities in $Zinc$ • It makes $Zinc$ to be used up even when current is not supplied	Cleaning $Zinc$ with $Conc\ H_2SO_4$ and coating it with mercury

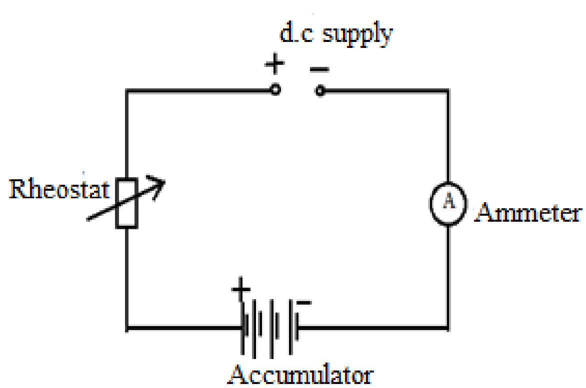
THE DRY CELL



- $Carbon$ is the anode and $Zinc$ is the cathode
- The electrolyte used is $amonium\ chloride\ jelly$
- The source of electrical energy is the chemical reaction between $Zinc$ and $amonium\ chloride$
- As a result, $Hydrogen$ is produced which collects at the $carbon$ and polarizes the cell
- $Mangenese\ (IV)oxide$ acts as a depolarizing agent which oxidizes the $hydrogen$ to water
- When the $Zinc$ is eaten away due to reaction, the cell becomes exhausted (used up)

NOTE

- Even if the cell is not working, $e.m.f$ reduces because of $local\ action$



- An accumulator is recharged by passing a $direct\ current\ (d.c)$ through it in opposite direction to the current it supplies
- The positive terminal of the $d.c$ source is connected to positive terminal of the accumulator while the negative terminal of the $d.c$ source is connected to negative terminal of the accumulator
- The acid becomes more concentrated during charging and the $relative\ density$ increases up to 1.25
- When the accumulator is fully charged, oxygen is given off from the positive plate and hydrogen from the negative terminal

NOTE

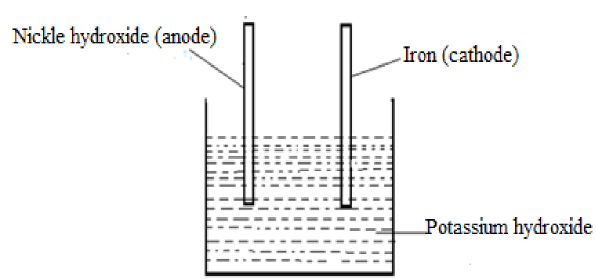
- $\boldsymbol{Gassing}$ is the giving off of gases from the terminals of the accumulator during charging
- When a battery is charging, electrical energy changes to chemical energy
- Direct current, $d.c$ is used during charging process because alternating current, $a.c$ would charge in the first cycle and then discharge in the next half cycle
- Rheostat is used to adjust current

ALKALINE CELLS

1. NICKLE – IRON ($Nife$) CELLS

The anode is $Nickle\ hydroxide$ and the cathode is $Iron$.

The electrolyte used is $Potassium\ hydroxide\ (caustic\ potash)$



- The $e.m.f$ of alkaline cells is low
- It has a higher internal resistance

USES

1. It is used for emergency lightning

ADVANTAGES OF ALKALINE CELLS OVER LEAD ACID ACCUMULATORS

1. They can stay un-charged for a longer period
2. They do not require much attention
3. They have a longer life span
4. They provide large currents without being damaged
5. It is not affected by overcharging

DISADVANTAGES

1. They are expensive
2. They have a low $e.m.f$ and high internal resistance

CAPACITY OF AN ACCUMULATOR

Is the amount of electricity which an accumulator can store

It is measured in $ampere\ hours\ (Ah)$

$$\boldsymbol{capacity = current\ (A) \times time(h)}$$

$$\boldsymbol{capacity = It}$$

$10Ah$ means that an accumulator can supply a current of $10A$ for 1 $hour$ or $5A$ in 2 $hours$

CURRENT ELECTRICITY

ELECTRIC CURRENT ($\boldsymbol{I}$)

Is the rate of flow of charge.

$$current, I = \frac{charge\ (Q)}{tme\ (,t)}$$

$$.I = \frac{Q}{t}$$

$$\boxed{.Q = It}$$

The $S.I$ unit of current is $\boldsymbol{amperes\ (A)}$

Current is measured using an ammeter

The $S.I$ unit of charge is $\boldsymbol{coulomb\ (C)}$

A $\boldsymbol{coulomb}$ is the quantity of charge that passes any point in a circuit when a steady current of $1A$ flows for $1s$

Examples

1. A current of $3A$ flows for 2 $minutes$ in the circuit containing a lamp. How much charge is flowing through the lamp

2. If a charge of $3C$ was passed for $1s$. What is current is flowing

3. A charge of $4C$ is flowing through a conductor at a rate of $0.5s$. calculate the current flowing

4. Calculate the amount of current flowing through a wire where $0.8C$ of charge passes a point in a given wire in $2s$

5. A charge of $180C$ flows through a lamp for $2minutes$. What is the current flowing in the lamp

ENERGY CONVERSIONS

Electric energy can be changed from one form to another using devices e.g.

1. Electric bulb converts electrical energy to heat and light energy
2. Motors convert electrical energy to mechanical energy
3. Heaters convert electrical energy to heat energy
4. Microphones convert sound energy to electrical energy

5. Generators convert mechanical energy to electrical energy
6. Loud speakers convert electrical energy to sound energy

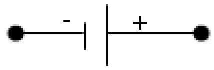
ELECTRIC CIRCUITS

Is a path through conductors in which current flows

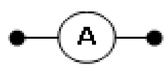
SYMBOLS USED IN ELECTRIC CIRCUITS

Battery

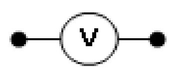
Cell



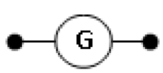
Ammeter



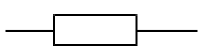
Voltmeter



Galvanometer

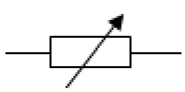


Fixed Resistor



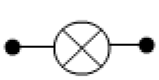
OR

Rheostat

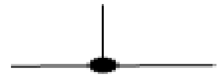


OR

Bulb

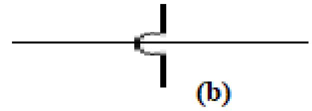


wires connected



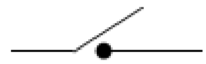
(a)

wires not connected

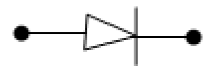


(b)

Open switch



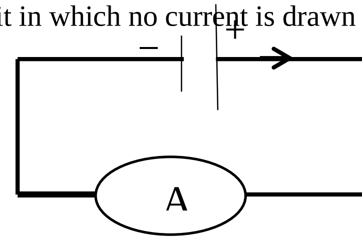
Diode



TYPES OF ELECTRIC CIRCUITS

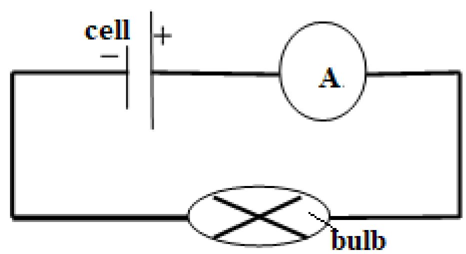
1. OPEN CIRCUIT

Is a circuit in which no current is drawn from the source



2. CLOSED CIRCUIT

Is a circuit in which current is drawn from the source to other components



EFFECTS OF ELECTRIC CURRENT

1. Heating and lighting of electric bulb
2. Deflection of a plotting compass
3. Formation of bubbles of hydrogen gas from the acids

POTENTIAL DIFFERENCE

Is the work done to move *one coulomb* of a charge from one point to another in a circuit

$.P.d,\ V = \frac{work\ done}{charge}$

$.V = \frac{W}{Q}$

$\boldsymbol{.W = VQ}$

The $S.I$ unit is $\boldsymbol{volts}$ $(\boldsymbol{V})$

$P.d$ is measured using a $voltmeter$

A $\boldsymbol{volt}$ is the $p.d$ between two points when $1\ joule$ of work moves $1C$ of charge between two points

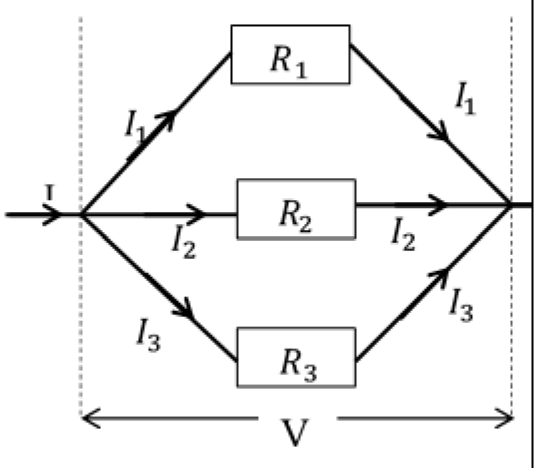
ELECTROMOTIVE FORCE $(\boldsymbol{E.M.F})$; $\boldsymbol{E}$

Is the terminal $p.d$ of a cell in an open circuit

OR

RESISTORS IN PARALLEL

- $p.d$ across each resistor is the same
- $current\ through\ each\ resistor$ is different
- Total current $I =$ sum of current in each resistor



$$I = I_1 + I_2 + I_3$$

$$but$$

$$I = \frac{V}{R}$$

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\boxed{\boldsymbol{\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}}$$

For only two resistors in parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R} = \frac{R_2 + R_1}{R_1 R_2}$$

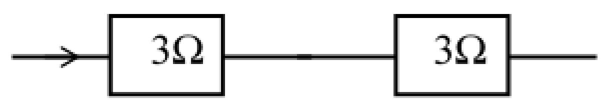
$$\boxed{\boldsymbol{R = \frac{R_1 \times R_2}{R_1 + R_2}}}$$

$$\boldsymbol{Total\ resistance = \frac{product}{sum}}$$

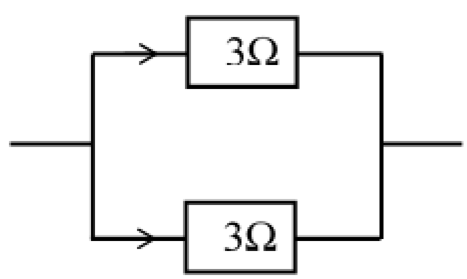
Examples

1. Calculate the effective resistance in the following arrangements

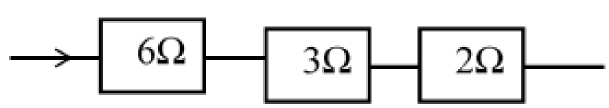
(a)



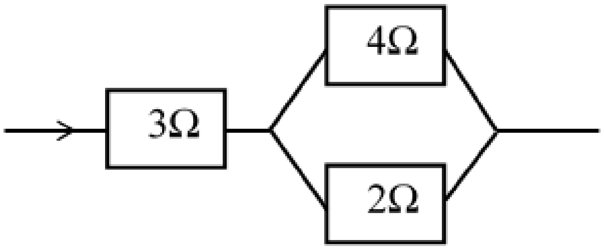
(b)



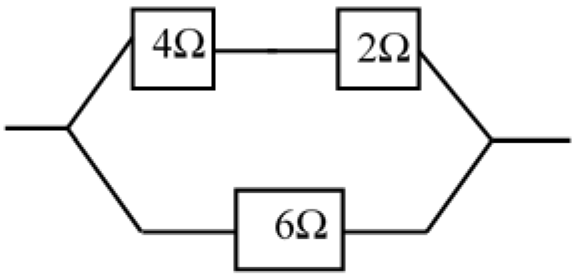
(c)



(d)



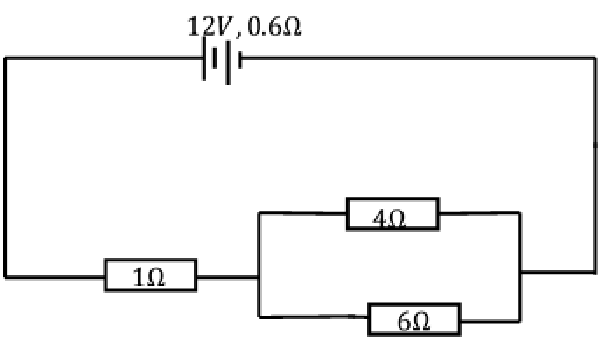
(e)



Calculate

(i) The current in the 6Ω resistor
(ii) The power expended in the 6Ω resistor
(iii) The total power expended

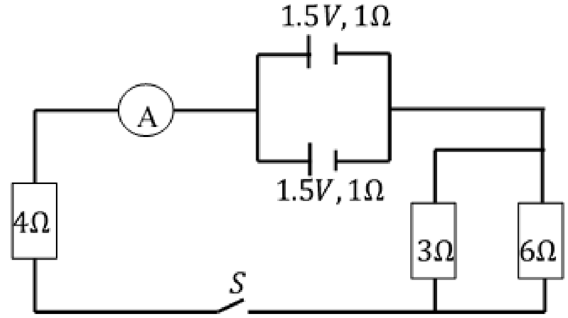
1. In the diagram below, a $12V$ battery of internal resistance 0.6Ω is connected to the three resistors of 10Ω, 4Ω and 6Ω as shown below



Find

(i) Current in each resistor
(ii) Power dissipated in the 4Ω resistor

2. In the figure below, two batteries of $e.m.f\, 1.5V$ and internal resistance 1Ω each are connected to a network of resistors in a circuit as shown



(i) What will be the reading of the ammeter when switch S is closed
(ii) What is the power developed in the 4Ω when $switch, S$ is closed

PAYING FOR ELECTRICITY

The board ($UMEME$) charges electricity it supplies

The energy consumed is measured in $\boldsymbol{KWh}$ ($\boldsymbol{kilowatt\ hour}$)

A **Kilowatt hour** ($\boldsymbol{KWh}$) is the electrical energy consumed by an appliance working at a rate of $1KW$ for one hour

$$number\ of\ units = power \times time$$

$$(energy\ consumed) \quad (KW) \quad (hrs)$$

$$total\ \ cost = number\ of\ units \times cost\ per\ unit$$

$$total\ cost = power \times time \times cost\ of\ one\ unit$$

$$\boldsymbol{total\ cost = P(KW) \times t(hr) \times costof\ one\ unit\ (shs)}$$

Examples

1. Four bulbs each rated at $75W$ each operates for $120 hours$. If the cost of electricity is $Shs\ 100$ per unit, find the total cost of electricity

2. An electric immersion heater is rated at $3000W, 240V$. Calculate the
   (i) Current and resistance of the heating filament
   (ii) Total number electric units it consumes in $1\frac{1}{2}$ hours
   (iii) Cost per unit if $Shs. 9000$ is paid after using it for $3 hours$ everyday for $10 days$

3. Mr. Mido uses 3kettles of $800W$ each, a flat iron of $1000W$, 3 bulbs of $60W$ each and 4 bulbs of $75W$each. If they are used for $3 hours$ every day for $30 days$ and that one unit of electricity costs $Shs. 200$, find the total cost of running the appliances

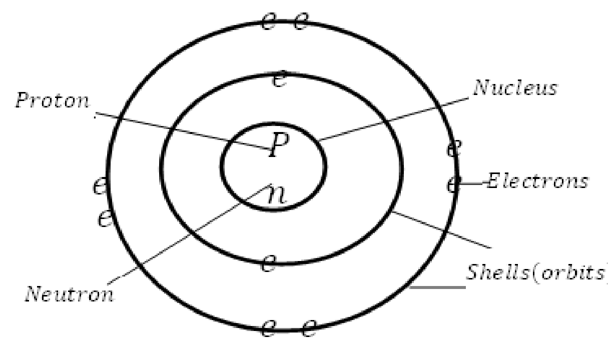
ATOMIC PHYSICS (MODERN PHYSICS)

STRUCTURE OF AN ATOM

An atom consists of a small positively charged nucleus with negatively charged electrons rotating around

The nucleus is the central positively charged part of an atom

The nucleus contain protons that are positively charged and the neutrons which are not charged



In a neutral atom, the number of protons is equal to the number of electrons

Neutrons and protons are collectively known as ***nucleons***

Particle	Symbol	Charge
Proton	${}^{1}_{1}P$	$+$
Electron	${}^{0}_{-1}e$	$-$
Neutron	${}^{1}_{0}n$	$none$

ATOMIC NUMER, MASS NUMBER AND ISOTOPES

1. **Atomic number (Z);** is the number of protons in the nucleus of an atom

2. **Mass number (Atomic mass) (A);** is the total number of protons and neutrons in the nucleus of an atom

$$A = Z + n$$

An atom X with atomic number Z and mass number A is represented as ${}^{A}_{Z}X$

Example

1. What is the composition of the atom ${}^{192}_{14}Y$
   $14 = 178$Atomic mass (mass number) $A = 192$
   Atomic number $Z = 14$
   Neutron number (number of neutrons)

$$n = 192 - 14 = 178$$

Number of electrons $= 14$

Isotopes; are atoms of the same element having the same number of protons but different number of neutrons

$$\boldsymbol{OR}$$

Isotopes; are atoms of the same element having the same atomic number but different mass number (atomic mass)

Examples of isotopes

1. Carbon ${}^{12}_{6}C \ \ and \ {}^{14}_{6}C$
2. Lithium ${}^{7}_{3}Li \ \ and \ {}^{6}_{3}Li$
3. Uranium ${}^{235}_{92}U \ \ and \ {}^{238}_{92}U$
4. Hydrogen ${}^{1}_{1}H$, ${}^{2}_{1}H \ and \ {}^{3}_{1}H$

Isotopes have the same number of protons, since the number of protons = the number of electrons

Therefore isotopes have the same number of electrons

The chemical properties depends on the number of electrons in the outmost shell, therefore isotopes have the same chemical properties and not easy to distinguish

RADIOACTIVITY

Is the spontaneous breakdown of unstable nucleus to form a stable nucleus with emission of alpha particles, beta particles and gamma rays

Radioactivity is a ***random process*** because no particular pattern is followed

It is a ***spontaneous*** because it cannot be affected by physical conditions like pressure and temperature but occurs on its own

During radioactivity, the atom disintegrating changes into atoms of different elements

Radioactive nuclide is the spontaneous breakdown of un-stable nucleus to a stable nucleus with emission of alpha, beta particles and gamma rays.

Examples of radioactive elements are; uranium, radon, polonium, thorium, cobalt

ALPHA PARTICLES (α)

When an alpha particle is emitted by a radioactive source, the mass number A ***reduces by* 4** and atomic number Z ***reduces by* 2**

$${}^{A}_{Z}\boldsymbol{X} \rightarrow {}^{A-4}_{Z-2}\boldsymbol{Y} + \boldsymbol{\alpha}$$

Therefore an alpha particle is equivalent to helium nucleus ${}^{4}_{2}He$

Alpha particle is a helium nucleus

$\boldsymbol{OR}$

Alpha particle is a helium atom that has lost its two orbital electrons

It has a mass number of 4 and atomic number of 2

PROPERTIES OF ALPHA PARTICLES

1. They are positively charged
2. They have the least penetrating power
3. They have the highest ionizing power
4. They are deflected by magnetic fields
5. They are deflected by electric fields
6. They are easily absorbed by matter
7. They travel at a slow speed (less than speed of light)
8. They cause florescence
9. They have short range in air
10. They are all emitted at the same speed

Examples

1. Uranium ${}^{238}_{92}U$ decays by emission of alpha particles to thorium Th. What is the composition of thorium Th

2. Uranium ${}^{238}_{92}U$ decays by emitting 4 alpha particles to nucleus X. What is the composition of nucleus X

BETA PARTICLES (β)

When an atom emits a beta particle, its mass number does not change but the atomic number increases by one (1)

$${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}Y + \beta$$

Therefore beta particle is equivalent to an electron ${}_{-1}^{0}e$

Definition

Beta particles are streams of high energy electrons

A bate particle has a mass number of zero (0) and atomic number -1

Electrons are accelerated towards the anode by the $E.H.T$

The electrons travel in a straight line and strike the screen where they produce a glow

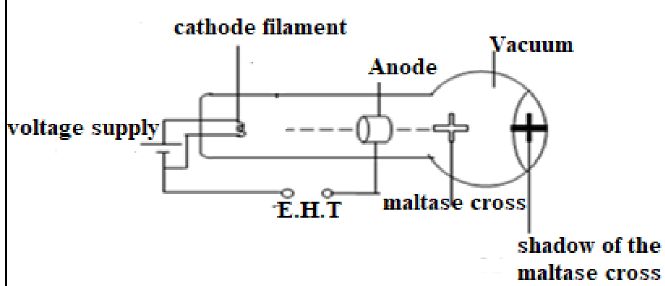
The stream of fast moving electron is cathode rays

PROPERTIES OF CATHODE RAYS

1. They travel in a straight line
2. They carry a negative charge
3. They are deflected by both magnetic and electric fields
4. They possess kinetic energy
5. They affect a photographic plate
6. They cause certain substances fluorescence
7. They cause ionization of gas molecules
8. They can penetrate a thin aluminum foil

TO SHOW THAT CATHODE RAYS TRAVEL IN A STRAIGHT LINE

The maltose cross tube

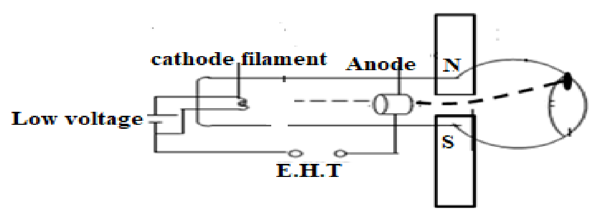


Cathode rays from the filament move through the anode in a straight line

Some are stopped by the maltese cross while the others strike the screen

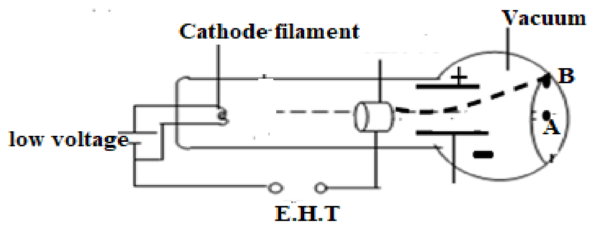
A sharp shadow is formed on the screen and this shows that cathode rays travel in a straight line

TO SHOW THAT CATHODE RAYS ARE DEFLECTED IN A MAGNETIC FIELD



When cathode rays are directed in between poles of a magnet, they are deflected towards the North Pole

TO SHOW THAT CATHODE RAYS ARE DEFLECTED IN ELECTRIC FIELDS



Before applying an electric energy on the plates, the spot is formed at A. When the electrical energy is applied on the plates, the spot is suddenly deflected to B.

This shows that cathode rays are deflected in an electric field towards the positive plate and that they carry a negative charge

APPLICATION OF CATHODE RAYS

1. X –rays
2. Cathode Ray Oscilloscope

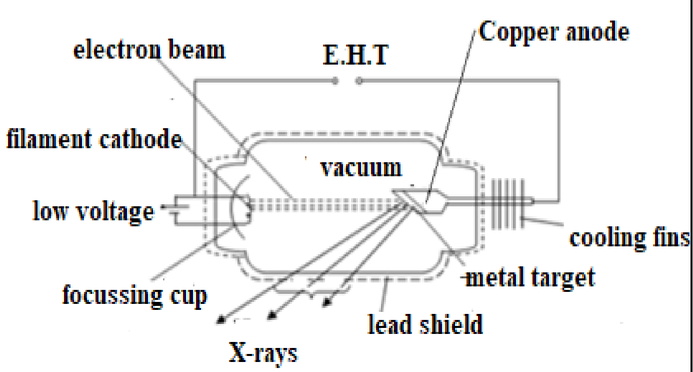
$X - RAYS$

These are electromagnetic radiations of very short wavelength produced when cathode rays strike a metal target

PRODUCTION OF $X - RAYS$

$X - rays$ are produced in an $X - ray$ tube

$X - RAY$ TUBE



The filament is heated by a low voltage supply

The filament emit electrons by thermionic emission

Electrons are accelerated towards the anode by the $E.H.T$ (accelerating voltage)

When the cathode rays strike the target, much of the kinetic energy is converted to heat and the rest to $X - rays$

Note

1. **The focusing cap** is concave and it focuses the beam of electrons onto the metal target

2. **The tube is evacuated** to prevent collisions with the air molecules which reduce the speed of electrons and this reduces the strength of the $X - rays$

3. **The cooling fins** are embedded on copper anode because copper is a good conductor of heat and it conducts away heat which reduces the temperature of the X –ray tube

4. **The lead shield** prevents stray X –rays

INTENSITY AND STRENGTH OF $X - RAYS$

INTENSITY

The intensity (quantity) of $X - rays$ produced is increased by increasing the filament current which increase the number of electrons produced hence increasing the number of electrons striking the target

STRENGTH

This is the quality of $X - rays$ produced. The strength is increased by increasing the accelerating voltage which increases the speed of electrons striking the target hence increasing the strength of $X - rays$ (penetrating power)

ENERGY CHANGES IN $X - RAY$ TUBE

Electrical energy → Heat energy → K.E → Heat energy + $X - rays$

PROPERTIES OF $X - RAYS$

1. They travel in a straight line
2. They can travel in a vacuum
3. They carry no charge
4. They are not deflected by electric and magnetic fields
5. They readily penetrate matter
6. They ionize gas molecules
7. They cause fluorescence
8. They affect a photographic plate
9. They travel at a speed of light in vacuum

USES OF $X - RAYS$

MEDICAL

1. They are used to detect lung $T.B$
2. They are used to treat cancer
3. They are used to detect bone fractures
4. They are used to sterilize medical equipment
5. They are used to detect foreign bodies e.g. coins, bullets in the body

INDUSTRIAL

1. They are used to detect hidden cracks in welded joints
2. They are used to study structures of crystals

It consists of a heater connected to a low voltage, cathode, control grid and anode

- The low voltage heats the heater
- The heater heats up the cathode
- The cathode emits electrons by thermionic emission
- The grid controls the number of electrons striking the screen and hence controlling the brightness of the spot
- The anode accelerates and focuses electrons on the screen

1. **Deflection system**

It consists of $X - plates$ and $Y - plates$

- The $X - plates$ deflects the electron beam horizontally
- The $Y - plates$ deflects the electron beam vertically

2. **Fluorescent screen**

- It produces a glow (bright spot) when a beam of electrons strike it

NOTE

- The vacuum prevents collisions between the electrons and air molecules
- Graphite coating prevents secondary emission of electrons

USES OF A $C.R.O$

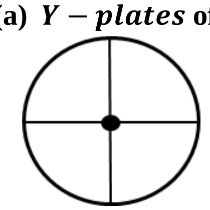
1. Used to measure both $d.c$ and $a.c$ voltage
2. Used to measure small time intervals
3. Used to display waveforms
4. Used to measure frequency
5. Used to display pictures in monitors of TVs, computers

THE APPEARANCE OF THE SPOT ON THE $C.R.O$ SCREEN

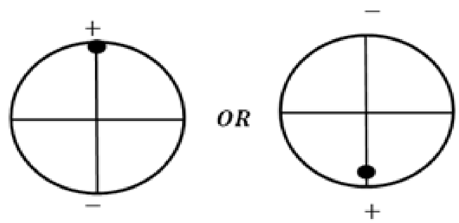
The $C.R.O$ is used to display waveforms showing how $p.d$ varies with time

The $p.d$ is applied to the $Y - plates$ and the a circuit called a time base is switched on which generates a $p.d$ across the $X - plates$

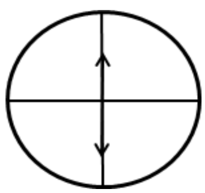
(a) $Y - plates$ off and time base off



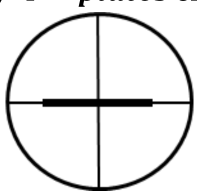
(b) $d.c$ on $Y - plates$ and time base off



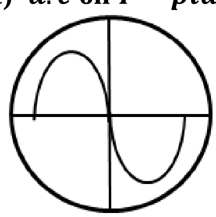
(c) $a.c$ on $Y - plates$ and time base off



(d) $Y - plates$ off and time base on



(e) $a.c$ on $Y - plates$ and time base on



ADVANTAGES OF $C.R.O$ OVER A VOLTMETER

1. A $C.R.O$ measures both $a.c$ and $d.c$ voltage
2. A $C.R.O$ draws very little current from the circuit because it has a very low resistance

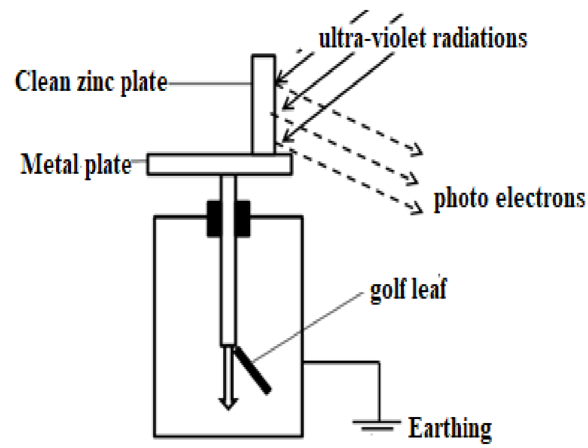
PHOTOELECTRIC EMISSION

Is a process by which electrons are produced from a clean metal surface when electromagnetic radiations of high frequency fall on it

The electrons produced are called $photoelectrons$

Examples of electromagnetic radiations that cause photoelectric are; ultra-violet and $x - rays$

EXPERIMENT TO DEMONSTRATE PHOTOELECTRIC EFFECT



- A clean zinc plate is placed on the metal cap of a $G.L.E$
- Ultra-violet light is directed towards the zinc plate
  If the $G.L.E$ is negatively charged, the leaf collapses as the light falls onto the zinc plate
- The electrons emitted are repelled by the negative charges on the zinc plate and this leaves the zinc plate positively charged
- Electrons move from the gold leaf to the zinc plate to replace the lost electrons, therefore the divergence of the gold leaf reduces
  If the $G.L.E$ is positively charged, no change in divergence of the gold leaf occurs
- Electrons are emitted from the zinc plate are attracted back by the positively charged zinc plate
- Hence there is no change in the magnitude of charge on the gold leaf

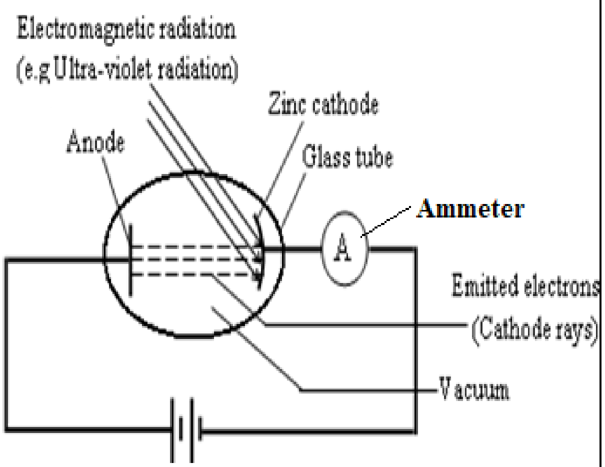
APPLICATIONS OF PHOTOELETRIC EMISSION

Used in $photocells$

Photocells find applications in;

1. Burglar alarms
2. Automatic doors
3. Automatic lighting controls

PHOTOCELL



- When $Ultra-violet$ radiation falls on a metal cathode, it emits electrons by photoelectric emission
- The electrons are attracted to the anode and completes the circuit

REFRACTION OF LIGHT

Is the change in direction of a light ray as it moves from one medium to another of different optical density

OR

Is the bending of a light ray as it moves from one medium to another of different optical densities

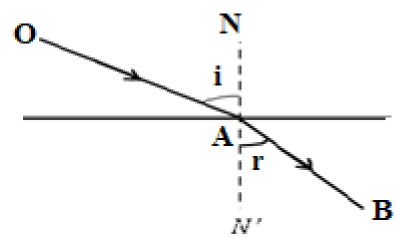
Refraction is due to change in velocity of light as it travels from one medium to another of different optical densities

OPTICAL DENSITY

It is how easy light travels through a given medium. The more easy light travels through a given medium, the lower the optical density of that medium.

Air has a lower optical density than glass and water

TERMS USED IN REFRACTION



NN' = Normal line

OA = Incident ray

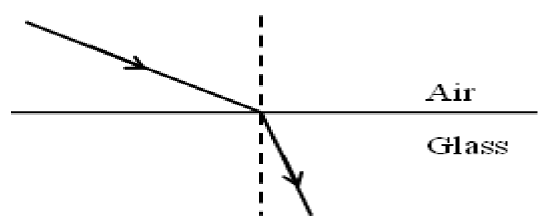
A = Point of incidence

AB = Refracted ray

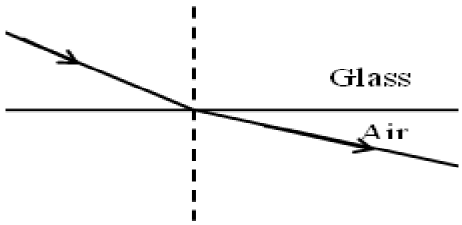
$i =$ Angle of incidence

r = Angle of refraction

When a light ray travels from an optically less dense medium to an optically denser medium, it is bent towards the normal



When a light ray travels from an optically denser medium to an optically less dense medium, it is bent away from the normal



LAWS OF REFRACTION OF LIGHT

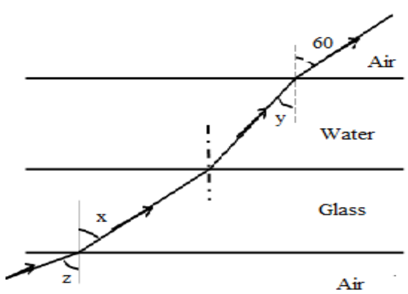
1. ***The constant, n*** **is called** ***The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane***
2. ***The ratio of sine of angle of incidence to the sine of angle of refraction is constant for any pair of media.***
   (this is called the Snell's law) i.e.
   $\frac{\sin i}{\sin r} = constant, n\ is$ the *refractive index*

REFRACTIVE INDEX, (n)

Is the ratio of sine of angle of incidence to the sine of angle of refraction for a ray of light moving from one medium to another of different optical density

$$n = \frac{\sin i}{\sin r}$$

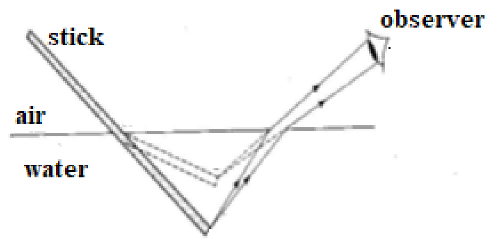
(a) Find the refractive index of water relative to glass



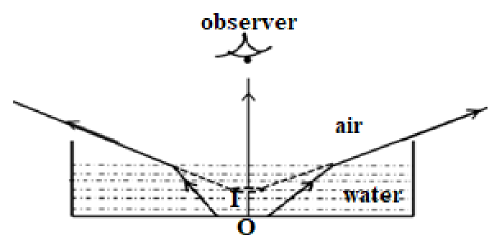
(a) Find the angles x, y and z
(b) Find the refractive index of glass relative to water

EFFECTS OF REFRACTION

1. A stick dipped in water appears bent

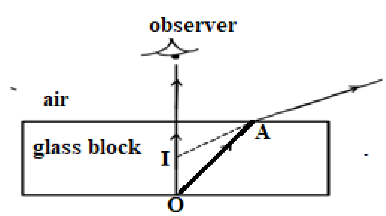


2. A pond appears shallower than its real depth



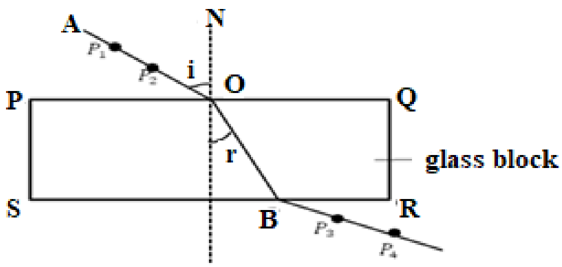
Light rays from the bottom surface are incident at the surface of water. The rays are refracted away from the normal. The observer sees the ray as if it is coming from I which is near than the real depth

3. An object placed under a glass block appears nearer



A light ray from O is refracted away from the normal on reaching point A, it appears to be coming from I which is the image of O which is nearer the surface

DETERMINING THE REFRACTIVE INDEX OF GLASS USING A GLASS BLOCK



A glass block is placed on a white sheet of paper and its outline $PQRS$ traced

A normal line ON is drawn at O

A line AO is drawn making an angle of $i = 10^0$ which the normal

The glass block is replaced onto its outline

Pins P_1 and P_2 are fixed along the line AO

While looking through side SR, pins P_3 and P_4 are also fixed such that they appear to be in a straight line with the images of P_1 and P_2

The glass block is removed together with the pins

A line is drawn passing through the holes of P_3 and P_4 to meet SR at B is drawn

Point B is joined to O and the angle r is measured

The experiment is repeated for different values of i

The results are tabulated including values of $\sin i$ *and* $\sin r$

A graph of $\sin i$ against $\sin r$ is plotted

A straight line through the origin is obtained

The slope, n of the graph is calculated

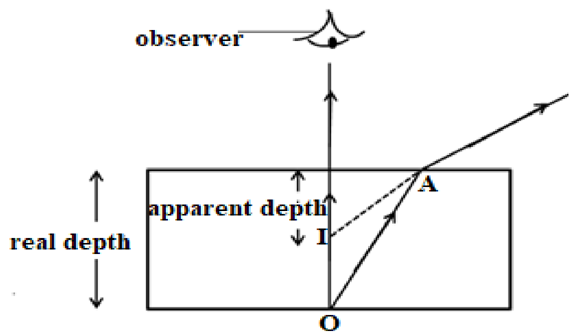
The slope, n is the refractive index of the glass

REAL DEPTH AND APPARENT DEPTH

Real depth is the actual depth of the medium

Apparent depth is the height between the image and the top surface of the medium

An object O placed below a glass appear to be nearer to the top when viewed from above, this depth is called *apparent depth*



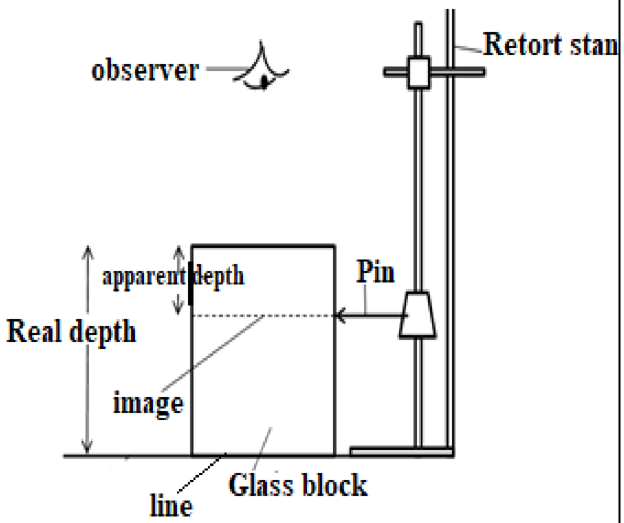
$$refractive\ index = \frac{real\ depth}{apparent\ depth}$$

Examples

1. A swimming pool appears to be only $1.5m$ deep. If the refractive index of water is $\frac{4}{3}$. Calculate the real depth of the water in the pool.

2. A pin at the bottom of a beaker containing a transparent liquid at a depth $24cm$ is apparently displaced by $6cm$. Calculate the refractive index of the liquid
3. A coin is placed at the bottom of the beaker which contains water at a depth of $8cm$. How far the coin when viewed from a above does it appear to be raised
4. The bottom of a fish pond appears to be $2.4m$ below the surface of the water. If the refractive index of water is 1.33. calculate the real depth

DETERMINATION OF REFRACTIVE INDEX OF GLASS USING REAL AND APPARENT DEPTH

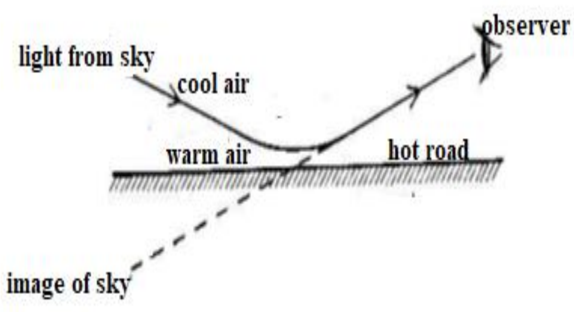


A glass block is placed vertically over a straight line drawn on a sheet of paper

A pin on a sliding cork adjacent to the block is then moved up and down until there is no parallax between it and the image of the line as seen through the block

The real depth and the apparent depth are measured and noted

Refractive index= $\frac{real\ depth}{apparent\ depth}$

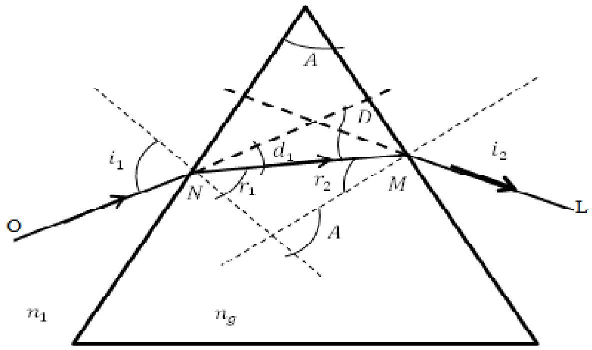


Light rays from the sky is gradually refracted away from the normal as it passes from dense layers of air to less dense layers

When light meets a layer at angle of incidence greater than the critical angle, it suffers total internal reflection

To an observer, the image of the sky appears as a pool of water on the road

REFRACTION THROUGH A TRIANGULAR PRISM



From the prism above

i_1 = Angle of incidence

ON = Incident ray

ML = Emergent ray

r_1 = Angle of refraction

i_2 = Angle of emergence

NS and MS = normal line

A = Prism angle ($refractive\ angle$)

D = Angle of deviation

Also $d_1 + d_2 = D$

. $r_1 + r_2 = A$

. $D = (i_1 + i_2) - A$

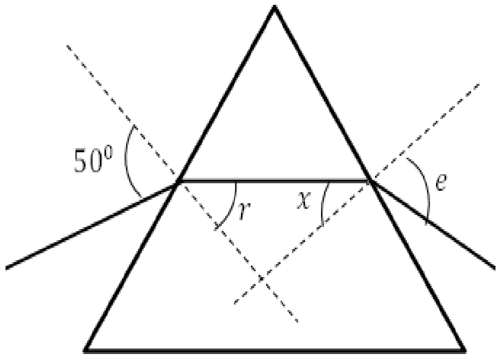
At point N $n_1 \sin i = n_2 \sin r$

At point M $n_g \sin r_2 = n_1 \sin i_2$

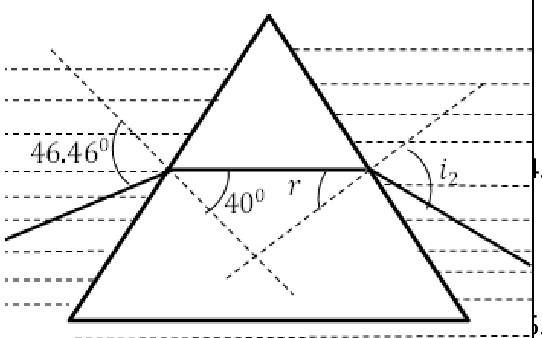
Examples

1. The figure below shows a ray of monochromatic light incident at an angle of 50^0 on an

equilateral prism of refractive index 1.52. calculate the angles r, x and e

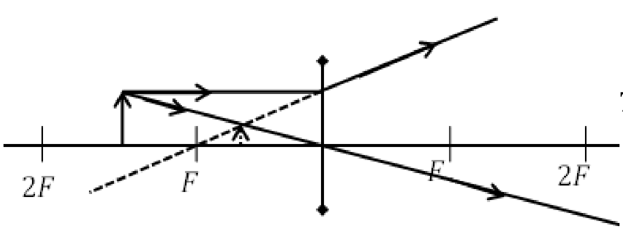


2. The diagram below shows a ray of light incident at angle of 46.46^0 one side of an equilateral prism immersed in liquid of refractive index n



Given that the refractive index of glass is 1.5. calculate

IMAGE FORMED BY A DIVERGING LENS (CONCAVE LENS)



The image is

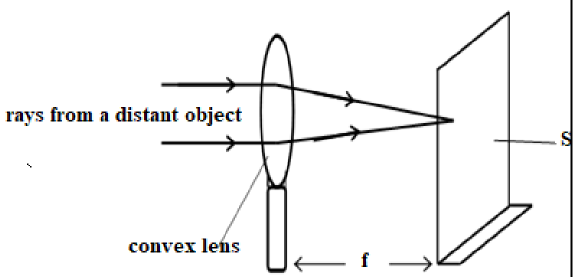
- Virtual
- Erect
- Diminished

GRAPHICAL CONSTRUCTION OF RAY DIAGRAMS (USE GRAPH BOOK)

1. An object $2cm$ high is placed $6cm$ from a convex lens with a focal length of $2cm$. Find by graphical method, the position and the size of the image
2. Draw a ray diagram to find the position of an image formed by a convex lens of focal length $15cm$ if the object distance is $30cm$
3. By scale drawing determine the position, size and the nature of the image formed by a convex lens of focal length $10cm$ when an object $2.5cm$ high is placed at a distance of $15cm$ from the lens
4. An object $2cm$ high is $40cm$ from a convex lens. Find the magnification and the size of the image which is $20cm$ from the lens
5. An object $2.0cm$ tall is placed $8cm$ infront of a convex lens of focal length $12cm$. Construct a ray diagram to determine the position of the image and magnification produced
6. An object $20cm$ high is placed $6cm$ from the convex lens with a focal length $2cm$. Find by graphical method the nature, position and size of the image
7. An object $10cm$ high is placed $30cm$ from a concave lens of focal length $15cm$. Find the nature, position and magnification of the image

DETERMINING THE FOCAL LENGTH OF THE CONVEX LENS

(a) Using a distant object

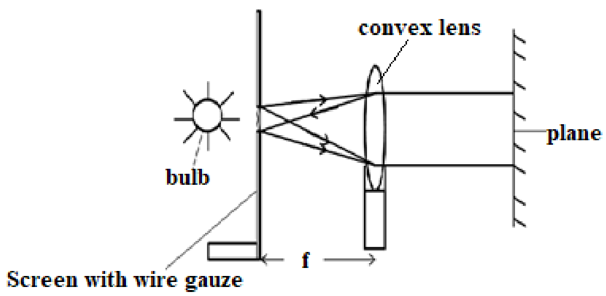


The position of the lens is adjusted until a sharp image of a distant object is formed on the screen

The distance between the lens and the screen is measured

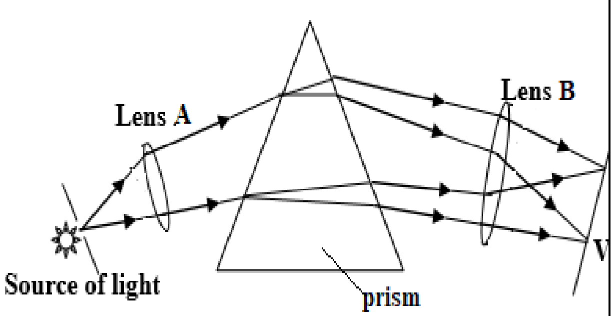
This is the focal length of the lens

(b) Using an illuminated object



The position of the lens is adjusted until a sharp image of the cross wire is formed on the screen

PRODUCTION OF A PURE SPECTRUM



A source of light is placed at the principal focus of lens A

A parallel beam of light falls on the prism

The prism disperses the white light

A parallel beam of each colour of light is focused at different points on the screen

This forms a pure spectrum

COLOURS OF LIGHT

There are two categories of colours of light

1. **PRIMARY COLOURS**
   Are colours that cannot be obtained by mixing other colours of light

   Examples

   - Red
   - Blue
   - Green

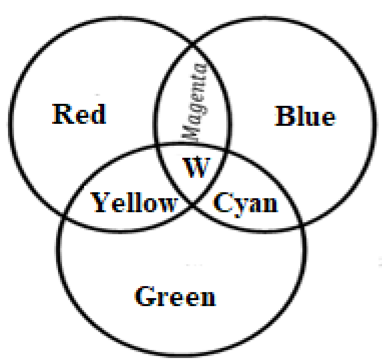
2. **SECONDARY COLOURS**
   Are colours that are obtained by mixing two primary colours

   Examples

   - Yellow $= (red + green)$
   - Magenta$= (red + blue)$
   - Cyan $= (ble + green)$

When all the three (3) primary colours are mixed, we form white light

This is illustrated using overlapping circle



Acronym

"$\boldsymbol{Red\ Yams\ Gave\ Charles\ Bad\ Manners}$" $\boldsymbol{Red}$

COMPLEMENTARY COLOURS

Is a pair of colors of light, one primary and the another secondary which when mixed form white light

Examples

- $Red + Cyan$
- $Green + Magenta$
- $Blue + Yellow$

APPEARANCE OF OBJECTS IN WHITE LIGHT

When white light falls on an object, either all the colours in white light are reflected and the object appears white or only some colours may be reflected while others are absorbed and the object appear coloured

When all colours are absorbed and none is reflected, the body appears black

THE GAS LAWS

When temperature subjected to a fixed mass of a gas enclosed in a container with a movable piston increase, the $k.e$ increases and the gas molecules move faster increasing the rate of collisions of gas molecules with the walls of the container which increases the pressure of the gas and this pushes the piston thus an increase in volume. This is summarized in three fundamental laws called $\boldsymbol{gas\ laws}$

They include

1. Boyle's law
2. Charles' law
3. Pressure law

BOYLE'S LAW

"The volume of a fixed mass of a gas is inversely proportional to pressure at constant temperature"

$$P\ \alpha\ \frac{1}{V}$$

$$P = \frac{K}{V}$$

$$PV = K$$

$$\boldsymbol{PV = constant}$$

$$\boldsymbol{P_1V_1 = P_2V_2}$$

Where

P_1 = Initial pressure

V_1 = Initial volume

P_2 = Final pressure

V_2 = Final volume

Examples

1. A volume of a fixed mass of a gas increases from $300cm^3$ to $500cm^3$ at a constant temperature. Find the new pressure if the initial pressure is $700cmHg$

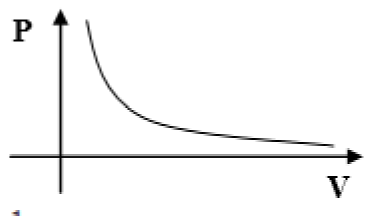
2. A mass of a gas occupies a volume of $20cm^3$ at a temperature of 24℃ and a pressure of 1.0 atmosphere. Calculate the volume when the pressure is doubled

3. A vessel contains $1000cm^3$ of air at $76cmHg$. The air is allowed to expand to $1200cm^3$ at constant temperature, calculate the new pressure

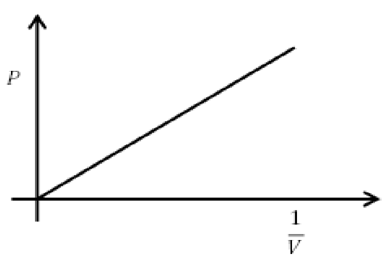
4. A given mass of a gas has a volume of $100cm^3$ at $75Nm^{-2}$. At what pressure is it when the volume is reduced to $60cm^3$

5. The pressure exerted by a gas of volume $0.024m^3$ at room temperature is $4.2 \times 10^5 Nm^{-2}$. Determine the pressure at which the volume of the gas reduces to $0.019m^3$ at the same temperature

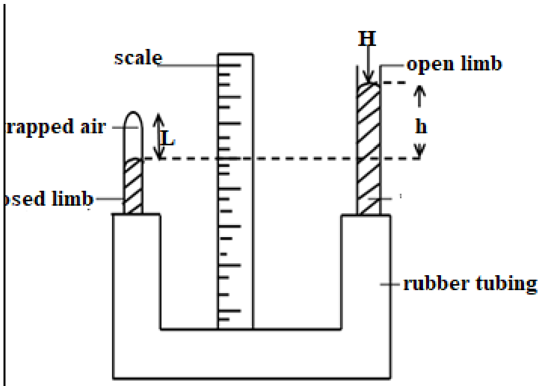
A graph of P against V



A graph of P AGAINST $\frac{1}{V}$



EXPERIMENT TO VERIFY BOYLE'S LAW



- Dry air is trapped above mercury in a closed limb of a uniform cross sectional area, A
- The difference, h in the levels of mercury in the closed and open limbs is noted
- The length, l of the air column is noted
- The pressure of air is varied by raising or lowering the open limb
- Different values of h and l are noted
- The pressure of air, $P = H \pm h$ is calculate
- Values are tabulated including values of $\frac{1}{l}$
- A graph of P against $\frac{1}{l}$ is plotted
- A straight line through the origin is obtained
- This shows that pressure is inversely proportional to volume hence verifying Boyle's law

CHARLES' LAW

"The volume of a fixed mass of a gas is directly proportional to its absolute temperature at a constant pressure"

$$V \, \alpha \, T$$

$$V = KT$$

$$\frac{V}{T} = K$$

$$\boldsymbol{\frac{V}{T} = constant}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Where

V_1 = Initial volume

T_1 = Initial temperature

V_2 = Final volume

T_2 = Final temperature

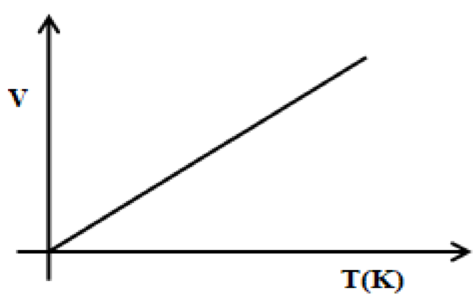
Examples

1. A gas of volume $3m^3$ at 27°C is heated to 327°C. What is its new volume

2. A gas of volume $1000cm^3$ at a pressure of $4.0 \times 10^5 Pa$ and temperature 17°C is heated to 89.5°C at a constant pressure. Find the new volume of that gas
3. The volume of a fixed mass of a gas collected at 91°C s $0.02m^3$ at normal pressure. Determine the volume when the temperature drops to 0°C at the same pressure

4. The temperature of a fixed mass of a gas is 27°C. If the volume is halved,
   (i) Find the new temperature
   (ii) State the assumption made

A graph of V against $T(K)$



An ideal gas is a gas which obeys all the three gas laws perfectly

OR

An ideal gas is a gas with negligible intermolecular forces of attraction

A real gas is a gas that does not obey gas laws at all conditions

Examples

1. A bicycle pump contains $50cm^3$ of air at 17°C and a pressure of $1.0 \times 10^5 Pa$. find the pressure when air is compressed to $10cm^3$ and its temperature raises to 27°C

2. A fixed mass of a gas occupies a volume of a gas occupies a volume of $300cm^3$ at a temperature of 127°C and pressure of $1000mmHg$. Find the new volume of a gas if the pressure of $760mmHg$ at a temperature of $273K$

3. A gas of volume $1000cm^3$ at a pressure of $40 \times 10^5 Pa$ and temperature of 17°C. Find the new volume of the gas at $s.t.p.$ ($Pressure = 76cmHg, T = 273K$)

4. The pressure of a fixed mass of a gas at 17°C is $10^5 Pa$. Find its pressure at 27°C if the volume is halved
5. A litre of a gas at 0°C and $10Nm^{-2}$ pressure is suddenly compressed to $\frac{1}{4}$ of its volume and its temperature rises to 273°C. Calculate the resulting pressure of the gas

NOTE
Standard temperature and pressure, $s.t.p$ means normal conditions of temperature and pressure at sea level
Standard pressure $= 76cmHg$
Standard temperature $= 0°C$

MEASUREMENT OF HEAT ENERGY, Q

HEAT CAPACITY, H

Is the quantity of heat required to raise the temperature of a substance by $1K$

$Quantity\ of\ heat = Heat\ Capacity \times Temperature\ change$

$Q = H\Delta\theta$

$$H = \frac{Q}{\Delta\theta}$$

The $S.I$ unit of heat capacity is $\boldsymbol{joule\ per\ kelvin}$ $(\boldsymbol{JK^{-1}})$

Examples

1. The heat capacity of a substance A is $60\ JK^{-1}$. What does this mean

2. $1000J$ of heat supplied to a substance B raises its temperature by $5K$. Find the heat capacity of B
3. The temperature of D increases from $30℃$ to $60℃$ when the body is supplied with $1500J$ of heat. Calculate the heat capacity`

SPECIFIC HEAT CAPACITY, c

Is the quantity of heat required to raise the temperature of $1kg$ of a substance by $1K$

$\boldsymbol{Quantity\ of\ heat = mass \times s.h.c \times temperature\ difference}$

$Q = mc\Delta\theta$

Therefore

$$c = \frac{Q}{m\Delta\theta}$$

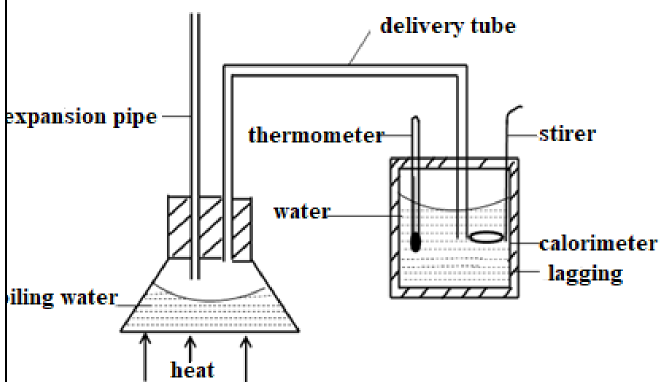
The $S.I$ unit of $s.h.c$ is $\boldsymbol{Jkg^{-1}K^{-1}}$ $(\boldsymbol{joule\ per\ kilogram\ per\ kelvin})$

$s.l.h$ of steam $= 2260{,}000Jkg^{-1}$

Examples

1. The $s.l.h$ of ice is $336{,}000Jkg^{-1}$, what does this mean
2. The $s.l.h$ of steam is $2260{,}000Jkg^{-1}$, what does this mean

DETERMINATION OF SPECIFIC LATENT HEAT OF VAPORIZATION OF STEAM BY METHOD OF MIXTURES



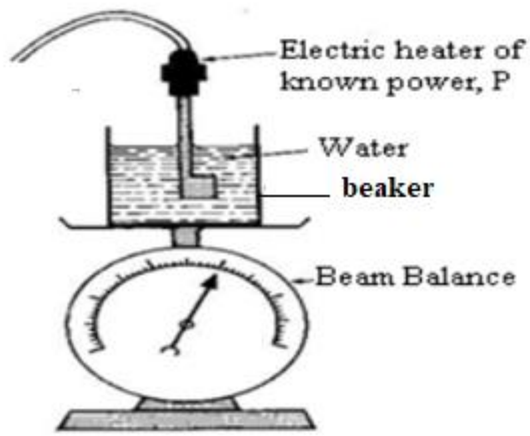
- A copper calorimeter of mass m_c and $s.h.c$, c_c is filled with water of mass, m_w and $s.h.c$, c_w
- The initial temperature, θ_1 of water is noted
- Dry steam is passed into the water for some time
- Water is well stirred and the final temperature θ_2 of the mixture is noted
- The apparatus is weighed again and the mass, m_s of condensed steam is obtained

Heat lost by stem = *heat gained by water* + *heat gained by calorimeter*

$$m_s l_v + m_s c_w(100 - \theta_2) = m_w c_w(\theta_2 - \theta_1) + m_c c_c(\theta_2 - \theta_1)$$

$$l_v = \frac{m_w c_w(\theta_2 - \theta_1) + m_c c_c(\theta_2 - \theta_1) - m_s c_w(100 - \theta_2)}{m_s}$$

DETERMINATION OF SPECIFIC LATENT HEAT OF VAPORIZATION BY ELECTRICAL METHOD



- Water is poured into a beaker placed on a beam balance
- The initial balance reading, m_0 is recorded
- An electric heater of known power, P is placed into the water
- The heater is switched on and the stop clock is started at the same time
- The water is heated until it boils
- After a time, t, the heater is switched off and removed from water
- The final balance reading, m_1 is recorded
- Mass of water evaporated $m = m_1 - m_0$
- Specific latent heat of vaporization, $l_v = \frac{Pt}{m}$

Examples

Where necessary use

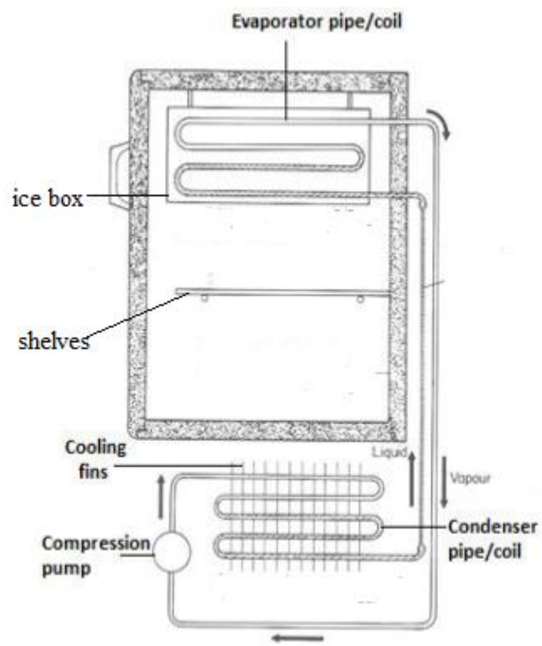
($s.h.c\ of\ water = 4200Jkg^{-1}K^{-1}$, and $s.h.c$ of calorimeter= $400Jkg^{-1}K^{-1}$)

1. A copper calorimeter of ass $60g$ is filled with water of mass $100g$ at a temperature of 25℃. Steam is passed into the water until a temperature of 45℃ is attained. If the final mass This is because steam condenses on the body giving out a large amount of latent heat which is absorbed by the skin causing severe burn.

Water loses a smaller amount of heat on cooling

THE REFRIGERATOR

This uses the principle of cooling by absorption of latent heat of vaporization



- A volatile liquid ($freon$) evaporates in the evaporator surrounding the ice box
- Latent heat of vaporization is absorbed from air around the evaporator
- The compressor ($pump$) forces the vapor into the condenser
- In the condenser, the vapor condenses releasing latent heat of vaporization to the surrounding to the surrounding by the cooling fins
- The liquid returns to the evaporator and the process repeats

HOW IS FOOD COOLED IN A REFRIGERATOR

- Air surrounding the ice box is cooled, becomes denser and falls passing over the food on the shelves and cool it
- Warm air at the bottom rises to occupy the space left by the falling cold air
- A convection current is set up and cools the food

WHY IS THE ICE BOX PLACED AT THE TOP

The air around the ice box becomes denser and falls. If the ice box was at the bottom, dense air cannot rise, it will stay at the bottom and food on the shelves rot

BOILING AND FREEZING

Boiling is the formation of bubbles throughout the liquid at a constant temperature

Boiling occurs at a constant temperature called *boiling point*

DIFFERENCE BETWEEN BOILING AND EVAPORATION

BOILING	EVAPORATION
• Occurs throughout the liquid • Occurs at a fixed temperature called boiling point • Formation of bubbles • Does not cause cooling	• Occurs at the liquid surface • Occurs at any temperature • No bubbles are formed • Causes cooling

FACTORS THAT AFFECT THE BOILING POINT OF A LIQUID

1. **Impurities**

- Addition of impurities rises the boiling point of a liquid

2. **Pressure**

COOKING AT A HIGH ALTITUDE

At a high altitude, the atmospheric pressure is very low.

The $s.v.p$ becomes equal to the external atmospheric pressure at a lower temperature and water boils below $100℃$. Therefore food takes long time to cook because its boiled at low temperatures

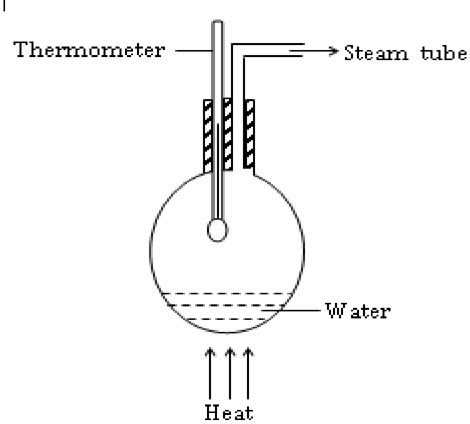
COOKING AT A LOW ALTITUDE

At a low altitude, the atmospheric pressure is very high.

The $s.v.p$ becomes equal to the external atmospheric pressure at a higher temperature and water boils above $100℃$. Therefore food takes little time to cook because its boiled at higher temperatures

BOILING UNDER REDUCED PRESSURE

Water can be made to boil at a temperature less than $100℃$. It is done by reducing the pressure above it to less than the $s.v.p$ at that temperature



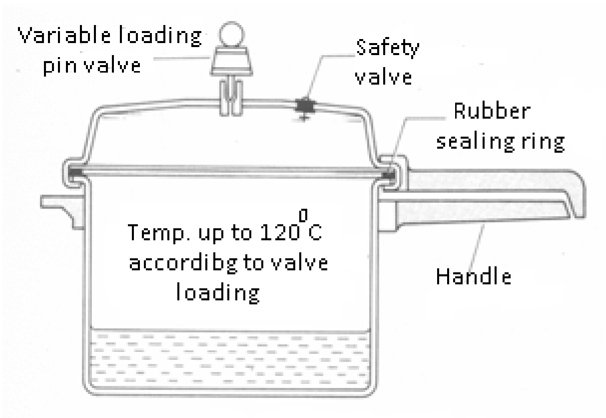
The pump reduces the pressure above the water to a value below $s.v.p$ at that temperature and water boils

THE PRESSURE COOKER

In a pressure cooker, the pressure of the steam is set to build up to twice the normal atmospheric pressure

This raises the boiling point of water to a higher temperature above 100℃

This makes the food to cook faster because it is boiled at a higher temperature



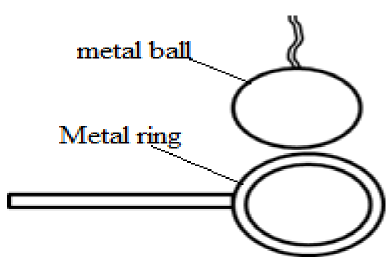
THERMAL EXPANSION AND CONTRACTION

Expansion is an increase in size of a substance in all directions when it is hot

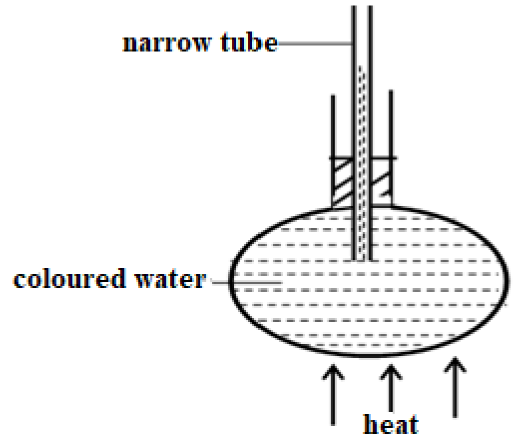
Contraction is the decrease in size of a substance in all directions when it gets cold

THERMAL EXPANSION AND CONTRACTION IN SOLIDS

This can be illustrated using a metal ball with a ring



DEMONSTRATION OF EXPANSION IN LIQUIDS

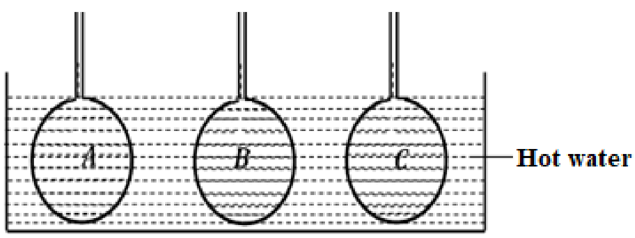


- The level of water in a narrow tube before heating is noted
- The flask is heated and new water level is noted
- It is seen that there is an increase in the water level when heated which shows that water expands when heated

NOTE

- Initially when the flask is heated, the water level drops momentarily and then rises
- This is because the flask first receives heat before water and it expands which increases its volume

COMPARING EXPANSION OF DIFFERENT LIQUIDS



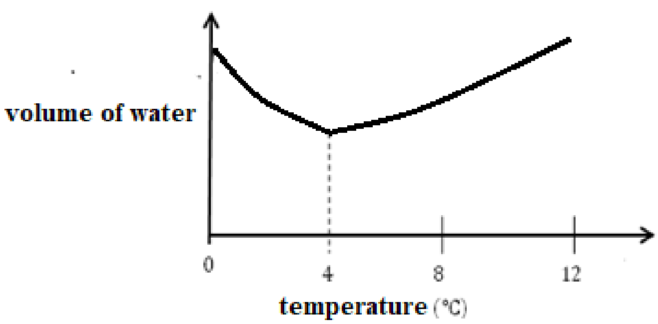
- Identical flasks are filled with different liquids A, B and C

- The flasks are placed in a beaker containing hot water
- After sometime, the liquid levels rise to different levels. This shows that liquids expand differently when heated even at the same temperature

ANOMALOUS (EXCEPTIONAL) EXPANSION OF WATER

- For all solids expect ice, when heated, they expand
- But ice melts to form water which contracts until 4℃
- Therefore water is exceptional or anomalous in the range of 0℃ to 4℃
- Water has a maximum density at 4℃

A graph of volume against temperature



EXPANSION IN GASES

- A gas expands when heated
- The expansion of a gas is too great compared to solids and liquids
- This is because gases have very weak intermolecular forces

MAGNETIC EFFECT ON AN ELECTRIC CURRENT

A current flowing through a wire creates a magnetic field around it.

The direction of a magnetic field around the wire depends on the direction of current in the wire. This is predicted using;

1. **The right-hand grip rule**

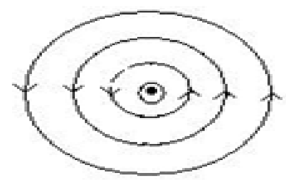
If the wire is held in the right hand with the thumb pointing along the direction of current, then the direction of the fingers is the direction of the magnetic field

2. **Maxwell's screw rule**

If the right handed screw moves forward in the direction of current, the direction of rotation of the screw is the direction of the field

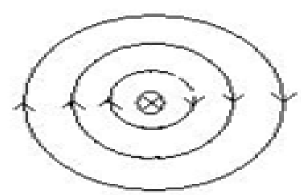
MAGNETIC FIELD DUE TO A STRAIGHT WIRE CARRYING CURRENT

1. Wire carrying current upwards (out of page)



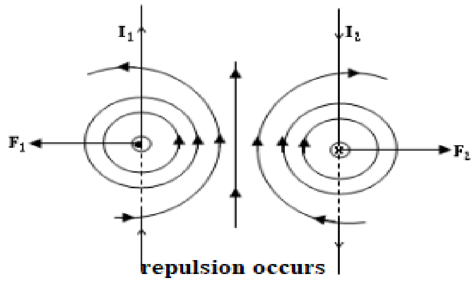
Current out of the paper

2. Wire carrying current downwards (into the page)



Current into the paper

3. Two wires carrying current in opposite direction

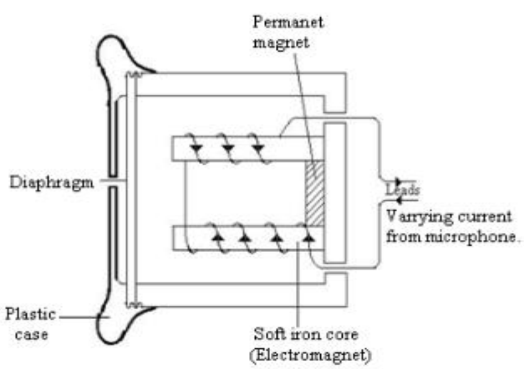


4. Two straight wires carrying current in the same direction

- The electromagnet is set above the iron sheets and current is switched on.
- It magnetizes and attracts the iron sheets
- The crane lifts the sheets to a suitable place
- Current is switched off, magnetism is lost and the sheets are left in the desired place

THE TELEPHONE RECEIVER

This changes electrical energy to sound energy



- The sound causes a varying current in the microphone which passes through the coils of the electromagnet and magnetizes it
- The electromagnet pulls the diaphragm towards it by a distance which depends on the current
- The diaphragm vibrates at the same frequency as the original sound
- This processes a copy of the sound wave that entered the microphone

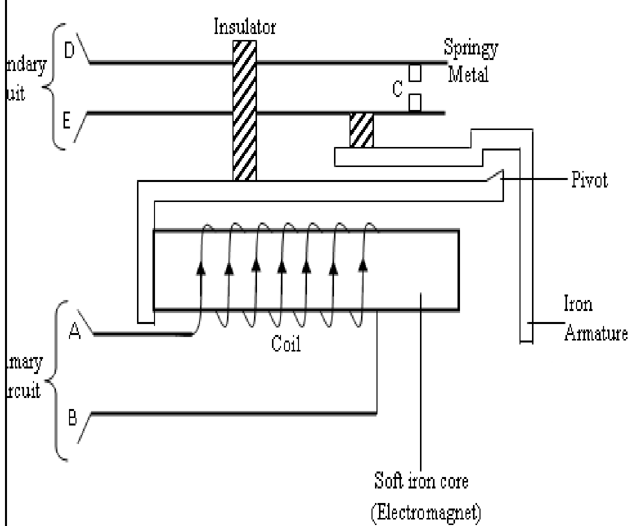
MAGNETIC SEPERATORS

These are used to sort iron pieces from scrap metals

- The electromagnet is positioned above the conveyer belt carrying the scrap
- The pieces of iron are attracted to the electromagnet when it is switched on

THE MAGNETIC RELAY

This enables one circuit to control another circuit without direct electrical connection



- The input circuit supplies current to the electromagnet
- The electromagnet attracts one end of a soft iron armature which is pivoted so that its other end acts as a lever
- The lever opens and closes contacts in output circuit by a spring metal strip

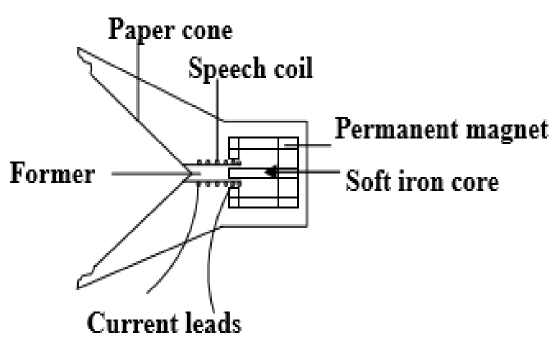
FORCE ON CURRENT CARRYING CONDUCTOR IN THE MAGNETIC FIELD.

When a conductor carrying current is placed in a magnetic field, it experiences a mechanical force.

The direction of the force is predicted using the Fleming's left hand rule

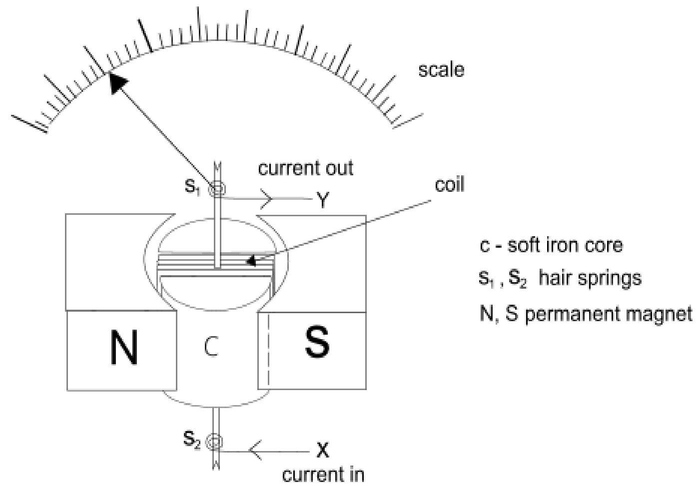
The Fleming's left hand rule

THE MOVING COIL LOUD SPEAKER



- A varying current from an amplifier flows through the coil
- This produces a varying electromagnetic force on the coil making it vibrate in and out together with the cone
- The cone sets the surrounding air to vibrate and reproduce a loud sound
- The cone vibrates at the same frequency as the current

MOVING COIL GALVANOMETER.



OPERATION

A current to be measured is let in and out through the hair springs S_1 and S_2

When current passes through the coil, the magnetic force on it makes it to turn together with the pointer

The coil turns until the magnetic force on it is balanced by the restoring force due to the tension of the hair spring

The position of a coil is then the measure of current.

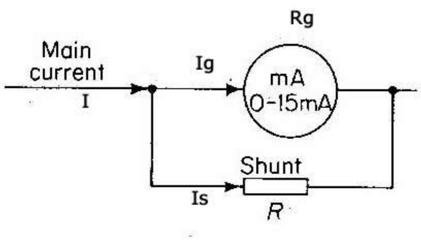
The sensitivity of the galvanometer can be increased by

1. Increase in the number of turns of coil.
2. Using a stronger magnet with a high magnetic flux
3. Using a coil of larger area
4. Using very weak hair springs

CONVERSION OF GALVANOMETER INTO AMMETER.

A galvanometer is used to detect small currents

To convert a galvanometer to an ammeter, a low resistance resistor called a ***shunt*** is connected parallel with the galvanometer



I – current to be measured

R_g – Resistance of galvanometer

R_s– Shunt resistance

I_g – Current thru galvanometer

Considering full scale deflection ($f.s.d$) current $I = I_g + I_s$

Since is R_s parallel to R_g then $V_g = V_s$

Applying ohms law $I_g R_g = I_s R_s$

Example

1. A galvanometer of resistance 5Ω and $f.s.d$ $15mA$ is to used to measure current up to $1.5A$. how should this be done

2. A galvanometer has a resistance of 20 ohms and gives the $f.s.d$ of $200mA$
   What is the voltage a cross the galvanometer
   What resistance (shunt) must be connected across the galvanometer for it to read 10 A

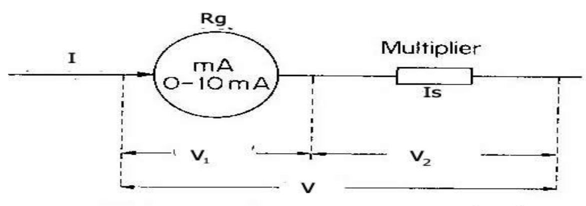
3. A galvanometer of resistance 10Ω reads $50mA$ at $f.s.d$. what resistance must be connected across the galvanometer to be converted to an ammeter in order to read 4A

4. A galvanometer of resistance 4Ω and $f.s.d$ $10mA$ is to used for the purpose of measuring current to $1.0A$. find the value of the shunt to be used

5. A millimeter has a resistance of 20Ω and gives a $f.s.d$ for a current of $2000\mu A$. If the galvanometer is converted to an ammeter which can read up to $1.0A$. what is the size of the extra low resistance

CONVERSION OF GALVANOMETER TO VOLTMETER

This is done by connecting a resistor of high resistance in series with the galvanometer. This resistor is called a **multiplier**



Suppose that a full scale deflection

I_g – Maximum current through G

$V - total\ p.d$

$V_g - p.d$ across galvanometer

$V_m\ - p.d$ across multiplier

$V = V_g + V_m$

$V = I_g R_g + I_m R_m$

But in series current is constant.(same current flows through the galvanometer and the multiplier)

$I_g = I_m$

Then $V = I_g(R_m + R_g)$

EXAMPLES

1. A galvanometer of resistance 12Ω reads 200mA at $.s.d$. What resistance must be connected in series with it in order to read 8N.

2. A current of 0.2A passes through the galvanometer of resistance 20Ω. What resistance must be connected in series with G to convert it to voltmeter in order to read 10V at $f.s.d.$

ELECTROMAGNETIC INDUCTION

When a conductor (wire) moves across a magnetic field such that it cuts the magnetic field lines, am emf or current is induced in the wire. This process is called ***electromagnetic induction***

Electromagnetic induction is a process where an emf is induced in a conductor when flux linking it changes

Laws of electromagnetic induction

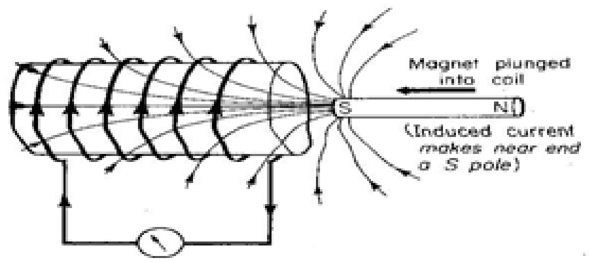
1. ***Faraday's law***

The strength of the induced emf is directly proportional to the rate of change of magnetic flux linking it

2. ***Lenz's law***

The induced current flows in a direction so as to oppose the change that causes it

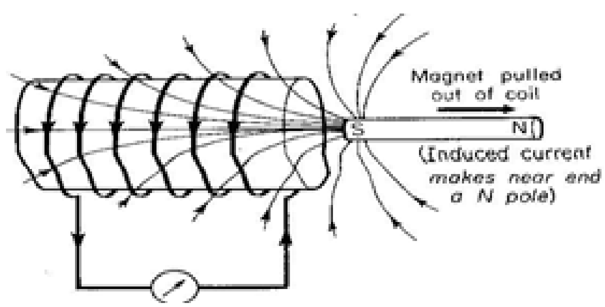
Faraday's experiment on electromagnetic induction



The end of the coil is connected to a sensitive galvanometer.

Then a magnet is moved into the coil, the galvanometer deflected showing that current had been induced in the coil.

The magnet is pulled out of the coil; the galvanometer deflects in opposite directions.



When the bar magnet is held stationary, the galvanometer pointer gives no deflection

CONCLUSION.

1. The direction of induced emf depends on the direction of motion of the magnet.
2. The magnitude of induced emf depends on
   (i) Speed of motion of the magnet.
   (ii) Number of turns of the coil.
   (iii) Strength of the magnetic fields

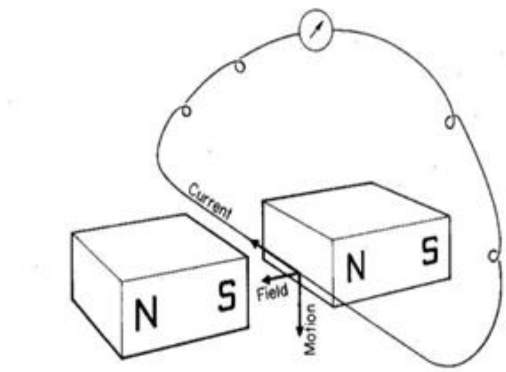
DIRCTION OF INDUCED CURRENT

This is predicted using the Fleming's right hand rule (Dynamo rule)

Fleming's right hand rule

If the thumb, first finger and the second finger of a right hand rule are held at right angles

If the **First** finger points in the direction of the **Field**, and the **Thumb** in the direction of motion, then the **Second finger** will point in the direction of the induced Current



MODIFICATION OF AC TO DC

The ends of the coil are connected to commutators instead of slip rings.

MODIFICATION OF DC TO AC

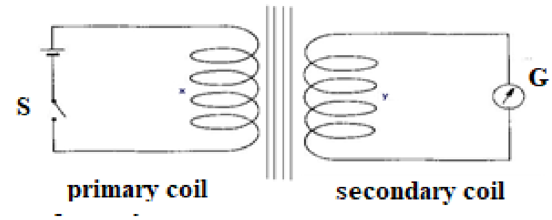
The ends of the coil are connected to slip rings instead of commutators

ADVANTAGES OF AC OVER D.C

1. A.C can be transmitted over long distance at low power loss
2. A.C can easily and cheaply be stepped up and down using a transformer
3. $A.C$ is easy to generate.

MUTUAL INDUCTION

Is a process by which an emf is induced in a coil due to the change in the magnetic flux linked with the neighboring coil



When the switch is closed, an electric current flow through the primary coil.

This increases magnetic flux and it cuts the secondary coil and an emf is induced in the secondary.

Current flows in the secondary coil and the galvanometer deflects

When the switch is opened, the magnetic flux reduces and it cuts the coil. The galvanometer deflects in opposite direction

This is called ***mutual induction***. This process is applied in transformers

SELF INDUCTION

Is where an emf is induced in a coil due to change in the magnetic flux linked with the coil itself

It occurs in a coil with many turns

EDDY CURRENTS

Are currents induced in a conductor when moving in a changing magnetic field

Uses of eddy current

1. Used in electric brakes of electric trains
2. Melting metals in electric furnace

Disadvantages of eddy current

1. Causes power loss in transformers and motors

TRANSFORMERS

Is a device that steps up or step down voltage.

It is based on the principle of mutual induction i.e. changes in the magnetic flux of the primary coil induces an emf in the secondary coil.

Transformers are divided into two

1. Step down transformers
2. Step up transformers

STRUCTURE OF A TRANSFORMER

Step up transformer

Is a transformer that increases voltage

It has more number of turns in the secondary coil than in the primary coil

PHYSICS 535/3 PRACTICALS

MEASURING INSTRUMENTS

1. **Metre rule**
Measures length in cm to $\mathbf{1}\boldsymbol{dp}$
e.g. 2.0 cm, 10.2 cm, 12.7 cm etc

2. **Stop clock**
Measures time in seconds (s) to $\mathbf{1}\boldsymbol{dp}$
e.g. $10.0s$ $25.5s$, $16.0s$ $17.5s$

3. **Stop watch**
Measures time in seconds (s) to $\mathbf{2}\boldsymbol{dps}$
e.g $12.43s$, $20.92s$, 16.73 etc

4. **Protractor**
Measures angles in degrees (º) to $\mathbf{0}\boldsymbol{dps}$
e.g. 10^0, 24^0 , 29^0 etc.

5. **Ammeter**
Measures current in amperes (A) to $\mathbf{2}\ \boldsymbol{dps}$
The last decimal value is 0 $or\ an\ even\ number$.
e.g $0.24A$, $1.40A$, $2.20A\ etc$

6. **Voltmeter**
Measures $p.d$ in volts (V) to $\mathbf{2}\ \boldsymbol{dps}\ \boldsymbol{OR}\ \mathbf{1}\ \boldsymbol{dp}$
Depending on the chosen scale

7. **Electronic beam balance.**
Measures mass in grams (g) to $\mathbf{1}\ \boldsymbol{dp}\ \boldsymbol{or}\ \mathbf{2}\boldsymbol{dps}$.
e.g. $45.00g$, $158.00g\ or\ 40.0g$, $34.0g\ etc$

UNITS AND SYMBOLS

- Units are stated using the right symbols.
- Abbreviation of units is not used e.g. Unit for time is, $(\boldsymbol{s})$ NOT sec
- Units named after Scientists are written with capital letters. e.g. watts (W), joule (J) ampere (A).
- Units must be written in brackets e.g. $m(kg)$, $t(s)$, $I(A)$ $etc.$ **NOT** m/kg, t/s, I/A

- Units of derived quantities are written using Scientific notations e.g. ms^{-1} **NOT** m/s, kgm^{-3} **NOT** kg/m^3, Ω **NOT** V/A.
- $\boldsymbol{sin, cos, tan, log}$ do not have units.
- Values of $\boldsymbol{sin, cos, tan, log}$, are written to 3 dps.

e.g. $sin30^0 = 0.500$

$log2 = 0.301$ $\qquad$ $cos30^0 = 0.866$

SIGNIFICANT FIGURES

All figures are significant except zeroes in-front of non-zero digits. E.g. 0.0002 all those zeroes in-front of 2 are not significant

GENERAL GUIDELINES

Float:

A float is a constant number. e.g π, $2, 10, 20\ etc$

1. Division and multiplication with a float.

Significant figures of a measured value are to be used. e.g.

If $t = 14.2s$ and n=20	If $I = 2.46A, then$
$T = \frac{t}{20}$	$\frac{1}{I} = \frac{1}{2.46\ (3sfs)}$
$= \frac{14.2\ (3sfs)}{20\ (float)}$	$= 0.406504065\ (cal)$
$= 0.71\ (cal)$ $= 0.710s\ (3sfs)$	$= 0.407A^{-1}\ (3sfs)$

2. Addition and subtraction with a float

Decimal values of a measured value are to used.

If $x = 14.2cm$ then $10 + x\ is\ calculated\ as$;

$$10 + x = 10 + 14.2(1dp)$$

$$= 24.2\ (cal)$$

$$= 24.2\ cm\ (1dp)$$