THE PHYSICS OF "O" LEVEL

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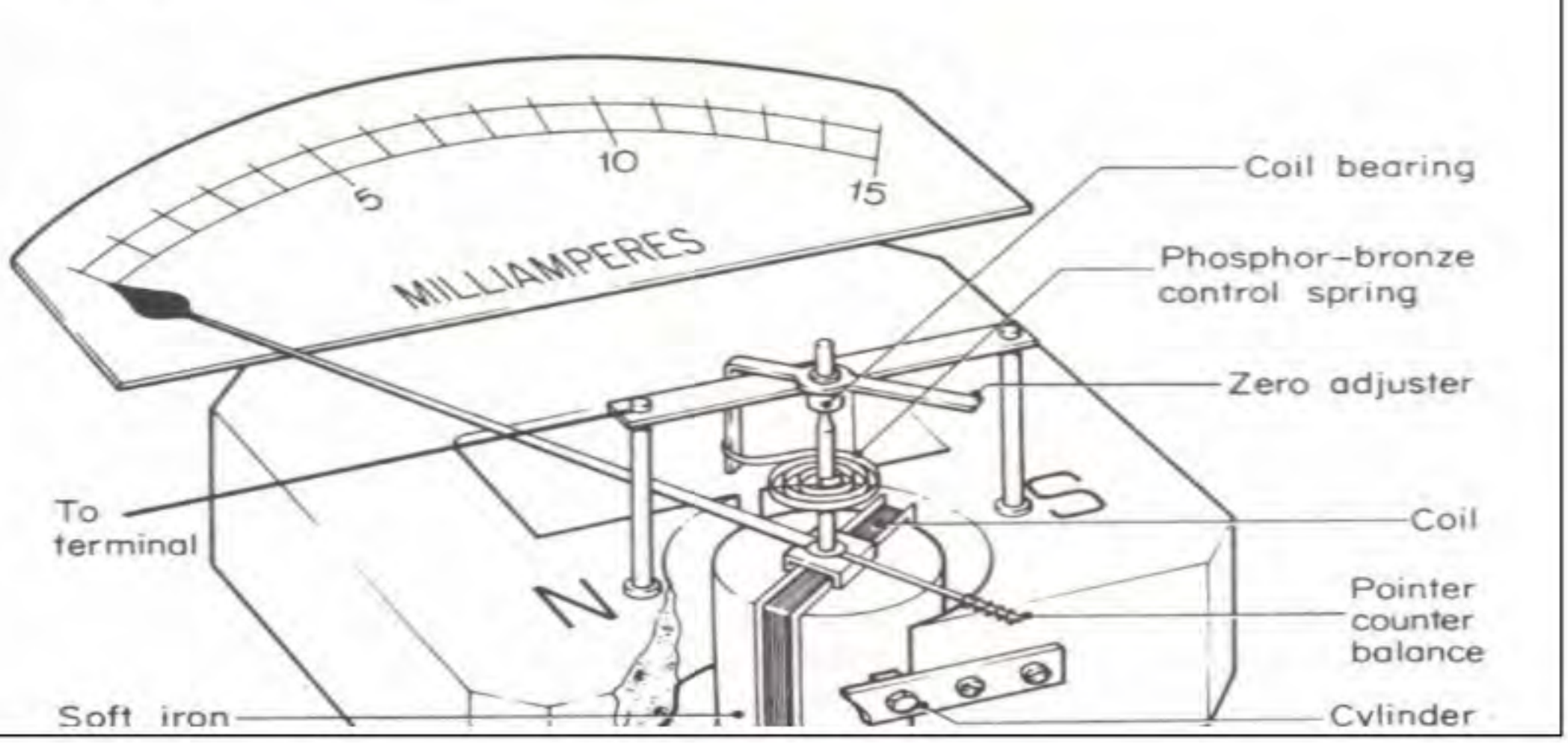
VOL.1



SOLUTIONS TO EXERCISE 1

1. (a) What is meant by the terms;

(i) Refraction of light:

This is the change in the direction of a light ray as it travels from one medium to another of different optical density.

(ii) Power of a lens.

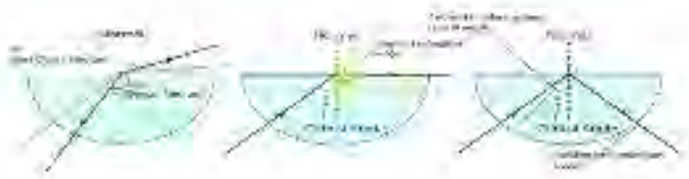
This is the reciprocal of it's focal length expressed in metres.

(iii) Critical angle.

This is the angle of incidence for a ray travelling from a more dense medium to a less dense medium that forms an angle of refraction in the less dense medium to be exactly 90°.

(iv) Total internal reflection.

This is a phenomenon which occurs when the angle of incidence for a ray travelling from a more dense medium to a less dense medium exceeds the critical angle and the ray is reflected back into the more dense medium.



(b) State the conditions necessary for total internal reflection to occur.

-The ray must be traveling from a more dense medium to a less dense medium.

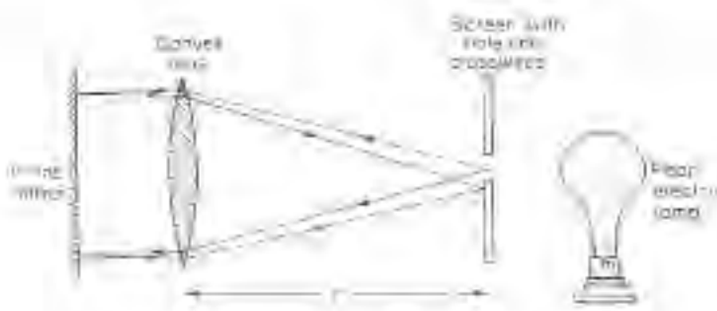
-The angle of incidence must exceed the critical angle.

(c) State the laws of refraction of light.

-The incident ray and the refracted ray are on the opposite sides of the normal at the point of incidence and all the three lie on the same plane.

- The ratio of sine of angle of incidence to sine of angle of refraction is a constant for any given pair of media.

(d) Describe an experiment to determine the focal length of a converging lens using a plane mirror.

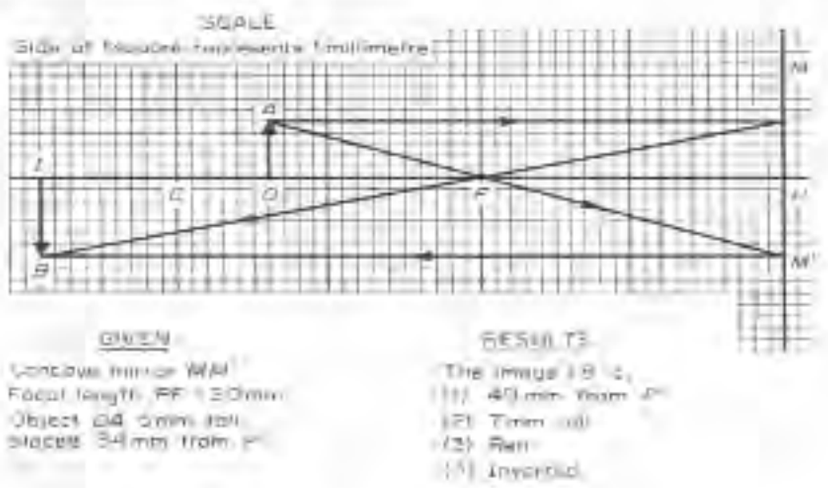


The lens is set up in a suitable holder with a plane mirror behind it so that light passing through the lens is reflected back again. The object used is a hole and cross-wire in a white screen illuminated by a pearl electric lamp.

The position of the lens holder is adjusted until a sharp image of the object is formed on the screen alongside the object itself.

The distance between the lens and the screen will be the focal length of the lens.

(e) By means of an accurate graphical construction, determine the position, size and nature of the image of an object 5mm tall, standing on the principal axis of a concave mirror of focal length 20mm and 34mm from the mirror.



2. (a) State Newton's laws of motion.

Law 1 : Every body continues in it's state of rest or of uniform motion in a straight line unless compelled by some external force to act otherwise.

Law 2: The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts.

Law 3: To every action there is an equal and opposite reaction.

(b)(i) What is linear momentum?

Is the product of mass of a body and it's velocity.

(ii) State the law of conservation of momentum.

When two or more bodies act upon one another, their total momentum remains constant, provided no external forces are acting.

(c) A bullet of mass 0.001kg is fired from a gun of mass 5kg. If the recoil velocity of the gun is $0.2ms^{-1}$, calculate the muzzle velocity.

mass of gun x recoil velocity= mass of bullet x muzzle velocity

$$5 \times 0.2 = 0.001 \times v$$

$$0.001v = 1$$

$$v = 1000ms^{-1}$$

(d) With examples distinguish between vector quantities and scalar quantities.

Vector quantities are physical quantities with both magnitude (size) and direction. Examples are; acceleration, displacement, force, weight, velocity etc.

While;

Scalar quantities are physical quantities with only magnitude (size). Examples are; area, distance, time, mass, density, volume ,speed etc.

(e) Define the term Power.

Is the rate of doing work.

3. (a) Distinguish between Heat capacity and Specific heat capacity.

Heat capacity is the quantity of heat required to raise the temperature of a substance by 1K or 1°C.

While;

Specific heat capacity is the quantity of heat required to raise the temperature of 1kg mass of a substance by 1K or 1°C .

(b) Describe an experiment to determine the specific heat capacity of a solid by method of mixtures.

A Copper calorimeter is weighted , it's mass recorded as m_c and half of its volume is filled with cold water of temperature Θ_1 . Then it is again weighted to know the mass of water , m_w .

The solid under test is weighed, it's mass recorded as m_s and then it's heated in a steam jacket until it attains a temperature Θ_2 .

The hot solid is then carefully transferred into the water in the well lagged copper calorimeter and the mixture well stirred until a constant temperature Θ_2 is obtained.

At this point,

Heat lost by the solid= Heat gained by water+Heat gained by the calorimeter.

$$m_s c_s(\Theta_3 - \Theta_2) = m_w c_w(\Theta_2 - \Theta_1) + m_c c_c(\Theta_2 - \Theta_1)$$

Hence c_s the specific heat capacity of the solid can be calculated.

(c) The temperature of 500g of a certain metal is raised to 100°C and it's then placed in 200g of water at 15°C. If the final steady temperature rises to 21°C, calculate the specific heat capacity of the metal.

Heat lost by the metal = Heat gained by water

$$mc(\Theta_3 - \Theta_2) = m_w c_w(\Theta_2 - \Theta_1)$$

$$0.5 \times c \times (100 - 21) = 0.2 \times 4200 \times (21 - 15)$$

$$c = 127.59\ Jkg^{-1}K^{-1}$$

(d) State any five advantages of mercury over alcohol as a thermometric liquid.

Mercury is preferred to alcohol as thermometric liquids because;

1. Mercury has a much greater conductivity than alcohol and expands rapidly, and thus indicates a temperature change quickly. Alcohol being a relatively poor conductor, expands slowly and thus responds to temperature changes slowly.

2. Its silvery surface makes mecury opaque, and hence it can be easily seen. Alcohol has to be coloured to be easily seen.

3. Mercury does not wet glass but alcohol because of its concave meniscus tends to cling to the walls of stem of the thermometer. This leads to an inaccurate reading when the thread is falling.

4. Mercury is not easily vaporized whereas alcohol is very easily vaporized even at low temperatures.

5. Mercury boils at 357°C while alcohol boils at 78°C. Mercury can therefore be used to measure higher temperatures than alcohol.

***Note:** Alcohol has the following advantages over*

Mercury as a thermometric liquid:

1. It freezes at -115°C whereas Mercury freezes at -39°C. Alcohol can therefore be used for

measuring very low temperatures.

2. The expansivity of alcohol is about six times that of Mercury for the same temperature rise.

(e) State any four differences between evaporation and boiling.

Evaporation	Boiling
-Occurs only from the surface of the liquid.	*- Occurs throughout the liquid*
-Does not produce bubbles.	*- Produces bubbles*
-Leads to cooling	*- Does not lead to cooling*
- Occurs at any temperature.	*- Occurs at a particular temperature.*

4. (a) Distinguish between transverse waves and longitudinal waves.

Transverse waves are waves where vibration of individual particles is at right angles to the direction of wave motion. While;

Longitudinal waves are waves where vibration of individual particles is parallel to the direction of wave motion.

(b) What is meant by the following terms;

(i) Amplitude:

Is the maximum displacement of a wave particle from it's rest position.

(ii) Frequency:

Is the number of complete cycles (oscillations) that a wave particle makes per second.

(iii) Wavelength:

Is the distance between two successive crests or troughs.

(iv) Period:

Is the time taken for a wave particle to make one complete cycle.

(c) State any four differences between electromagnetic waves and mechanical waves.

Electromagnetic	Mechanical

Do not require a material medium for propagation.Travel with or without air	*Require a material medium like air for propagation*
Travel through a vacuum	*Do not travel through a vacuum*
Travel at a relatively higher speed. ($3x10^8 ms^{-1}$ in a vacuum)	*Travel at a relatively lower speed.*
Have relatively shorter wavelength	*Have relatively longer wavelength*

(d)(i) What are Ultra sonic sound waves?

These are sound waves of very high frequency above 20kHz. They can not be detected by the human ear.

(ii) State any four applications of ultrasonic sound waves.

- Used to detect flaws in any metal objects.

- Echolocation. Animals such as bats and dolphins send out ultrasound waves and use their echoes, or reflected waves , to identify the locations of objects they cannot see.This is called echolocation.

- Used in echo sounding systems of ships to detect shoals of fish and to measure the depth of the sea.

- Ultrasonography.Medical ultrasound is a diagnostic imaging technique, or therapeutic application of ultrasound. It is used to create an image of internal body structures such as tendons, muscles, joints, blood vessels, and internal organs.

5.(a) Define the following terms.

(i) Pressure.

This is the force acting normally per unit area.

(ii) Surface tension.

This is a tangential force acting normally per unit length across any line in the surface of the liquid.

(iii) Diffusion.

This is the spreading of molecules of a substance into another from a region of higher concentration to a region of lower concentration.

(b) With aid of a diagram, explain how a lift pump works.

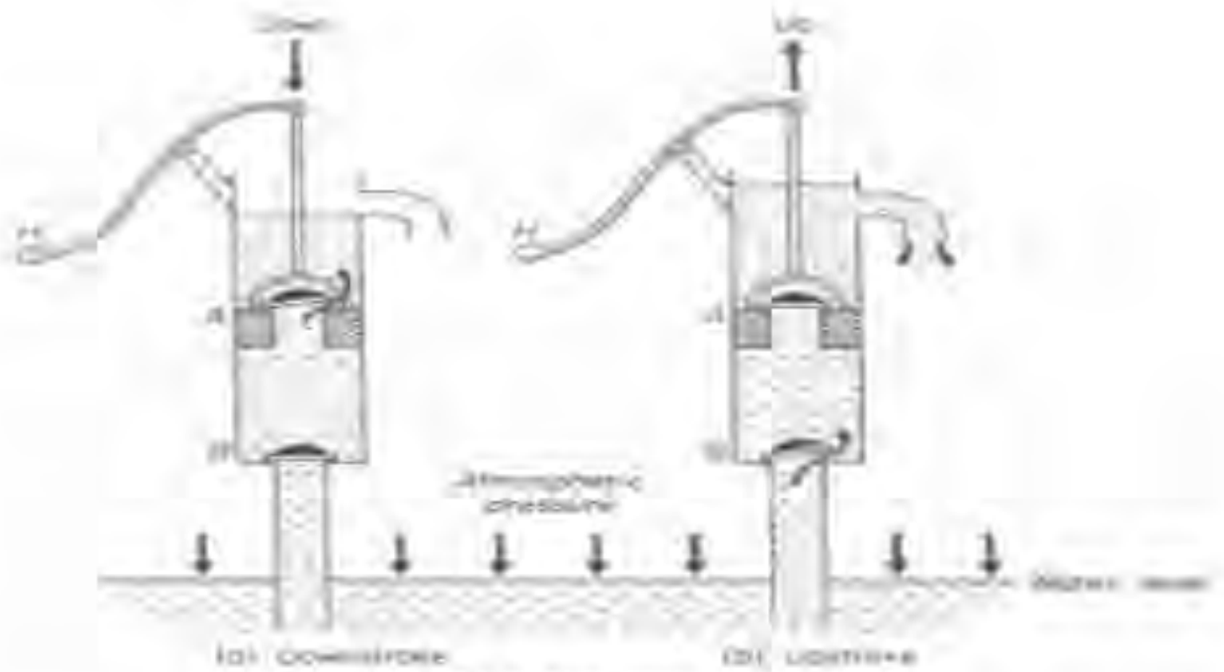


Fig. 11.2: The common pump

Down stroke: When the plunger moves downwards the valve B closes owing to the force of gravity on it and the weight of water above it. At the same time water inside the pump passes upwards through valve A into the space above the plunger.

Up stroke: On the up stroke the valve A closes owing to the force of gravity on it and the weight of water above it. Also as the plunger rises, water is pushed up the pipe through the valve B by atmospheric pressure acting on the surface of the water in the well. At the same time, the water above the plunger is raised and flows out of the spout.

(c) (i) State the law of floatation.

It states that a floating body displaces it's own weight of the fluid in which it floats.

(ii) A solid of volume 400cm^3 floats on water with half of it's volume submerged, find the mass of this solid.

From the law of floatation; weight of the solid= Weight of water displaced

Mass of the solid = mass of water displaced

= Volume of water displaced x density of water

$$= \frac{\{1/2 \times 400\}}{100 \times 100 \times 100} \times 1000$$

$$= 0.2kg$$

(d) Distinguish between Displacement and distance.

Displacement is the distance moved in a specific direction. While;

Distance is the length between any two points.

(e) What are cohesion forces?

These are forces of attraction between molecules of the same substance.

6 (a) Distinguish between hard magnetic materials and soft magnetic materials.

Hard magnetic materials are materials that are hard to magnetize and hard to de-magnetize.

While:

Soft magnetic materials are materials that are easy to magnetize and easy to de-magnetize.

(b) Describe the electrical method of magnetising a steel bar.

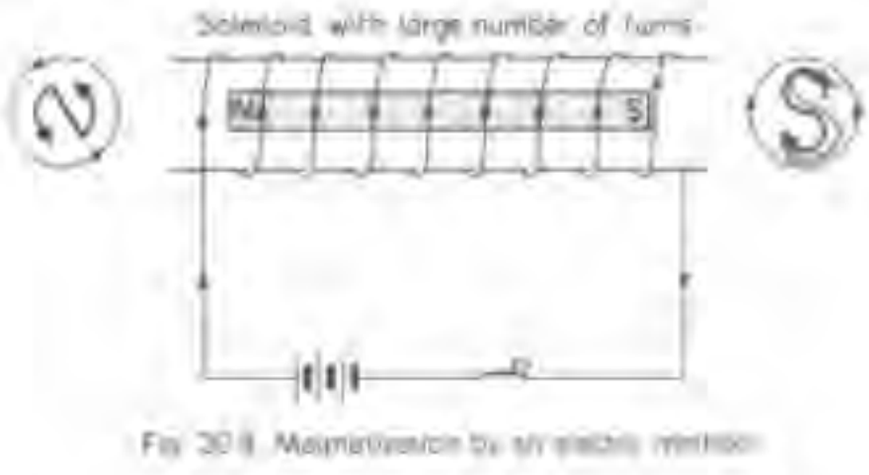


Fig. 20.8 Magnetization by an electric method

A steel bar is placed inside the coil and the current from the d.c supply switched on and off. On removing and testing the bar it is found to be magnetized. It's unnecessary to leave the current on for any length of time, as the bar will not become magnetized any more strongly and the coil may be damaged through over heating.

The polarity of the magnet depends on the direction of flow of the current. If, on looking at the end of the bar, the current is flowing in a clockwise direction, that end will be a S pole; if anticlockwise, it will be a N pole.

Note: *Also; on griping the steel bar using the right hand such that the fingers curl in the direction of flow of current, the thumb points in the N pole.*

(c)What is meant by;

(i) Magnetic poles

These are places in a magnet where the resultant attractive force appears to be concentrated.

(ii) Magnetic meridian

Magnetic meridian at any place is a vertical plane containing the magnetic axis of a freely suspended magnet at rest under the action of the earth's field.

(iii) Geographic meridian

Geographic meridian at a place is a plane containing the place and the earth's axis of rotation.

(iv) Magnetic declination

This is the angle between the magnetic and geographic meridians.

(v) Inclination or dip

This is the angle between the direction of the earth's magnetic flux and the horizontal.

(d) Draw a horizontal magnetic flux pattern near a bar magnet with it's axis in the magnetic meridian and its;

(i) S pole pointing north.

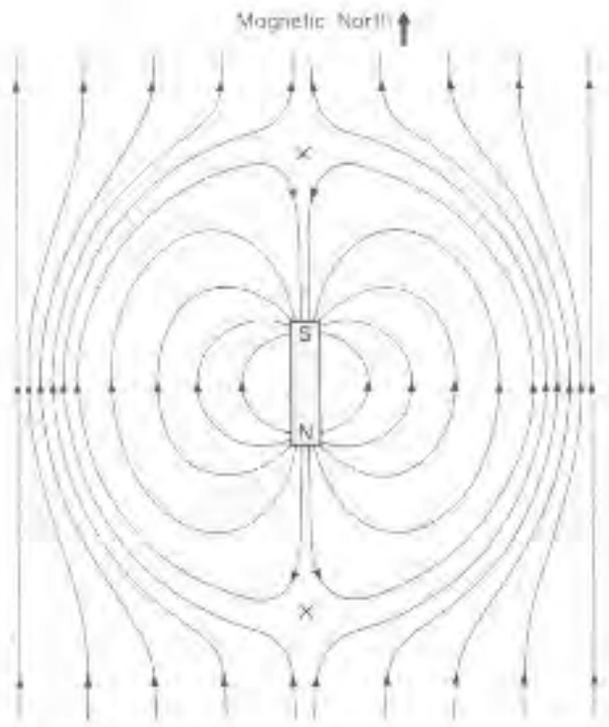


Fig. 31.11. Horizontal magnetic flux pattern near a bar magnet with its axis in the magnetic meridian and its S pole pointing north

(ii) N pole pointing north

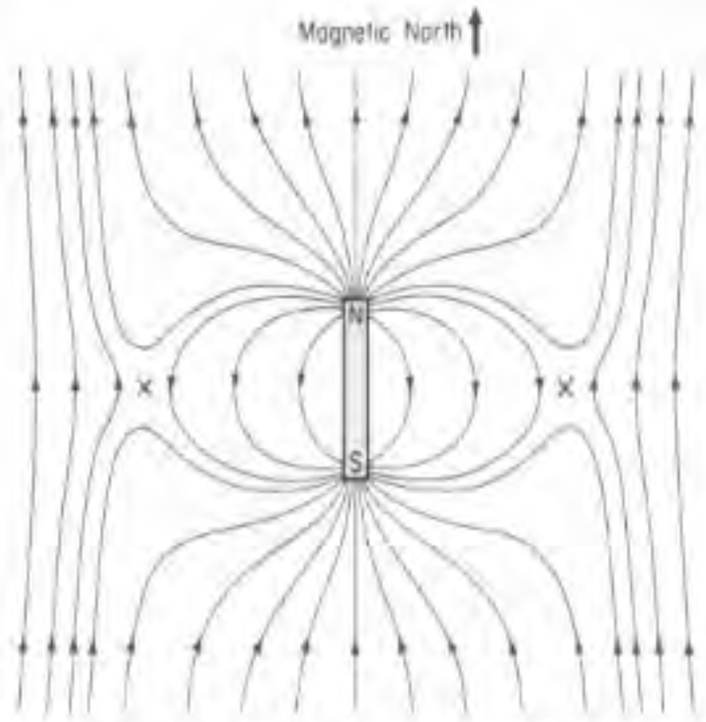


Fig. 31.12. Horizontal magnetic flux pattern near a bar magnet with its axis in the magnetic meridian and its N pole pointing north

7. (a) Define the following terms.

(i) Density.

Is the mass per unit volume of a substance.

(ii) Volume.

Is the space occupied by an object.

(iii) Mass.

Is the quantity of matter that an object contains.

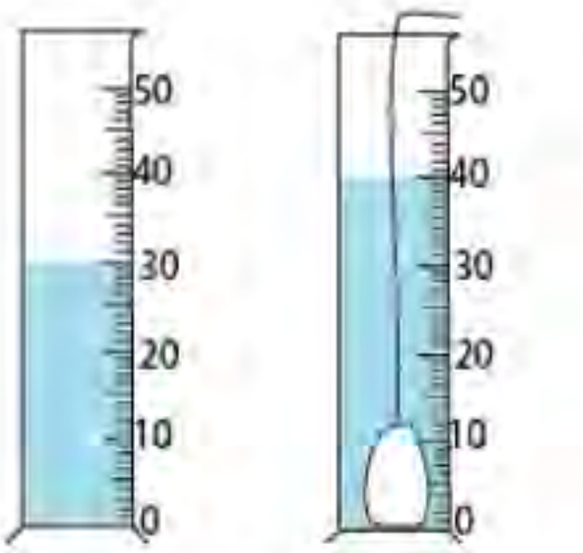
(b) Describe an experiment to measure the volume of an irregular object using an over flow can.

Water is poured into the over flow can and left to drip until the dripping stops.

A beaker is placed under the spout and the irregular object tied on a thread gently lowered into the water. Some water is displaced into the beaker.

Volume of displaced water = volume of the irregular object.

(c) An object is carefully placed into a cylinder containing $30cm^3$ of water. This causes the water level to rise to $40cm^3$. What is the volume of the object?



Volume of the object =(40-30) cm^3 = $10cm^3$

(d) State any three differences between mass and weight.

Mass	Weight
Is the quantity of matter that an object contains	*Is a force that a body exerts on anything which freely supports it.*
Is measured in kilograms	*Is measured in newtons.*
Is constant every where on earth	*Varies from place to place on earth.*

(e) What is a Newton?

Is a force that gives a body of mass 1kg an acceleration of $1ms^{-2}$.

8. (a) Distinguish between x-rays and cathode rays.

X-rays are electromagnetic radiations of very short wavelength produced when fast moving electrons are suddenly stopped by matter. While;

Cathode rays are streams of fast moving electrons.

(b) Explain the process of production of x-rays in an x-ray tube.

The cathode filament is heated by the low voltage supply to produce electrons by thermionic emission. The produced electrons are then focused towards the anode by the focussing cup.

These electrons are accelerated to a high speed towards the anode by the high p.d across the tube.

On reaching the anode, they strike the tungsten target and their kinetic energy is converted into heat and x-rays. The heat generated is removed by the cooling fins.

(c)(i) What is meant by the term Half life?

Is the time taken for half the sample of a radioactive substance to decay.

(ii) A radioactive substance of mass 96g has a half life of 2 days. Find its mass that decays after 6 days.

Time (days)	Remaining mass (g)
0	*96*
2	*48*
4	*24*
6	*12*

Decayed mass = Original mass - Remaining mass

= (96 - 12)g

= 84g

(d) State four uses of radioactive emissions.

- Used in sterilising medical equipments

- Used in the treatment of cancer.

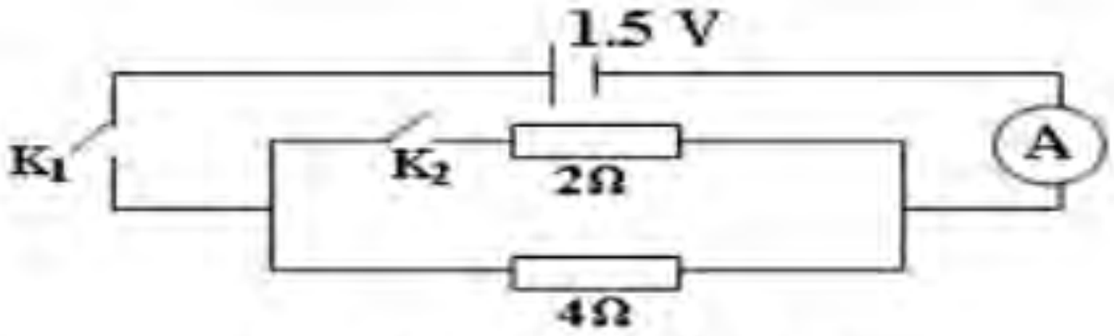
- Used in industry to monitor thickness of sheets of paper.

- Used by archaeologists to date historical specimen.

9. (a)What is meant by the term Electromotive force?

Is the work done in joules per coulomb of electricity conveyed in a circuit in which the cell is connected.

(b) The figure below shows an arrangement of resistors. Find the Ammeter reading when the switch K_2 is;



(i) Open and K_1 is closed
(ii) Closed and K_1 is closed.

Solution:

(i) When K_2 is open and K_1 closed, current flows through the 4Ω only. Let R = 4Ω, V=1.5 V, I=?

First determine the effective resistance, R	Now that we know I and R, let us use Ohms law; **V=IR**
$R = 4\Omega$	$V = IR$ $1.5 = I \times 4$ $I = 0.375\ A$

(ii) When K_2 is closed and K_1 closed, current divides into the 2Ω and 4Ω. Let $R_1 = 2\Omega$, $R_2 = 4\Omega$, V=1.5 V, I=?

First determine the effective resistance, R	Now that we know I and R, let us use Ohms law; **V=IR**
$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{R} = \frac{1}{2} + \frac{1}{4} = \frac{3}{4}$ $R = \frac{4}{3}\Omega = 1.33\Omega$	$V = IR$ $1.5 = I \times \frac{4}{3}$ $I = 1.125\ A$

(c) Explain the defects of a Simple cell and how each can be minimised.

- Polarization. This defect results from the formation of a layer of hydrogen bubbles on the copper plate. The gas partially insulates the plate and increases the internal resistance of the cell. The hydrogen layer also sets up a back emf in the cell in opposite direction to that due to the copper and zinc. This can be minimised by adding a depolarizing agent such as Potassium dichromate to the acid , which oxidizes the hydrogen to form water. The hydrogen bubbles will rapidly disappear and the original emf is restored.

- Local action. . This is caused by the presence of small impurities in the Zinc. This causes giving off of hydrogen bubbles from the Impurity and the surrounding zinc slowly dissolves in the acid. This wastes the zinc. This can be prevented by cleaning the zinc in sulphuric acid and then rubbing a small globule of mercury over the surface with a small piece of cotton wool. This forms a coating of zinc amalgam all over the surface. Local action will not occur since the amalgam covers up the impurities. It can also be prevented by using pure zinc.

(d) State Ohm's law.

The current through a metallic conductor is directly proportional to the potential difference

between it's ends , provided temperature and other physical conditions are kept constant.

10.How can the sensitivity of a moving galvanometer be increased?

This can be done by:

- Using a coil of large area

- Using a large number of turns in the coil

- Using a special alloy permanent magnet which gives high magnetic flux.

- Weak hair springs to give a small control couple.

SOLUTIONS TO EXERCISE 2 .

1. (a) State the laws of reflection of light.

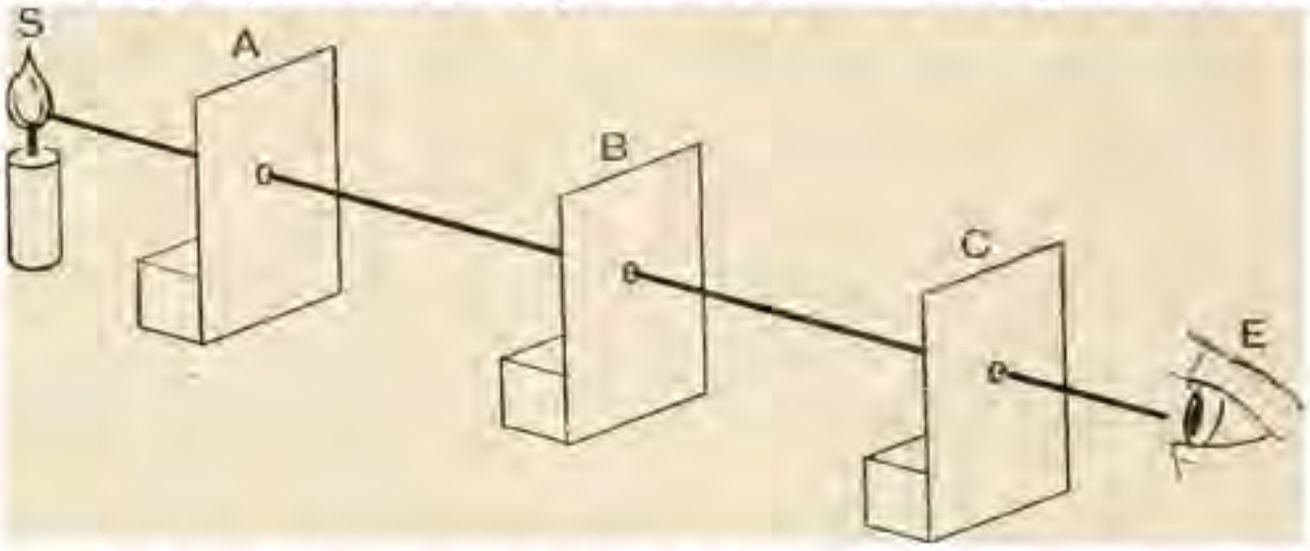
- The incident ray, the reflected ray and the normal at the point of incidence all lie in the same plane.

- The angle of incidence is equal to the angle of reflection.

(b) (i) What is meant by the term rectilinear propagation?

Is the tendency of light to travel in a straight line.

(ii) With aid of a diagram, describe an experiment to show that light travels in a straight line.



Three card boards A, B and C are made with holes in their centres. A taut string is passed through their holes to ensure that they are in a straight line.

When a source of light is placed at S and the observer's eye at E, the observer is able to see the light. When one of the card boards is displaced from it's position, the observer will no longer see the light. This shows that light travels in a straight line.

(c)(i) State the properties of images formed by a Plane mirror.

The image formed is;

- Virtual

- Laterally inverted

-Upright

- Same size as the object -

- Same distance from the mirror as the object.

(ii) Distinguish between a real image and a virtual image.

A real image is an image formed by actual intersection of light rays. While;

A virtual image is an image formed by apparent intersection of light rays.

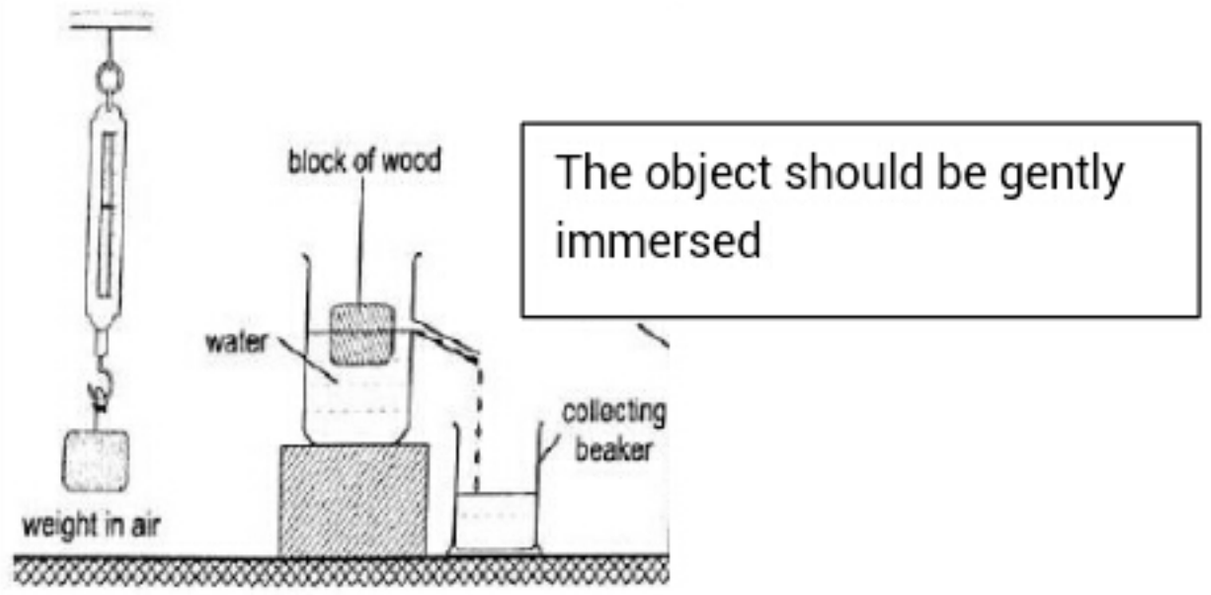
(d) Why are convex mirrors preferred for use to other mirrors as driving mirrors?

Convex mirrors form erect images of objects for all object positions and have a wider field of view.

2. (a) State Archimede's principle.

It states that, a body wholly or partially immersed in a fluid experiences an upthrust equal to the weight of the fluid displaced.

(b) Describe an experiment to verify Archimede's principle.



A solid is suspended on a spring balance and it's weight in air noted as W_a .

Water is then poured into an over flow can and left to drip until the dripping stops. A beaker is then placed under the spout.

The solid, still on the spring balance, is gently immersed into the water. The new spring balance

reading is noted as weight of the solid in water, W_w.

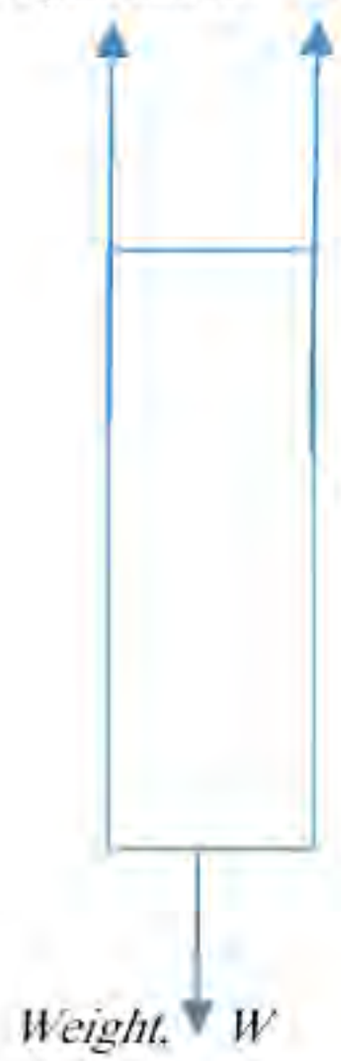
So; upthrust = W_a- W_w

At the same time, some water is displaced into the beaker.

When the displaced water is weighed, it's weight will be seen to be equal to the upthrust.

This verifies Archimede's principle.

(c) Explain what happens to a parachutist who jumps from a high flying plane.



The parachutist is acted on by the three forces as shown above.

Initially, (U+F) is less than his weight, W. This makes him accelerate downwards.

As he does so, F increases until a point is reached when W= (U+F).

At this point, the resultant force on him is zero and this makes him fall with a constant velocity called terminal velocity.

(d) Explain why a steel ship floats on water yet steel is more denser than water.

A piece of solid steel sinks, but a ship made of steel floats. This is because a ship is hollow and contains air, it's average density is less than that of water. This makes it to float.

3. (a)(i) What is a saturated vapour?

A saturated vapour is one which is in a state of dynamic equilibrium with it's own liquid.

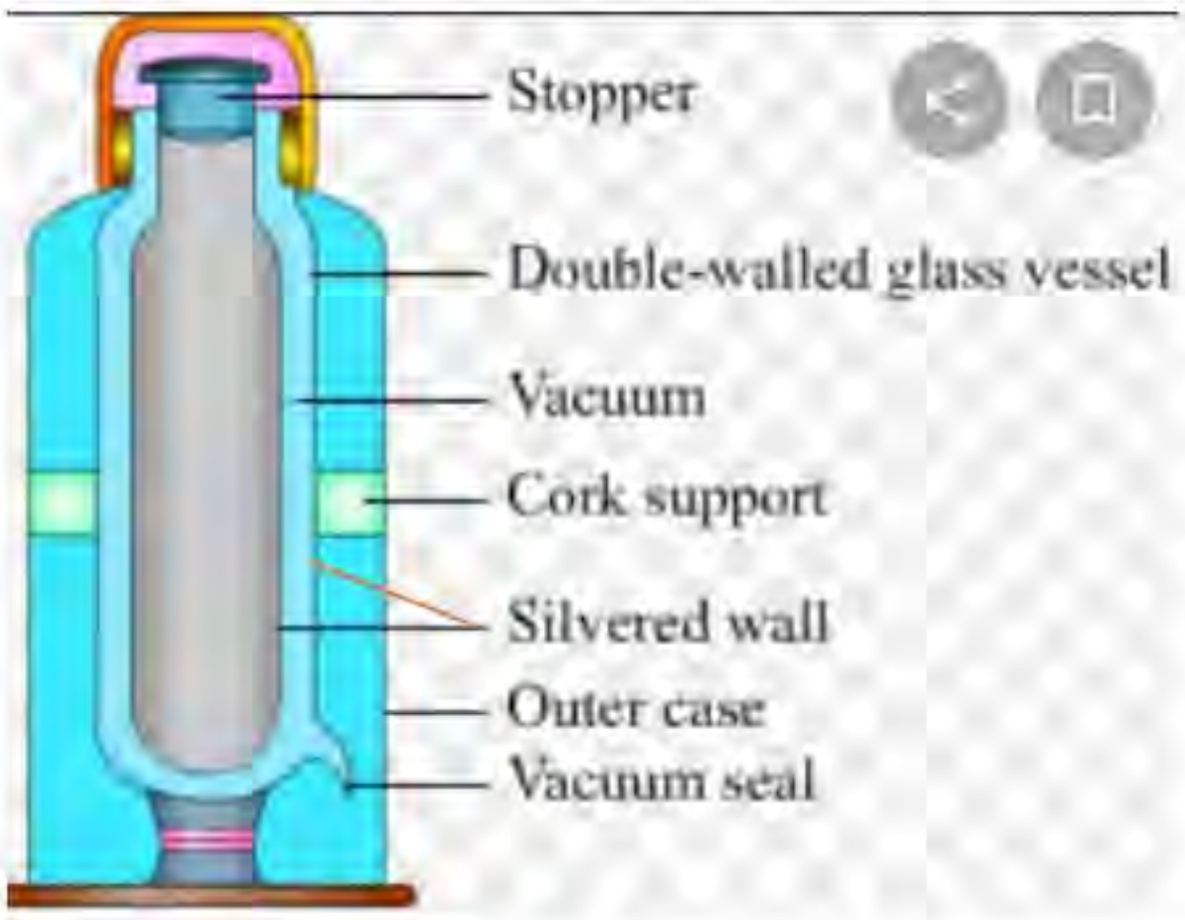
(ii)Use kinetic theory to explain the process of cooling by evaporation.

The molecules of a liquid have an average kinetic energy which increases with temperature. Molecules near the surface which happen to be moving faster than average can escape from the attraction of their neighbours and escape out of the liquid. Some of these may collide with other molecules above the liquid and so bounce back into it. But many others may escape altogether and their escape will be assisted if a current of air is passed over or through the liquid. Bubbling air through the liquid also increases the rate of evaporation by increasing the surface area from which molecules may escape.

In this way, the liquid loses its most energetic molecules while the less energetic ones are left behind. The average kinetic energy of the remaining molecules is therefore reduced and this results in a fall in temperature.

(b)Explain how a vacuum flask keeps liquids hotter for a longer time.

It has a vacuum which prevents heat loss by conduction or convection. The double silvered walls minimise heat loss by radiation. It has a poorly conducting cork stopper which minimises heat loss through convection and conduction. This makes it able to keep hot liquids hotter for a longer time.



(c) State Boyle's law.

The volume of a fixed mass of a gas is inversely proportional to the pressure, provided the temperature remains constant.

4.State any two differences between solids and liquids.

-A solid is a state of matter that has a definite shape and volume while a liquid is a state of matter that has volume but no definite shape. A liquid takes the shape of the container that holds it.

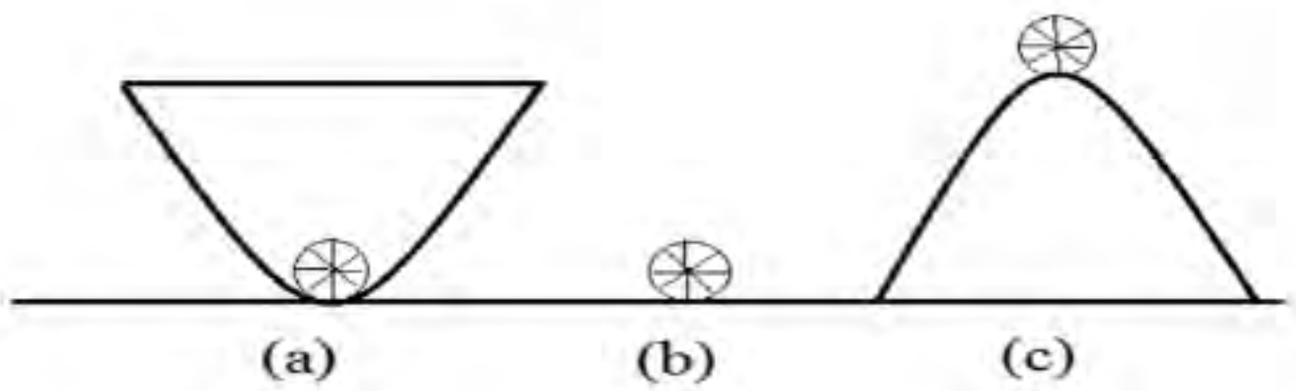
- Particles in solid state are very closely packed together while those in liquid state are fairly packed together.

5.Describe an experiment to show that water is a poor conductor of heat.

A hard glass test tube containing cold water is clamped on a retort stand and a tiny ice cube wrapped in a wire-gauze is dropped into it. The test tube is heated near it's mouth. It is noted that water starts boiling near the top but the ice does not melt. This experiment shows that water is a poor conductor of heat .

6.(a)State the conditions necessary for a body to be in stable, neutral and unstable equilibrium.

Figure 1



(a) Stable equilibrium.

When the body is slightly displaced, it returns to it's original position.

The position of the body's centre of gravity is low ,but when displaced it becomes raised.

(b) Neutral equilibrium.

The position of it's centre of gravity remains constant when the body is slightly displaced.

(c) Unstable equilibrium

When the body is slightly displaced, it does not return to it's original position.

The position of the body's centre of gravity is high, but when slightly displaced it becomes lowered.

(b) Why is it advisable for luggage in buses to be loaded in the boots at the bottom rather than the top racks?

Keeping the luggage below, in the boot, keeps the center of gravity of the bus lower, making the bus more stable on the road.

7.(a) What is an electromagnet?

Is any current carrying conductor that acts as a magnet.

(b) Describe an experiment to verify lenz's law.

LENZ'S LAW

An induced Current always flows in a direction such that it opposes the change which produced it.

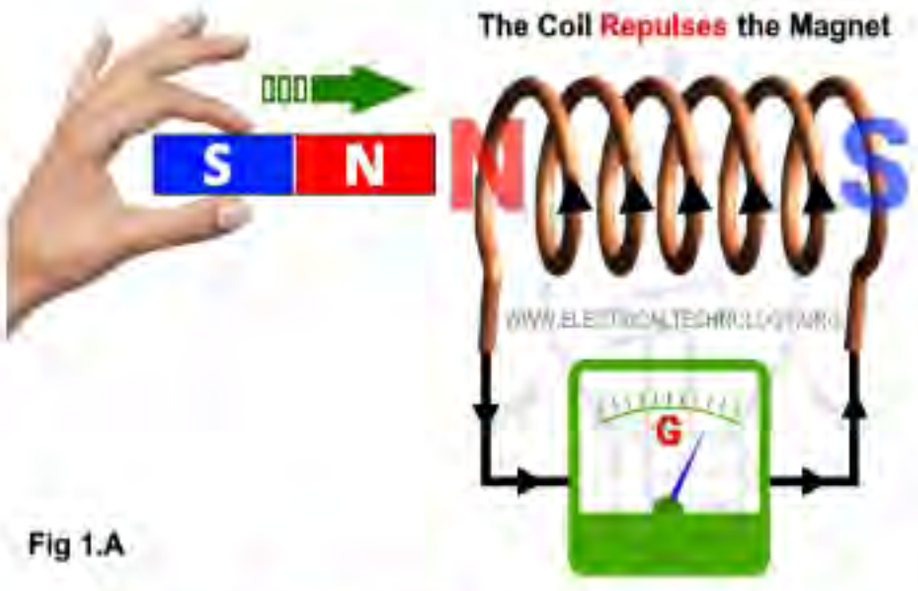


Fig 1.A

When the "N" Pole of the magnet is moved towards the coil, end of the coil becomes "N" Pole.

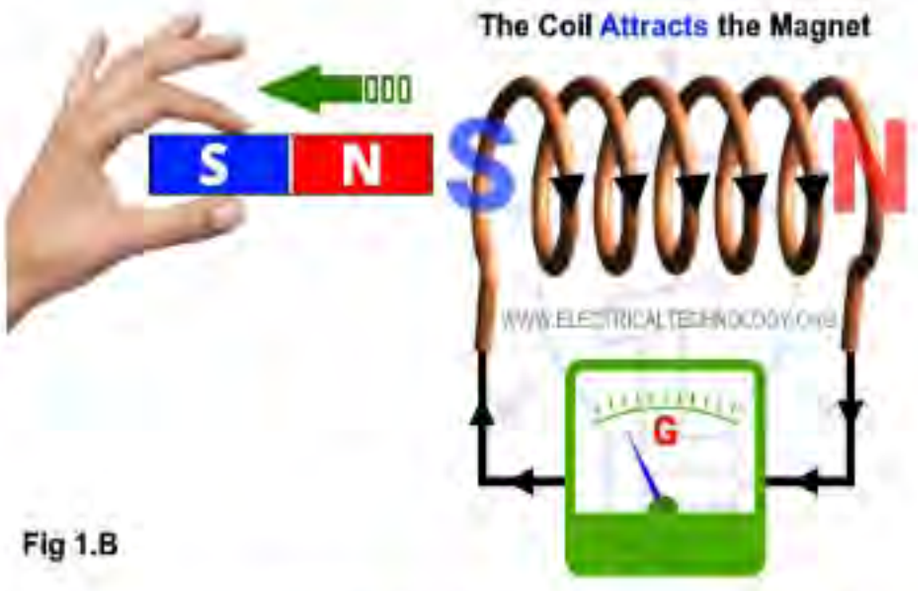
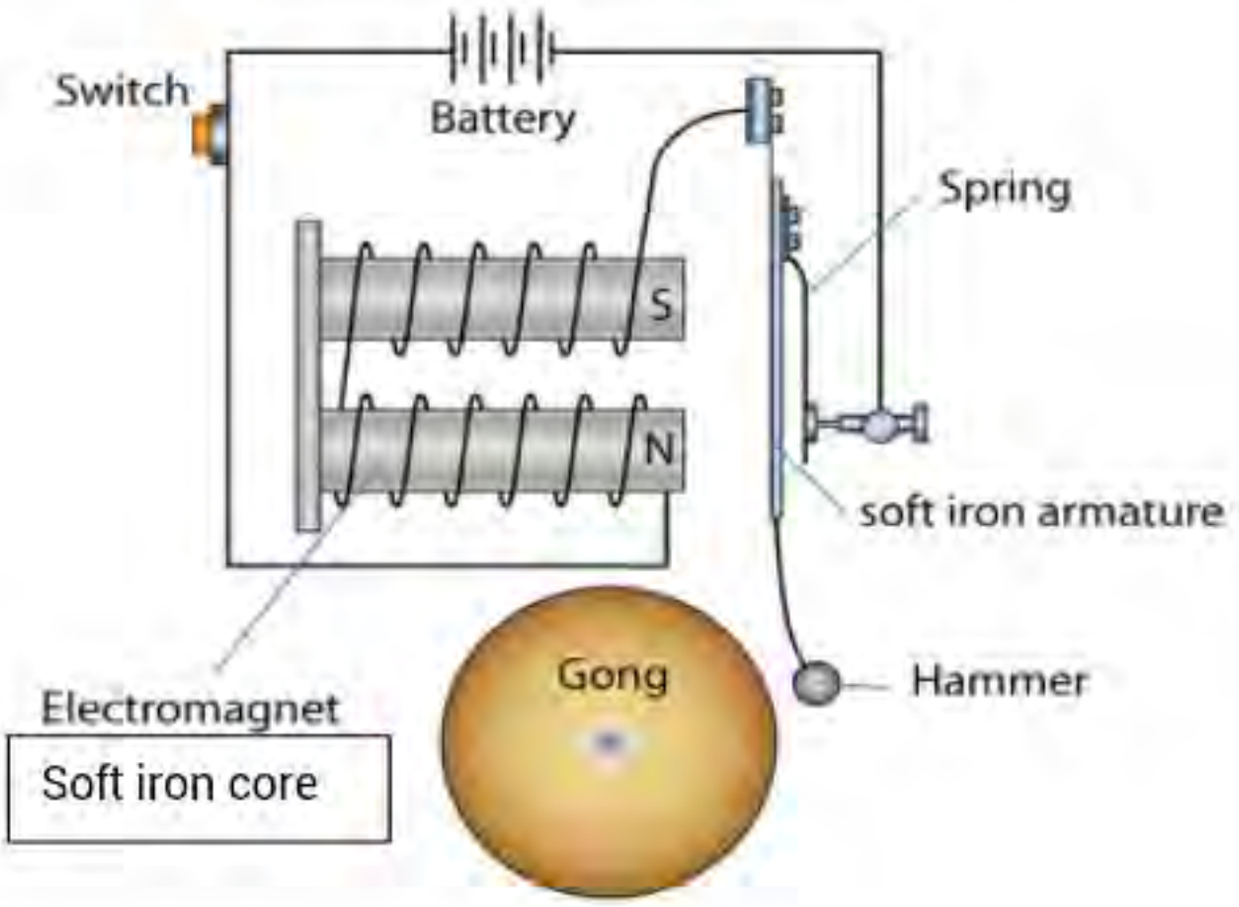


Fig 1.B

When the "N" Poles of the magnet is moved away from the coil, end of the coil becomes "S" Pole.

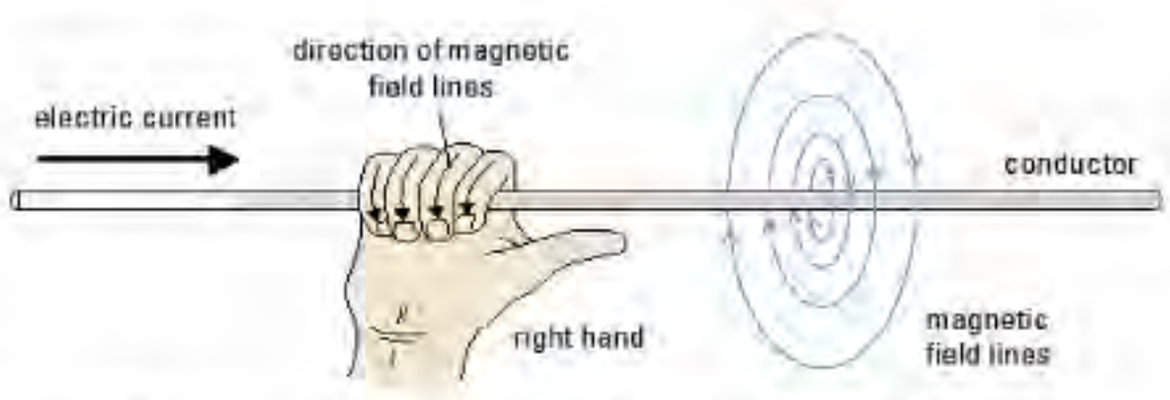
(c) With aid of a diagram, explain how an electric bell works.



When the switch is pressed current flows through the circuit and the cores become magnetized. The resultant attraction of the armature separates the contacts and breaks the circuit. The magnetism in the cores then disappears and the armature is returned by the spring to it's original position. Contact is now remade and the action repeated. Consequently, the armature vibrates and the hammer attached to it strikes the gong.

(d) State the right hand grip rule.

It states that; Imagine the wire to be grasped in the right hand with the thumb pointing along the wire in the direction of the current, the direction of the fingers will give the direction of the magnetic flux.



8. (a) What is meant by the following terms?

(i) Centre of gravity.

This is the point of application of the resultant force on a body due to the earth's attraction on it.

(ii) Moment of a force.

Is the product of force and the perpendicular distance from it's line of action to the turning point.

(iii) A couple.

Is a pair of equal and opposite parallel forces.

(b) State the conditions necessary for a body to be in equilibrium under the action of a number of parallel forces.

Sum of forces in one direction must be equal to the sum of forces in the opposite direction.

Sum of the anticlockwise moments about any point must be equal to the sum of clockwise moments about the point.

(c) Describe an experiment to show how efficiency of a pulley system varies with load.

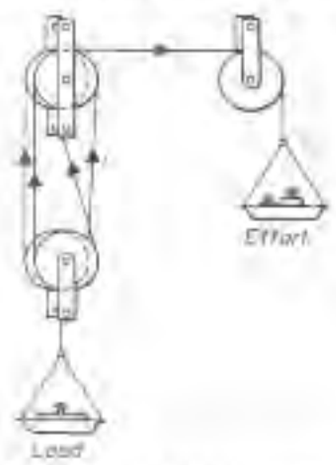


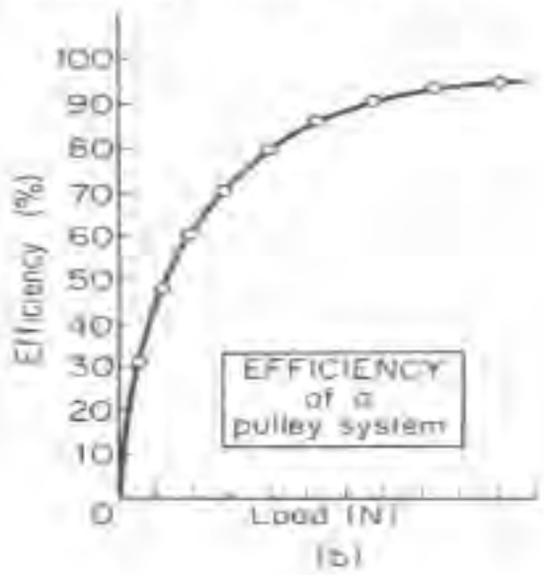
Fig. 8.7 Block and tackle system

A known weight is added to the load pan. Small weights are then added to the effort pan until the load just rises slowly with a steady velocity. The experiment is repeated with different weights in the load pan and effort pan.

The results are recorded in a suitable table as shown below.

Load (N)	*Effort* (N)	$M.A. = \frac{Load}{Effort}$	$Efficiency = \frac{M.A.}{V.R.} \times 100\%$

A graph of efficiency against load is plotted and obtained as;



The efficiency increases with increase in the load but owing to the energy wasted in overcoming friction and raising moving parts, the efficiency is less than 100% .

(d) (i)Distinguish between mechanical advantage and velocity ratio.

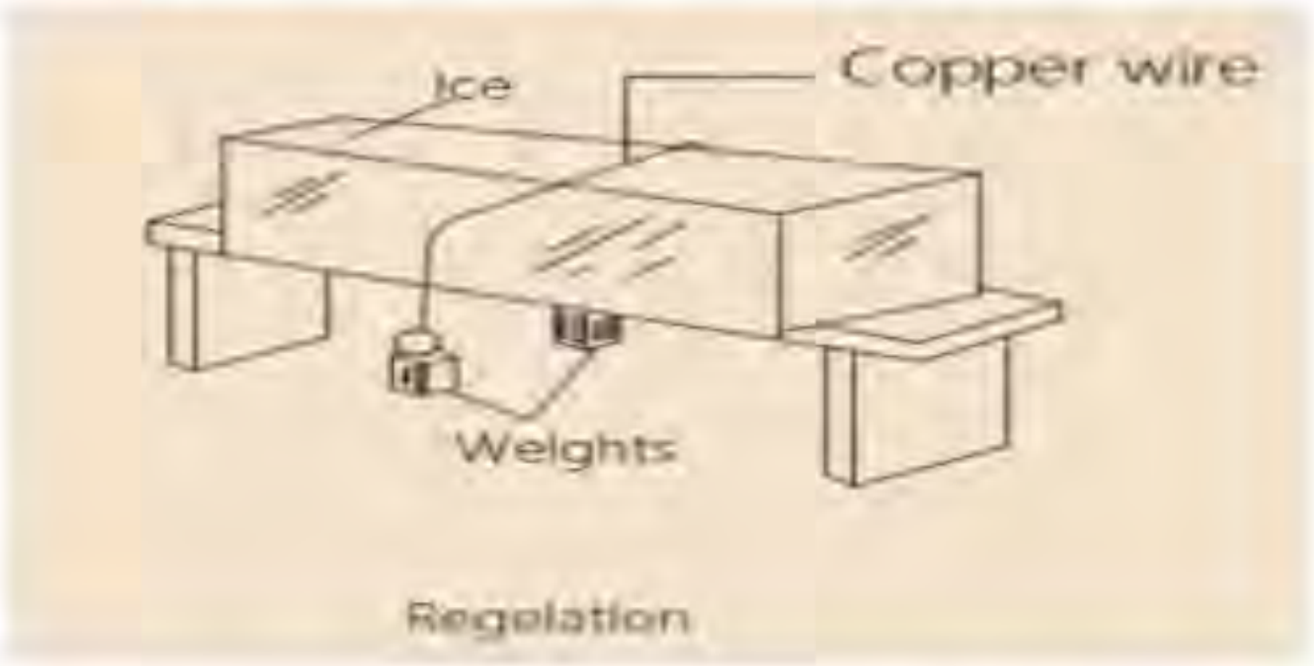
Mechanical advantage is the ratio of load to effort. While,

Velocity ratio is the ratio of effort distance to load distance.

(ii) What is a machine?

Is any device by means of which a force applied at one point can be used to overcome a force at some other point.

9. Describe an experiment to show the effect of pressure on melting point (regelation).



A block of ice rests on two supports, and a thin copper wire with heavy weights at each end is hung over it. After some time, the wire cuts right through it and falls to the floor, leaving the ice still in a solid block.

The pressure of the wire lowers the melting point of the ice in contact with it, and so the ice melts and flows above the wire. The latent heat required for the melting comes from the copper wire. As soon as the water passes above the wire, it's no longer under pressure and therefore refreezes.

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