REVISION

PHYSICS TECHNIQUES

DOMINIC MAGUT

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PREFACE

Even seasoned academicians also admit that exams and exam times are the most horrible times in academic life. .Nobody goes into exams expecting to fail, we all want to pass. However, passing in exams is not a walk in the park. Passing exams requires effort.

"A winning effort begins with preparation." -Joe Gibbs.

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We endeavor to continue enriching the contents of these books, so that they become the most comprehensive revision guides for students. This cannot be achieved without your input as a reader, we therefore look forward to the comments, suggestions and criticism from the readers. Constructive suggestions and feedback from users would be highly appreciated, gratefully acknowledged and suitably incorporated.

Best wishes

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CHAPTER ONE

MATTER

1. Define the term matter

Matter is anything that takes up space and can be weighed. In other words, matter has volume and mass. There are many different substances, or types of matter, in the universe. Chemists describe matter based on both physical characteristics, such as color or mass, and chemical characteristics, such as how one type of matter interacts with another type of matter. There are many ways to describe and classify matter.

2. Differentiate between the three states of matter

There are three common states of matter:

Solids – relatively rigid, definite volume and shape. In a solid, the atoms and molecules are attached to each other. They vibrate in place but don't move around.

Liquids – definite volume but able to change shape by flowing. In a liquid, the atoms and molecules are loosely bonded. They move around but stay close together.

Gases – no definite volume or shape. The atoms and molecules move freely and spread apart from one another.

3. **(a) State the kinetic theory of matter**

The kinetic theory of matter states that matter is made up of tiny particles which are in a constant random motion

(b) State **two** reasons why gas particles diffuse faster than solid particles

– Gas particles have low cohesive forces

- Gas particles have high kinetic energy

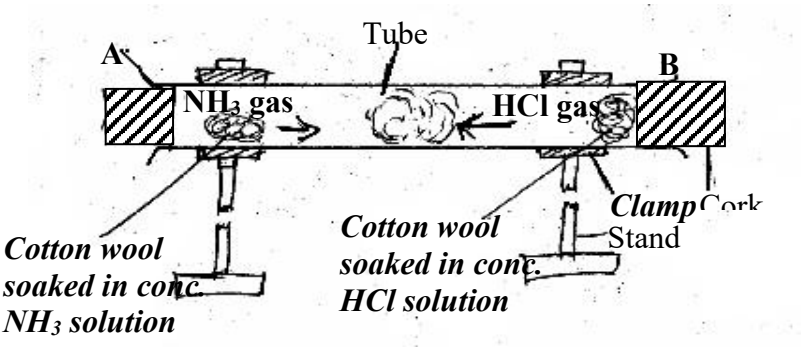
- Gas particles have low density,

4. Use kinetic theory to explain why air kept under constant temperature and volume exerts constant pressure

The pressure of a gas is ***inversely proportional to its volume when temperature is constant****. The product of pressure and volume is constant when temperature is constant. This relationship is known as Boyle's law*

5. You are provided with a long glass-tube, fitting corks, cotton wool, concentrated solution hydrochloric acid and concentrated ammonia solution.

(i) Draw a possible set-up to compare the rates of diffusion of ammonia gas and hydrochloric acid gas



(ii) Outline a clear procedure on how the experiment can be carried out

Experiment procedure

- *A long glass tube is clamped horizontally as sown in the figure below*
- *A piece of cotton wool is soaked n concentrated solution of hydrochloric acid and another in concentrated ammonia solution*
- *Simultaneously, the soaked cotton wool pieces are inserted at the opposite ends of the horizontal glass tube and cork.*
- *Observations are the noted*

(iii) What are the possible observations and conclusion

Possible observation

A white deposit of ammonium chloride forms on the walls on the walls of the glass tube in the region nearer end B

Conclusion

- Different gases have different rates f diffusion

6. Using kinetic theory of matter , explain what happens to a solid when heated ?

7. a. State charles law.

Charles law states that the volume of an ideal gas is directly proportional to the absolute temperature at constant pressure. The law also states that the Kelvin temperature and the volume will be in direct proportion when the pressure exerted on a sample of a dry gas is held constant.

b. a bicycle pump contains 50cm^3 of air at 17°c in 1 atmospheric pressure . determine the pressure when the air is compressed to 10cm3 and its temperature rises to 27°c

8. Distinguish between gases and liquids in terms of inter molecule forces.

Gases have weaker (small) intermolecular forces while while have relatively stronger (bigger) intermolecular forces Or Water has stronger intermolecular forces than gases.

3. What is the experimental evidence that shows that molecules in gases and liquids are in a state of motion

Brownian motion in liquids and gases

4.State Newton's second law of motion.

The rate of change of momentum of a body is directly proportional to the resultant external force producing the change and acts in the direction of the force

5. Smoke particles in air when strongly illuminated were observed to describe continuous, random haphazard movements. Explain what would be observed when the air temperature is decreased

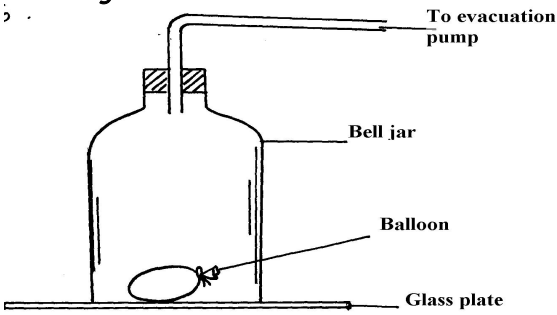
The K. E of the smoke particles reduce and hence their movements will be slower (reduces)

6. State how heat transfer by radiation is reduced in a vacuum flask

The silver coating on the inner surfaces of the double walled glass

7. (a) A partially filled balloon is placed in a bell jar with its open end on a thick glass plate as shown in *figure 16.* The contact between the jar and the glass plate is greased to make it air tight:

fig. 16



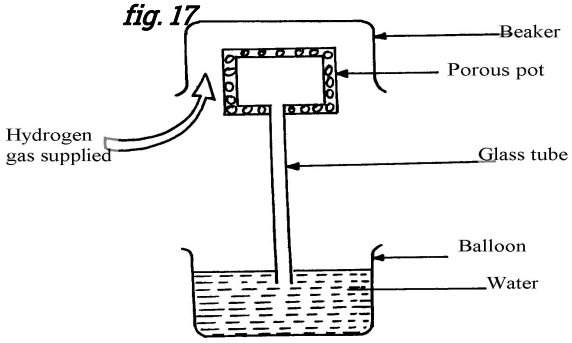
State and explain what happens to the balloon when air in the ball jar is slowly evacuated

The balloon expands (increases in volume)

- Evaluation reduces air pressure in the bell jar. Reduction on pressure in the jar leads to expansion of air in balloon

(b) *Figure 17* below shows an arrangement to demonstrate diffusion through solids:-

fig. 17



The hydrogen gas is supplied for sometimes then stopped. State and explain what is likely to be observed when the hydrogen gas supply:-

(i) is on

Hydrogen gas diffuses faster into the porous pot mixing with air initially in the pot, this increases pressure in the pot causing air to move out through the tube forming bubbles.

(ii) is stopped

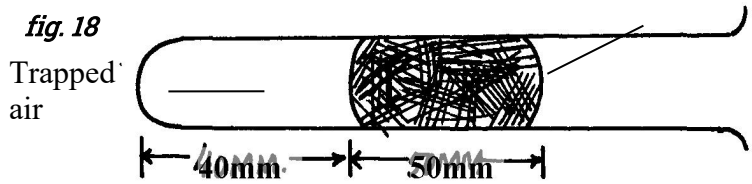
Hydrogen gas diffuses faster out of the pot. This reduces the gas pressure inside the pot

hence higher atmospheric pressure on the surface of water in the beaker to push water up

the glass tube.

(c) The diagram fig. 18 shows a glass tube containing enclosed air by a thread of mercury 50mm long when the tube is held in a horizontal position

fig. 18



(i) **The tube is slowly raised in a vertical position with the open end facing up. Determine the new length of the trapped air (tube has same area of cross-section; atmospheric pressure = 750mmHg)**

$P_1V_1 = P_2V_2$

$P_1L_1 = P_2L_2$

$P_1 = 750mmHg$, $P_2 = (750 + 50) = 800mmHg$

$L_1 = 40mm$

$750 \times 40 = 800 \times L_2$

$L_2 = \frac{750 \times 40}{800}$

$= 37.5mm$

(ii) Account for the difference in the column of trapped air using kinetic theory of matter assuming that temperature is constant.

The pressure on trapped air is higher when the tube is vertical than when it is horizontal

Increase in pressure lead to reduction in volume in order to increase the number of collisions per unit time between the air particle and the walls of the glass. This increases the air pressure to balance the increased external pressure. ✓1 ✓1

8. (a) Differentiate between a molecule of water and a molecule of ice

The structure of liquid water (left) consists of molecules connected by short-lived hydrogen bonds because water is a fluid. In ice (right), the hydrogen bonds become permanent, resulting in an interconnected hexagonally-shaped framework of molecules. Ice is less dense than liquid water and so it floats.

(b) explain why a bubble of air burst as soon as it emerges out of water

When a bubble rises to the surface of a liquid, it typically forms a thin, liquid, dome-shaped film supported by the gas trapped inside it. Once this film develops a hole, surface tension causes the film to retract further, and the bubble bursts.

9. Explain the Brownian motion

Brownian motion is the random motion of a particle as a result of collisions with surrounding gaseous molecules.

8. **Two samples of bromine vapour are allowed to diffuse separately under different conditions, one in a vacuum and the other in air. State with reasons the conditions in which bromine will diffuse faster**

Diffusion is faster in vacuum since there are no air particles to interfere with motion

9. **In terms of kinetic theory of matter, explain why evaporation causes cooling** *Energetic molecules gain heat energy from the substance in which the liquid is in contact and escapes. This causes cooling of the latter*

10. **(a) In an experiment to demonstrate Brownian motion, smoke was placed in air cell and observed under a microscope. Smoke particles were observed to move randomly in the cell.**

(i) Explain the observation

Air molecules/particles which were in a state of continuous random motion collided with smoke particles

(ii) Give a reason for using small particles such as those of smoke in this experiment

They are light hence move significantly when bombarded by air molecules

(iii) **What would be the most likely observation if the temperature in the smoke cell was raised?**

There would be increased rate of movement

(b) An oil drop of average diameter 0.7mm spreads out into a circular patch of diameter 75cm on the surface of water in a trough

(i) Calculate the average thickness of a molecule of oil

Volume of oil drops = volume f patch

$\frac{4}{3} R^3 = \frac{d^2 t}{4}$ *t = thickness*

$\frac{4}{3} \times (\frac{7}{2} \times 10^{-4})^3$

$= (\frac{0.75}{4})^2 t$

$5.7166 \times 10^{-11} = 0.1406t$

$Thickness, t = \frac{5.7166 \times 10^{-11}}{0.1406}$

$= 4.066 \times 10^{-10}$ *m (accept other units other than metres*

(ii) State **two** assumptions made in **(i)** above

Assumptions- Oil drop forms a perfect sphere (1mk)

- Patch formed is a perfect circle (1mk)

11. Give a reason why gases are more compressible than liquids

The particles making up gases are further apart than those in liquids

CHAPTER TWO

MEASUREMENT

1. Differentiate between basic units and derived units, giving an example of each

Basic/ Fundamental Unit	Derived Unit
Fundamental units are all those units which are independent of any other unit (including themselves).	Derived units are all those units which are obtained by multiplying and/or dividing one or more fundamental units with or without introducing any other numerical factor.
Fundamental units cannot be further reduced to elementary level; in fact, these are elementary units.	Derived units can be reduced to its elementary level, which are composed of fundamental units.
Fundamental units cannot be expressed in terms of derived units.	Derived units can be expressed in terms of fundamental units.
Only seven fundamental units exist in Metric System or SI system.	There exist a large number of derived units in Metric System.
Examples • Length (Meter, m) • Mass (Kilogram, kg) • Time (Second, s) • Temperature (Kelvin, K) • Amount of substance (Mole, mole) • Electric current (Ampere, A) • Luminous intensity (Candela, cd)	Examples • Velocity (m/s) • Acceleration (m2/s) • Momentum (kg-m/s) • Force (N) • Density (kg/m3) • Heat (J) • Energy (J) • Power (W), etc.

2. List any four instruments used for measuring length

Tools that can be used to measure length include rulers, vernier calipers, micrometer screw gauges, measuring tape etc

3. List four apparatus for measuring volume

graduated cylinders, pipets, burets and volumetric flasks.

4. Convert the following measurements into SI units

(a) 0.05cm

(b) 0.05cm3

(c) 750,000mm

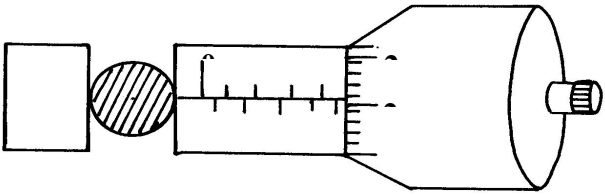
(d) 200 miliseconds

5. Using kinetic theory of matter , explain why gases are compressible but not solids or liquids

In gases the interparticle space is very large and hence they are compressible, but in case of solids and liquids particles are close to each other and hence cannot be compressed.

6. **The level of the liquid in a burette is 8.2cm3 ,50 spherical liquid droplets each of diameter 0.2 cm fall out, determine the new reading of the burette**

9. A ball bearing of mass 0.0015 kg is held between the anvil and spindle of a micrometer screw gauge. The reading on the gauge when the jaws are closed without anything in between is 0.11mm. Use this information and the position of the scale in the figure below to answer the questions (a) and (b) below:



a) **What is the diameter of the ball bearing?**

Exact diameter reading – 0.11

b) **Find the density of the ball bearing giving your answer correct to three significant**

2. **Water in a dam falls through a height 24.5m. If we assume that there are no energy losses, calculate the new temperature of the water as it strikes the lower end, given that its initial temperature at the top of the dam is 18.9°C**

Take specific heat capacity of water = 4200Jkg^{-1}

$\cancel{m}hg = \cancel{m}C\Delta\theta$

24.5 X 1Ø= 420Øj/kg k X (θ -18.9)

$\frac{24.5}{420} = \theta - 18.9$

$\theta = 18.9583^{0}c$ or k

3. Lycopodium powder is lightly sprinkled on a clean water surface in a large tray. A red hot needle is plunged at the centre of the water surface. State and explain the observation

The powder around the hot needle moves away.

Reason

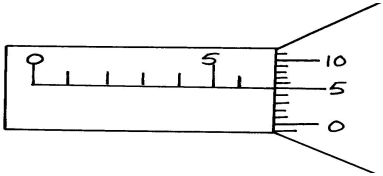
- *The high temperature of the needle lowers the surface tension of the water around it.*
- *High surface tension on the sided pits the powder away*

4. **A micrometer screw gauge has a negative zero error of 0.06mm. Show on a micrometer screw gauge, including the essential parts only a reading of 5.99mm**

-ve error is added *5.99*

0.06

6.05mm



6. (a) The data below was obtained in an experiment to estimate the diameter of an oil molecule:-

- Level of oil in burette= 26cm^3

- **Level of oil in burettes after adding 50drops of oil=25.2cm^3**
- **Diameter of oil patch= 7cm**

(i) **Determine the volume of one drop of oil**

Volume of one drop = $\frac{26.00 - 25.2}{50}$

= $\frac{0.8}{50}$ = 0.016cm^3

(ii) **Calculate the thickness of a molecule**

Thickness of oil molecule = $\frac{\text{vol. of drop}}{\text{Area of drop}}$

= $\frac{0.016}{3.142 \times 3.5 \times 3.5}$= 4.15 x 10^{-4}cm

(iii) **State any two assumptions made in this experiment**

The patch is even therefore Oil drop forms a monolayer

(iv) In the experiment 14.(a) lycopodium powder is used on the water surface. What is the role of the lycopodium powder?

To show the circular patch formed by the oil drop

(b) A molecule of a liquid occupies a space about 1.5 x 10^{-9}m high and about 0.6 x 10^{-9}m in thickness and breadth. Calculate the number of molecules in a litre of the liquid

Vol. of molecule = 1.5 x 10^{-9} x 0.6 x 10^{-9} x 0.6 x 10^{-9}

= 0.54 x 10^{-27} = 5.4 x 10^{-28}m^3

1 litre = 1000cm^3

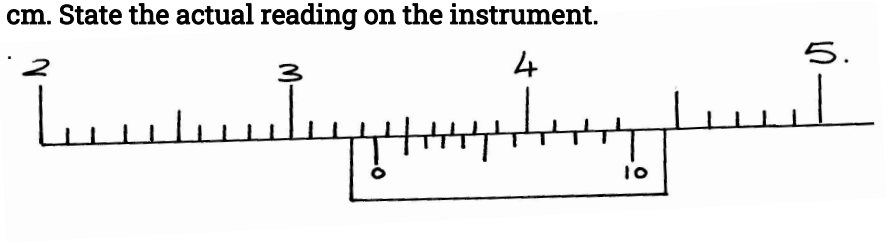
= 1.0 x 10^{-3} m^3

No. of molecules in 1litre = $\frac{1.0 \times 10^{-3}}{5.4 \times 10^{-28}}$

= 0.18515 x 10^{25}

= 1.8519 x 10^{24} molecules

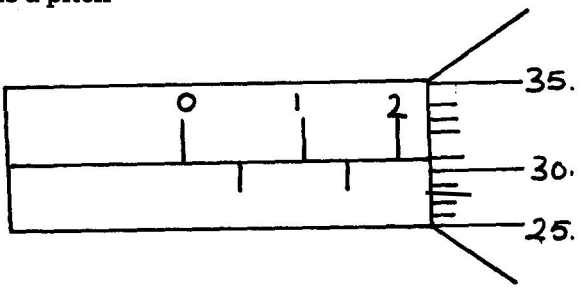
7. **The vernier calipers shown below have a zero error of -0.06 cm. State the actual reading on the instrument.**



Actual reading = 3.21 + 0.06; = 3.27cm;

8. A micrometer screw gauge with zero error of -0.01mm is used to determine the diameter of a marble whose diameter is 2.32mm.
(i) State the reading taken when the cylinder is grasped by the jaws
Reading = actual reading = zero error
= 2.32mm + -0.01
= 2.31mm

(ii) **In the space below, sketch the scale that gives the reading in (a) above if it has a pitch**



9. Figure 1 below shows an object of volume 300cm^3 placed on the pan of a beam balance. The pointer was initially at the zero mark . Determine the density of the object in Kgm^{-3}

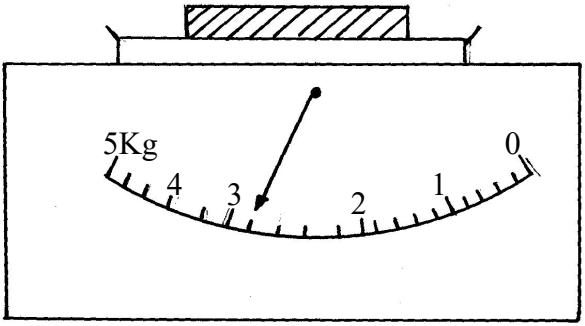


Fig. 1

Reading, mass = 2.75Kg√1

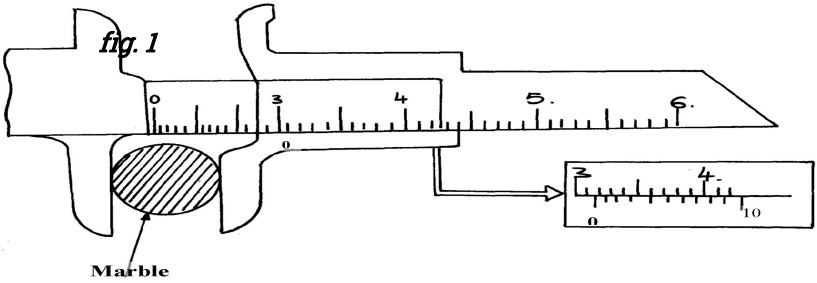
Density = mass/volume

= 2.75kg/ 3x 10^4 cm^3

= 9.167 x 10^{3}Kg/m^3√1

= 9167Kg/m^3

10. Figure 1 shows marble of mass 2.0g placed between the jaws of Vernier calipers. The magnified section is also shown. The reading of the gauge when the jaws were fully closed without the marble was 0.01cm. Use this information and the figure to answer questions 1 and 2.



What is the diameter of the marble?

Main scale reading = 3.1cm = 3.1cm

Vernier scale reading = (4x 0.01) = 0.04cm

Diameter f the marble = 3.13 x 10^{-2}m

11. **Determine the density of the marble give your answer to three significant figure (assume that the marble is spherical)**

Volume of the marble = $^4/_3\pi r^3$

= 4 x 3.14 x 1.565 x 1.565 x 1.565 x 10^{-6}

= 10.0476 x $10^{-6}m^3$

Mass of the marble = 2.0 x 10^{-3}kg

Density of the disc = $\frac{mass}{volume}$

= $\frac{2.0 \times 10^{-3}}{10.0476 \times 10^{-6}}$

= 0.1246 x 10^3

= 12.46 x 10^2Kg/m^3

13. **When a drop of olive oil of radius 1.36mm is placed on the surface of water, it spreads out to form a circular film of diameter 40cm. Calculate;**

(a) The volume of the olive oil drop in m^3 (Take $\pi = ^{22}/_7$)

Volume of drop = $^4/3\ r^3$

$V = ^4/_3 X\ ^{22}/_7 X\ (^{1.36}/_{1000})^3$

= 1.054 X 10^8m^3

(b) Using the value of (a) above, estimate the thickness of the film.

$^4/_3r^3 = R^2t\sqrt{1}$

$t = ^4/_3 X\ \frac{(1.36 X 10^{-3})^3}{(4.0 X 10^{-1})^2}$

$t = ^4/_3 X\ \frac{1.36^3 X 10^{-9}}{4.0^2 X 10^{-2}}$

= 0.2096 X 10^{-7}

= 2.096 X $10^{-8}m$

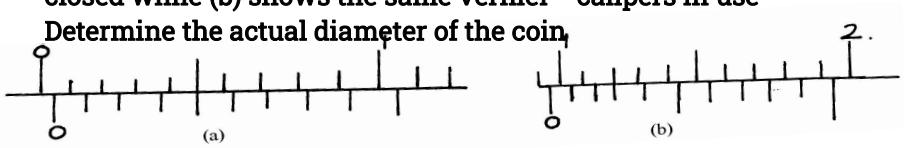
(c) **Explain why lycopodium powder is sprinkled on the surface of water before the oil is dropped on it.**

Lycopodium powder makes the film outline clearly visible

(d) **State two assumptions made when finding the thickness of the film formed.**

- *The film/ patch is a perfect circle*
- *The film is a monolayer*
- *There is no space between the molecule*

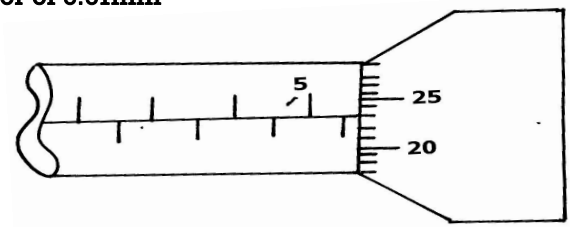
14. **Figure (a) Shows vernier calipers with the jaws completely closed while (b) shows the same vernier calipers in use Determine the actual diameter of the coin**



Zero error + 0.04

Reading diameter = 0.93 – 0.04

15. **Give the reading on the micrometer screw gauge if it has a positive zero error of 0.01mm**



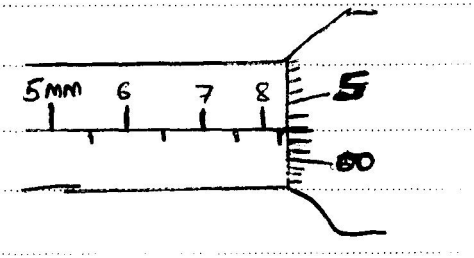
Main scale = 5.5mm

Head scale coincidence = $\frac{23mm}{100}$

Reading = 5.50
- 0.23
5.73mm

Actual reading = 5.73mm – 0.01mm = 5.72mm

16. **Draw a sketch of a micrometer screw gauge showing a reading of 8.53mm.**



CHAPTER THREE

DENSITY

1. **(a) Distinguish between density and relative density of a substance**

Density is the mass per unit volume of a substance, while relative density is the number of times a substance is denser than water- 2mks of each is defined properly

(b) state the law of floatation

When a body floats in a liquid, the weight of the liquid displaced by its immersed part is equal to the total weight of the body.

(c) a solid object of volume 25cm^3 has a density of 0.8g/cm3. determine the weight of water displaced if the object is floating freely(take g=10N/Kg)

(c) A ship of mass 1300 tonnes floats on sea water:

(i) What volume of sea water is displaced (Density of sea water is 1025kg/m^3)

Mass of the ship = mass of water displaced

Mass of water displaced = 1300000kg

$$\text{Volume of water displaced} = \frac{\text{mass}}{\text{Density}}$$

$$= \frac{1{,}300{,}000\text{kg}}{1025\text{kg/m}^3}$$

$$= 1268.3\text{m}^3$$

(ii) **Suppose it sails from sea water to fresh water, what cargo must be removed so that the same volume of water is displaced? (Density of fresh water = 1000kg/m^3**

Weight of ship − weight of cargo = upthrust in fresh water

13,000,000kg − W = weight of water displaced in fresh water

*13000000 − W = (1268.3 x1000) x10*TEZ**

W = 13,000,000 − 12, 683,000

W = 31,7000N

Cargo removed = 317tonnes

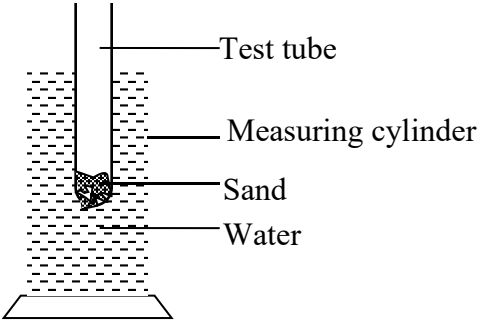
(c) Describe an experiment to verify the law of floatation

Apparatus

- Measuring cylinder, water, test tube, sand and a weighing balance

Procedure

1. *A measuring cylinder is half-filled with water and the level recorded*
2. *Then a clean dry test tube is placed into the cylinder and some sand is added to it so that it floats upright. The new level of water is recorded.*
3. *the volume of water displaced is then noted, the test tube is then removed from the cylinder, it is dried and its weight determined*
4. *The experiment is repeated four times, adding a little more sand each time*



Observation ½mk for correct observation

The test-tube sinks deeper with each addition of sand. Weight of test-tube with its contents is equal to weight of water displaced.

Conclusion – ½mk for correct conclusion

A floating object displaces its own weight of the fluid in which it floats. This is the fluid in which it floats. This is the law of floatation

2. Define

(a) Density

Density is the substance's mass per unit of volume. It is essentially a measurement of how tightly matter is packed together

(b) Relative density

Relative density is defined as the ration of density of substance to the density of water Or the ration of mass of a substance to the mass of equal volume of water.

(c) List three equivalent expressions of determining the relative density of a substance

Relative density of the substance= weight of sample of the substance/ weight of the sample in water.

3. In an experiment using density bottle , the following were obtained.

mass of the bottle =30g

Mass of the bottle and water =58g

Mass of bottle and liquid x = 62g

Calculate the relative density of liquid X

4. **A bathroom shower has 200 holes each 2.5mm^2 in area. Water flows from a pipe of cross-section area of 15cm^2 at 5m/s to the shower. Determine the speed of the spray.**

$A_1V_1 = A_2V_2$

$200 \times 2.5 \times 10^{-6} \times V = 15 \times 10^{-4} \times 5$

$V = \frac{15 \times 10^{-4} \times 5}{200 \times 2.5 \times 10^{-6}}$

$= \frac{75 \times 10^{-4}}{500 \times 10^{-6}} = \frac{7500}{500}$

$= 15m/s$

4. A piece of metal N of mass 2kg weighs 18N in water and 12N in liquid M. Determine the density of ;

(i) The metal N

Relation density $= \frac{\text{weight in air}}{\text{Up thrust in water}}$

$= \frac{20}{} = \frac{20}{} = 10$

20−18 2

Density = 10 x 1000

= 1000kgm^{-3}

(ii) The liquid **M**

R.d = upthrust in liquid

Upthrust in water

= 20 − 16 = 4 = 2

20 − 18 2

Density = 2 x 1000

= 2000kg,$^{-3}$

5. **A measuring cylinder contains 50cm^3 of light oil at 0°C. When a lump of dried ice is placed in the oil, the total volume is 72cm^3. Determine the density of the ice**

Volume of ice = 72-50= 22cm^3

Volume of water = 70-50=20cm^3

Mass of water = mass of ice = volume x density

= 20cm^3 x 1gcm^{-3}

= 20g

Density of ice = m = 20 ; = 0.909

V 22

= 0.91cm^{-3}

6. a. State Archimedes principle

Archimedes' principle states that: "The upward buoyant force that is exerted on a body immersed in a fluid, whether partially or fully submerged, is equal to the weight of the fluid that the body displaces and acts in the upward direction at the center of mass of the displaced fluid".

b. Explain why an object immersed in water weighs less than in air

When objects are placed in water they feel lighter because of buoyancy. Buoyancy is the upward force all liquids and gases exert

on any object immersed in them in the presence of gravity. Archimedes' principle says that the force pushing an object under the water, is equal to the mass of the water the object is pushing out of the way. So objects will seem lighter because the water is actually pushing the object up.

6. **A body of mass 3kgs weighs 22N in kerosene and 20N in water Determine**

(a) The relative density of kerosene

(b) The density of kerosene

7. A box of 6cm square base contain s water to a height of 7cm. When a stone of mass 200g is completely immersed in water ,the water level rises to a height of 9cm . Determine

(a) volume of the stones

(b) The density of the stone

8. Figure I below shows a cylindrical tube of diameter 14cm filled with led shots floating vertically in water

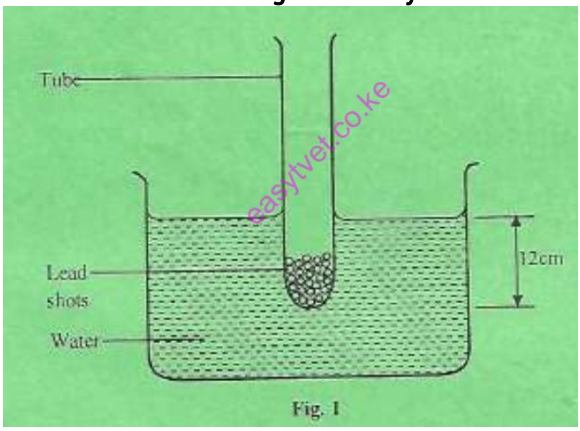


Fig. 1

a. Determine the volume of water displaced

b. Weight of water displaced

9. A trainee recorded the following the following readings in an experiment on determination of the density of liquid
Mass of density bottle full of water = 45g
Mass of density bottle full of liquid =360g
Mass of empty density bottle =20g

a. Outline the expected procedure in this determination
b. Calculate the density of liquid in kg/m^3(density of water =$1g/cm^3$)
Ensure the maintenance of group safety equipment such as spill control kits, first aid kits, and eyewash facilities. waste is being collected and tagged properly. a n d o t h e r s a f e t y requirements and setting a good example for their peers.
10. Explain why lead -brick weighs less in the moon than on earth but the density of the lead is the same on both places
Gravity on the moon is weaker (about 6 times weaker) than on the earth because the moon is smaller, the value of g on the moon is different than on the earth... This reduction in weight is due to a change in the gravitational force of the earth and not due to any other effect.

CHAPTER FOUR

PRESSURE

1. a. Define the term atmospheric pressure

atmospheric pressure is the force exerted at any given point on the Earth's surface by the weight of the air above that point. In short: the air that surrounds the Earth creates atmospheric pressure and this pressure is determined by the collective weight of air molecules. Air molecules at higher altitudes have fewer molecules pressing down on them from above and therefore experience lower pressure, while lower molecules have more force or pressure exerted on them by molecules piled on top of them and are more tightly packed together. When you go up into the mountains or fly high in an airplane, the air is thinner and the pressure is lower. The air pressure at sea level at a temperature of 59°F (15°C) is equal to one atmosphere (Atm), and this is the baseline reading for determining relative pressure.

c. Name three units that are used to measure pressure

torr, barr, atm, at, ba, psi, and manometric units like mm Hg .

2. **State the possible reason why, if water is used as a barometer liquid, the glass tube required to hold the column of the liquid is longer** *Because of its low density*

2. **Define atmospheric pressure**

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

3. The air pressure at the foot and the top of the mountain is 760 and 650mm of mercury respectively .Determine its height in Km

4. **What is the density of alcohol?**

$h_w \rho_w g = h_w \rho_w g$

$\therefore h_w \rho_w = h_a \rho_a$

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

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

5. A person's lung pressure as recorded by a mercury manometer is 90 mm Hg. Express this pressure in SI units.

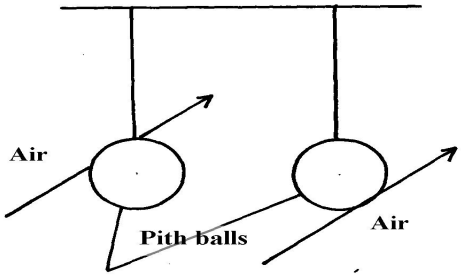
P = hρg

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

$= 12\ 240 NM^{-2}$

6. **A woman 840N stands upright on the floor , the contact area for her shoes and foot is 420cm2. determine the pressure exerted on the floor in pascals**

5. **The figure below shows to light pith balls arranged as shown.**



Pith balls

7. **State what is observed when air is blown on the outer sides of the pith balls.**

The balls move apart since the pressure on the sides is reduced by the fast moving air. High pressure between the balls pushes them outwards.

6.**The barometric height at sea level is 76cm of mercury while at a point on a highland it is 74cm of mercury. What is the altitude of the point? (Take g = 10m/s^2, density of mercury = 13600kg/m^3 and density of air as 1.25kg/m^3)**

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

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

$= 217.6\ m$

8. a) Define specific latent heat of fusion of a substance

This is the heat energy required by a unit mass of a solid to change to liquid state at constant temperature.

9. Figure 4 below shows a measuring cylinder of height 30cm filled to a height of 20cm with water and the rest occupied by kerosene

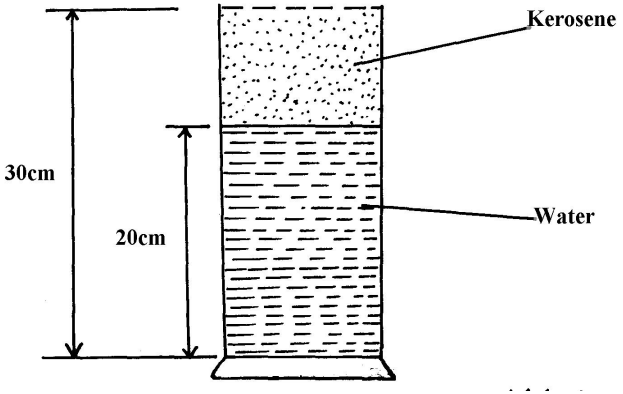


Fig. 4

Given that density of water = 1000Kgm^{-3}, density of kerosene = 800Kgm^{-3} and atmospheric pressure = 1.03x10^{5} pascals, determine the pressure acting on the base of the container

Pressure due to kerosene = K hkg

= 800 x 0.1 x 10 = 800p.a

Pressure due to water = w hwg

= 1000 x 0.2 x 10 = 2000p.a

Atmospheric pressure = 103,000p.a

Total pressure = 800 + 2000 + 103000

= 105800 p.a

10. State Pascal's principle of transmission of pressure

States that Pressure applied at one part in a liquid is transmitted equally to all other parts of the enclosed liquid.

11. **A helical spring extends by 1 cm when a force of 1.5N is applied to it. Find the elastic potential energy stored in it.**

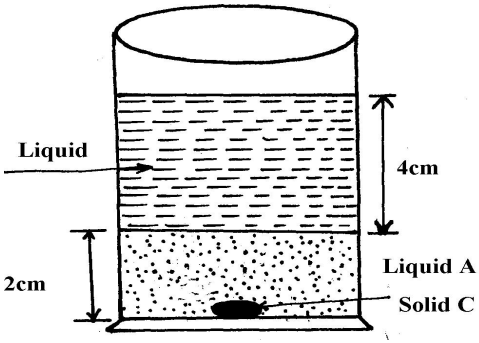
Elastic PE = ½ Fe

= ½ x 1.5 x 0.01;

= 7.5 x 10-3 J;

12. **Two immiscible liquids are poured in a container to the levels shown in the diagram below.**

Figure 5



If the densities of the liquids A and B are 1g/cm^3 and 0.8g/cm^3 respectively, find the pressure acting upon solid C at the bottom of the container due to the liquids

Pressure on = Lfg;

Solid at c = (0.02 x 1000 x 10) + (0.04 x 800 x 10);

= 200 + 320

= 520N/m^2 ;

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

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

16. (a) State two ways of increasing pressure in solids

Increasing the force (weight)

(b) **The figure 1 shows a liquid in a pailSuggest a reason why pail manufacturers prefer the shape shown to other shapes**

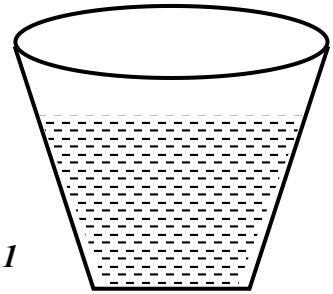


fig. 1

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

17. ***Figure 8*** **shows a funnel inverted over a light ball.Explain the observation that would be made when streamlines of air is blown strongly down the narrow section of the funnel**

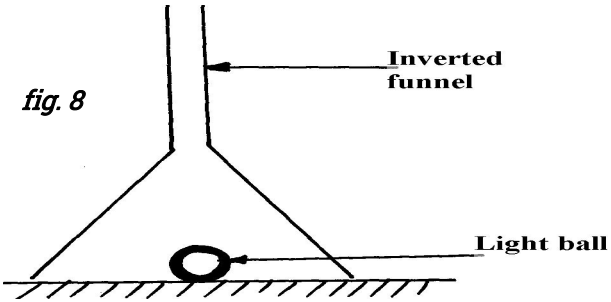


fig. 8

In the narrow section of the funnel, air moves with high velocity hence followed by 10N pressure and when they emerge into the wider section, they spread, hence more min-low velocity resulting to high pressure. The high pressure below the ball lifts the ball up to the neck of the funnel.

17. **A block measuring 20cm x 10cm by 5cm rests on a flat surface. The block has a weight of 3N. Determine the maximum pressure it exerts on the surface.**

Max pressure = Force/ Min Area

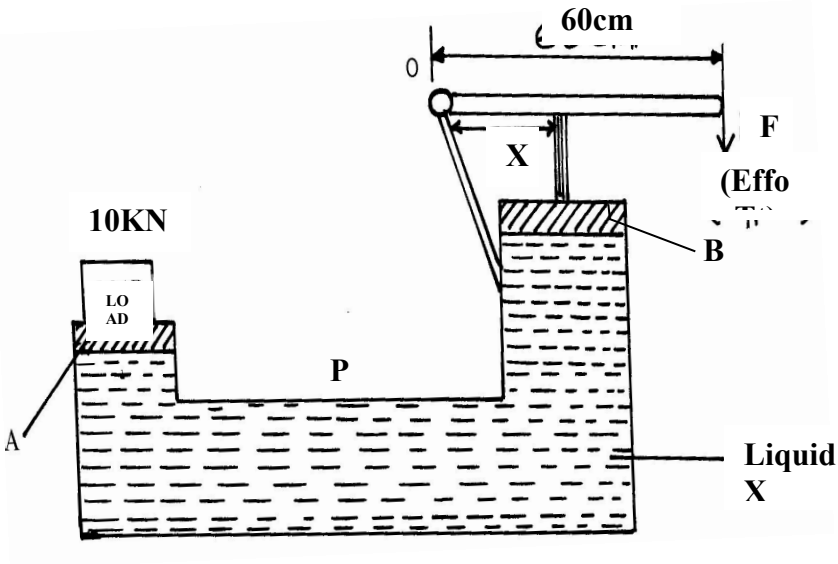
= 3N / 0.1 X 0.05

= 600N/m^2

19. **a.State the principle of transmission of pressure in liquids**

c. **A block of copper of density 8.9g/cm3 measures 5cm by 3cm by 2cm. Determine the minimum pressure it exerts on the horizontal surface**

20. **The figure below shows a hydraulic press P which is used to raise a load of 10KN. A force F of 25N is applied at the end of a lever pivoted at O to raise the load**



(a) State one property of liquid X

– Incompressible

– Not corrosive

– Has low freezing point and high boiling point

19. **A mercury –in-glass barometer shows a height of 70cm. What height would be shown in the barometer at the same place if water density 1.0 x 10^3kg/m^3 is used. (Density of mercury = 13600kgm^{-3})**

$h_1p_1g = h_2p_2g$

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

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

$= 9.52m$

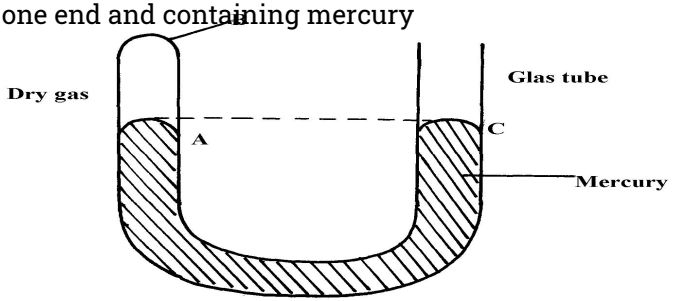
20. **The total weight of a car with passengers is 25,000N. The area of contact of each of the four tyres with the ground is 0.025m^2. Determine the minimum car tyre pressure**

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

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

$= 250,000Pa$

21. (a) The diagram below represents a u-shaped glass tube sealed at one end and containing mercury



(i) What is the pressure of the gas as shown in the diagram above?

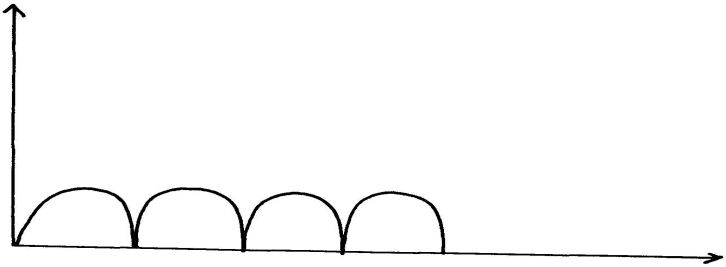
i) Atmospheric pressure 1.05 x 10^5N/M^2

(ii) Explain why the gas should be dry if it is to be used to verify a gas law

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

(iii) Describe how the arrangement can be used to verify Boyle's law.

Fix a millimeter scale to read the length (L) of air column B and the difference in height (h) between the levels A and C
- Adjust the level of C by adding more mercury a little at a time and record the corresponding values of L and h each time
A graph of L against h represents Boyle's law



(b) Use the kinetic theory of gases to explain why;

(i) the pressure of a gas increases with temperature increase

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

(ii) The pressure of a gas decreases as volume increases

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

CHAPTER FIVE

QUALITY OF HEAT

1. **(a) Define the term specific heat capacity.**

Specific heat capacity is defined as the quantity of heat required to raise the temperature of a unit mass of a substance by one Kelvin.

(b) A block of metal of mass 300g at 100^0c is dropped into a logged calorimeter of heat capacity 40Jk^{-1}, containing 200g of water at 20^0c. The temperature of the resulting mixture is 34^0c.

(Specific heat capacity of water = 4200$Jkg^{-1}k^{-1}$)

Determine:

(i) **Heat gained by calorimeter.**

heat gained by calorimeter

$Q_E = C\Delta\theta$

$= 400Jk^{-1} \times (34 - 20)k \quad = 560j$

(ii) Heat gained by water.

Heat gained by water

$Q_W = MC\Delta\theta$

$= 200\ kg \times 4200kg^{-1}k^{-1} \times (34 - 20)k$

$= 11760j$

(iii) **Heat lost by the metal block.**

Heat lost by the metal = heat gained by the calorimeter + heat gained by Water.

$= 560j + 11760j \quad = 12320j$

(iv) Specific heat capacity of the metal block.

Specific heat capacity of the metal.

$C = \frac{Q}{M\Delta\theta}$

$= \frac{12320\ j}{0.3\ kg \times (100 - 34)}$

$= \frac{12320j}{0.3kg \times 66\ k}$

$= 622.22\ jkg^{-1}k^{-1}$

2. **(a) State two differences between boiling and evaporation.**

Boiling	*Evaporation*
- *Takes place at constant temperature* - *Not affected by surface area of liquid exposure* - *Vigorous, visible process all over the liquid*	- *Takes place at all temperatures* - *Increases with increase in surface area* - *Slow invisible process at the liquid surface*
	-

(b) 200g of a solid was uniformly heated by a 0.2 kw heater for sometime. The graph in the figure below shows how the temperature of the solid changed with time.

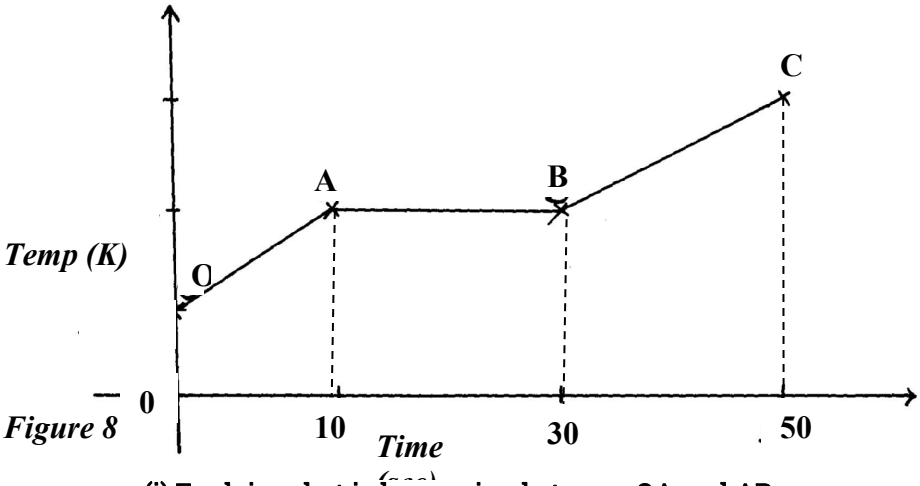


Figure 8

(i) Explain what is happening between OA and AB.

A – Temperature of the solid in increasing;

AB- solid is melting;

(ii) Calculate the specific heat capacity of the solid.

Heat supplied = Heat gained

$p \times t = MC\Delta\theta$

$200 \times 100 = 0.2 \times C \times 100$

$20 \times 100 = 0.2 \times C \times (350 - 250)$

$C = 1000 JKg^{-1} K^{-1};$

(iii) Calculate the specific latent heat of fusion k of the solid.

Heat applied = heat gained; OR

$p \times t = Mlf;$

$200 \times 200 = 0.2 \times lf;$

$lf = 200{,}000 J/Kg;$

3. **(a) Define the term heat capacity**

The quantity of heat required to raise the temperature of a given mass of a material by one Kelvin.

(b) A block of metal of mass 150g at 100°C is dropped into a logged calorimeter of heat capacity $40Jk^{-1}$ containing 100g of water at 25°C. The temperature of the resulting mixture is 34°C.

(Specific heat capacity of water = 4200J/KgK)

Determine;-

(i) Heat gained by calorimeter

$$C = \frac{Q}{\theta}$$

$Q = C\theta$

$= 40 \times (34-25)$

$= 40 \times 9 = 360J$

(ii) Heat gained by water

$M_w C_w D = (0.1 \times 9 \times 4200) = 3780J$

(iii) Heat lost by the metal block

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

$= 3780 + 360 = 4140J$ *or* $4.14KJ$

(iv) Specific heat capacity of the metal block

$\frac{150}{1000} \times C_m \times \Delta\theta = 4140$

$0.15 \times (100 - 34)\, C_m = 4140$

$9.9C = 4140$

$Cm = \frac{4140}{9.9} =$

$= 48.18 JKg^{-1}K^{-1}$

4. (a) state three factors that affect transfer of heat by conduction

- ✓ **the temperature gradient,**
- ✓ **the cross section of the materials involved,**
- ✓ **their path length,**
- ✓ **and the properties of those materials.**

(c) State and explain three principle modes of heat transfer

- ✓ *Conduction is the transfer of energy from one molecule to another by direct contact. ...*
- ✓ *Convection is the movement of heat by a fluid such as water or air. ...*
- ✓ *Radiation is the transfer of heat by electromagnetic waves.*

(c) List three applications of heat transfer

- ✓ *automotive engineering,*
- ✓ *thermal management of electronic devices and systems,*
- ✓ *climate control,*
- ✓ *insulation,*
- ✓ *materials processing,*
- ✓ *chemical engineering*
- ✓ *power station engineering.*

(d) State and explain two differences between clinical and ordinary liquid-in - liquid thermometer .

The clinical thermometer is used to measure the body's temp. but an ordinary thermometer is used to measure any object's temperature. The clinical thermometer range is from 35° to 42° Celsius whereas the ordinary laboratory thermometer range is from -10° to 110° Celsius. Clinical thermometer has a kink(constriction) whereas the laboratory thermometer doesn't have kink. Since clinical thermometer has a kink the temperature does not fall on its own after removing from the

persons mouth. This helps in taking reading after removing from the person. To lower the mercury level again, a small jerk is needed. Since ordinary thermometer does not have a kink, the temperature changes immediately. So reading has to be taken while the thermometer is in contact with object

(e) Give two reasons why mercury is preferred over alcohol for use in thermometers

mercury has greater boiling point than alcohol.The boiling point of mercury is

356.7◦ C and that of alcohol is approximately 80◦ C. Due to its low boiling point alcohol cannot be used to measure high temperatures. It is mostly used in cold climate.

(f) Give four reasons why water is not a suitable thermometric liquid

Water cannot be used in thermometer because of its higher freezing point and lower boiling point than other liquids . If water is used in a thermometer , it will start phase change at $0^{o}C$ and $100^{o}C$ and will not measure temperature , out of this range .

5. Dry steam is passed into a well lagged copper can of mass 250g containing 400g of water and 50g of ice at 0°c . the mixture is well stirred and the steam supply is cut off when the temperature of the can and its content reaches 20°c.

(i) Determine the mass of the steam

(ii) State one assumption on the calculation

Take : specific heat capacity of water =4200j/gk

Specific heat capacity of Copper =0.4 j/gk

Specific latent heat of steam and ice as 2260j/g and 336j/g

6. Define the following terms

(a) Specific latent heat of fusion

(b) Specific latent heat of vaporization

7. A 3.0KW kettle containing 1.5kg of water at 100°c is left switched on .Calculate the time it will take to boil of all the water. (Take specific latent heat of vaporization of water =2.26 x $10^{6}jkg^{-1}$)

8. A metal block of mass 600gm is heated to 120°c then immersed into 3kg of water . the final temperature is found to be 60°c .

Determine the initial temperature of water .(specific heat capacity of water =4200j/kg k. specific heat capacity of metal= 840j/kgk)

4. (a) A jet delivering 0.44g of dry steam per second, at 100°C is directed on to crushed ice at 0.0°C contained in an unlagged copper can which has a hole in the base. 4.44g of water at 0.0°C flow out of the hole per second

(i) How many joules of heat are given out per second by condensing steam and cooling to 0.0°C of water formed?(Latent heat of vaporization of steam = $2.26 \times 10^6 JKg^{-1}$, c for water = $4200JKg^{-1}K^{-1}$)

Heat $= ml_v + MC\Delta\theta$

$= 0.44 \times \frac{2.26}{1000} \times 10^6 + 0.44 \times \frac{4200}{1000} \times 100;$

$=994.4 + 184.8 = 1179.2J;$

(ii) How much heat is taken in per second by the ice which melts?

$Q = \frac{mLf}{t} \quad t;$

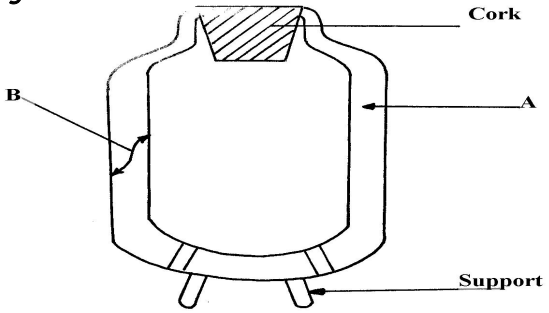
$= 4.4 \times 10^{-3} \times 3.34 \times 10^5$

$= 1336J;$

(iii) Suggest why these amounts above are different

- Heat is absorbed from the surrounding since the can is unlagged

(c) *Figure 7* below shows a cross-section of a vacuum flask



(i) Name the parts labelled A and B on the diagram

A = Vacuum;

B = Silvered (shiny) surfaces/polished/smooth;

(ii) Explain how the heat losses are minimized when hot liquid is poured into the flask

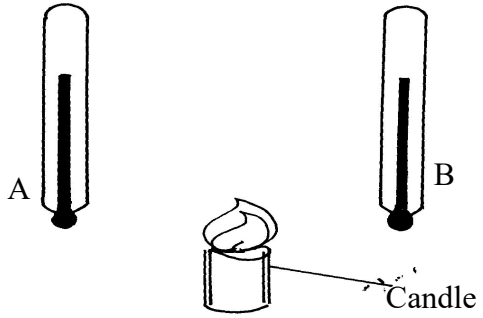
- Loss of heat by conduction is reduced by cork and vacuum;

- Loss of convection is reduced by vacuum;

- Loss by radiation is reduced by silvered wall;

9. (a) Figure 2 shows two identical thermometers. Thermometer A has a blackened bulb while thermometer B has a silvery bulb. A candle is placed equidistant between the two thermometers

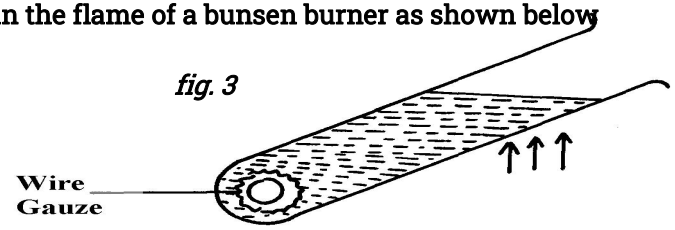
Fig. 2



State with a reason the observations made after some time
Thermometer A gives a higher reading than B;
Black surface is better absorber of heat than silvery surface√1

5. **(b)** ***Figure 3*** **shows a test tube partially filled with water. An ice wrapped in wire gauze is placed at the bottom of the test-tube. It is then held in the flame of a bunsen burner as shown below**

fig. 3



State and explain what will be observed after some time
Water at the top part of the boiling tube boils while the ice remains unmelted. This is because water is a poor conductor of heat and hot air less dense remain at the top.

7. ***Explain why a burn from steam is more severe that of boiling water at the same temperature***

10. **Explain why steel feels colder than wood at the same temperature**
Steel is a good conductor of heat; therefore draws heat from your body unlike wood which is a poor conductor of heat

8. **An electric heater 1KW 240V is used to raise the temperature of a 5kg copper block from 15°C to 33°C. If the specific heat capacity of copper is 400JKg^{-1}K^{-1} and assuming no heat is lost to the surrounding, Calculate the time taken**

Pt = MCDT *DT = 35 – 15 = 18K*

T = MCDT

$= \frac{5kg \times 400JKg^{-1}K^{-1} \, 18K}{1000JS^{-1}}$

= 36s

9. **(a) Define specific latent heat of fusion**

It is the quantity of heat required to convert a unit mass of the substance from the solid to the liquid state without change of temperature

(b) 0.5kg of naphthalene contained in an aluminium can of mass 0.4kg is melted in a water bath and raised to a temperature of 100°C . Calculate the total heat given out when the can and its contents are allowed to cool to room temperature, 20°C . Neglect losses by evaporation during heating process and give your answer to the nearest kilojoule.

(For naphthalene melting point = 80°C , Specific heat capacity for both liquid and solid =2100J/KgK; specific latent heat of fusion = 170000J/Kg.

For aluminium: specific heat capacity = 900J/Kgk

Heat lost by naphthalene

T = 100-80=20k

H1 = 0.5kg x 2100JKg^{-1}K^{-1} x 20K = 2100J

Lf = mLf = 0.5kg x 170000JKg^{-1} = 85000J

T = 80 -20 = 60k , H_2 = 0.5kg x 2100JKg^{-1}K^{-1} x 60k = 63000J

Heat lost by aluminium

T = 100 – 20 = 80k

H = 0.4kg x 900JKg^{-1}K^{-1} x80k = 28800J

Total heat lost = 169000J + 28800J = 197800J

= 197.8KJ

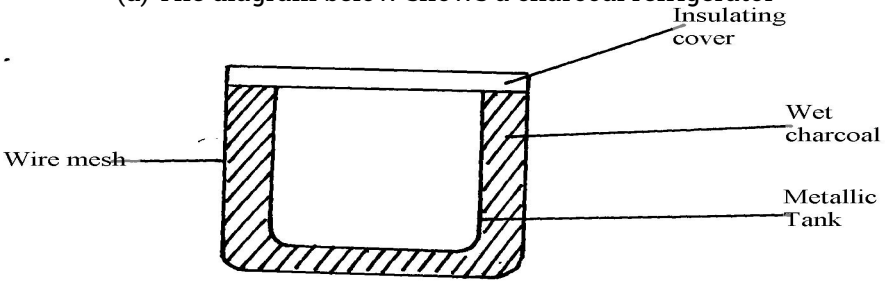
= 198KJ

(c) **Briefly explain two ways other than direct heating by which quantity of liquid may be made to evaporate more quickly**

i.Blowing wind over the surface of the liquid increases the kinetic energy of the liquid molecules

ii. It can also be made to evaporate faster by bubbling air though the liquid as it increases the surface area from which the liquid molecules may escape

(d) The diagram below shows a charcoal refrigerator



(i) Explain why charcoal is used and why it is sprinkled with water

– Charcoal is a black body and therefore a better absorber of heat

- charcoal is sprinkled with water, so that it takes latent heat from the air around the air around and evaporates , causing cooling in cabinet

(ii) What is the role of the metallic tank and the wire mesh

Heat is conducted by the by the metallic tank and the wire mesh to the surrounding air

10. An electric kettle with a shinny outer surface would be more efficient than one with a dull outer surface. Give a reason for this

Loss of heat through radiation is reduced/ minimized

11. 500g of a metal is heated to 100°C and then placed in a 200g mass of water at 15°C. If the final temperature rises to 21°C, calculate the specific heat capacity of the metal.

(Specific heat capacity of water = $4200J^{-1}kg^{-1}$

Heat lost by the metal = Heat gained by the water

MmCm= MWCW

$\frac{500}{1000} \times CM(100-21)^{o}C = \frac{200}{1000} \times 4200 \times (21-15)^{o}C$

$0.5x\ CM(100-21)^{o}C = 0.2 \times 4200x\ (21-15)^{o}C$

$Cm = \frac{5040}{39.5} = 127.59JKg^{-1}K^{-1}$

12.Figure 1 shows a beam balance made out of concrete and reinforced with steel

Use a diagram to explain the behaviour of the shape of the beam when heated up

- *The beam expands linearly*
- *The beam remains straight but longer than before heating*
- ***Both concrete and steel have same rates of expansion***

13,. (a) Sate **two** liquids which are used in thermometer.

– *Alcohol.*
- *Mercury.*

(b) With a reason, state which of the two liquids in 3 (a) above is used to measure temperature in areas where temperatures are:

. (i) below -40^{0}c

alcohol because it has a low freezing point of –115^{o}c. (Mercury freezes at -39^{o}c.)

(ii) 150^{0}c

mercury because it has a high boiling point of 357^o, (alcohol boils at 78^{o}c.)

14. What do you understand by the statement 'lower fixed point' on a temperature scale?

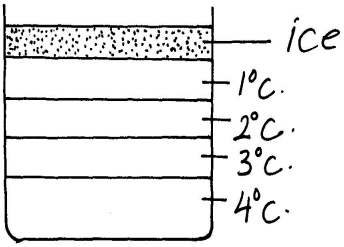
This is the temperature of pure melting ice at standard/normal atmospheric pressure;

15. **Name two adaptations that can be made to a mercury thermometer to make it more sensitive**

- *Using a thin walled bulb*
- *Using a narrower capillary tube*

15. Aquatic animals and plants are observed to survive in frozen ponds. Explain this observation

Water freezes and the ice formed floats in water because its density is less than that of water, insulating water below it. Temperatures increases down the pond because of anomalous expansion of water



CHAPTER SIX

FORCE

1. a.State the difference between elastic and inelastic collision

Elastic collisions occur when two objects collide and kinetic energy isn't lost. The objects rebound from each other and kinetic energy and momentum are conserved. Inelastic collisions are said to occur when the two objects remain together after the collision so we are dealing with an elastic collision.

b.Differentiate between upthrust and gravitational force

gravity is the force that keeps you on the ground. Upthrust is the force that is pushing you up - to stop you from sinking right into the Earth.

C. Define center of gravity of an object.

centre of gravity, in physics, an imaginary point in a body of matter where, for convenience in certain calculations, the total weight of the body may be thought to be concentrated.

2. Explain why

(a) Water wets the glass surface

Because of adhesive forces which are stronger than cohesive forces. Therefore, the water molecule wets the glass.

(b) Mercury forms spherical drops

Mercury has force of adhesion less than the force of cohesion and hence prefers to stick to itself rather than the glass surface. To achieve this, mercury takes the spherical shape to minimize its contact with the glass surface.

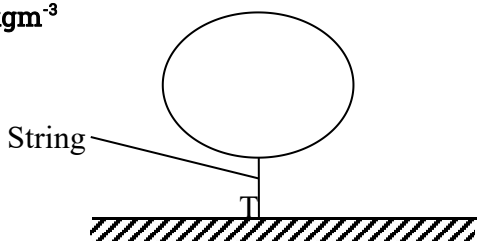
(c) Explain why some liquids spread over a solid surface while others do not

This is because of The difference in strength between cohesive forces and adhesive forces between the molecules and the solid surface in which they are in contact with determine the behavior of a liquid in contact with a solid surface.

(d) Explain why heating of liquids decreases their surface tension

This is because surface tension occurs due to cohesive force of attraction between liquid molecules at the surface. When temperature increases, molecules start moving faster, resulting in decrease in force of attraction and thus, the surface tension also decreases.

2.. **The figure below shows a balloon carrying hydrogen gas $3m^3$ of density $0.09kgm^{-3.}$ The mass of the balloon fabric is 2kg and the density of air is $1.25kgm^{-3}$**



i) **Determine the tension in the string**

The mass of the balloon fabric is 2kg and the density of air is $1.25kgm^{-3}$

mass of gas = 3X 0.9 kg kj = 0.27kg

Total weight of balloon

10 X (2+ 027) = 22.7

Mass of air displaced.

1.25 X 3 = 3.75

Wt of air displaced

1.25 X 3 = 3.75N

Tension = U − W

= 37.5N − 22.7 N= 14 .8N

ii) If the string is suddenly cut, calculate the acceleration of the balloon upwards

F = M

14.8 = m *where m = 2.27 kg*

14.8 = 2.27

2.27 m/s^2

iii) What is the maximum mass of the equipment the balloon can lift at a constant velocity

maximum mass that the balloon can carry

$\frac{14.8.N}{10N/kg} = 1.48kg$

b) State and explain **two** features of a hydrometer that make it **sensitive** in its function

- *The stem is thin. This makes the hydrometer sensitive such that a small change in density of liquid causes a large change on the stem.*
- *The bulb is large to make it float.*

The bulb is heavy to make it float a upright.

3. a) Define the term surface tension

b) Explain how impurities affect surface tension

4. Define each of the following terms as used in materials

(a) Strength

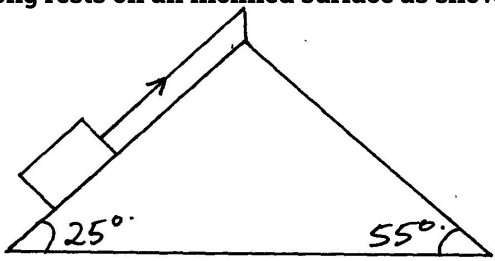
(b) Stiffness

(c) Ductility

(d) Brittleness

(e) ellasticity

2. A block of mass 5kg rests on an inclined surface as shown in the diagram below:



Determine the static friction on the block

Static friction = mg sinθ

= 5x 10sin25°

= 5 x 10 x 0.4226= 21.13

3.State two factors that would raise the boiling point of a liquid

- *Increase in pressure*

- *Addition of impurities*

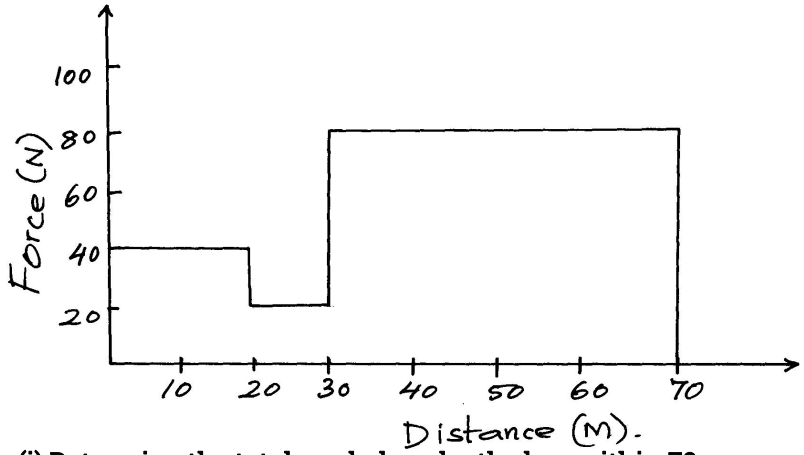
4. **Give a reason why water wets glass while mercury does not.**

In water the cohesion forces between molecules water molecules is lower than the adhesive forces between water and glass. Which in mercury the cohesion forces between mercury molecules are greater than adhesive forces between mercury and glass.

5. (a) Give an example where force is applied and no work is done

a) Pushing a wall/anything that does not more when force is applied

(b) The graph below shows the variation between force and distance for a boy pushing a concrete block of mass 25kg through a vertically height of 12m.



(i) Determine the total work done by the boy within 70m

work done = Area under the graph

= (40x20) + (20 x 10) = (80 x 40)

= 800 + 200 + 3200 = 4200J

(ii) How much energy is wasted?

work done = mgh

= 25 x 10 x 12 = 3000J

Energy wasted = (4200 – 3000)J = 1200J

(iii) Give an account for the energy wasted

Friction force between the surfaces. Some work is done against friction

6. **State the principle of moments.**

For a system in equilibrium the sum of clockwise moments about a point is equal to the sum of anticlockwise moments about the same point;

7. State any two factors that affect the earth's gravitational force

– the latitude of the location

- The altitude of the location

8 Figure 3 below shows a wire loop with a string that has been dipped into soap solution.

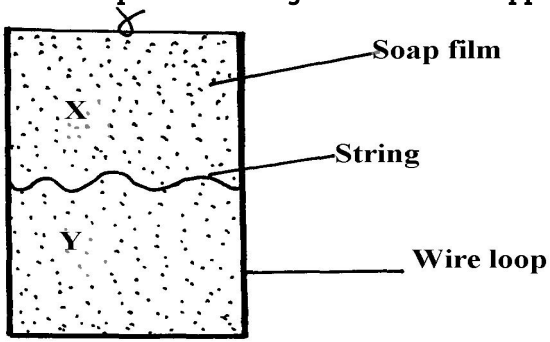
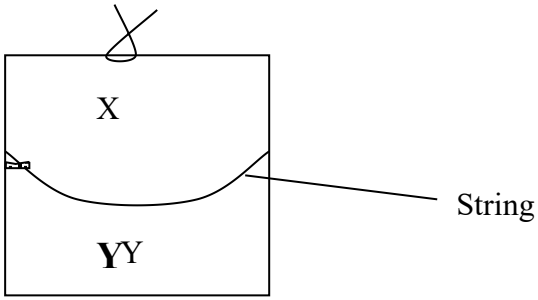


Fig. 3

i) Sketch a similar diagram to show the observed effect if the soap film is punctured at X

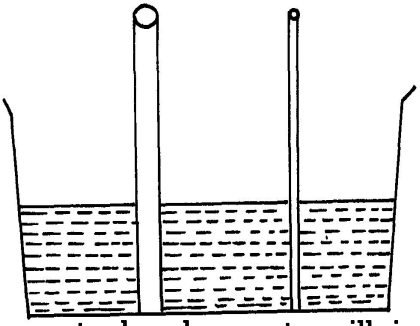


ii) Explain the observations made in (i) above

ii) When side x of the film is broken, surface tension acts only on one side Y of the film; surface tension of the film tends to make the surface area to be minimum hence it pulls the string to make a smooth curve

7. ***Figure 2*** **shows two glass tubes of different size of bore, dipped in a glass beaker half full of water**

fig. 2



Complete the diagram to show how water will rise up in the two glass tubes

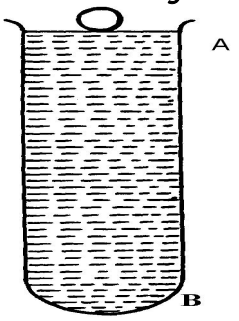
Explanation- Water rises higher in a glass tube with narrow bore than the one with larger bore because more water molecules get in contact with glass molecules because of greater adhesive force between glass molecules and water molecules, then in the one with large bore.

10. (a) State the conditions necessary for the law of conservation of linear momentum to hold

If no external force acts on the system of colliding bodies

(b) The diagram *figure 13* below shows a steel ball bearing gently dipped in a viscous liquid contained in a tall cylinder

fig. 13



(i) Name giving their directions the forces acting on the ball bearing as it moves down the cylinder

– Viscosity acting upwards- each forces

- Upthrust acting upwards and correct directions

- Weight acting downwards

(c) (i) A breakdown truck tows a car of mass 1000kg along a level road, and accelerates at 0.5m/s^2. What is the tension in the tow line

Tension = force on car

$F = ma$

$= 1000 \times 0.5 = 500N$

(ii) **If the tow line in (c)(i) above breaks when the car reaches a speed of 36km/h, how far will the car travel before coming to rest if the breaking force is 2000N?**

$$\text{Retardation} = \frac{F}{m} = \frac{2000}{1000} = 2m/s^s$$

$$n = \frac{36 \times 1000}{60 \times 60} = 10m/s$$

$V^2 = u^2 + 2as$

$O = (10)^2 + 2(-2)s$

$S = \frac{100}{4} = 25m$

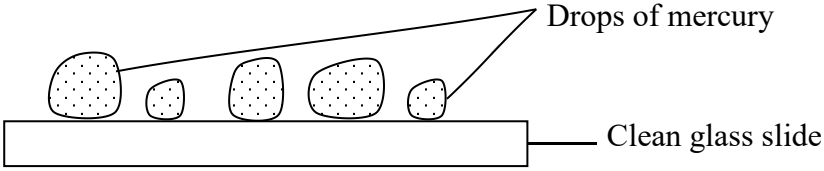
11. **Explain why it is easier to ride a bicycle round a bend on a road if the surface is dry than when it is wet**

When the surface is dry, the frictional force between the tyres and the surface is higher than when wet, hence there is less skidding

12. **Give one difference between limiting and dynamic forces of friction**

Limiting friction	*Dynamic friction*
Friction between objects just before moving	*Friction between surfaces in relative motion*

13. **Mercury on a clean glass slide collects into small spherical balls as shown in figure 2 below. Explain why**



Cohesive force between mercury molecules is stronger than the adhesive force between mercury molecules and the glass side;

14. **The *figure 7* below shows two blocks of masses M_1=1.5kg and M_2 = 2.0kg which are in contact on a frictionless table**

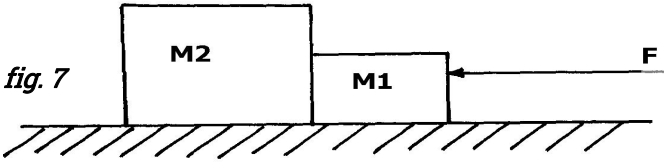


fig. 7

A force F=7N acts on the bodies, determine the force on mass M_2

$$\text{Acceleration } (a) = \frac{M_2 g}{(M_1 + M_2)}$$

$$a = \frac{(4x10)}{(2+4)}$$

$$= \frac{40}{6}$$

$$= 6.66$$

$$= 6.7 ms^{-2}$$

16. (a) State three factors that affect the stability of a body

(g) State the application of stability

HOOKE'S LAW

1. State hookes law.

Hooke's law states that "the extension of a spring is proportional to the applied force, provided that the force is not large enough to deform the spring permanently".

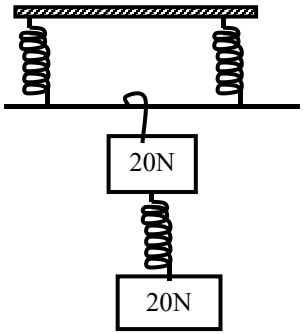
Mathematically expressed as

Force α extension

$F = -kX.$

2. The three springs shown in figure 2 are identical and have negligible weight. The extension produced on the system of springs is 20cm

fig. 2



Determine the constant of each spring

$$F_1 = Ke_1 = 40 = Ke_1$$

$$e_1 = \frac{40}{K}$$

$$F_2 = \frac{Ke_2}{K} = \frac{20}{K} = Ke_2$$

$$e_2 = \frac{20}{K}$$

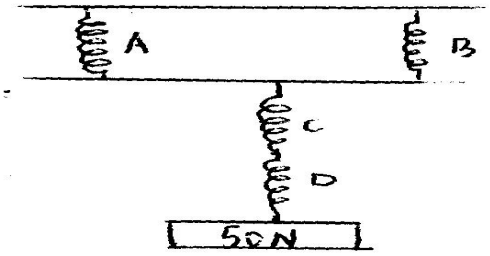
but $e_1 + e_2 = 20$

$$\frac{40}{K} + \frac{20}{K} = 20cm$$

$$60 = 20k$$

K = 3N/cm

The springs A, B, C and D are identical and each extends by 2cm, when a force of 6N is suspended on the system. Determine the extension of the system



6N purchase 2cm extension

$$50N = \frac{2X50}{6} = 16.667\ cm$$

$$Total\ extension = 16.667\ X\ 2 + \frac{16.667}{2}$$

$$= 33.33 + 8.33 = \underline{\underline{41.66\ cm}}$$

3. **The extension of a spring balance is 2.0N when 5.0 N is hanged on it . determine the force that produces extension of 25mm if elastic limit of the spring is not exceeded**

4. **The graphs in figure 8 represents the relations between extension e and mass, m added on two springs x and y**

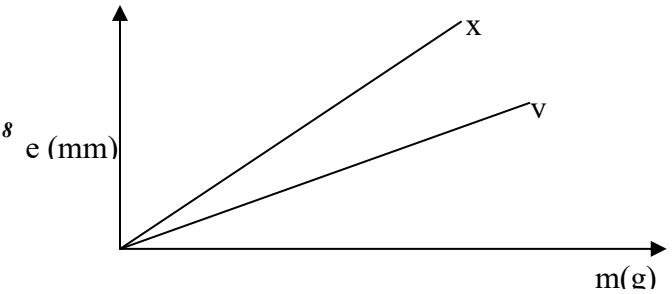


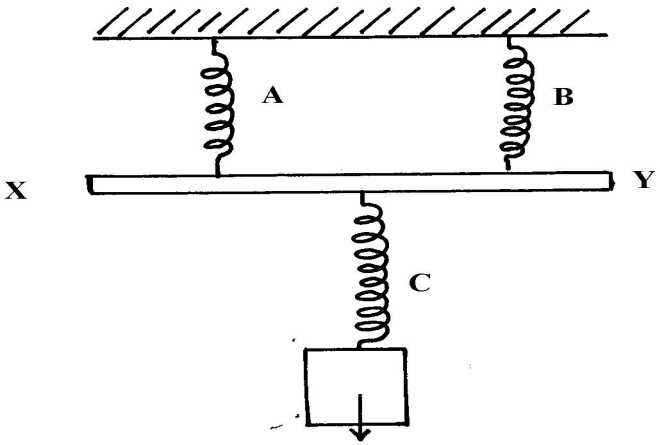
Fig. 8

Given that the two springs are made from the same material, give a reason why the graphs are different

- ✓ *Diameter of coils are different*
- ✓ *Thickness are different*
- ✓ *No. of turns per unit length are different*
- ✓ *length of spring are different are different*

5. **Three identical springs A, B and C of negligible weight are arranged as shown below;**

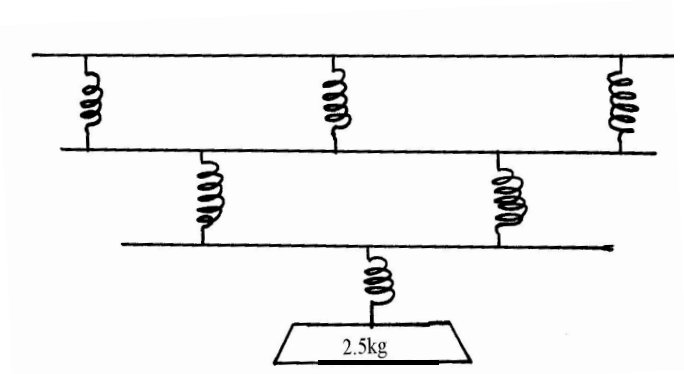
6.



If C stretches by 3cm, and bar XY is assumed to be weightless, determine the extension in A

½ X 3= 1.5cm

4. A single light spring extends by 3.6cm when supporting a load of 2.5kg. What is the total extension in the arrangement shown below. (**Assume the springs are identical)**



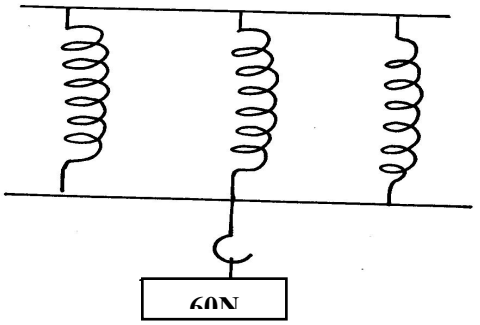
Upper springs, e = 3.6
3

Middle springs , e = 3.6 = 18cm
2

Lower springs, e = 3.6 = 3.6cm
1

Total extension = 1.2 + 1.8 + 3.6
= 6.6cm

6. Three identical springs with proportionality constant of 50N/m. each are connected as shown below and support a load of 60N



Calculate;

(a) The extesion in one spring

a) Load on each spring = 60/3 = 20N

Extension (e) in one spring = F/K

for one spring

= 20/50 = 0.4m

(b) The extensive proportionality constant of the springs

The effective constant (K)

$= K_1 + K_2 + K_3$

= 3(50)

= 150N/M

7. A mass of of 100g was hanged from a lower end of a spring , the spring extended by 100mm and its elastic limit was not exceeded . Determine the springs constant

7. When a load of 20N is hung from a spring, the spring has a length of 15 cm. The same spring has a length of 17 cm when supporting a load of 25N. Determine the spring length when supporting no load.

A load of (25 – 20)N causes extension of (17 – 15) cm.

i.e. 5N causes extension of 2 cm

20N = ?

$\frac{20\ N}{5\ N} \times 2\ cm = 8\ cm$

When no mass is hung.

Length of the spring = 15cm – 8ch

= 7 cm

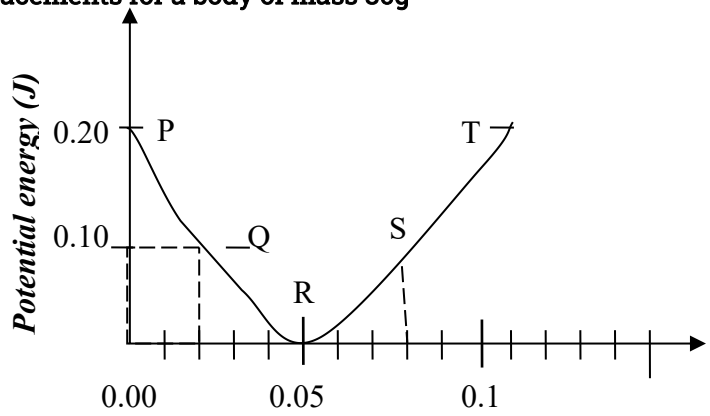
CHAPTER SEVEN

WORK, ENERGY AND POWER

1. **(a) State the law of conservation of energy**

The law of conservation of energy states that the sum of kinetic energy and potential energy of a system is a constant

(b) The graph below shows the potential energy against displacements for a body of mass 80g



The body oscillates about point R. Calculate the velocity of the body at:

(i) P and T

At P and T potential energy is a maximum and kinetic energy is a minimum. Hence velocity is zero (2mks)

(ii) Q and S

At Q and S P.E has reduced by 0.1J. This equals the K.E

$K.E = ½ MV^2$

$0.1 = ½ \times 0.8V^2$

$0.1 = 0.4V^2$

$0.1 = V^2$

$V^2 = ¼ = 0.25$

$V = 0.5m/s$

(c) A wheel and axle are used to raise a load of 280N by a force 40N applied to the rim of the wheel. If the radii of the rim and axle are 70cm and 5cm respectively, calculate:

(i) The mechanical advantage

$$M.A = \frac{L}{E} = \frac{280N}{40N} = 7$$

(ii) The velocity ratio

$$V.R = \frac{P}{R} = \frac{70}{5} = 14$$

(iii) The efficiency

$$n = \frac{M.A}{V.R} \times 100\%$$

$$= \frac{7}{14} \times 100\%$$

$$= 50\%$$

2. (a) A bicycle has wheels 66 cm in diameter. Its crank wheel has 44 teeth and the rear sprocket 16 teeth. The crank radius is 16.5 cm. (i) Determine the radius of the rear sprocket.

a) (i) $CR = \frac{2\pi R}{2\pi r} = \frac{\text{No of teeth draw}}{\text{No. of teeth of driven}}$

$\therefore \frac{16.5\ cm}{r} = \frac{44}{16}$

$r = \frac{16.5\ cm \times 16}{44}$

$R = 6\ cm$

(ii) The bicycle moves when the rear sprocket is made to move. Hence determine the velocity ratio.

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

$$= \frac{16.5\ cm}{6\ cm}$$

$$= 2.75$$

(b) A man uses a block and tackle mechanism of velocity ratio 6 to lift a car engine smoothly through a height of 1 m in 5s. The man applies a force of 300N while the mass of the engine is 120 kg. Determine:

(i) The mechanical advantage of the pulley system.

M.A. = L *120kg x 10N/kg = 1200N*

E

= 1200N

300N

= 4

(ii) its efficiency.

D = M.A x 100%

V.R.

= 4 x 100%

6

= 66.67%

3. (a) Define work and state its S.I units

(a) Work is said to be done when the body on which a force is applied moves in the direction of force; S.I unit if the Joule, J or (Nm);

(b) A crane lifts a load 500kg through a vertical distance of 4m in 8 seconds. Determine:

(i) Work done by the crane

Work done = P.E gained ;

= mgh

= 500 x 4 x 10;

= 20,000J;

(ii) Power developed by the crane

Power = work done

time taken

= 20,000

8

= 2.5KW ; or (2500 watts);

(iii) Efficiency of the crane given that it is operated by an electric motor rated 2.8Kw

Efficiency = work output x100;
work input
= 2.5 x 100;
2.8
= 89.29%;

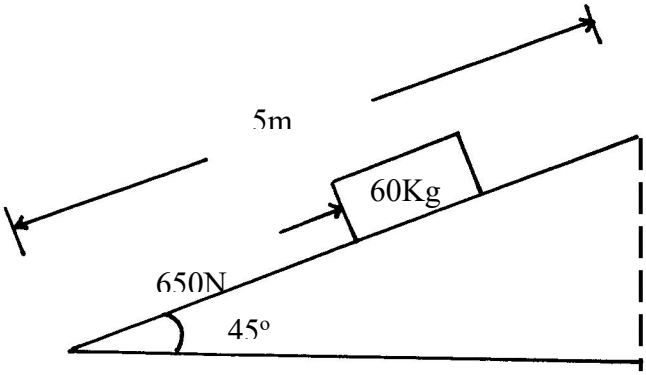
(iv) State two effects which contribute to the efficiency being less than 100%

– Friction between movable parts
- *Sound due to moving parts*
- *heat –some of the electrical energy is converted to unnecessary heat*

CHAPTER NINE

MACHINES & INCLINED PLANES

1. An inclined plane of length 5m is used to raise a body of mass 60kg to the back of a lorry. If the plane is inclined at an angle 25° from the horizontal, calculate the efficiency of the system given that a constant force of 650 N is used to push the body up the plane



$$M.A = \frac{600M}{650M} = 0.92307$$

$$V.R = \frac{1}{\sin 25} = 2.366$$

$$\eta = \frac{M.A}{V.R} \times 100$$

$$= \frac{0.92307}{2.366} \times 100 = 39.01\%$$

2. **Vicky performed an experiment using a pulley system as shown in the figure.**

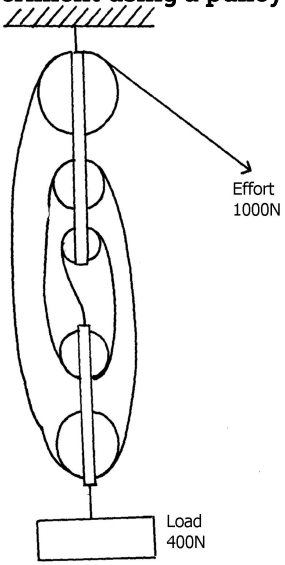


Figure 13

(a) **What is the V.R. of the system?**

V.R = 5

(b) Determine the M.A. of the system.

$$MA = \frac{L}{E}$$

$$= \frac{4000}{1000}$$

$$= 4$$

(c) Calculate the efficiency of the system.

$$eff. = \frac{M.A}{VR} \times 100\%$$

$$= 4/5 \times 100$$

$$= 80\%$$

(d) Explain why efficiency of a practical machine is always less than 100% *Some work is done overcoming friction or lifting the moving parts*

(e) If the load moves a distance of 5 cm. Find the work done on the load.

$$W = F \times d$$
$$= 40{,}000 \times 0.05 = 2000J$$

3. **The figure below shows a pulley system being used to raise a load. Use the information given in the figure to answer questions (a) and (b)**

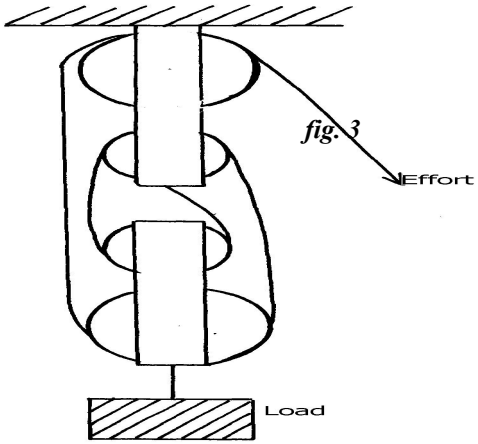


fig. 3

(ii) If a load of 100N is raised by applying an effort of 48N, determine the efficiency of the system.

$$VR = 4$$
$$A = L = 100$$
$$E \quad 48$$
$$\therefore u = M.A \times 100\%$$
$$V.R$$
$$= \frac{100}{48} \times \frac{1}{4} = 52.08\%$$

4. **(a) (i) Define the term velocity ratio (V.R)**

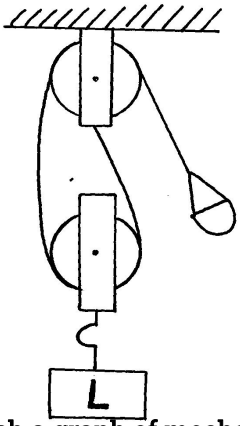
Velocity ration is the distance moved by the effort to the distance moved by the load

in the same time

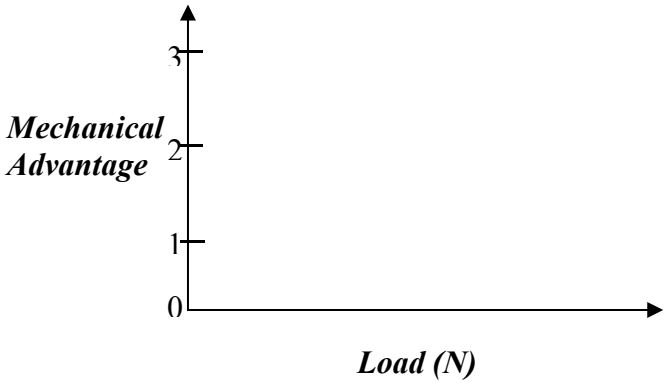
(ii) Name one machine that has a velocity ratio of less than one (V.R < 1)

- *Pulley belts*
- *Gears*

(b) The figure below shows a set-up used to find the mechanical advantage of a pulley system



On the axes provided sketch a graph of mechanical advantage (M.A) against load (L)



(c) A hydraulic machine is used to raise a load of 100kg at a constant velocity through a height of 2.5m. The radius of the effort piston is 1.4cm while that of the load piston is 7.0cm. Given that the machine is 80% efficient, calculate:-

(i) The effort needed

$$V.R = \frac{R^2}{r^2} = \frac{7x\ 7}{1.4\ x\ 1.4} = 25$$

$$Efficiency = \frac{M.A\ x\ 100\%}{V.R}$$

$$M.A = r\ x\ V.R = \frac{80}{100}\ x\ 25 = 20$$

$$E = \frac{KL}{M.A} = \frac{100}{20}\ x\ 10 = 50N$$

(ii) The energy wasted in using the machine

$$EH = \frac{work\ output\ x\ 100\%}{Work\ input}$$

$$Work\ output = mgh$$

$$= 100\ x\ 10\ x\ 2.5$$

$$= 2500J$$

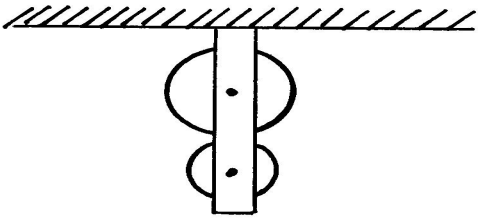
$$80 = \frac{2500\ \ x\ \ 100}{Work\ output}$$

$$Work\ out\ put = \frac{2500\ x\ 100}{80} = 3125J$$

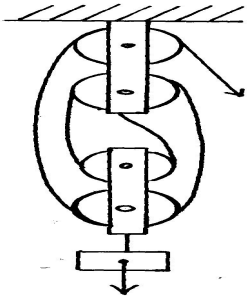
$$Energy\ lost = 3125 - 2500$$

$$= 625J$$

5. (i) complete the diagram below to show how the pulley can be used to raise a load L by applying an effort E



i) Answer



(ii) The pulley system above has a mechanical advantage of 3. Calculate the total work done when a load of 60N is raised through a height of 9M ***E*** *= L/MA*

= 60/3

= 20N

Total work done by effort

= E x Distance moved by effort

= 20 x 9 x V.R

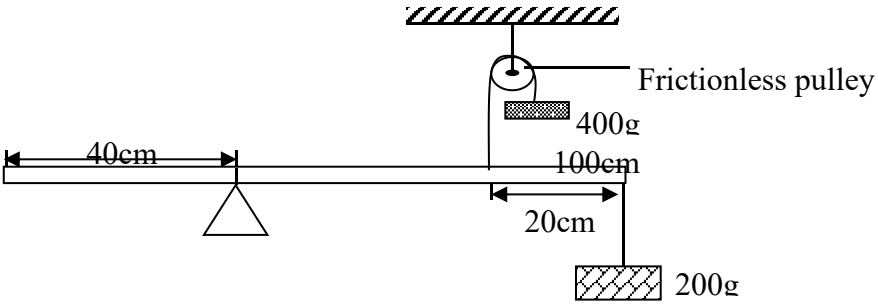
= 20 x 9 x 4

= 720J

CHAPTER NINE

TURNING EFFECT OF A FORCE

1. Figure 4 below shows a uniform metre rule in equilibrium under the forces shown



Determine the weight of the metre rule

Sum of clockwise moments = sum of anticlockwise moments

60cm x 200g + 50cm x Mg = 40cm x 400g

12000cmg + 50mcMg = 16000cmg

50Mcmg = 4000cmg

50M = 4000

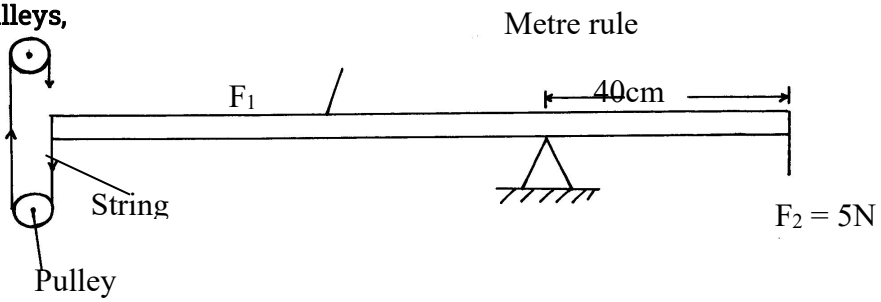
M = 4000 = 80g

50

w = 0.8N

2. The diagram below shows a uniform meter rule of mass 300g balanced by two forces F_1 and F_2.

Force F_2 is 5N. Assuming there is no frictional force on the pulleys,



Calculate the force F_1

$40 X 5 = f X 60 + 3 X 10$

$200 = 60F + 30$

$60 F = 170$

$F = \frac{170}{60}$

$= 2.833N$

2. Figure 2. shows a uniform metal rod pivoted at 45cm mark with a mass 7.0 kgs suspended at 0cm mark. The system is in equilibrium .

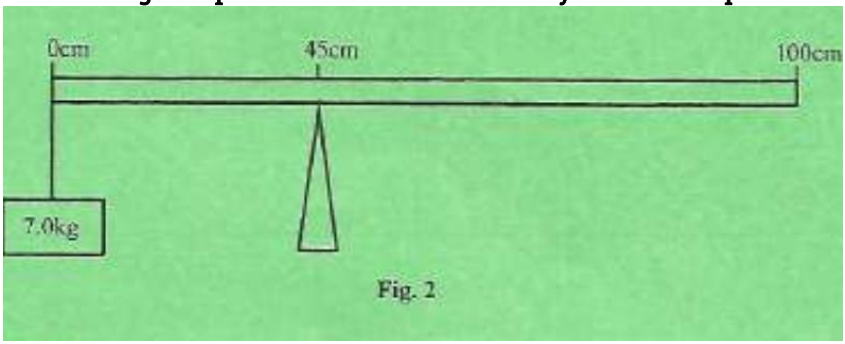


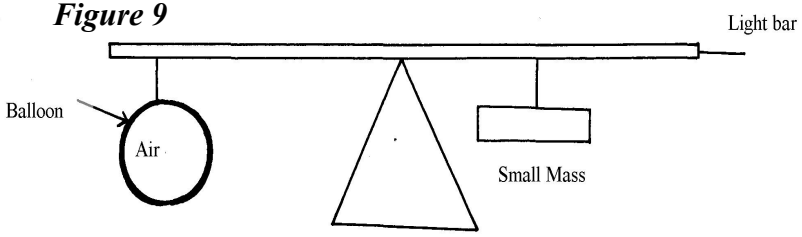
Fig. 2

a. Determine the mass of the metal rod

b. Normal reaction at pivot point

3. (a) The figure below shows a system in equilibrium at room temperature. The system is taken outside where the temperature is 20°C higher for sometime.

Figure 9



Explain why it tips to the right when it is taken outside the room.
Balloon and air will expand therefore up thrust on balloon increases thus clockwise moment increases

(c) The fig. below shows a floating object of volume 40,000 cm^3 and mass 10g. It is held as shown in water of density 1.25g/cm^3 by a light cable at the bottom so that ¾ of the volume of the object is below the water surface. (Assume that up thrust due to air is negligible)

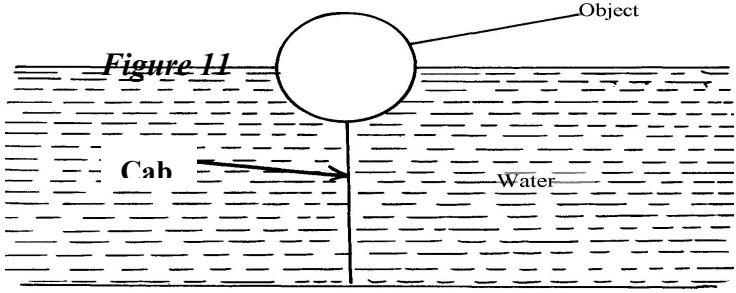


Figure 11

(iii) (I) Calculate the volume of the object under water.

Volume under water = ¾ x 40,000
= 30,000cm^3.

4. State the principle of moments.

For a system in equilibrium the sum of clockwise moments about a point is equal to the sum of anticlockwise moments about the same point;

5. Differentiate between stable and unstable equilibrium

6. Figure 4 shows a uniform wooden plank which weighs 10N. The plank is balanced at 0.8m from one end by a mass of 2.5kg

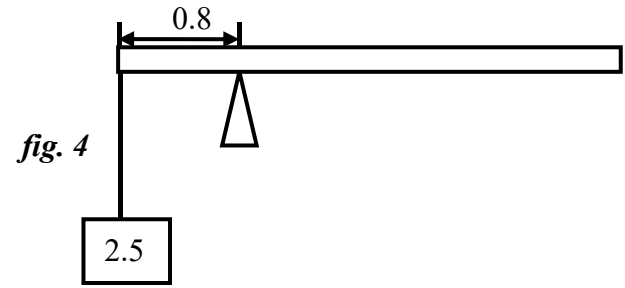
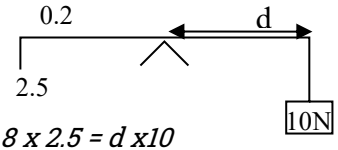


fig. 4

What is the length of the wooden plank in metres?



0.8 x 2.5 = d x10

d = (0.8 x 25) = 2.0

10

length = (0.8 + 2) 2 = 5.6cm

6. *Figure 4* shows a uniform rod AE which is 40cm long. It has a mass of 2kg and pivoted at D. If 2N is acting at point E, and 30N force is passed through a frictionless pulley

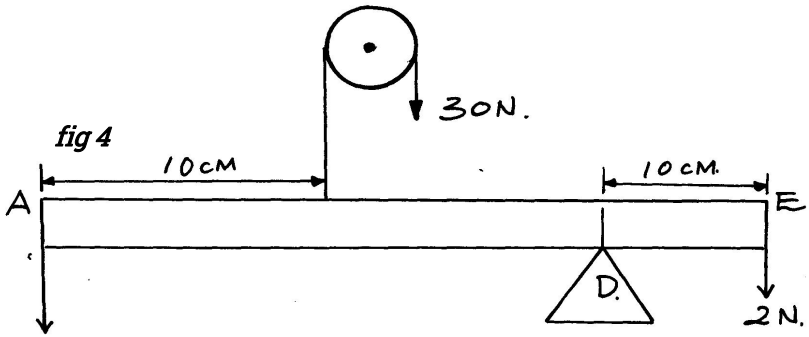


fig 4

X

Find the force (**x**) acting at end **A**

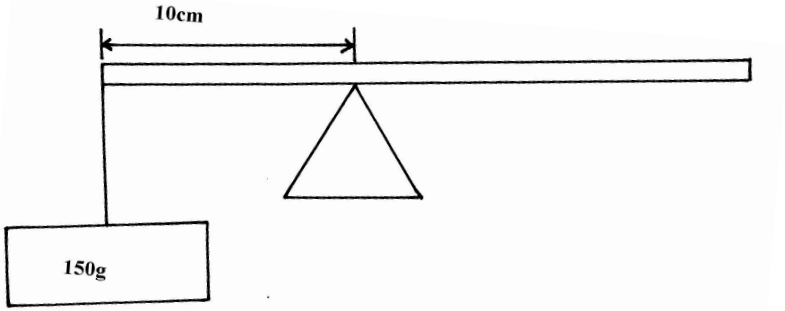
actm = ctm

x(0.3) + 2.0 x 0.1 = (30 x 0.2) + 2 x 0.1

0.3x = 6.2 – 2.0

x = 14N

7. A uniform half metre long beam, pivoted at the 10cm mark, balances when a mass of 150g is suspended at the 0cm mark as shown below:



Calculate the weight of the beam

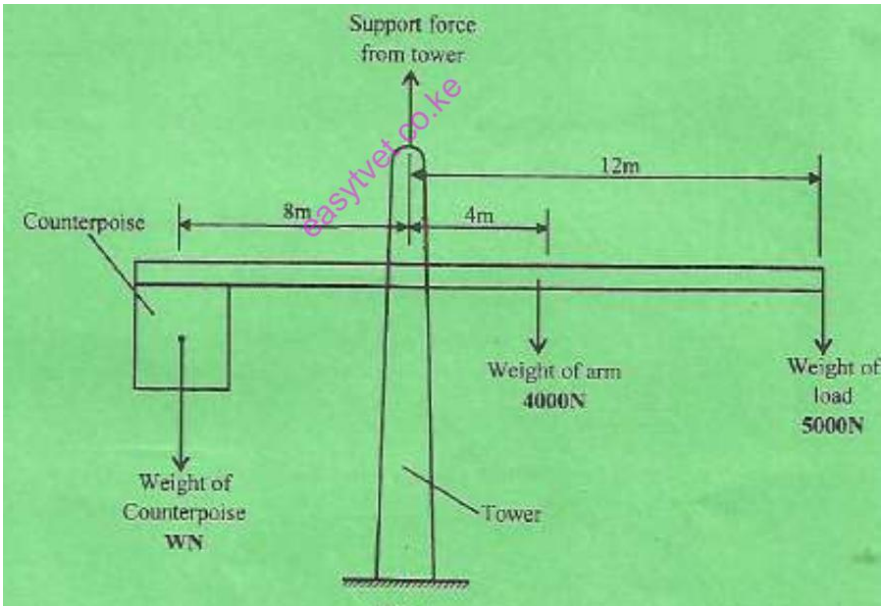
Clockwise moments = Anticlockwise moments

1.5 X 0.1 = W X 0.15 √

$W = {}^{0.15}/_{0.15}$

W= 1N

8. Figure below represents the arm of a tower in equilibrium with the loading forces acting on it at specified distances.



a. Calculate the weight of the counterpose W in Newtons(N)
b. Support force provided by the tower (g=10N/kg)
c. State three types of equilibrium

CHAPTER TEN

NEWTON'S LAW

1. (a) State Newton's first law of motion

- A body remains in its state of rest or uniform motion in a straight line unless acted upon by an external force

(b) Distinguish between elastic collision and inelastic collision

Elastic collision is one in which both kinetic energy and momentum are conserved, while inelastic collision is one in which momentum is conserved, but kinetic energy is not

(c) A minibus of mass 2000kg traveling at a constant velocity of 36km/h collides with a stationary car of mass 1000kg. The impact takes 2 seconds before the two move together at a constant velocity for 20 seconds. Calculate:

(i) The common velocity

Momentum before collision = momentum after collision

$(2000 \times 10) + (1000 \times 0) = (2000 + 1000)V$

$3000V = 20000$

$V = 6^2/_3 m/s$

(ii) The distance moved after impact

$d = Velocity \times time$

$= \frac{20}{3} \times 20 = \frac{400m}{3} = 133^1/_3 Meters$

(iii) The impulse force

$Impulse = change\ in\ momentum$

$= 2000 (10-6^2/_3 m/s) - for\ the\ minibus$

$Or= 1000 (6^2/_3 m/s-0) - for\ the\ car$

$= 6667NS$

$Impulse\ of\ force = \frac{Impulse}{Time}$

$= \frac{6667}{2} = 3333.5N$

(iv) The change in kinetic energy

$K.E\ before\ collision = ½ \times 2000 \times 10^2 = 100{,}000J$

K.E after collision = ½ x 3000 x $(6^2/_3)^2$ = 66,666.7J

Change in K.E = (100,000 – 66666.7) J

= 33,333.3J

2. State Newton's second law of motion

The rate of change of momentum is directly proportional to the external force acting on a body it is in the direction of force

3. State the law of inertia

A body continues in its initial state rest or uniform motion unless compelled by an external force to make it behave differently.

4. A footballer kicks a ball of 600g initially at rest using a force of 900N. If the foot was in contact with the ball for 0.1sec. What was the take off speed of the ball?

F = Ma

900 = 600a

100 a = $\frac{9000}{10}$ = 900ms^{-2}

but a = $\frac{v-u}{t}$

at = v-u

(900 x 0.1) = v = 90ms^{-1}

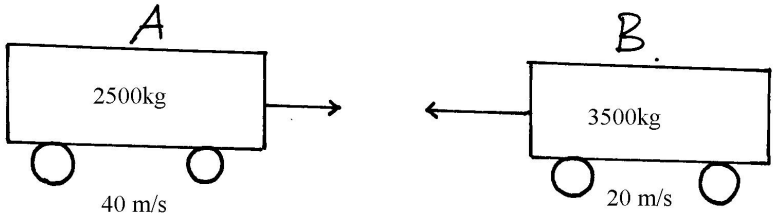
5. **State Newton's third law of motion**

For every action there is an equal and opposite reaction

6. **(a) State Newton's second law of motion**

The rate of change of momentum of a body is directly proportional to the resultant external force producing the change and takes place in e direction of force.

(b) The figure below shows two mini buses A and B at a speed of 40m/s and 20m/s respectively moving in opposite directions. They collided head on



Determine the common speed of the vehicles if they stuck to each other

$$m_1u_1 - m_2u_2 = (m_1 + m_2)$$

$$V = \frac{m_1u_1 - m_2u_2}{M_1 + m_2}$$

$$= \frac{(2500 \times 40) - (3500 \times 20)}{2500 + 3500}$$

$$= \frac{30000}{6000} = 5ms^{-1}$$

7.A supermarket trolley of mass 1.8kg rest on a horizontal surface . Another trolley of mass 1.3kg moving at 5.4ms^{-1} collides with the first trolley and the two trolleys stick together . Determine

(a) The total momentum before collision

(b) The velocity of the trolley immediately after collision

CHAPTER ELEVEN

LINEAR MOTION

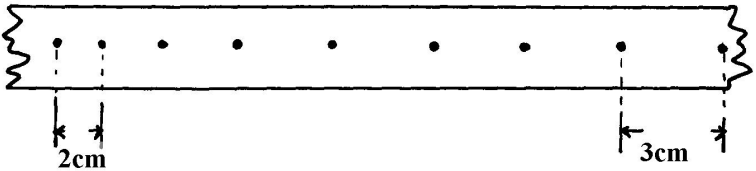
1. a) Distinguish between the terms 'uniform velocity' and 'uniform acceleration'

Uniform velocity :- The change in displacement for equal time intervals is the same.

Uniform acceleration:- Change in velocity for equal time intervals is the same.

b) The figure below shows a section of a ticker tape. The dots were made at a frequency of 50 Hz.

Determine the acceleration of the trolley pulling the tape

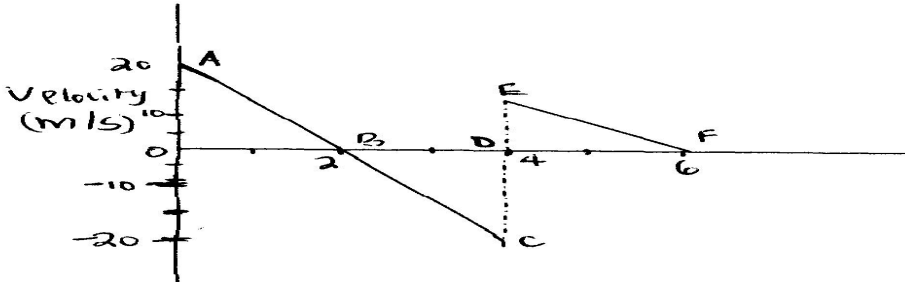


$Va = \frac{2}{0.02} = 100cm/s$ $V_b = \frac{3}{0.02} = 150\ cm/s$ $a = \frac{V-U}{t}$

$= (150 - 100)/ (7X0.02 - 0.02)$

$a = 416.67\ cm/s^2$

c) The graph below shows a part of the motion of a basket ball which is projected vertically upwards from the ground and is allowed to bounce on the Ground



c) i) Determine the motion of the ball relating it to its different positions along the following

II BC the body falls back to the starting point (moving in the opposite direction)

III CE the body be rebounds on the ground (at starting point) and starts moving up again

ii) From the graph calculate the acceleration due to gravity

$a = \frac{v-u}{t}$ | $a = -10m/s^2$

$= 10m/s^2$

$= \frac{0-20}{2}$

b) Determine the acceleration of the trolley pulling the tape

$Va = \frac{2}{0.02} = 100cm/s$ $V_b = \frac{3}{0.02} = 150\ cm/s$ $a = \frac{V-U}{t}$

$= (150 - 100)/ (7X0.02 – 0.02)$

$a = 416.67\ cm/s^2$

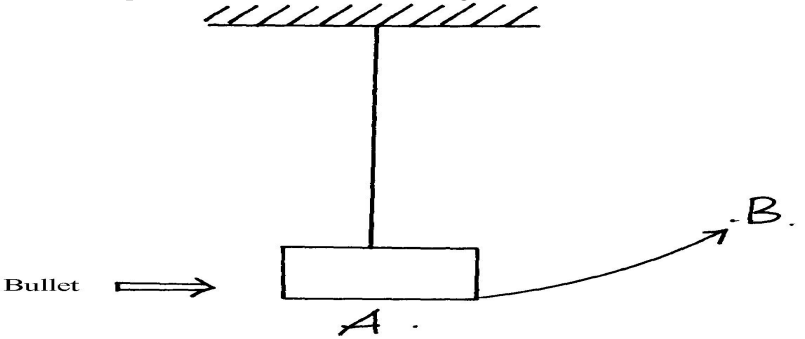
2. A pistol of mass 500gm fires a bullet of mass 2.0gm. The bullet leaves the pistol at a velocity of 300m/s. determine the recoil velocity of the pistol.

3. **One end of a metal rod is heated in a flame. After some time the other end becomes hot. Explain this observation**

Conduction

Free electrons at the heated end gain more kinetic energy and spread the heat energy to other parts of the rod

3. **A bullet of mass 150g moving at an initial velocity of 80m/s strikes a suspended block of mass 2.5kg**



(a) The block swings from point A to B. Determine the vertical displacement between A and B

(a) Momentum before collision = momentum after collision

$$\frac{150 \times 80}{1000} = 2.65 \times V$$

$$16 = 2.65V$$

$$V = \frac{16}{2.65}$$

$$= 6.0377$$

But $\frac{1}{2} mV^2 = mgh$

$$h = \frac{V^2}{2g} = \frac{(6.0377)}{2 \times 10}$$

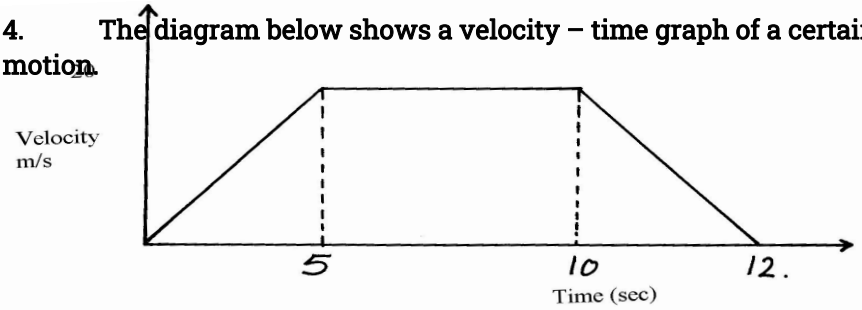
$$h = \frac{36.4538}{20}$$

$$= 1.82269m$$

. (b) What observations are you likely to observe on the block after collision

The block will be deformed

4. The diagram below shows a velocity – time graph of a certain motion.



From the graph, determine the average speed of the body.

Total distance = Area under graph;

= ½ (12 + 5) x 20; OR

= 170m;

Average speed = 170m / 12s

= 14.17m/s;

5. The diagram below shows a ball being whirled in a vertical plane.

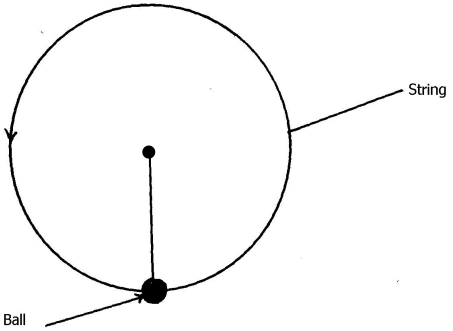
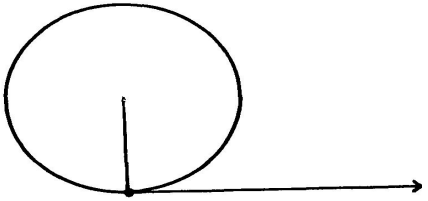
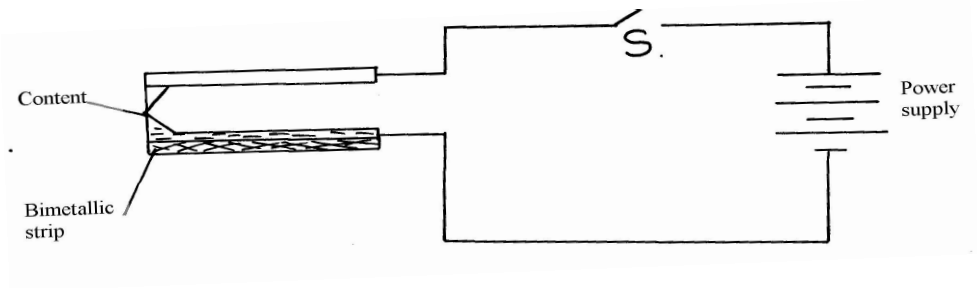


Figure 7

(a) Sketch on the same diagram, the path followed by the ball if the string cuts when the ball is at position shown in the diagram.



7. The figure below shows a circuit diagram for controlling temperature of a room.



(i) Explain the purpose of the strip.

(i) Acts as a thermostat

(ii) Describe how the circuit controls the temperature when the switch S is closed.

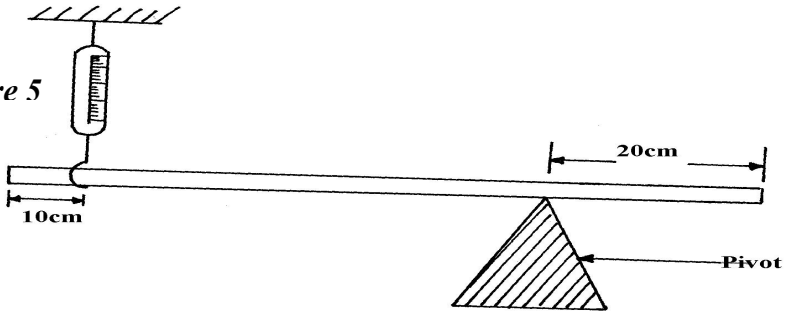
On closing, the switch, current becomes complete, the current flows causing heating effect, the bimetallic strip bends downwards and contents separates.

when the room becomes cool the strip bends upward completing the current and the process repeats itself on and off regulating the temperature

- Weight of the fluid in which it floats

7. The *figure 5* below shows a uniform bar of length 1.0m pivoted near one end. The bar is kept in equilibrium by a spring balance as shown:

figure 5



Given that the reading of the spring balance is 0.6N, determine the reaction force at the pivot

Clockwise moments = anticlockwise moments at equilibrium

0.6 x 0.7 = W x 0.3;

$$W = \frac{0.6 \times 0.7}{0.3}$$

= 1.4N;

0.6 + R = 1.4

R = 0.8N;

8. **The *figure 8* shows the motio**n of a train over a section of track which includes a sharp bend

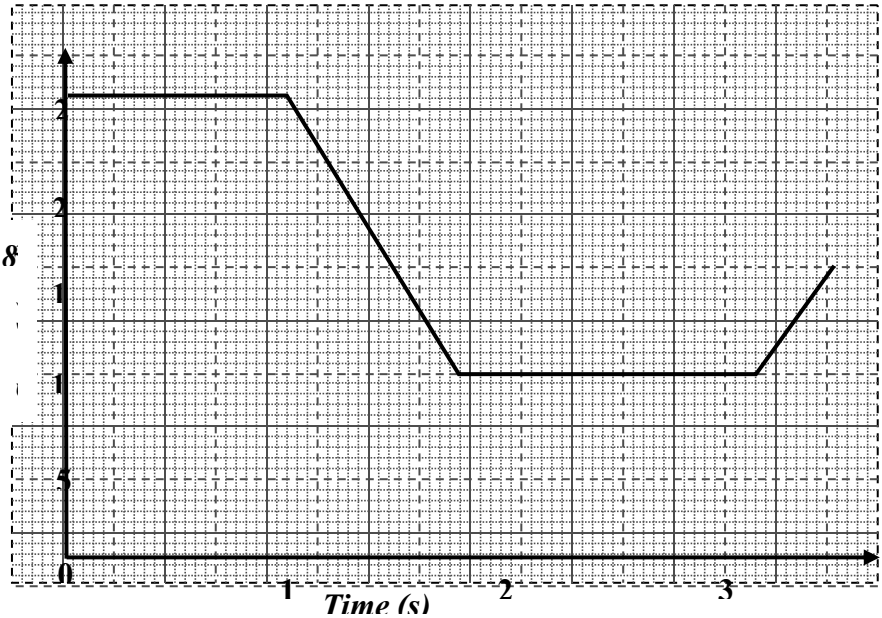


figure 8

(a) The section of the track with the sharp bend has a maximum speed restriction. The train decelerates approaching the bend so that at the start of the bend, it has just reached the maximum speed allowed. The train is driven around the bend at the maximum speed allowed and accelerates immediately on leaving the bend. Calculate the length of the bend

(a) Length = area under curve

= 10 x (32-18);

= 10 x 14

= 140m;

(b) The train has to slow down to go round the bend. Calculate the deceleration

$\frac{10-25}{18-10} = \frac{-15}{8}$; *= -1.875ms-1*

(c) As the train is driven round the bend, there is an extra force acting, called the centripetal force.

(i) On the *figure 9* below, draw an arrow to show the direction of this force

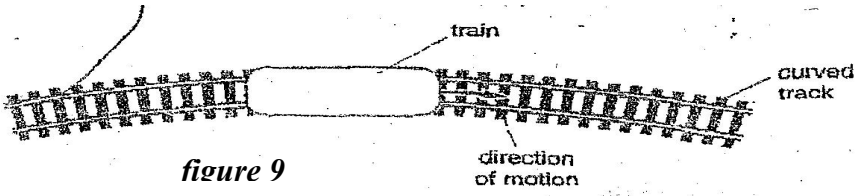


figure 9

(ii) State the effect that this force has on the motion

Keep the train in circular motion;

(iii) State how this force is provided

Friction force between the wheels and rails;

(d) *Figure 10* below shows a car with a dummy driver before and after a collision test:

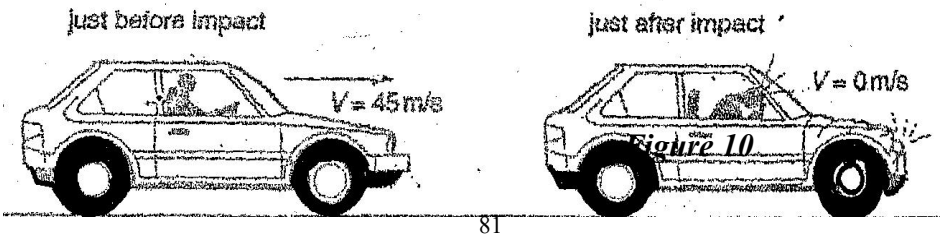


Figure 10

The mass of the dummy driver is 90kg. The impact time to reduce the dummy's speed from $45ms^{-1}$ to zero is 1.2 seconds:

(i) Calculate the average force on the dummy during impact

$F = \frac{m(v-u)}{t}$

$= \frac{90(0-45)}{1.2};$

$= -3375N;$

(ii) **State the main energy transformation during the collision**

Kinetic energy – Heat + sound + P.E(deformation;

(iii) **Calculate how much of the dummy's energy is transformed during the collision** $E = ½ Mv^2;$

$= ½ \times 90 \times 45s;$

$= 91,125J;$

9. (a) The velocity-time graph in the figure below illustrates the motion of a ball which has been projected vertically upwards from the surface of the moon. The weight of the object on earth's surface is 20N, when the acceleration due to gravity is $10ms^{-2}$.

(i) State why the velocity becomes negative after 3seconds. *When a body is projected vertically upwards, it under goes a uniform retardation due to the gravitational pull. The body thus slows down, comes to rest them starts falling with an increasing velocity (in opposite direction)*

(ii) Determine the acceleration of free fall on the moon showing clearly your work

Acc of free fall = gradient / slope of the graph

$= \frac{5 - 0}{3 - 0} = \frac{5}{3} = 1.66ms^{-2}$

(iii) **Determine the total distance travelled by the ball in 5.0sec**

Total distance = Area under the curve

(½ x 5 x 3) +(½ x 2 x 3.3.)

$\frac{15}{2} + \frac{10}{3} = \frac{30}{6} + \frac{20}{6} = \frac{50}{3} = 25 = 8\frac{1}{3}m$

(iv) **Find the weight of the ball on the moon**

- Wt in the moon = mg = 2kg x $^{5}/_{3}$ = $^{10}/_{3}$ = $3^{1}/_{3}$N

10. (a) State Boyle's law

states that the volume of a fixed mass of gas is inversely proportional to its pressure provided temperature is kept constant.

(c) 100°C - 0°C = 98 -11

1 division = $\frac{87}{100}$

Reading = $\frac{8 \times 56}{1000}$

= 48.72°C

(c) The volume of a bubble at the base of a container of water is 3cm^3. The depth of water is 30cm. The bubble rises up the column until the surface ;

(i) **Explain what happens to the bubble as it rises up the water column**

The bubble expands as it comes up finally bursts when at the surface

(ii) Determine the volume of the bubble at a point 5cm below the water surface $p_1V_1 = P2V_2$

(76 + 30) x 3 = (76 + 5) V_2

106 x3 = 81 X V_2

$V_2 = \frac{106 \times 3}{81}$

= 3.93cm^3

(c) A faulty thermometer records 11°C instead of 0°C and 98°C instead of 100°C. Determine the reading on the thermometer when dipped in liquid at a temperature of 56°C

100°C - 0°C = 98 -11

1 division = $\frac{87}{100}$

Reading = $\frac{8 \times 56}{1000}$

= 48.72°C

11. Figure 9 is a velocity- time graph describing the motion of a particle

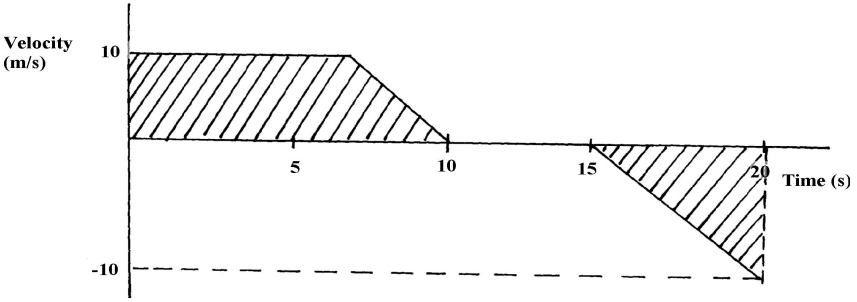


Fig. 9

What does the shaded area represent?

Distance traveled

12.a) State Newton's first law of motion

A body continues with its state of rest or uniform motion unless acted upon by some external forces

b) A parcel is to be dropped from an aeroplane traveling horizontally at $120ms^{-1}$, at an altitude of 720m, to fall into a certain village.

Determine:

i) The time taken for the parcel to reach the ground

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

$$720 = \frac{1}{2} \times 10 \times t^2$$

$$t^2 = 144$$

$$t = \sqrt{144} = 12 \text{ sec}$$

ii) How far ahead of the plane, the village should be when the parcel is released

$$Range = ut$$

$$= 120 \times 12\sqrt{1}$$

$$= 1440m$$

c) A small stone, M_1 of mass 20g is attached to a string which in turn is passed through a smooth thin cylinder. The other end of

the string is tied to mass M_2. The mass M_1 is whirled in a horizontal circle of radius 1m and mass M_2 remains stationary as shown in figure 10

i) State two forces acting on the system other than the tension in the thread on M_2

– Centripetal force acting on M_1 √1

- Weight (M_2g) acting on M_2√1

ii) Explain the observation made on mass M_2 if the speed of M_1, is increased *ii) M_2 moves upwards; √1*

When the speed of M1 increases centripetal force remains the same, the radius of the circle described by M1 increases√1

iii) Calculate the velocity of M_1, if the mass M_2 is 50g and the radius of the circle is 1m

Centripetal force = weight of M_2

$M_1V^2/_r = M_2g$

$0.020\ V^2/_1 = 0.050 \times 10$

$V^2 = 0.5/_{0.02} = 25$

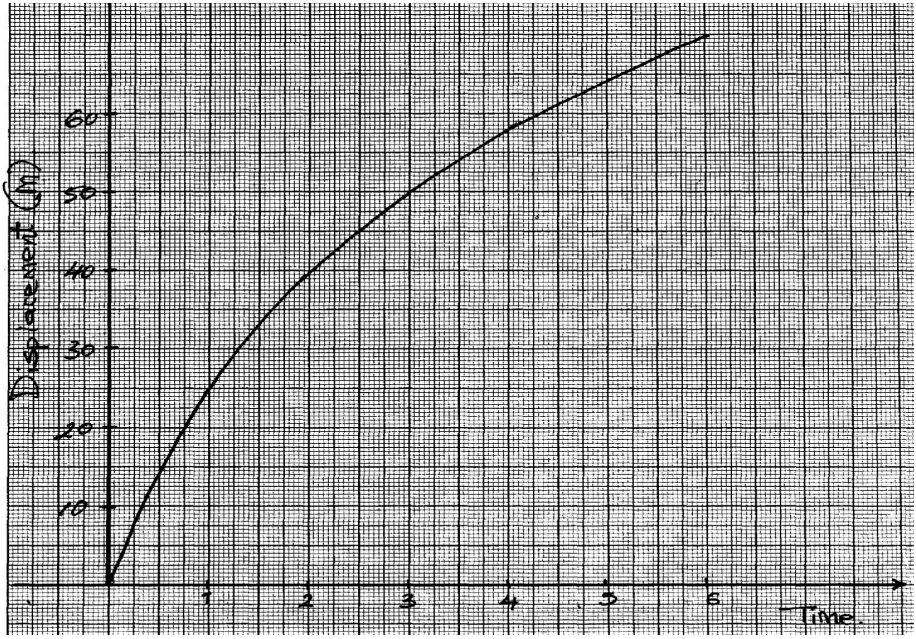
$V = \checkmark 25 = 5m/s$

13. **(a) Define uniform velocity**

(a) *Constant rate of change of displacement with time OR- A body is said to be moving with uniform velocity it its rate of change of displacement with time is constant*

(b) The graph *figure 10* below shows displacement –time graph of a in motion

fig 10



(i) Determine the instanteous velocities at t = 1second and at t = 4 seconds

For one correct tangent

Velocity t = 1s $= \frac{42 - 20}{2 - 0.5}$

$= 14.67 m/s$

Velocity at t = 4s $= \frac{67.5 - 30}{5 - 0.5}$

$= 8.33 m/s$ *(accuracy)*

(ii) **Use the results in (b)(i) above to determine the acceleration of the body**

$a = \frac{V - u}{t} = \frac{8.33 - 14.67}{4-1} = \frac{6.34}{3}$

$= 2.11 m/s^2$

14. A ball of mass 100g is kicked horizontally from the top of a cliff. If the ball takes 4 seconds to hit the ground, determine the height of the cliff

$S = ½ gt^2$ since $u = 0$

$= ½ \times 10 \times 4 \times 4 = 80m$

15. A ball is kicked vertically upward from the ground with a velocity of 60m/s and reaches a maximum height (h), it then falls freely back to the ground and bounces upwards to a height of 5M

(a) Sketch a velocity-time graph to represent the motion of the ball from the time it is kicked vertically upwards until it bounces to a height of 5M

(b) Determine:

(i) the time taken by the ball to reach the maximum height(h)

i) $t = \frac{v - u}{g}$

$= \frac{0 - 60}{-10}$

$= 6 \text{ secs}$

(ii) The maximum height (h) reached by the ball

ii) $h = ut - ½ gt^2$

$= 60 \times 6 - ½ \times 10 \times 6^2$

$= 360 - 180$

$= 180m$

(iii) The velocity with which it bounces after striking the ground for the first time

iii) $V^2 = U^2 + 2aS$

$O = U^2 + 2 \times -10 \times 5$

$O = U^2 - 100$

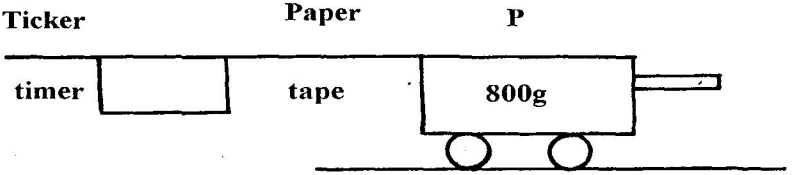
$U = 10m/s$

(c) State any assumption made in your calculations in (b) above

Resistance/ friction with air is negligible

16. In an experiment on momentum, trolley P of mass 800g was attached to a ticker timer of frequency 50Hz. Trolley P, initially

moving with a velocity of 0.5m/s, was made to collide with a stationary trolley Q of mass 400g. A copy of the tape as it appeared after the collision is presented in the figure below:-



Tape drawn to scale

(a) Determine the velocity of the trolley P after collision

a) Length of nine dots = 6.9cm

Time taken = $^{1}/_{50}$ x 9 = 0.02 x 9

= 0.185

Velocity = $\frac{6.9cm}{0.18s}$

= 38cm/s or 0.38m/s

(b) Calculate the impulsive force experienced by trolley P

Ft = 0.8 x 0.5 – 0.8 x 0.38

Ft = 0.096

F = $\frac{0.096}{0.18}$ = 0.533N

17. I. (a) State the three equations of linear motion.

a) Equations of linear motion.

i) V = u + at.

ii) $V^2 = u^2 + 2as$

iii) $S = ut + \frac{1}{2}at^2$.

(b) A car is traveling uniformly at 100km/hr when the driver observes a road block ahead. He takes 0.5 s before applying the

brakes which brings the car to rest with a uniform deceleration of $4m/s^2$. Determine the distance traveled by the car from the time the driver observed the road block until the car comes to rest.

$\frac{100\ km/h}{36} \times 10 = 27.78m/s$

In 0.5 sec the driver covers $27.78m/s \times 0.55 = 13.89\ M$ ✓1

After applying brake

$a = -4m/s^2$

$u = 27.78m/s.$

$v = 0$

$\therefore v^2 = u^2 + 2as$ ✓1

$-2as = u^2$. since $v = 0$

$S = \frac{u^2}{-2a} = \frac{(27.78m/s)^2}{(-2)(-4m/s^2)} = 96.47M$ ✓1

Total distance covered = (13.89 + 96.476)M = 110.36 M ✓1

(c) A car moves at a constant speed of $20ms^{-1}$ for 50s and then accelerates uniformly to a speed of $25ms^{-1}$ over a period of 10s. This speed is maintained for 50 s before the car is brought to rest with uniform deceleration in 15s.

(d) Draw a graph of velocity (Y – axis) against time (graph paper to be availed)

(II) Calculate:

(i) The average speed for the whole journey.

Average speed of the whole journey = Total distance covered / Total time taken

Distance = Area under the graph

= (20m/s x 50s) + (½ (20 + 25) x 10) + ½ (50 + 65) x 25

= 1000m + 225m + 1437.5m = 2662.5m

Total time = 125s

Speed = $\frac{2662.5}{125s}$ = 21.3 m/s

= 21.3 m/s

(ii) The acceleration when the velocity changes from 20 ms^{-1} to 25ms^{-1} .

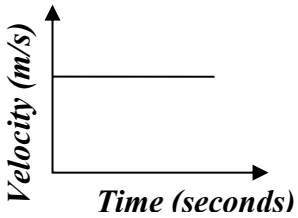
m, show that $v^2=2as+u^2$

(ii) a = v-u

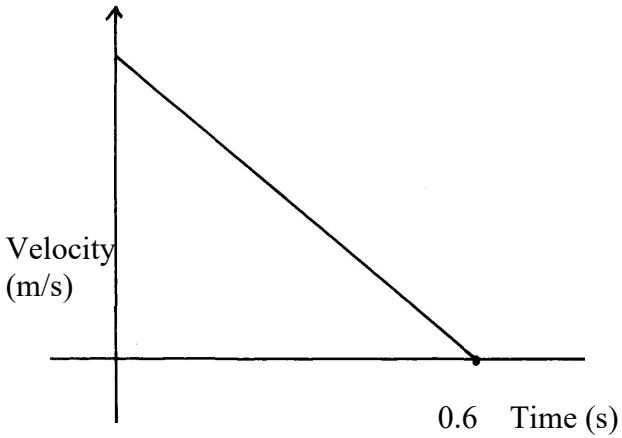
$$T = \frac{(25 - 20)\ m/s}{10\ s}$$

$$= 0.5m/s^2$$

18. Sketch a velocity-time graph for a body moving with zero acceleration

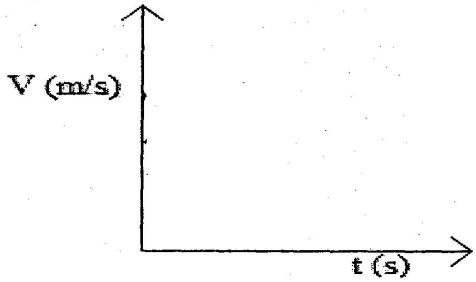


19. The figure below shows a velocity –time graph of a ball bouncing vertically upward from the ground. The velocity upward is taken positive.



Determine the maximum height when the ball rises.

20. (a) On the axes provide below, sketch a graph of velocity V versus time (t) for uniformly accelerated motion given that when t = 0, V is greater than zero.



(b) A car is brought to Rest from a speed of 20 ms^{-1} in time of 2 seconds. Calculate the deceleration.

21. (a). State the law of conservation of linear momentum

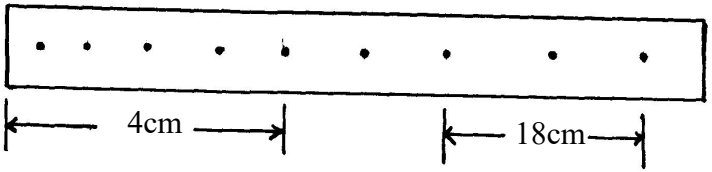
The principle of conservation of momentum states that if two objects collide, then the total momentum before and after the collision will be the same if there is no external force acting on the colliding objects.

(b). A marble of mass 50g moving on a horizontal surface at a velocity of V collides with another glass marble of mass 75g resting on same horizontal surface. After collision, the marble bounces back a long the path at a speed of 3.5m/s while the other marble moving with a speed of 3.0m/s .Forward .

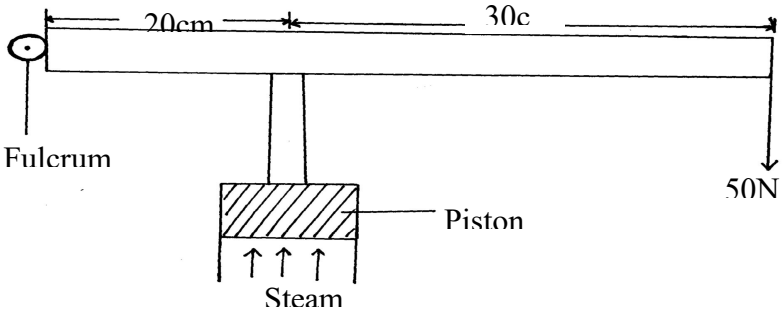
Determine the speed V.

(c). The paper below was attached to a trolley and pulled through a ticker tape times of frequency

50Hz. Determine the acceleration of the trolley.



(d). Study the figure below

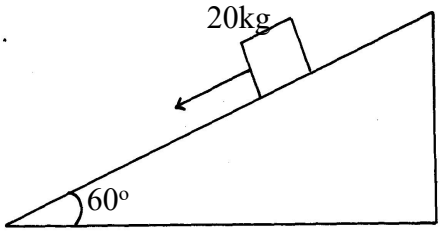


Calculate the pressure in the steam in the cylinder which would just raise the piston if area of the piston in contact with steam is $2cm^2$ and Atmospheric pressure is$1.0 \times 10^5 Nm^{-2}$.

(e) State a reason why the earth is colder at night than daytime during a sunny

The sun will heat the Earth's surface during the day. Then at night, the sun is on the other side of the globe, so temperatures cool back down. The ground routinely starts to cool after the sun sets because it emits more radiation than it gains from the atmosphere. In other words, the temperature of the ground starts to lower because it runs a radiation deficit (more losses than gains).

21. A block of mass 20kg slides downward a plane inclined of 6o0 with the horizontal. The coefficient of friction between the plane and the block is 0.4.



Calculate the acceleration of the block.

22. A body accelerates uniformly from initial velocity of U m/s to a final velocity of V m/s in time t seconds. If acceleration during the motion is a m/s^2 and the distance covered is S

25. Two inelastic masses of 16kg and 4kg move in opposite direction from each other with velocity of 3m/s-1 and 5m/s-1 respectively. Determine the resultant velocity on collision if they stuck together

CHAPTER TWELVE

CIRCULAR MOTION

1. **Give a reason why bodies in circular motion undergo acceleration even when their speed is constant**

The direction of the speed keeps changing hence the velocity at each point on the circular path is given by the tangent to the path at that point

2. Explain the principle of separation of milk from cream using a centrifuge machine (milk is more dense than cream)

3. Define the term

a) **angular velocity**

This is the rate of change of angular displacement with pimp

c) Angular displacement

Angular displacement is defined as "the angle in radians (degrees, revolutions) through which a point or line has been rotated in a specified sense about a specified axis". It is the angle of the movement of a body in a circular path.

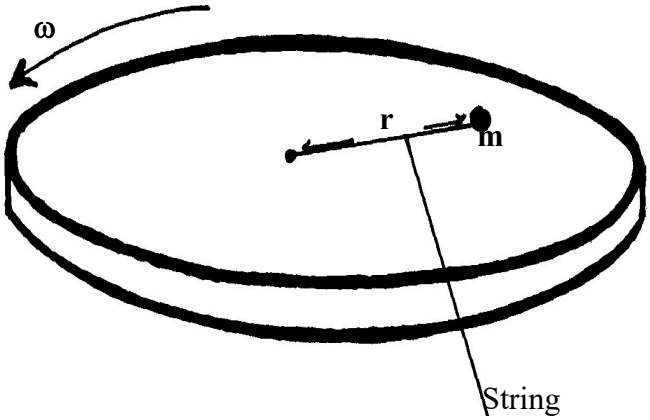
d) Centripetal force

Centripetal force is the name given to any force which causes a change in direction of velocity toward the center of the circular motion.

e) Centripetal acceleration

Centripetal acceleration is defined as the property of the motion of an object traversing a circular path. Any object that is moving in a circle and has an acceleration vector pointed towards the centre of that circle is known as Centripetal acceleration.

4. The figure shows a body of mass m attached to the centre of a rotating table with a string whose tension can be measure. (the device for measuring tension is not shown in the figure)



The tension T, on the string was measured for various values of angular velocity, ω. The distance r from the centre was maintained at 30cm. The results are as shown below :

Angular velocity ω (rad $^{-1}$)	2.0	3.	4.0	5.0	6.0
Tension T (N)	0.04	0.34	0.76	1.30	1.96

i) Plot the graph of T (y – axis) againstω^2

The tension T, on the string was measured for various values of angular velocity, ω . The distance r from the centre was maintained at 30cm. The results are as shown below

Angular velocity ω (rad s^{-1})	*2.0*	*3.0*	*4.0*	*5.0*	*6.0*
Tension T (N)	*0.04*	*0.34*	*0.76*	*1.30*	*1.96*
W^2 (rad$_s^{-2}$)	*4*	*Q*	*16*	*25*	*36*

ii) From the graph, determine the mass, m, of the body given that

$T = m\omega^2 r - C$ Where **C** is a constant

From the graph, determine the mass, m, of the body given that

$$T = \omega^2 r - C$$

Where C is a constant

Gradient = Mr

Gradient = 0.76 – 0.04

16 -4

= 0.06 N/(rad^{2}1^{-2})

$M = \frac{gradient}{r}$

$= \frac{0.06}{30/100} = \frac{0.6}{3} = 0.2\ kg$

ii) **Determine the constant C and suggest what it represents in the set up**

Determine the constant C and suggest what it represents in the set up

C is the Y –intercept

C = - 0.2 N

3. (a) A body moving in a uniform circular motion accelerates even though the speed is constant.

Explain this observation.

It keeps changing direction and hence must experience centripetal acceleration

5. A fun fair ride of diameter 12m makes 0.5 revolutions per second.

(i) Determine the periodic time, T, of the revolutions.

f = 0.5HZ

$T = 1/f$

$= \frac{1}{0.5} = 2sec$

(ii) Determine its angular velocity, ω.

$w = \frac{2\pi}{T}$;

$= \frac{2 \times 3.142}{2}$

= 3.142 / sec;

(iii) Determine the linear velocity of the child riding in it.

$V = rw$;or

$= 6 \times 3.12 \quad = 18.852 m/s$

(iv) If the mass of the child is 30 kg, find the centripetal force that keeps the child in the motion.

$$F = \frac{MV^2}{r}$$

$$= 30 \times \frac{(18.852)^2}{6}$$

$$= 1776.99N$$

OR $F = mrw^2$

$= 30 \times 6 \times (3.142)^2 \quad = 1776.99N$

6. A body of mass 0.6kg is tied to a string and whirled in a horizontal circle of radius 2m with a speed of 3.0m/s. calculate

a. The centripetal acceleration

b. The tension in the string

5. (a) (i) In uniform circular motion, a particle undergoes an acceleration while its speed remains constant. Explain how the acceleration if caused

The direction of the particle is tangential to the path of any given point. There is instantaneous change in direction of velocity, this causes acceleration of the particle.

(ii) A car of mass 1.5×10^3kg negotiates a level round about of radius 20m at a speed of 10m/s. Calculate the centripetal force acting on the car

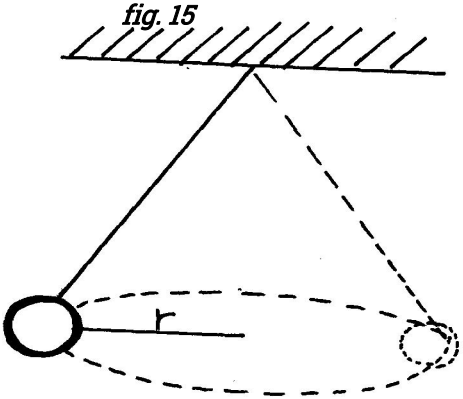
(ii) $F = \frac{mV^2}{r}$

$$= \frac{1.5 \times 10^3 \times 10 \times 10}{20}$$

$= 7.5 \times 10^3 N$

(b) The diagram ***figure 15*** below shows a conical pendulum:-

fig. 15



(i) **State and explain the effect on r of increasing the speed of the pendulum, given that the string is inextensible**

The value of r increases. Increase in speed leads to increase in centripetal force on the bob.

This leads to increase in radius of path (centripetal force is directly proportional to radius)

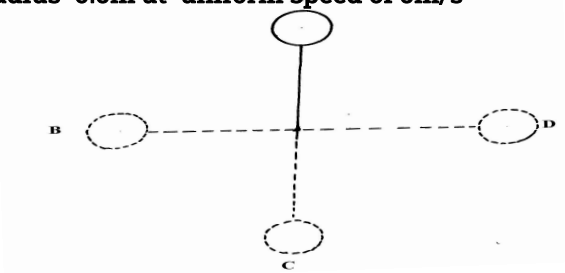
(c) Explain why a cyclist going round a bend at high speed tilts inwards

The cyclist leans inwards in order to have enough component of the contact force to provide adequate centripetal force.

6. **(a) Define angular velocity**

a) The rate of change of angular displacement with time

(b) The figure below shows an object of mass 0.2kg whirled in a verticle cycle of radius 0.5m at uniform speed of 5m/s



Determine

(i) The tension in the string at position A

$T_A = {}^{mv2}/_{r} - mg \surd 1$

$= \underline{0.2 \text{ X } 5^2} \quad - 2.0$

$0.5 = 8N$

(ii) The tension in the string at position B

ii) $T_B = {}^{mv2}/_{r}$

$= \underline{0.2 \text{ X } 5^2}$

$0.5 \qquad = 10N$

(iii) The tension in the string at position C

iii) $T_C = Mv2 + mg$

$= \underline{0.2 \text{ X } 5^2} \quad + 2$

0.5

$= 12 \text{ N}$

(c) From the values obtained in (i) (ii) and (iii) above, determine the point the string will most likely snap. Explain

c) At point C where tension is maximum

(d) A small pendulum bob having a mass of 150g is suspended by an inelastic string of length 0.5m. The mass is made to rotate in a horizontal circle of radius 0.4m and whose centre is vertically below the point of suspension

(i) Determine the tension in the string

$T \cos Q = mg$

$T (0.3/0.5) = 1.5$

$T = 2.5 \text{ N}$

$T \cos Q = {}^{150}/_{1000} \text{ X } 10$

$T = \underline{1.5 \text{ X } 5}$

3

$T \cos Q = 1.5$

(ii) State one application of the pendulum

ii) Speed governor

A setelite takes 84min to revolve around the earth once in a circular obit of radius 8000kms . calculate its

(a) Angular velocity

(b) Centripetal acceleration

6. **(a) Explain why a body moving in a circular path with constant speed is said to be accelerating**

(a) The direction of its velocity is continuously changing (1mk)

(b) (i) A wooden block of mass 200g is placed at various distances from the center of a turntable,which is rotating at constant angular velocity. It is found that at a distance of 8.0cm from the center, the block just starts to slide off the table. If the force of friction between the block and the table is 0.4N, Calculate:

(I) The angular velocity of the table

$Fr = mw^2r$ *(1mk)*

$0.4 = 0.2 \times w^2 \times 0.08$

$w^2 = \frac{0.4}{0.2 \times 0.08}$ *(1mk)*

$w_2 = 25$ *and* 25^{-2}

$w = 5$ *rad* 6^{-1} *(1mk)*

(II) The force required to hold the block at a distance of 12cm from the center of the table

$F = mw^2r$

$= 0.2 \times 5 \times 5 \times 0.12$

$= 0.6N$ *(must be shown*

(c) **A block of mass 400g is now placed at distance of 8.0cm from the centre of the turntable in (i) above and the turntable rotated at the same angular velocity. State with a reason whether or not the ball will slide off**

The block will slide (1mk)

Frictional force (0.4N) is less than the force required to maintain it in uniform circle (1mk)

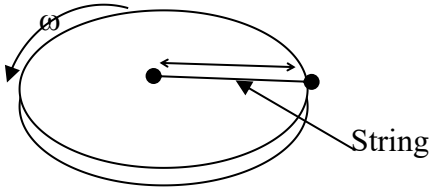
8. **A small object moving in a horizontal circle of radius 0.2m makes 8 revolutions per second.**

Determine its centripetal acceleration

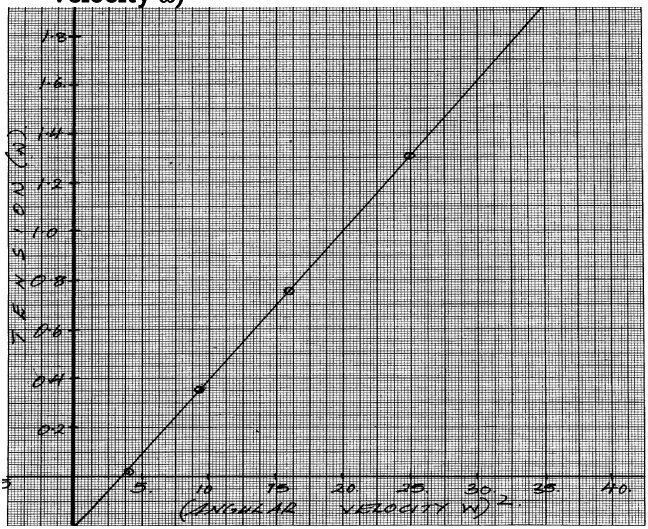
$$\propto = rw^2 = 0.2(16\ \pi)^2$$

$$= 505.3m/s^2$$

9. (a) The figure below shows a body of mass m attached to the centre of a rotating table with a string whose tension can be measured. The device for measuring the tension is not shown in the diagram:



The tension T on the string was measured for various values of angular velocity,ω . The distance r of the body from the centre was maintained at 30cm. The graph below shows the results obtained when Tension (y-axis) is plotted against (angular velocity ω)^2



(i) Name the force represented by the Tension (**T**)

Centrifugal force

(ii) From the graph, determine the mass m, of the body given that $T=M\omega^2r$ - c where c is a constant

The gradient of the graph = mass x radius

$$T = MW^2r - C$$

From Mr = gradient

$$Mr = \frac{1.30 - 0.76}{25 - 16} = 0.06$$

$$Mr = 0.06$$

$$M \times 0.3 = 0.06$$

$$M = \frac{0.06}{0.3} = 0.2kg$$

(iii) Determine the constant c and suggest what it represents in the set-up

$$y - intercept = -0.2N$$

$$-0.2 = -C$$

$$\mathbf{0.2 = C}$$

Frictional force

10. A mass of 2kg is attached to a string of length 50 cm. It is whirled in a circle in a vertical plane at 10 revolution per second about a horizontal axis. Calculate the tension in the string when the mass is at the :-

(a) Highest point of the circle.

at the highest point of the circle

$$T = \frac{Mv^2}{r} - mg$$

$$\frac{Mv^2}{R} = Fe = MW^2R$$

$$\therefore T = Mw^2r - mg$$

But $w = 2\pi f$

$T = (2\pi \times 10)^2 \times 2kg \times 0.5) - (2 \times 10)$

$= 400\pi^2 - 20 = 3927.84\ N$

(b) Lowest part of the circle.

T at the lowest point

$T = Fe + Mg$

$= Mw^2r + Mg$

$= 400\pi^2 + 20$

$= 3967.84\ N$

CHAPTER THIRTEEN

ELECTROSTATICS

1. a.. state the law of charges

States that Like charges repel each other; unlike charges attract. Thus, two negative charges repel one another, while a positive charge attracts a negative charge. The attraction or repulsion acts along the line between the two charges. The size of the force varies inversely as the square of the distance between the two charges

c. Explain why polythene is an insulator while copper is a conductor of electricity

Copper is a good conductor because it has free electrons hence allows current flows easily . Nylon do not have free electrons hence does not conduct electricity or make it flow through them easily.

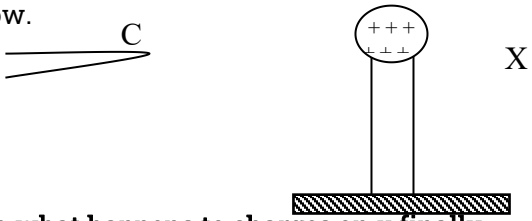
2. a. Define the term capacitor

A capacitor is a two-terminal electrical device that can store energy in the form of an electric charge. It consists of two electrical conductors that are separated by a distance. The space between the conductors may be filled by vacuum or with an insulating material known as a dielectric.

c. Name three types of capacitors

1. (a) An earthed pointed conductor C is placed near an insulated conductor X charged positively

as shown below.



State and explain what happens to charges on x finally.

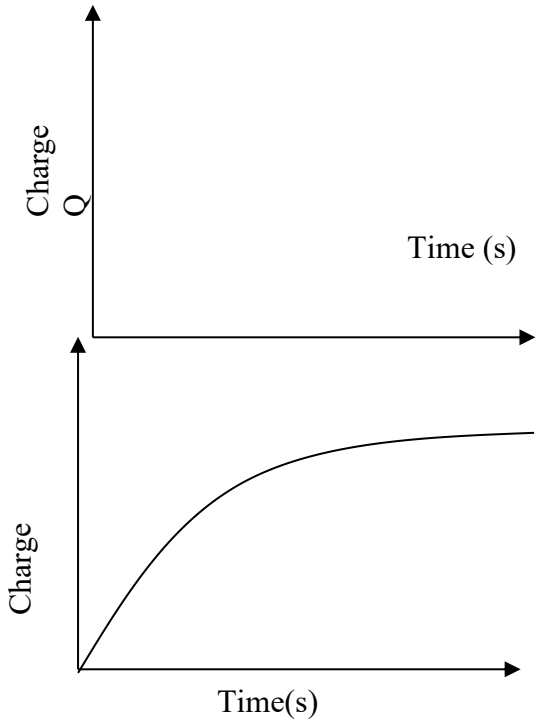
Charges at x get neutralized.

C is pointed and due to point action charges leak off from C and are attracted to x neutralizing it.

(b) A spherical metal sphere is charged positively and brought to contact with the inside surface of a hollow conductor it is then transferred to the cap of the telescope. State and explain what is observed. *Leaf rises.*

A position charge is induced on the surface of hollow conductor, these repels the charges from the cap of the electroscope making the leaf to diverge with the charge

(c) On the axes below sketch a graph of charge against time for charging capacitor.



(d) State two applications of capacitors.

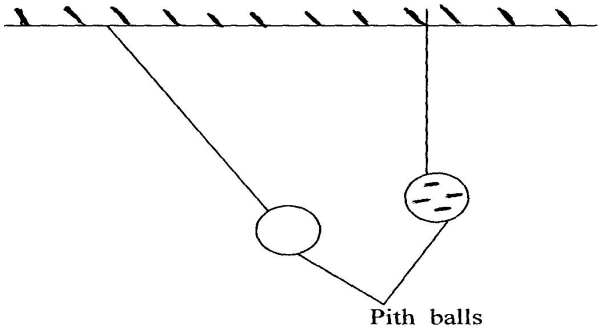
– Smoothening waves.

- Reduction of sparks in induction coil

- In camera flash.

- delay circuits

2. The figure below shows an uncharged pith ball under the attraction of a charged ball.



State and explain what would be observed after the two pith balls touch

After touching, the pith balls share the charge and become negative hence they repel.

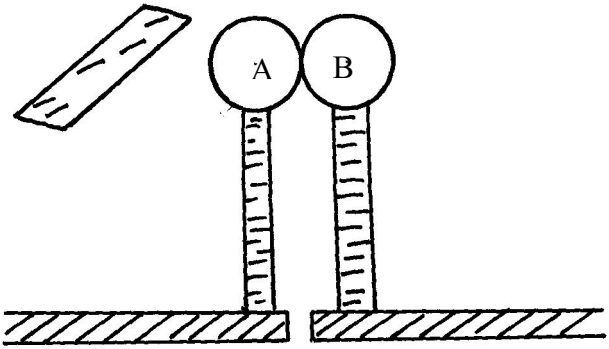
3. a) Two metal cons A and B of different sizes rest on two identical gold leaf electroscope as shown.

Compare the divergence of the gold leaves of the two electroscopes. Explain your answer

a) – The divergence of B is greater the divergence of A

- B has a smaller surface area than A, has low capacitance than A (Q= CV)

b) Two identical spheres A and B each standing on an insulated base are in contact. A negatively charged rod is brought near sphere A as shown below

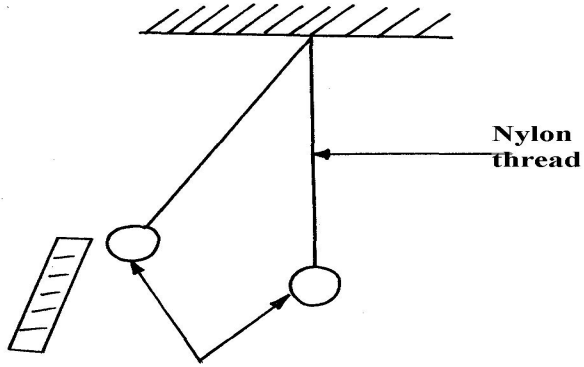


In what way will A differ from B if separated while the rod is near?

b) - A will have a net positive charge while B will have a net negative charge

4. In the *figure 1* below, explain what happens when one of the metal balls comes into contact with a negatively charged rod

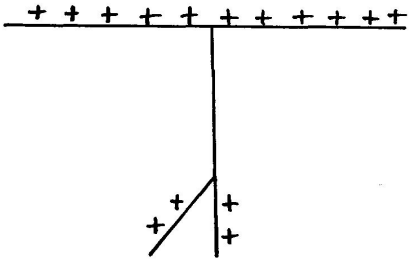
figure 2



The two balls will acquire negative charge and repel

5. **A gold leaf electroscope is positively charged as shown in the diagram in figure 1 where C is the cap and L is the gold leaf. State and explain what happens to L when a positively charged rod is brought near C without touching it.**

Figure 1

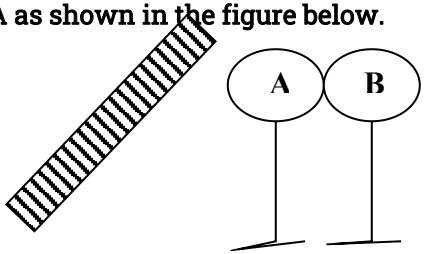


The gold leaf will diverge further because more positive charges will be repelled from the cap to the leaf by the positively charged rod

6. **You are provided with a charged electroscope, an insulator and a conductor. Describe how you would use these apparatus to distinguish in the insulator from the conductor**

Each material is brought in turn to touch the cap. The conductor will discharge the electroscope while the insulator will not (accept bring near conductor gauge)

7. **Two identical metal spheres A and B each standing on an insulating base are in contact. A negatively charged rod is brought near sphere A as shown in the figure below.**



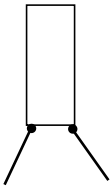
In what way will sphere **A** differ from **B** if it is separated while the rod is near? *A will have a positive charge when charged rod is brought near metal A. positive charges are attracted towards it while the negative charges are repelled*

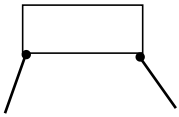
7. ***Plates of parallel-plate capacitors are separated are separated by a distance of 40mm. The potential difference between the plates and capacitance are 100v and 5.53x 10^{12} F respectively. Calculate the area of the plate in meters (***Take ϵ_0= 8.85 x 10^{-12}F/m)

CHAPTER FOURTEEN

MAGNETSIM

1. (a Two pins are attached to each of the magnets as shown below.

(i) 

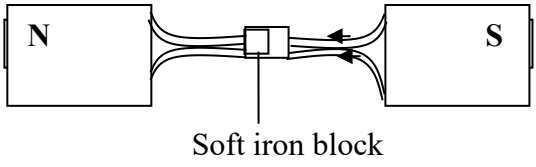
(ii) 

Explain the behaviour of pins in each case.

i) The free ends repel because they have some polarity,

ii) Free ends have different polarity hence attract.

(b **(i) Draw the magnetic field pattern around the magnets** below.



(ii) **Give one application of this behaviour of soft iron.**

magnetic shielding.

2. Define each of the following terms

a. Magnetic flux

Magnetic flux is defined as the number of magnetic field lines passing through a given closed surface. It provides the measurement of the total magnetic field that passes through a given surface area.

Here, the area under consideration can be of any size and under any orientation with respect to the direction of the magnetic field.

b. Magnetic induction

Magnetic induction, also known as electromagnetic induction, refers to the production of voltage (or EMF) across an electrical conductor placed inside a varying magnetic field.

c. Electromagnetic induction

Electromagnetic Induction or Induction is a process in which a conductor is put in a particular position and magnetic field keeps varying or magnetic field is stationary and a conductor is moving. This produces a Voltage or EMF (Electromotive Force) across the electrical conductor.

2 **Give a reason why attraction in magnetism is not regarded as a reliable method of testing for polarity**

All ferromagnetic materials are attracted by magnets or any magnetic material is attracted

3. Differentiate between magnetic flux and magnetic flux density

Magnetic flux refers in general to the lines of force in a magnetic field. The magnetic flux density at a point refers to the number of lines of force crossing unit area perpendicular to the field lines at the point, and this just translates to the magnetic field strength at that point.

4. Explain why pure iron rather than steel is used as a core of electromagnet

Soft iron is generally used for making electromagnets because it has high magnetic permeability, i.e it can easily gain magnetic properties when current is passed around the core and quickly lose when current is stopped. . Steel has a low magnetic permeability and thus once attaining magnetic properties, it holds on to these properties for a long time. Hence steel is often used for making permanent magnet

3 (a) The diagram ***figure 7*** below shows an electromagnet made by a student of Bura Girls secondary school, in the laboratory. The magnet was meant to pick up and release a metal object

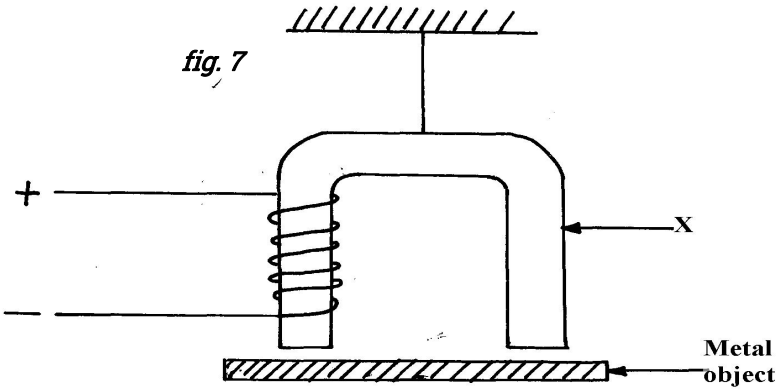


fig. 7

(i) Name giving reasons a suitable material for part X

(a) (i) Soft iron

- It is easy to magnetize and demagnetize

(b) Correct coil around A

Correct coil around B

Complete correct circuit

(ii) The electromagnet will just lift a metal of mass 150g. Taking g = 10N/Kg, what will be the least force exerted by the magnet to do this

Least force = mg

= 150 x 10 = 1.5N

1000

(iii) State the changes which the student should make so that a heavier metal object could be lifted by the magnet

– Increase the number of turns of the coil.

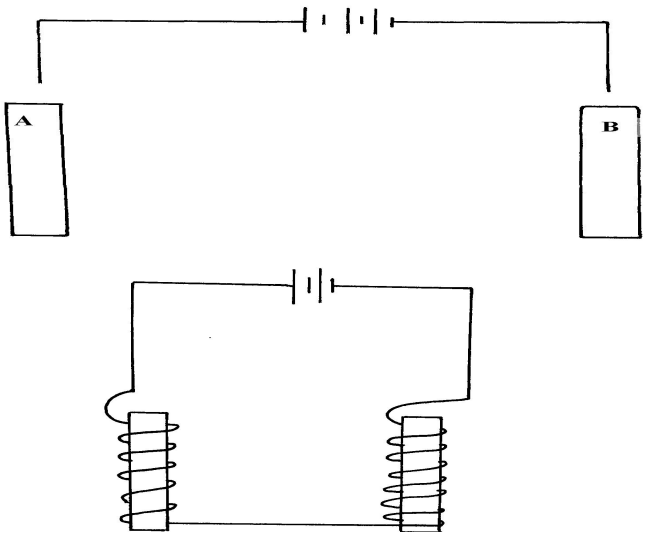
- Increase the amount f current /p.d

(iv) Explain why the strength of the above magnet cannot be increased indefinitely

When all the domains have been aligned i.e point of magnetic saturation, the strength of magnet is maximum and cannot increase beyond this point

(b) The diagram figure 8 below shows one method of making a magnet. Complete the diagram to make both ends A and B of the cores be North poles

fig. 8



5. Use the domain theory to differentiate between hard magnetic materials and soft magnetic materials

Domains of soft magnetic materials are easy to arrange and disarrange while the domains of hard magnetic materials are hard to arrange and disarrange.

5. **Two similar pins were placed one on a wooden block and the other on an iron block. The two blocks were placed near a magnet. State and explain the observations noted**

The pin or wooden block was attracted while the one on the metal block was not attracted. Magnet induces magnetism on the pin. On the iron block which induces magnetism on the iron block. The pin on the wooden block didn't induce magnetism to the wooden block.

7. Distinguish between intrinsic and extrinsic semi-conductors

The semiconductor is divided into two types. One is Intrinsic Semiconductor and other is an Extrinsic semiconductor. The pure form of the semiconductor is known as the intrinsic semiconductor and the semiconductor in which intentionally impurities is added for making it conductive is known as the extrinsic semiconductor.

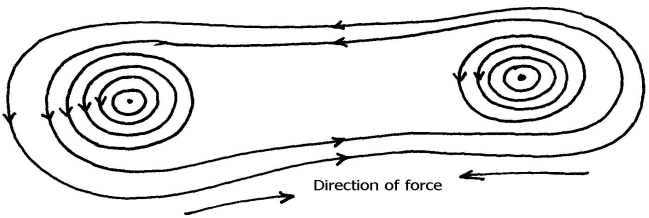
B. Distinguish between conduction band and valence band

Valence and Conduction band are the two different energy levels separated by a certain amount of energy. The main difference between the valence band and conduction band is that valence band specifies the energy level of electrons present in the valence shell of an atomic structure. As against a conduction band holds those electrons that are responsible for conduction.

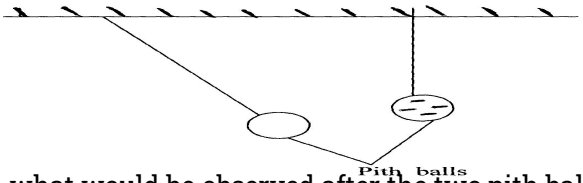
6.**Draw the magnetic field pattern in the figure below and indicate the direction of the force.**

Figure 5

Answer



8. The figure below shows uncharged pith ball under the attraction of a charged ball



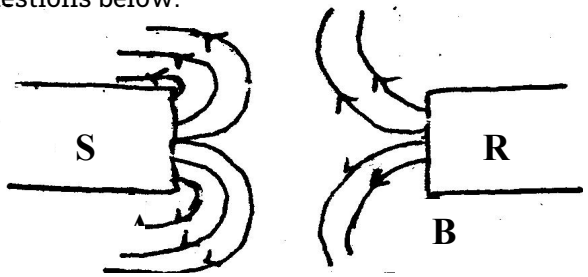
State and explain what would be observed after the two pith balls touch

The two pith balls separate

Charges (-ve) are transferred from the uncharged pith ball but are not enough to neutralize the charged one. The initially uncharged pith ball now becomes positively charged hence the separation/repulsion. ½½

8. **The diagram below shows a magnetic field patterns between magnets S and R. use it to answer**

questions below:-



(a) Identify the poles A and B

A – North pole *B – North pole*

(b) State which of the two magnets R and S is stronger. Explain

R is stronger. It repels more field lines revealing its strength

9. **You are provided with a two metal bars; one is magnetized while the other is un-magnetized. Describe briefly how you can identify the two bars without using repulsion method**

- Supposed each bar at a time. Displace them in turn and let them come to rest. Note the direction in which they rest. Repeat 2 or

3 times for each. This one that always settles facing N-S directions is a magnet

9. A conducting coil of 300turns is placed in a magnetic field. The magnetic flux changes from 6.0x 10^{-5} weber in 0.01 seconds . Determin the electromagnetic force induced in the coil

10. **A steel bar can be magnetized and not an aluminum bar. Explain**
A steel bar has dipoles in its domains while aluminium bar does not have the dipoles

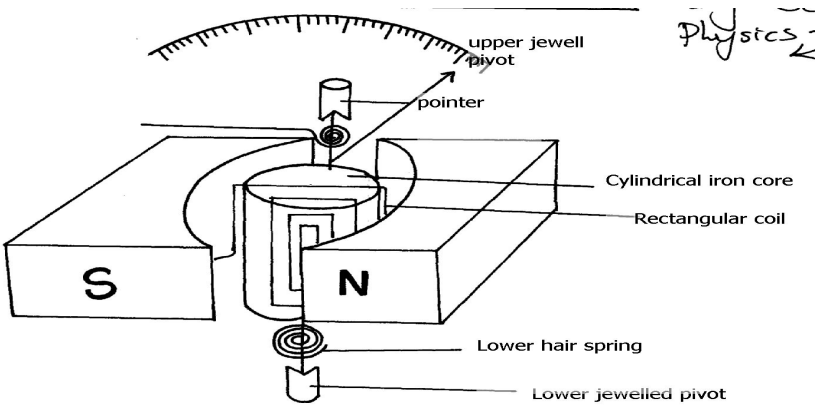
11. **(a) State the two laws of electromagnetic induction**
(i) The magnitude of the induced e.m.f is directly proportional to the rate of change of magnetic flux linkage
(ii) The direction of the induced emf is such that the current which it causes to flow produces a magnetic effect which tends to oppose the change causing it

(b) State one way through which energy is lost in a transformer and give a remedy for it.*(i) Resistance of the coil- remedy – thick copper coil)*
(ii) Hysterosis loss– remedy – soft iron core
(iii) Eddy currents – remedy – laminated iron core
(iv) Poor flux linkage – Remedy winding primary coil and secondary coil on the same core

(c) The resistance of a length of power transmitting cable is 20Ω and is used to transmit 12KV at a current of 1A. If the voltage is stopped up to 18KV by a transformer, determine the power loss. (Assume the transformer is ideal)

$VpIp = VsIs$
$12000 \times 1 = 1800 \times Is$
$Is = 0.6667A$
$Power\ loss = I^2R$
$= 0.6667^2 \times 20 = 8.89w$

(d) Using a well- labeled diagram explain how a moving coil meter works

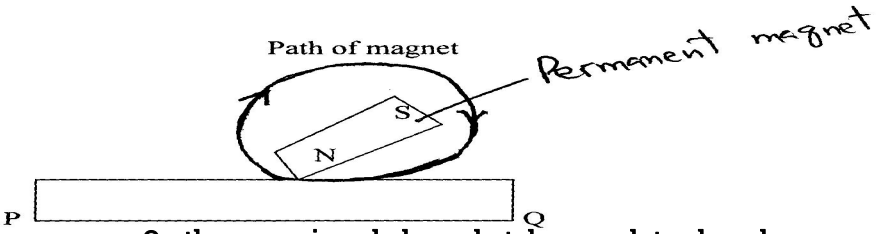


Current enters the coil thorough the hair springs and flows into the core through the rectangular coils. This causes the coil to be magnetized. The magnetic field created cuts the radial magnetic field of the magnetat right angles. This causes the core to rotate. The rotation of the core is opposed by the torque of the hair spring. When the force due to the rotation of the core is equal to the force due to the torque of the hair spring, the core comes to rest and the pointer gives the reading.

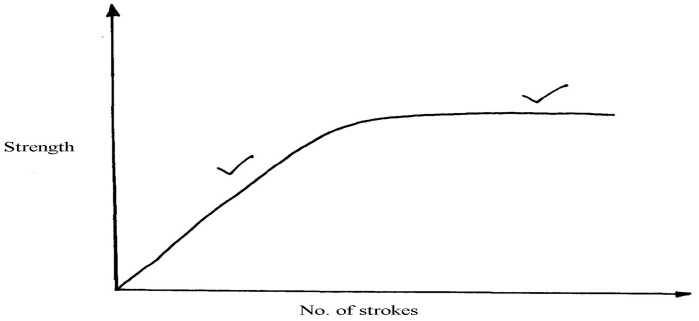
(e) Suggest one method of decreasing the sensitivity of a moving coil meter

(i)– Using a weak permanent magnet
(ii) Using strong hair springs
(iii) Using few turns of the rectangular coil

12. **The diagram below shows a ferromagnetic material being magnetized by the method shown**



On the axes given below, sketch a graph to show h strength of the magnet being created varies with the numb strokes

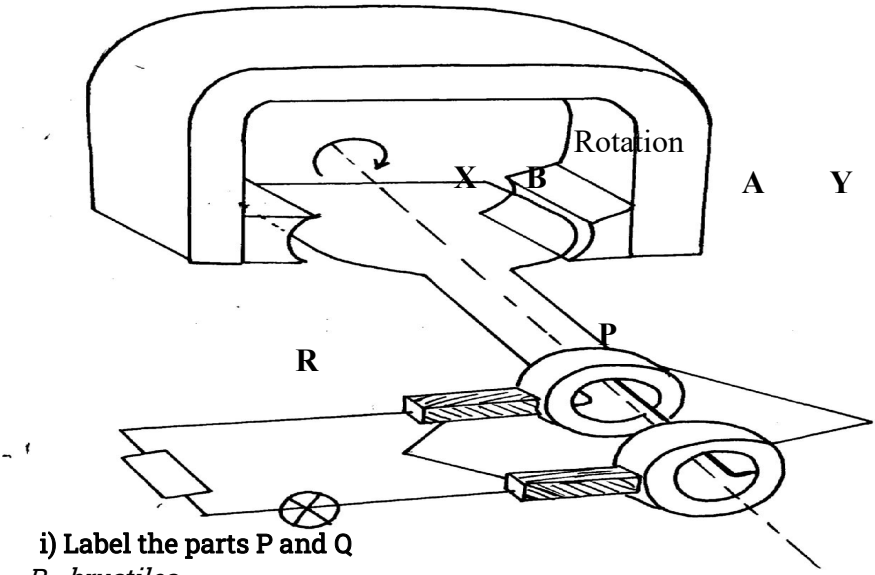


13. **Arrange the following types of waves in order of increasing frequency:-Ultra-violet radiation, visible light, radio waves and x-rays** *Radiowaves, visible light, ultraviolet light;*

15. **a) State Lenz's law of electromagnetic induction**

Induced current flows in such away as to oppose the charge producing it

b) The figure 6 below shows a diagram of a simple electric generator



i) Label the parts P and Q

P - brustiles

Q- ship rings

ii) Identify the polarities of the poles X and **Y**

ii) X- North

Y- South

iii) State two ways of increasing the voltage – output in this generator

- *Increasing speed of rotation of the coil*
- *Increasing the number of turns in the coil*
- *Increasing the strength of the magnet*

c) A transformer supplies a current of 13.5A at a voltage of 48v to a device from a.c. main supply of 240V. Given the transformer is 80% efficient; calculate

i) The power supplied to the transformer

Efficiency = Power output X 100 %

Power input

80 = 48 X 13.5 X 100
Power input

Power input = 810w

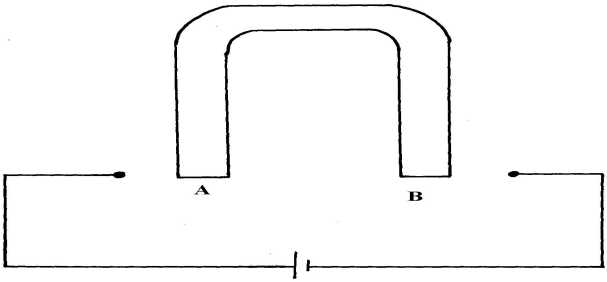
ii) Current in the primary coil

ii) Power input = Ip X Vp

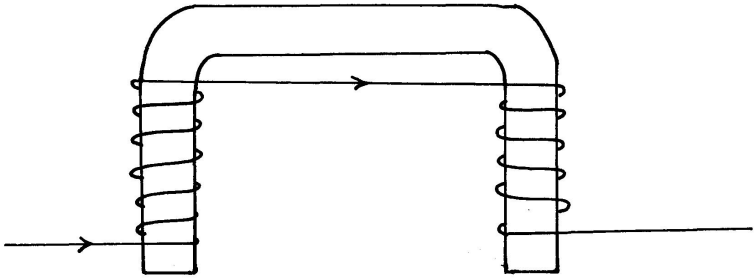
810 = 240 X IP

IP = 3.375 A

15. The figure below shows a magnetic material being magnetized



Complete the diagram showing the windings on the magnetic material so as to produce polarities at A and B both south poles



16. Explain why repulsion method is the surest test for polarity of a magnet as opposed to attraction

Repulsion occur between like poles, unlike poles and magnetic materials

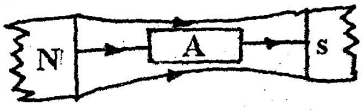
16. **A nail is electrically magnetized. It attracts an increasing number of iron pins as the magnetizing current increases. After sometime, the nail can no longer attract any more pins. Explain this observation.**

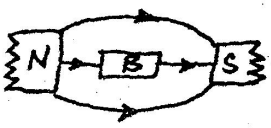
18. **The table below shows the type of radiation, detection method and uses of electromagnetic radiations. Complete the table:**

Type of radiation	Detection method	Use
Ultraviolet	Photopraphic paper	
	Blackened thermometer	Warmth sensation
Radio waves		Communication

19. **The figure 3 shows the effect on the magnetic field when two materials .A and B are placed in the magnetic field.**

Fig 3





State the difference between A and B.

20. **A nail is electrically magnetized. It attracts an increasing number of iron pins as the magnetizing current increases. After sometime, the nail can no longer attract any more pins. Explain this observation.**

21. **Use the domain theory to explain the process of magnetization**

ferromagnetic material consists of a large number of tiny regions, and each region gets spontaneously magnetized to saturation. The domains are free to move among those tiny regions. The spin

magnetic moments of all the atoms in a domain are oriented in a particular direction. These domains are prone to the influence of external magnetic fields. Initially the direction of these domains is such that they are randomly oriented and the magnetization due to these cancel out each other, so that the resultant magnetization of the material is zero in the absence of an external magnetic field. Thus, we get weak magnetization.
But in the presence of a strong magnetic field, these domains get aligned in one particular direction and as a result strong magnetization gets produced.

CHAPTER FIFTEEN

CURRENT ELECTRICITY

1. **(a) State Coulomb's law of electrostatics**

Coulomb's law states that the force between two point charges is directly proportional to the product of the magnitude of the charges and inversely proportional to the square of the distance between the charges.

2. **(i) State factors affecting conductivity of materia**l

- ✓ ***Temperature***

As the temperature of a metal increases, the motion of its atoms and electrons also increases. This can lead to an increase in the number of delocalized electrons available to carry current, resulting in an increase in electrical conductivity.

- ✓ *Impurities*

Impurities, or foreign atoms, can also affect the electrical conductivity of a metal. When an impurity is introduced into a metal, it can disrupt the flow of delocalized electrons and reduce the metal's ability to conduct electricity.

- ✓ *Strain*

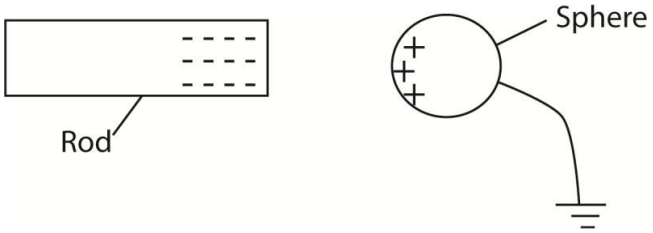
The electrical conductivity of a metal can also be affected by mechanical strain, or the stretching or compressing of the metal's lattice structure. Strain can alter the distribution of delocalized electrons and affect the metal's ability to conduct electricity.

- ✓ *Pressure*

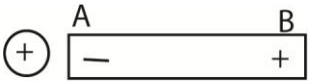
The electrical conductivity of a metal can also be affected by pressure, as the increased density of the metal can lead to an increase in the number of delocalized electrons.

(iii) Describe how a conductor may be positively charge but remains atzero potential

A negatively charged rod is brought near a neutral sphere. Distribution of charges occurs. The sphere is then earthed in the presence of the rod. Electrons flow to the earth. The sphere is positively charged and at zero potential. When the rod is remove the sphere remain positively charged.



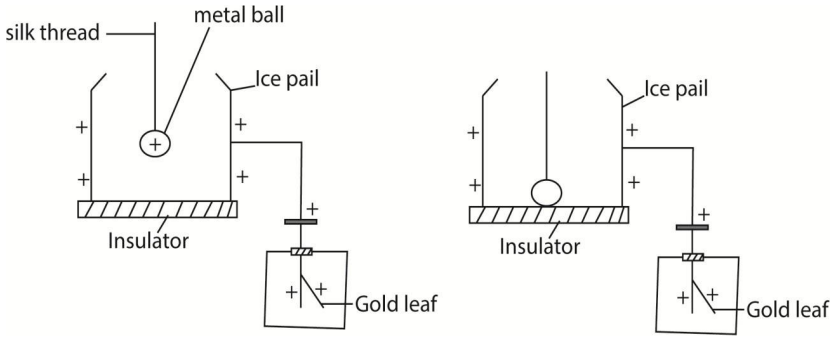
(ii) Explain how the presence of a neutral conductor near a charged conducting sphere may reduce the potential of the sphere.



When a positively charged insulated sphere A is placed close to a neutral insulted sphere B, negative charges are attracted to side close to A while positive charges are repelled to the far end. Potential at ab; V= V_a + V_b + V_c. Since V_b and V_c are of opposite sign and c is further from A, the negative charges at b effectively reduce the potential at a.

3.Describe with the aid of a diagram an experiment to show that excess charge resides onlyon outside of hollow conductor.

Experiment to show that excess charge resides only on the outside of a hollow conductor.



- *Ice pail is placed on an insulator and connected to a gold leaf electroscope*
- *A positively charged metal ball held on a long silk thread is lowered into the pail without touching the sided nor the bottom.*
- *Positive charges are induced on the outside of the pail and golf leaf diverges. The divergence does not change when the ball is moved about as long as it does not touch the pail.*
- *When the metal ball is allowed to touch the bottom, the divergence remains unchanged although it loses the charge.*
- *This shows that the charge induced inside the ice pail (hollow conductor) is of equal magnitude and opposite to the charge on the metal ball. Thus the total charge inside the hollow conductor is zero.*
- *Hence excess charge resides only on the outside of a hollow conductor.*

4. (a)(i) Define e.m.f of a battery.

E.m.f of a battery is energy supplied by the battery Or It is the p.d across the terminals of the battery on an open circuit.

(ii) Explain why e.m.f of a battery left standing in a room for long decreases.

Moisture in the room contains ions which allow electric conductions between the terminals of the battery and therefore the e.m.f of the battery reduces

.

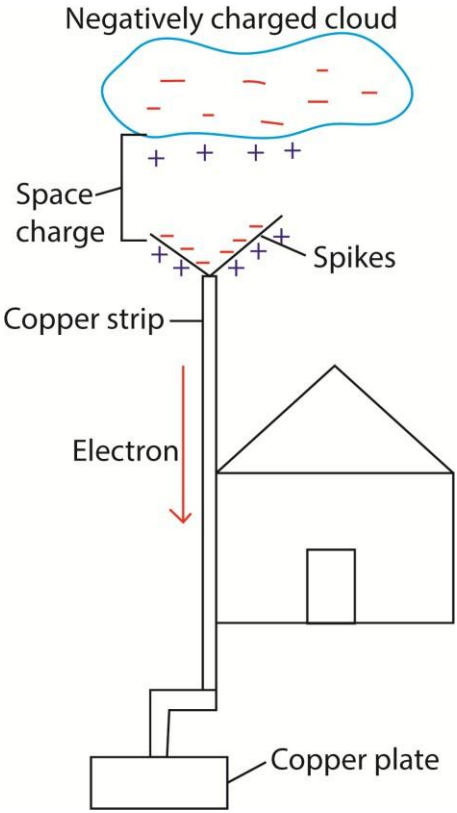
5. Define the following terms
(a) Intrinsic semiconductors
(b) Extrinsic semiconductors
(c) P-type semiconductors
(d) N-type semiconductors

6. Differentiate between thermionic and photoelectric emissions
During thermionic emission, electrons are emitted from the metal surface by providing heat energy, whereas during photoelectric emission ,light energy is emitted when electrons are emitted from the surface of the metal
7. Define farady.
A faraday is the capacitance of a capacitor when a charge stored is 1C and potential difference is 1V.
(ii) Describe briefly the energy transformations that take place when charging a capacitor using a dry cell. (02marks)
Chemical energy in the cell → electrical energy → electrostatic potential energy when the charge is being stored on the capacitor plates + heat

(b)(i) What is meant by dielectric constant?

Dielectric constant is the ratio of capacitance of a capacitor with a medium between its plates to the capacitance of the same capacitor with a vacuum between its plates. Or Dielectric constant is the ratio of permittivity of a medium to permittivity of space.

8. Explain the principles of operation of a lightning conductor. (05marks)



(i) When a negatively charged cloud passes over lightning conductor, it induces positive charges on the spikes by repelling electrons to the grounds through copper conductor.
(ii) A high electric field concentration of positive ions on the spikes ionizes air around it causing positively charged ions and negatively ions.

(iii) *The negatively charged ions are attracted and discharged at the spikes while the positively charged ions are repelled to form a space charges which neutralizes the negative charge on the cloud. In this way the harmful effect of the cloud is reduced.*

9. A torch bulb has a resistance of 1 Ω when cold. It draws a current of 0.2 A from a source of 2 V and glows. Calculate

(i) the resistance of the bulb when glowing

When the bulb glows:

V = I R —- Ohm's law R = V/I = 2/.2 =10 Ω

(ii) explain the reason for the difference in resistance.

Resistance of the filament of the bulb increases with increase in temperature. Hence when it glows its resistances is greater than when it is cold.

3. **Calculate the resistance of 1 km long copper wire of radius 1 mm. (Resistivity of copper = 1.72 x 1 0-8**

L = 1 km = 1000 m

R = 1 mm = 1 x 1 0-3

p = 1.72 x 1 0-8 W m

Area of cross section = p r2 = 3.14 x 1 0^{-3} x 1 0^{-3}

= 3.14 x 1 0^{-6}

R = pl/A = (1.72 x 1 0^{-8} x 1000) / 3.14 x 1 0^{-6}

= 5.5 W

4. When a potential difference of 2 V is applied across the ends of a wire of 5 m length, a current of 1 A is found to flow through it. Calculate:

(i) the resistance per unit length of the wire

V = I R —– Ohm's law R=V/I=2/1= 2 Ohm

Resistance per unit length: 2/5= 0.4 Ohm/m

(iv) the resistance of 2 m length of this wire

Resistance of 2 m length of the wire = 0.4 x 2=0.8 ohm

(iii) the resistance across the ends of the wire if it is doubled on itself.

When the wire is doubled on itself:

(a) the area of cross-section is doubled. If A is the original C.S. area, now it is 2 A.

(b) The length becomes half i.e.L/2
Resistance of this wire =R' = p (l/2)/(2A) = 1/4(p(L/A)
But p(L/A) = 2 ohm
R' = 1/4 x 2=0.5 Ohm

5. How much work is done in moving 4 C across two point having pd. 10 v

W = VQ = 10 x 4 = 40J

6. How much energy is given to each coulomb of charge passing through a 9 v battery?

Potential difference = Work done
= Potential difference × charge
Where, Charge = 1 C and Potential difference = 9V
Work done = 9×1 = 9 Joule.

7. 100 j of work is done in moving a charge of 5 C from one terminal of battery to another . What is the potential difference of battery?

V = W/Q = 100j/5C = 20 V

8. If 4 x 10 -3 J of work is done in moving a particles carrying a charge of 16 x 10^{-6} C from infinity to point P .What will be the potential at a point?

the potential at a point is work done to carry unit from one point to another
= (4 x 10^{-3}) /(16 x 10^{-6} C) = 250 V

9. **Calculate the current and resistance of a 100 W ,200V electric bulb.**

Power,P = 100W and Voltage,V = 200V
Power P = VI
So, Current I = P/v = 100/200 = 0.5A
Resistance R = V/I = 200/0.5 = 400W.

10.Calculate the power rating of the heater coil when used on 220V supply taking 5 Amps.

Voltage ,V = 220V and Current ,I = 5A,
Power,P = VI = 220 × 5 = 1100W = 1.1 KW.

11.A lamp can work on a 50 volt mains taking 2 amps.What value of the resistance must be connected in series with it so that it can be operated from 200 volt mains giving the same power.

Lamp voltage ,V = 50V and Current ,I = 2 amps.
Resistance of the lamp = V/I = 50 / 2 = 25 Ω

Resistance connected in series with lamp = r.
Supply voltage = 200 volt. and Circuit current I = 2 A
Total resistance Rt= V/I = 200/2 = 100Ω
Rt = R + r => 100 = 25 + r => r = 75Ω

12. Calculate the work done in moving a charge of 5 coulombs from a point at a potential of 210 volts to another point at 240 volts
Potential difference = 210 – 240 = 30 V
So, W.= V x Q = 30V x 5C = 150 Joules
13. How many electrons pass through a lamp in one minute if the current be 220 mA?
I = 220 mA = 0.22 A
I = Q/T
0.22 = Q/60
Q= 0.22 x 60 = 13.2 C
No of electron carry 1 C charge = 6 x 10 18
No of electron carry 13.2 C charge = 6 x 10 18 x 13.2 C = 79.2 x 10 18
14.Calculate the current supplied by a cell if the amount of charge passing through the cell in 4 seconds is 12 C ?
I = Q/t = 12/4 = 3A
15. A 2 Volt cell is connected to a 1 Ω resistor. How many electrons come out of the negative terminal of the cell in 2 minutes?
V = IR => I = V/R = 2/1 = 2 A
I = Q/t => Q = It = 2 x 2 x 20 = 80 C
No of electron carry 1 C charge = 6 x 10^{18}
No of electron carry 80 C charge = 6 x 10^{18} x 80 C
= 108 x 10^{18} = 1. 08 x 10^{20}
17. (a) How much current will an electric bulb draw from a 220 V source, if the resistance of the bulb filament is 1200 Ω?
We are given V = 220 V; R = 1200 Ω.
we have the current I = V/R = 220 V/1200 Ω = 0.18 A.

(b) How much current will an electric heater coil draw from a 220 V source, if the resistance of the heater coil is 100 Ω?
We are given, V = 220 V, R = 100 Ω.
we have the current I = V/R = 220 V/100 Ω = 2.2 A.

17. The potential difference between the terminals of an electric heater is 60 V when it draws a current of 4 A from the source. What current will the heater draw if the potential difference is increased to 120 V?

We are given,
potential difference V = 60 V, current I = 4 A.
According to Ohm's law, R = V/I = 60/4 =15Ω
When the potential difference is increased to 120 V
the current is given by current
= V/R = 120V/15 = 8A
The current through the heater becomes 8 A.

18. A 4 Ω resistance wire is doubled on it. Calculate the new resistance of the wire.

We are given, R = 4 Ω.
When a wire is doubled on it, its length would become half and area of cross-section would double. T
So, a wire of length l and area of cross-section A becomes of length l/2 and area of cross section 2A. we have R = ρ(l/A)
R1 = ρ((l/A) / 2A) where R1 is the new resistance.
Therefore, R1/R = ρ((l/A)/2A) / ρ(l/A) = 1/4
Or, R1 = R/4 = 4Ω/4 = 1Ω
The new resistance of the wire is 1 Ω.

19 A circuit is made of 0.4 Ω wire,a 150Ω bulb and a 120Ω rheostat connected inseries.Determine the total resistance of the resistance of the circuit.

Resistance of the wire = 0.4Ω
Resistance of bulb = 150Ω
Resistance of rheostat = 120Ω
In series, Total resistance ,
R = 0.4 + 150 +120 = 270.4Ω

20. A current of 0.2 Ampere flows through a conductor of resistance 4.5 Ω. Calculate the potential difference at the ends of the conductor.

The potential difference at the ends of the conductor. = V = IR = 0.2 x 4.5 = 0.9 V

21. A lamp has a resistance of 96 ohms. How much current flows through the lamp when it is connected to 120 volts?

I = V/R = 120/96 = 1.25 A [V = IR]

The current through the lamp equals 1.25 A.'

22. The manufacturer specifies that a certain lamp will allow 0.8 ampere of current when 120 volts is applied to it. What is the resistance of the lamp?

V = IR So, R = V/I = 120/0.8 = 150 W

23. How much voltage is required to cause 1.6 amperes in a device that has 30 ohms of resistance?

Given: V = IR = 1.6 x 30 = 48 V

24. How much power is dissipated when 0.2 ampere of current flows through a 100-ohm resistor?

P = V I = IR x I = I2 R = 0.2 x 0.2 x 100 = 4 W

10. Describe an experiment to show that when two dissimilar dielectrics are rubbed together, they acquire equal but opposite charge.

- *Wool is wrapped round on end of a polythene rod and several turns of thread wound over wool. The loose end of the thread is pulled so that the wool rubs the polythene making sure that the hands do not touch the wool.*
- *The end of the rod with wool is inserted in the metal can place on neutral electroscope.*

No divergence is observed.

- *When the polythene is carefully pulled out to leave the wool, a divergence of the leaf of electroscope is observed.*
- *The wool is then withdrawn and the electroscope discharged, when the rod is placed inside the can, the electroscope is observed to diverge to the same extent as before.*
- *Therefore two dissimilar dielectric have acquired equal but opposite charges.*

11. (a) Define the following

(i) Capacitance

It is the ratio of the magnitude of a charge on either plates of a capacitor to the potential difference between the plates.

Or It is the magnitudes of charge on a conductor to potential of the conductor.

(ii) Relative permittivity

It is the ration of the permittivity of a material to permittivity of free space.

12. (a)(i) State the law of conservation of current at a junction in an electric circuit.

Law of conservation of current at a point/junction states that the total current flowing through a junction is equal to the total current flowing out of a junction.

(ii) Explain why current from a battery is greater when bulbs are connected in parallel than when they are in series across a battery. (03marks)

The effective resistance across the bulbs is smaller when the bulbs are in parallel than when they are in series. Since the current is a ratio of p.d to resistance the current is higher when the bulbs are connected in parallel than when connected in series.

13. Define electrical resistivity and the ohm.

Electrical resistivity is the electrical resistance across opposite faces of a cube of a material of length 1m

Units is Ohm-meter (Ωm)

An Ohm is the resistance of a conductor through which 1 ampere flows when the potential difference across it is 1 volt.

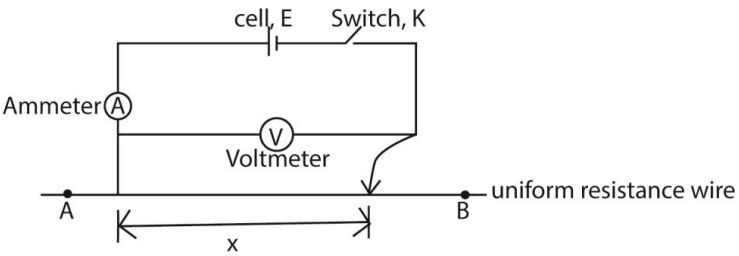
14. State ohm's law

Ohm's law states that the current flowing through a given conductor is directly proportional to the potential different difference between its ends provided the physical conditions remain constant.

15. State the factors which affect the resistance of a conductor.

- *Length of a conductor*
- *Cross-section area of the conductor*

16. Describe an experiment to determine the resistivity of the material of a wire using an ammeter, meter rule and voltmeter



3. **(a) (i) Define temperature coefficient of resistance and state its units.**

The temperature coefficient of resistance is the fractional change in resistance at 00C for very degree Celsius rise in temperature.
Units is K^{-1}

(ii)Explain why temperature coefficient of resistance is positive for metals.
The resistance of a metal increases with increase in temperature because when the temperature increases, the atoms of the metal vibrate with higher amplitude reducing the mean free path for conduction of electrons.
17. (a) (i) What is meant by capacitance of a capacitor?
Capacitance of a capacitor is the ratio of the magnitude of charge on either plates of a capacitor to the capacitor to the potential difference between the plates

18. State four uses of capacitors

19. A parallel plate capacitor is connected across a battery and charged fully. When a dielectric material is now inserted between its plates, the amount of charge stored in the capacitor changes. Explain the change.

- *When a dielectric is inserted between the plates of a charged capacitor, its molecules get polarized. The surfaces of the dielectric thus develops charges opposite to those on adjacent capacitor plates.*
- *Electric field intensity develops between the faces of the dielectric in the opposition of the applied field and this reduces the electric field between the plates.*
- *Since the p.d is now less than the terminal p.d of the battery, more charges are conducted to the capacitor until the p.d is again equal to that of the battery. Hence charge on the capacitor increase.*

b).**Give any three factors that influence the capacitance of parallel -plate capacitor**

The three factors which affect the capacitance of a parallel-plate capacitor are the area of the plates, the distance apart of the plates and the nature of the insulating material or dielectric between them.

20. (a) **What is the meaning of a secondary cell**

An electric cell that can be rechargeable and can therefore be used to store electrical energy in the form of chemical energy is called secondary cell.

b) Give two types of secondary cells

Some examples of secondary cells include a lead-acid accumulator, nickel cadmium (NiCd), nickel metal hydride (NiMH), lithium ion (Li-ion) etc.

CHAPTER SIXTEEN

LIGHT

1. Define the following terms

(a) radius of curvature

The radius of the hollow sphere of which the spherical mirror is a part is called the radius of curvature of the spherical mirror.

In other words, the distance between the pole and centre of curvature of the spherical mirror is called its radius of curvature.

(b) Focal length of lens

The distance between the optical center of the concave lens and the principal focus is called the focal length.

(c) Magnification in lens

The magnification of a lens is defined as the ratio of the height of an image to the height of an object. It is also given in terms of image distance and object distance. It is equal to the ratio of image distance to that of object distance.

(d) Power of lens

The ability of a lens to bend the light falling on it is called the power of a lens. The power of a lens is defined as the reciprocal of the focal length. Lens power is measured in dioptres (D). Converging (convex) lenses have positive focal lengths, so they also have positive power values.

Since the lens of shorter focal length will bend the light rays more will have more power. A convex lens converges the light rays towards the principal axis whereas a concave lens diverges the light rays away from the principal axis.

2. **State three possible reasons under which an image of real object may not be formed by a convex lens on the screen.**

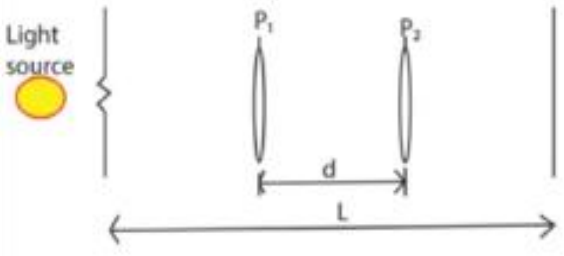
- *When the object is placed between the lens and optical center.*
- *When the distance between the object and the screen is four times the focal length of the lens*
- *When the object is at the principal focus*
- *When the screen is between the lens and its principal focus.*

2. An object is placed 30cm in front of a concave mirror of focal length 20cm

(a) Determine the position of the image formed

(b) State with reason the nature of image

(b) Describe an experiment to determine the focal length of a convex lens fixed inside a short cylindrical tube



- The tube is placed between an illuminated object and a screen a distance l slightly more than 4 times the approximate focal length of a lens to form a clear magnified image at the screen. The position of the front part P_1 is noted

- The tube is moved towards the screen until a clear diminished image is formed on the screen and position P_2 of the front part is noted

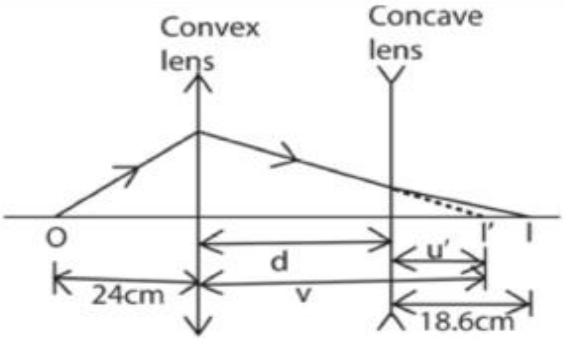
- The displacement, $d = P_2 - P_1$ is noted

The focal length, f of the lens $= \frac{l^2 - d^2}{4l}$

(c) A convex lens of focal length 10cm is arranged coaxially with a concave lens of focal length 18cm. the lens system is

used to focus an object placed 24cm from the convex lens on the side remote from the concave lens. the final image is formed on a screen placed 18.6cm from the concave lens. Calculate the;

(i) separation between the lenses.



Let the separation between the lenses be d.

For convex lens

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{10} = \frac{1}{24} + \frac{1}{v}$; v = 17.14cm

For concave lens

$\frac{1}{-18} = \frac{1}{u'} + \frac{1}{18.6}$, u' = -9.15cm (-ve because object is virtual)

Separation, d = v-u' = 17.14 – 9.15 = 7.99cm

(ii) Magnification (03marks)

$M = M_1 \times M_2$

$= \frac{v}{u} \times \frac{v'}{u'}$

$= \frac{17.14}{24} \times \frac{18.6}{9.15} = 1.45$

2. (a) (i) State the laws of refraction of light.

- *The incident ray, refracted ray and the normal at the point of incidence all lie in the same plane*
- *The ratio of the angle of incidence to the sine of angle of refraction is constant for a given pair of media.*

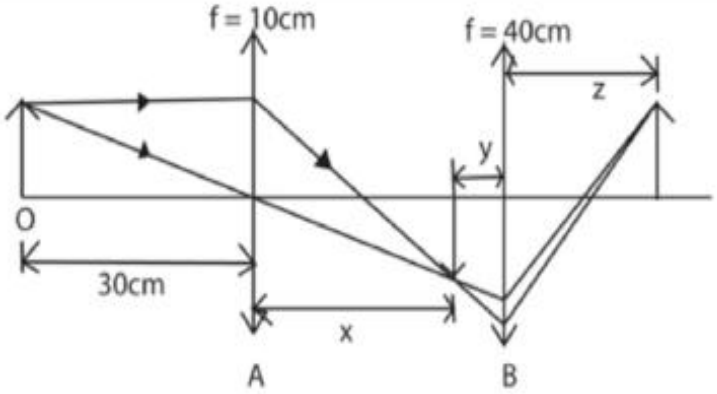
3. (a) State Snell's law

Snell's law, also known as the law of refraction, is a law stating the relationship between the angles of incidence and refraction, when referring to light.

The Snell's law of refraction states that: The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant for the pair of the given media.

b) a ray of light passes from air into water at an angle of 60°c. Determine the angle of refraction .(Take refractive index of water as 4/3)

(ii) A small object is placed at a distance of 30.0cm from a converging lens of focal length 10.0cm. Calculate the distance from the first lens where a second converging lens of focal length 40.0cm must be placed in order to produce an erect image of the same size as the object.



$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{10} = \frac{1}{30} + \frac{1}{x}; \; x = 15\text{cm}$$

Magnification, $M_1 = \frac{v}{u} = \frac{15}{30} = \frac{1}{2}$

Magnification, $M_2 = \frac{z}{y}$

But $m = M_1 \times M_2$

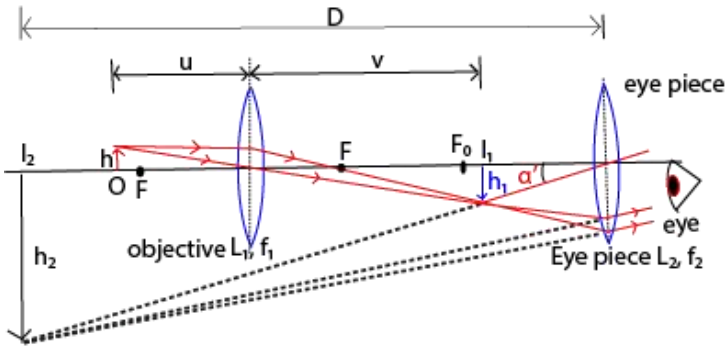
$$1 = \frac{1}{2} \times \frac{z}{y}; \; z = 2y$$

Action of second lens

$$\frac{1}{40} = \frac{1}{y} + \frac{1}{2y}; \; y = 60\text{cm}$$

Position = x + y= 15 + 60 = 75cm from the first lens

(b) (i) Draw a diagram to show the formation of an image by a compound microscope in normal adjustment and use it to derive an expression for the magnifying power.



Compound microscope in normal use

Linear magnification can also be expressed as, $m = \frac{h_2}{h} \times \frac{h}{h_1} = m_e \times m_o$.

Where, m_e and m_o are linear magnifications of the eye piece and objective lenses respectively.

$m_o = \frac{v}{f_o} - 1$ and $m_e = \frac{-D}{f_e} - 1$

$m = (\frac{-D}{f_e} - 1)(\frac{v}{f_o} - 1)$

(ii) A microscope has an objective of focal length 10.0cm and eye piece of focal length 20.0cm. If the distance between the objective and eye piece is 20 cm, calculate the magnifying power of the microscope.

Given, $f_0 = 10cm$, $f_e = 20$, $D = -25cm$

$v_0 + v_e = 20.0cm$

Using eye piece lens;

$$\frac{1}{f_e} = \frac{1}{u_e} + \frac{1}{D}$$

$$\frac{1}{20} = \frac{1}{u_e} + \frac{1}{-25}$$

$$u_e = 11.11$$

$$v_o + u_e = 20$$

$$v_0 = 20 - 11.11 = 8.89cm$$

$$\text{Using } m = \left(\frac{-D}{f_e} - 1\right)\left(\frac{v}{f_0} - 1\right) = \left(\frac{-25}{20} - 1\right)\left(\frac{8.89}{10} - 1\right) = 0.2475$$

(c) What is meant by the following:

(i) total internal reflection

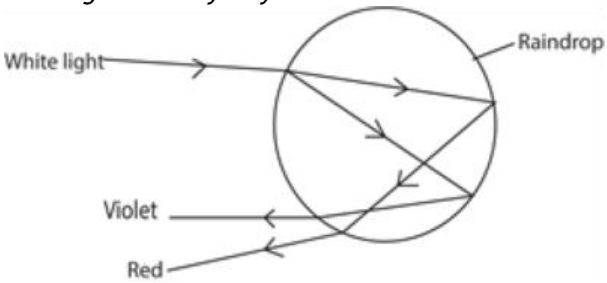
Total internal reflection is the bouncing back of all incident light into the more dense medium when the angle of incidence exceeds the critical angle for a ray originally travelling from the more dense to a lens dense medium.

(ii) critical angle (01mark)

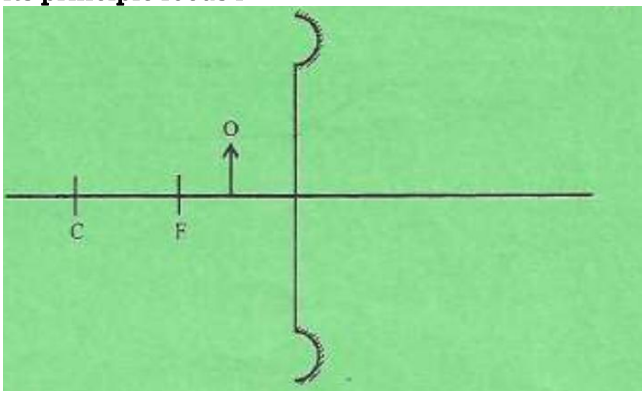
Critical angle is the angle of incidence in more optically denser medium for which the angle of refraction in the less dense medium is 90^0.

(d) Briefly explain why an observer sees a spectrum of colors through rain drops when it is raining on a sunny day. (02marks)

White light from the sun undergoes dispersion as it enter into the rain drops of water in the sky. Total internal reflection takes place at the opposite side of the rain drop and different colors emerge from the raindrop after refraction. Hence the observer sees a spectrum of colors through raindrops when it is raining on sunny day.



3. **the figure below represents a diagram drawn to scale showing an object O placed in front of a concave mirror and its principle focus F**



a. Copy and complete the diagram to show the image formed
b. State one characteristic of the image formed above

4. A river whose real depth 16m appear to be 12m deep. Calculate the refractive index of the water in the river.

6.An image is place 10cm in front of a convex lens of focal length 15cm . Calculate the

a. Image distance

b.Magnification

6. **A spherical mirror with a focal length of 20cm forms a magnified image four times the size of the object on the screen**

(a) with a reason , state the kind of mirror used

(b) determine the object distance from the mirror

3. (a) Define the following as applied to telescope

- **Eye-ring (01marks)**

Eye-ring of a telescope is the image of objective formed by the eyepiece.

- **Magnifying power(01mark)**

Magnifying power is the ratio of the angle subtended by the final image at the eye when using the telescope to the angle subtended by the object at unaided eye.

(b) What is the significance of the eye-ring of an astronomical telescope?

It is the best position for best view in a telescope

(c) State two advantages of a reflecting telescope over a refracting telescope

- *there is no chromatic aberration*
- *there is no spherical aberration*
- *it is relatively cheap since only one face of the objective needs grinding*
- *Has high resolving power since the objective may have a high field of view.*
- *The image is brighter.*

(d) The figure below shows an optical system consisting of two thin converging lenses arranged coaxially. Lens A has a focal

length of 40mm and lens B has a focal length of 375mm. an object O of height 5mm is placed 50mm from A. I_1 is the real image of O and I_2 is the virtual image of I_1 in B and is 250mm from B.

(i) Determine the value of distance, Y of image I_1 from lens A

$$\text{Using } \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\Rightarrow \frac{1}{40} - \frac{1}{50} = \frac{1}{y}; \; y = 200\text{mm}$$

(ii) Calculate the distance, x, between the images I_1 and I_2.

$$\frac{1}{u} = \frac{1}{f} - \frac{1}{v}$$

$$= \frac{1}{375} - \frac{1}{(-250)}$$

$$u = 150\text{mm}$$

$$\text{distance } x = v\text{-}u = 250 - 150 = 100\text{mm}$$

(iii) Find the linear magnification produced by the lens system.

$$M = M_1 \times M_2 = \frac{200}{50} \; x \; \frac{250}{150} = 6.7$$

(e) Name one defect of the image formed by a lens and explain how the defect is minimized in practice.

(i) Chromatic aberration can be minimized by placing the eye very close to the lens. This insures that images due to different colors subtend the same angle at the eye. Or by use of chromatic doublet in which the dispersion produced by one lens is reversed by another.

Or

(ii) Spherical aberration can be minimized by using a stopper which allows only central rays to form a sharp image. Or by grinding the lens to suitable shape. Or using a narrow aperture

(f) Explain the following

(i) total internal reflection

If a ray of light is incident from a denser to less dense medium, there is partial reflection and partial refraction. When the angle of incidence exceeds the critical angle, all the incident light is reflected back into the denser medium. This is called total internal reflection.

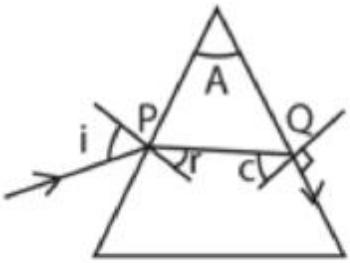
(ii) Formation of mirages

On a hot day, layer on air near the ground are hotter and lens dense than layers above. This leads to total internal reflection of rays of light from the sky. And mirage is the image of the sky to the eye by total internal reflection

4. (a) State the laws of refraction of light.

- *The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane*
- *The ratio of the sine of angle incidence to the angle of refraction is constant for a given pair of the media.*

(b) **A ray of light is refracted through a prism in a plane perpendicular to its edge. The angle of incidence is 30^0 and the refractive index of the prism is 1.50. Calculate the angle of the prism such that the ray does not emerge when it strikes the second face.**



At P

$r = \sin^{-1}(\frac{\sin 30}{1.5}) = 19.5^0$

At Q

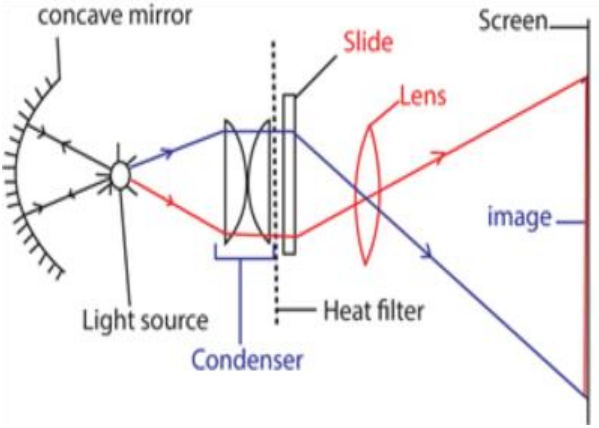
$c = \sin\text{-}1\ (\frac{1}{1.5}) = 41.8^0$

Angle of the prism = c + r = 19.5 + 41.8 = 61.3^0

(d) (i) Describe with the aid of a labelled diagram, the structure and operation of projection lantern.

A **projector** is an instrument used to produce a large image of a small object.

- *The slide, or film, is placed behind the **projector** lens outside its focal length and is illuminated buy a small but powerful source of light from concave reflector through condensing lenses.*
- *A magnified, real and inverted image on the screen*



$$\text{Area magnification} = \frac{Area\ of\ the\ image}{Area\ of\ the\ object}$$

(ii) A projector produces an image of area $2m^2$ on a screen placed 5m from the projection lens. If the area of the object slide is $8cm^2$, calculate the focal length of the projection lens.

$$\text{Area magnification} = \frac{Area\ of\ the\ image}{Area\ of\ the\ object} = \frac{2}{8\ x\ 10^{-4}} = 2500$$

$$\text{Linear magnification} = \sqrt{2500} = 50$$

$$\text{From } M = \frac{v}{f} - 1$$

$$50 = \frac{5}{f} - 1$$

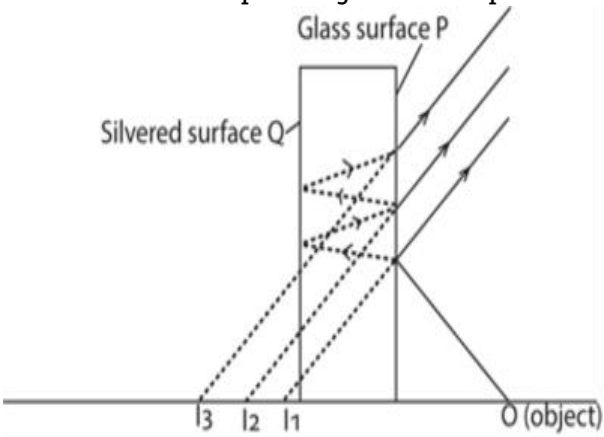
$$f = \frac{5}{51} = 0.098m = 9.8cm$$

5. (a) (i) State two differences between real and virtual images

A real image is formed by actual intersection of rays and can be formed on a screen while virtual image is formed by apparent intersection of rays and cannot be formed on a screen.

(ii) Explain with the aid of a diagram how thick plane mirror forms multiple images (04marks)

Formation of multiple images in thick plane mirror



Multiple images are formed due to partial reflection and refraction at the non-silvered surface of the mirror.

- *İmage I_1 is formed by reflection on the glass surface P*
- *The image I_2 (the brightest is formed by reflection of the most light on the silvered surface Q*
- *Others by partial refraction*

(b) A convex mirror forms a real image which is three times the linear size of the object. When the object is displaced though a distance y, the real mage formed is four times the linear size of he object. If the distance between the two image positions is 20 cm, find the

(i) focal length of the mirror

$M_1 = \frac{v_1}{f} - 1$ and $M_2 = \frac{v_2}{f} - 1$

$M_2 - M_1 = \frac{v_2 - v_1}{f}$

$4 - 3 = \frac{20}{f}$

f = 20cm

(ii) distance, y. (03marks)

Also $\frac{1}{M} = \frac{u}{f} - 1$

$\frac{1}{3} = \frac{u_1}{f} - 1$

$\frac{1}{4} = \frac{u_2}{f} - 1$

$\frac{1}{3} - \frac{1}{4} = \frac{u_1 - u_2}{f} = \frac{y}{20}$

y = 1.67cm

7. **(a) Define the following as applied to a converging lens;**

(i) Principal focus

The principal focus of converging lens is the point on the principal axis to which paraxial rays converge after refraction from the lens.

(ii) center of curvature

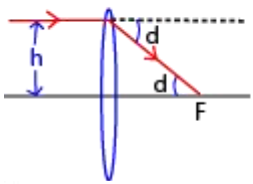
The center of curvature of lens is the center of the sphere of which one of the spherical surfaces of the lens form part.

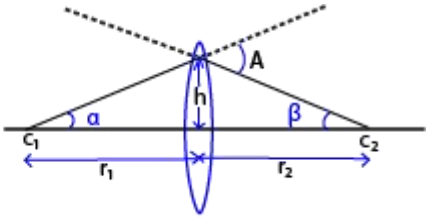
(b) Find the power of a lens of focal length 15 cm

Power of lens = $\frac{1}{f(m)} = \frac{1}{0.15} = 6.67D$

(c) Derive an expression for focal length of a lens in terms of the radii of curvature of its surfaces and refractive index

Consider a ray parallel to the principal axis, incident at height, h.





$\tan d = \frac{h}{f}$ d is small in radian, $d = \frac{h}{f}$ ..... (i)

For small angle prisms d = (n-l) A ..... (ii)

From the diagram above, $\alpha + \beta = A$ ..... (iii)

For small angle

$A \approx \tan\alpha = \frac{h}{r_1}$ and $\beta \approx \tan\beta = \frac{h}{r_2}$

Substitution α and β in equation (iii)

$\left(\frac{h}{r_1} + \frac{h}{r_2}\right) = A$ ..... (iv)

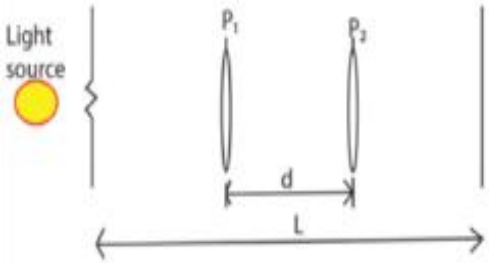
Substituting equation (i) and (iv) in equation (ii)

$\frac{h}{f} = (n-1)\left(\frac{h}{r_1} + \frac{h}{r_2}\right)$

Dividing by h

$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$

(d) Describe an experiment to determine the focal length of a thin converging lens mounted inside a short cylindrical tube.



- The tube is placed between an illuminated object and a screen a distance l slightly more than 4 times the approximate focal length of a lens to form a clear magnified image at the screen. The position of the front part P_1 is noted

- The tube is moved towards the screen until a clear diminished image is formed on the screen and position P_2 of the front part is noted

- The displacement, $d = P_2 - P_1$ is noted

The focal length, f of the lens $= \frac{l^2 - d^2}{4l}$

(e) A compound microscope consists of two thin lenses, an objective of focal length 1.0cm and eye piece of focal length 5.0cm. The objective forms an image of an object placed in front of it at a point 16.0cm away. If the final image is formed at the near point of the eye, calculate the

(i) Separation of the lenses

Consider the eyepiece lens, using $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{5} = \frac{1}{u_e} + \frac{1}{-25}$; $u_e = 4.17m$

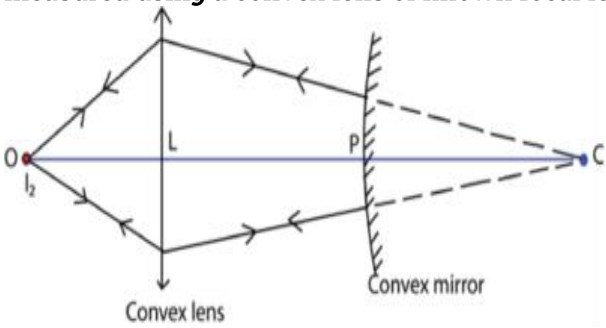
Separation of lenses = $v_o + u_e = 16.0 + 4.17 = 20.17cm$

(ii) magnifying power of the instrument

$$M = \left(\frac{-D}{f_e} - 1\right)\left(\frac{v}{f_0} - 1\right) = \left(\frac{-25}{5} - 1\right)\left(\frac{1}{1} - 1\right) = -90$$

7. (a) (i) Describe how the focal length of a convex mirror can be measured using a convex lens of known focal length. (04marks)

Determination of the focal length of a convex mirror can be measured using a convex lens of known focal length.

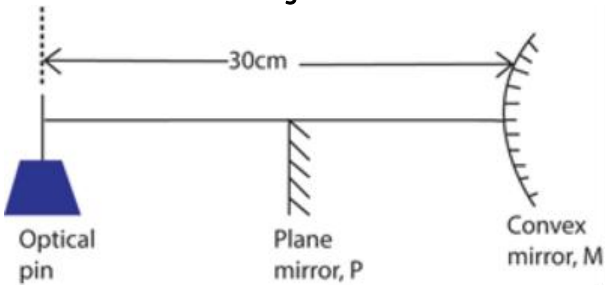


- *The apparatus is arranged as shown above*
- *An object, O is placed in front of a convex lens L and its image formed at C*
- *The distance LC is measured and recorded.*
- *The convex mirror whose focal length, f, is required is placed is placed between L and C with its reflecting surface facing the lens.*
- *The lens is then moved along the axis, OC until a converging beam incident normally on the mirror forms its image at O*
- *Distance LP is measured*

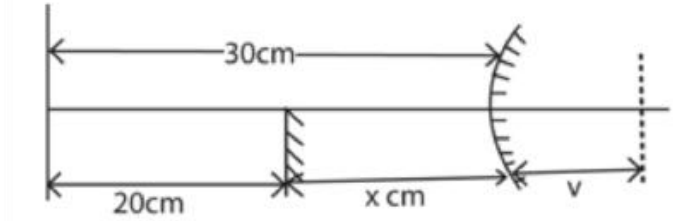
PC = LC – LP thus, f can be determined from

$$f = \frac{PC}{2}$$

(ii) The plane mirror, P, in the figure below is adjusted to a position20cm from optical pin, the image of the pin in P coincides with its image in M.



Calculate the focal length of the convex mirror.



$v = 20 - x$

$= 20 - (30\text{-}20) = 10\text{cm}$

Using $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

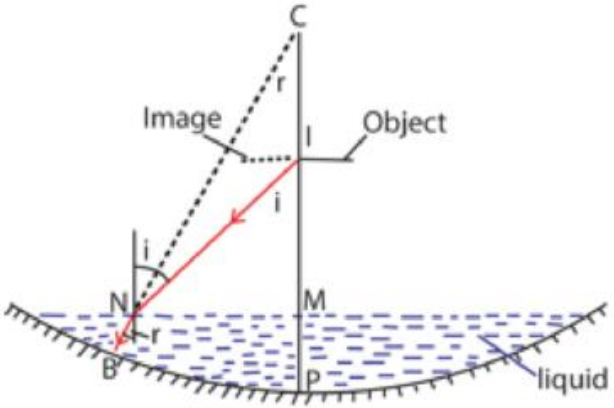
$= \frac{1}{30} + \frac{1}{-10}$

$f = 15\text{cm}$

(b) A pin is clamped horizontally above a concave mirror with its tip along the principal axis. When the pin is adjusted, it coincides with its image at a distance R from the mirror. When a small liquid of refractive index, n, is put on the mirror, the pin again coincides with its image at a distance R' from the mirror. Show that the refractive index, n, is given by

$$n = \frac{R}{R'}$$

Setup



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

From the diagram,

$\sin i = \frac{NM}{NI}$ and $\sin r = \frac{NM}{NC}$

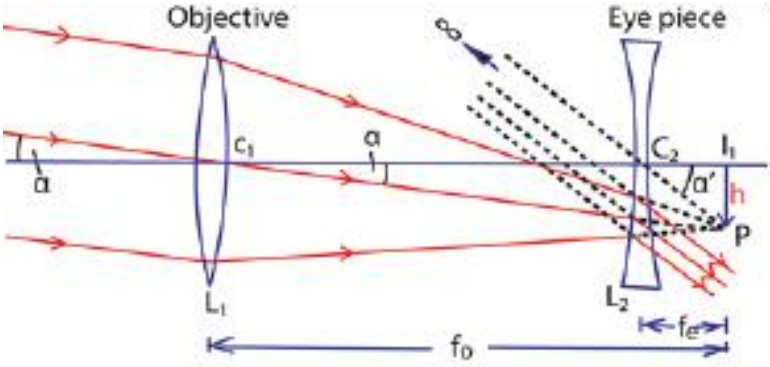
$n = \frac{NM}{NI} \div \frac{NM}{NC} = \frac{NM}{NI} \times \frac{NC}{NM} = \frac{NC}{NI}$

For small angle, i, and small liquid

$NC \approx PC = R$ and $NI \approx PI = R'$

Thus, $n = \frac{R}{R'}$

(c) Draw a ray diagram to show the formation of final image in Galilean telescope in normal adjustment.



Galilean telescope in normal adjustment

(iii) Explain two advantages and one disadvantage of the telescope in (c)(ii) above.

Advantages of a Galilean telescope

It forms a final erect image.

It is shorter than the terrestrial and astronomical telescopes because the separation of lenses is

f_0-f_e.

Disadvantages of a Galilean telescope

It has a small field of view.

It has a virtual eye ring not accessible to the observer

8. (a)(i) When does light pass through a prism symmetrically?

Light is said to pass through a prism symmetrically when the angle of incidence is equal to the angle of emergence or when minimum deviation occurs.

(ii) Find the angle of incidence, i, on an equilateral prism of refractive index 1.5 placed in air, when light passes through it symmetrically.

From Snell's law, $1.5 = \frac{\sin i}{\sin r}$

But, $r = \frac{A}{2} = \frac{60}{2} = 30^0$

$\sin i = 1.5 \sin 30^0$

$i = 48.6^0$

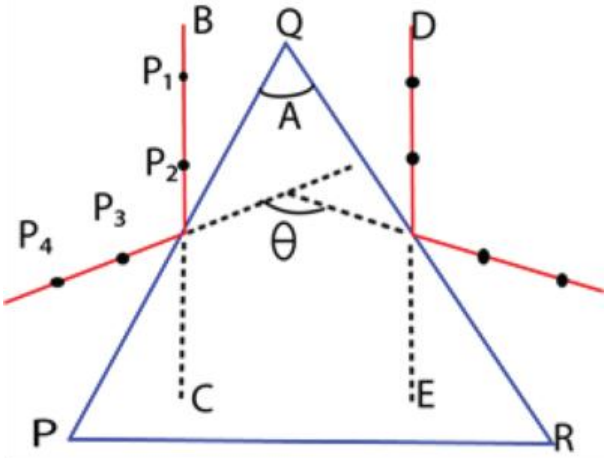
(iii) Describe what happens to the deviation of light passing through a prism in (a) (ii) when the angle of incidence is increased from a value less than i to a value greater than i.

Angle of deviation increases when either angle i is increased or decreased.

(b) Describe how the refractive angle of a prism can be determined using optical pins.

Using optical pins

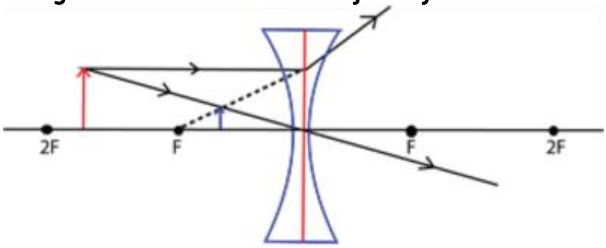
A white paper is stuck to the soft board using top-headed pins. Two parallel lines AB and DC are drawn on the paper and the prism is placed with its apex as shown.



- *Two optical pins P1and P2 are placed along AB and pins P3 and P4 are placed such that they appear to be in line with the images of P1and P2 as seen by reflection from face P*
- *The procedure is repeated for face The prism is removed and angle θ is measured..*

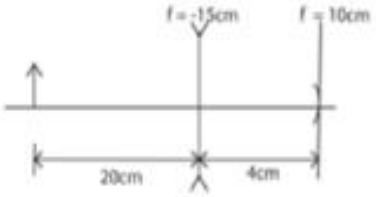
The required refracting angle A = θ/2

(c) **(i) Draw a sketch ray diagram showing formation of the image of a finite size real object by a concave lens.**



(ii) A concave lens of focal length 15.0cm is arranged coaxially with a concave mirror of focal length 10.0cm, a distance of 4.0cm apart. An object is placed 20.0cm in from of the lens on

the side remote from the mirror. Find the distance of the final image from the lens.



Action of concave lens

$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-15} - \frac{1}{20}$

$v = \frac{-60}{7} = -8.6cm$

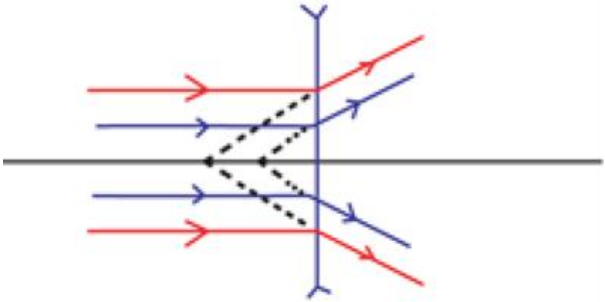
Action of concave mirror

u = 8.6 + 4 = 12.6cm, f = 10

$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{10} - \frac{1}{12.6}$; u = 48.5cm

Distance of image from the lens = 48.5- (20 + 4) =24.5 cm on the side remote to the mirror

(d) With the aid of a sketch ray diagram explain spherical aberration in a concave lens, and state how it is minimized. (03marks)

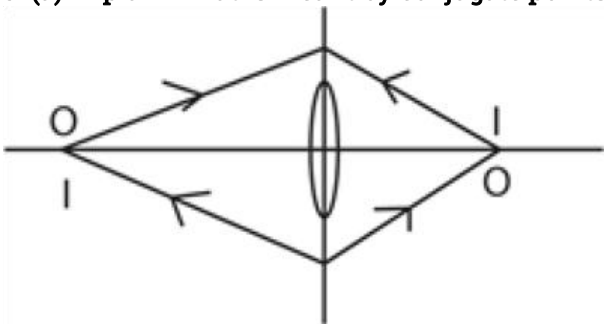


Concace lens

When a wide beam of light falls on the lens, marginal rays are refracted and appear to come from a point different from that of the central rays.

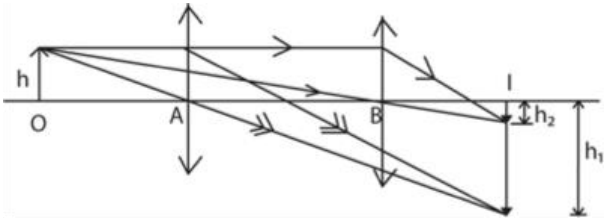
The image formed is thus blurred (distorted). This is called spherical aberration. It is minimized by using an opaque disc with central hole to allow only central rays to pass through

9. (a) Explain what is meant by conjugate points.



These are two points, O and I. each on the opposite side of a convex lens such that an object and its image at these points are interchangeable.

(b) A converging lens forms an image of height, h_1 on a screen of an object O of height, h. When the lens is displaced towards the screen, an image of height, h_2 is formed on the screen.
(i) Sketch a ray diagram to show the formation of the images on the screen.



(ii) Show that $h = \sqrt{h_1 h_2}$ (04marks)

O and I are conjugate points with respect to the lens

OB = AI and OA = BI

At point A, linear magnification, $Ma = \frac{AI}{OA} = \frac{h_1}{h}$ ..... (i)

At point B, linear magnification, $Mb = \frac{BI}{OB} = \frac{h_2}{h}$ ..... (ii)

But AI = OB

$$\frac{h}{h_1} = \frac{h_2}{h}$$

$h^2 = h_1 h_2$

$h = \sqrt{h_1 h_2}$

(d) The objective of astronomical telescope in normal adjustment has a diameter of 150mm and focal length of 3.0m. The eyepiece has focal length of 25.0mm. Calculate

(i) the position of the eye ring (03marks)

$u = f_0 + f_e = 3000 + 25 = 3025mm$

$f = f_e = 25mm$

From $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{25} = \frac{1}{3025} + \frac{1}{v}$; $v = 25.2mm$

∴ position of eye-ring = 25.2mm

(ii) diameter of the eye-ring (03marks)

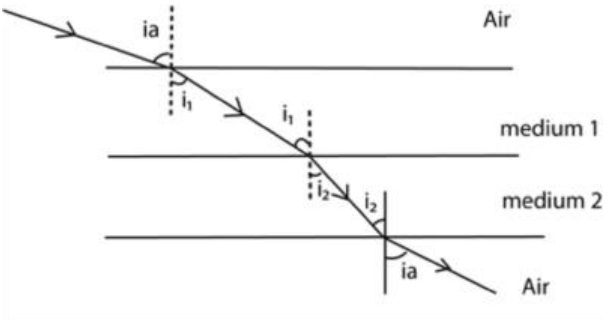
Angular magnification, $M = \frac{diameter\ of\ objective}{diameter\ of\ eye-ring} = \frac{f_e}{f_0}$

$\frac{150}{D_e} = \frac{3000}{25}$

$D_e = 1.25mm$

(c) Give one advantage of placing the eye at the eye-ring
A clearest image is observed.

10. (a) show that for a ray of light passing through layers of transparent media separated by parallel boundaries, nsini = a where a is a constant and n is the refractive index of the medium containing angle i.
Consider a ray of light moving from air through a series of media **1, 2** and then finally emerge into air as shown.



At air – medium 1 interface, Snell's law gives $\frac{\sin i_a}{\sin i_1} = n_1$

⇨ Sin i_a = $n_1$sin i_1 ..... (i)

At air – medium 2 interface, Snell's law gives $\frac{\sin i_a}{\sin i_2} = n_2$

⇨ Sin i_a = $n_2$sin i_2 ..... (ii)

Equating equation (i) and (ii) gives

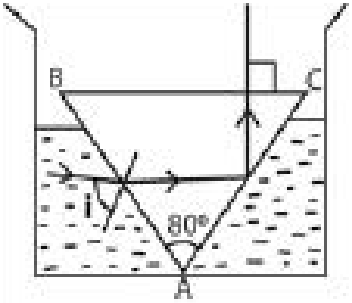
$n_1 \sin i_1 = n_2 \sin i_2$.

∴ **n sin i = a constant.**

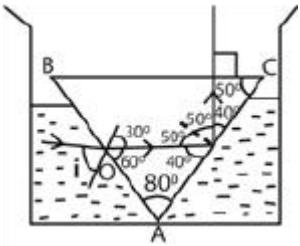
(b) (i) What is meant by critical angle?

Critical angle is the angle of incidence in a denser medium for which the angle of refraction in a less dense medium is 90^0.

(c) The figure below shows an isosceles prism ABC of refractive index 1.51, dipped in a liquid with refractive edge downwards. A ray of light incident on the prism at an angle i = 34.6^0 emerges perpendicularly through the base.

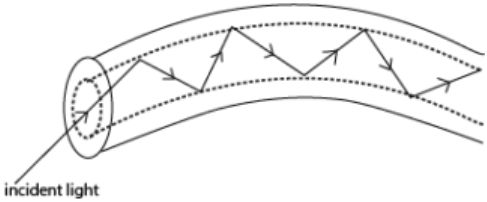


(i) **Calculate the refractive index of the liquid (04marks)**
Solution



The angles are represented on the diagram above, r = 30^0
From nsin i = constant
nsin34.6 = 1.51sin30
n = 1.33

(d) **Explain how an optical cable transmits light.**



An optical fiber is made of a transparent material coated with another less optically dense material. Light entering the pipe strikes the boundary of the media at an angle of incidence

greater than the critical angle. Total internal reflection thus occurs. This takes place repeatedly in the pipe until the light beam emerges from the pipe.

(e) An optical pin held above a concave mirror containing water of refractive index 1.33, coincides with its image at a distance of 12cm above the mirror. When the water is replaced by a little quantity of a certain liquid, the point of coincidence of the object and the image becomes 13.3cm. Calculate the refractive index of the liquid.

Let the radius of curvature of the mirror be r

$$\eta_w = \frac{r}{h_w} \text{ and } \eta_l = \frac{r}{h_l}$$

$$\Rightarrow \frac{\eta_l}{\eta_w} = \frac{h_w}{h_l}$$

$$\Rightarrow \frac{\eta_l}{1.33} = \frac{12}{13.3}$$

$$\eta_l = 1.2$$

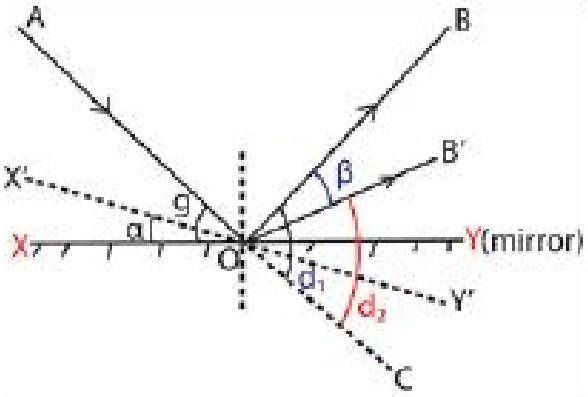
11. (a) (i) State the laws of reflection of light.

- *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*

(ii) A ray of light is incident on a plane mirror. The mirror is then turned through an angle α keeping the direction of the incident ray constant. If a reflected ray turned through angle β, find the relationship between α and β.

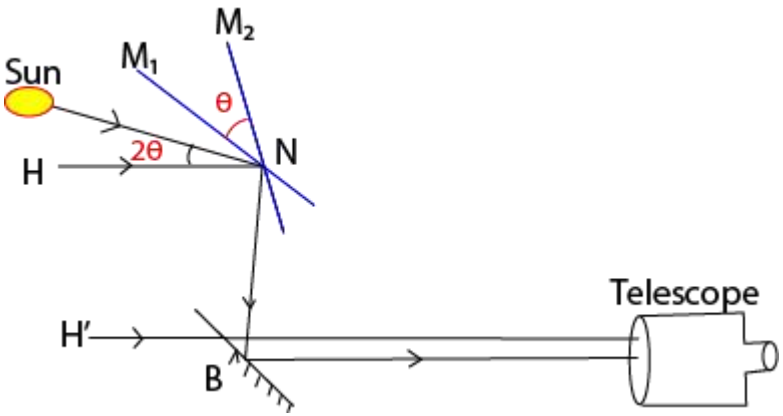
Let XY be the initial position of the mirror with ray AO making a glancing angle g. By keeping the direction of the incident ray

fixed, the mirror is rotated through an angle ***α*** *to a new position X'Y' as shown.*



Case 1 (mirror in position XY)
Glancing angle = g
Deviation $d_1 = 2g$..... (i)
Case 2**(mirror in position X'Y')**
Glancing angle = $(g - \alpha)$
Deviation $d_2 = 2(g - \alpha)$ .....(ii)
$\beta = d_1 - d_2$
$= 2g - 2(g - \alpha)$
$= 2g - 2g + 2\alpha$
$= 2\alpha$

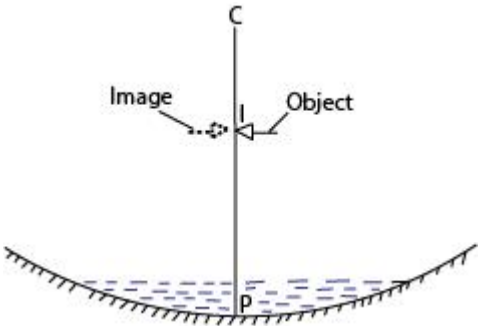
(b) **Describe how a sextant is used to determine the angle of elevation of a star.**
Setup



- *A sextant consists of a fully silvered mirror M1 which can be rotated about a horizontal axis and a fixed half silvered mirror B.*
- *Mirror M1 is adjusted to become parallel to B by rotating it until the image of the horizon, H' is seen directly through the unsilvered part of mirror B by successive reflection in mirror M_1 and B respectively*
- *The mirror M_1 is rotated to position M_2 such that the image of the horizon H, and the sun coincides at H'*
- *The angle of rotation is measured from the scale on the instrument. The elevation of the sun is 2θ.*

(c) ***Describe an experiment to determine the refractive index of a small quantity of a liquid using a concave mirror.***

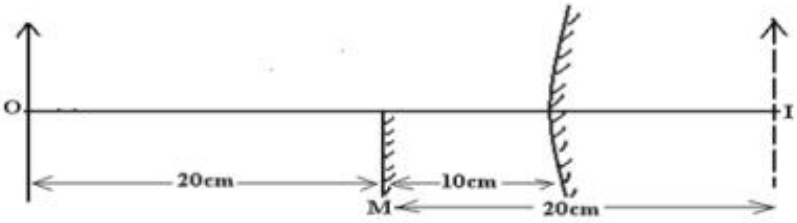
An experiment to determine refractive index of a liquid using a concave mirror



- *A clamped pin with its tip along the principal axis above the concave mirror is coincided with its image at C and distance PC is measured*
- *A small quantity of the liquid under test is poured into a concave mirror and a new point I at which the object pin coincides with its image is obtained.*
- *Distance IP is measured.*
- *The required refractive index of a liquid,*

$$n_l = \frac{PC}{IP}$$

(d) **A plane mirror is placed 10cmin front of a convex mirror so that it covers about half of the convex mirror surface. A pin placed 20cm in front of the plane mirror gives an image which coincides with that of the pin in the convex mirror. Find the focal length of the convex mirror.**



Consider the action of a convex mirror

u = 30cm and v = - (20 - 10) = -10cm "The image formed is virtual "

Using the lens formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ give

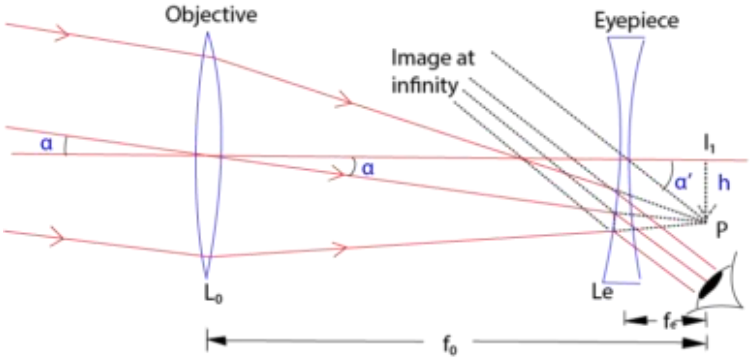
Image distance v of the lens = $\frac{fu}{u-f} = \frac{-10\,x\,30}{30-10} = -15cm$

12. (a) Define angular magnification of an optical instrument.

This is the ratio of the angle subtended at the eye by the image when using an instrument to the angle subtended at unaided eye by the object.

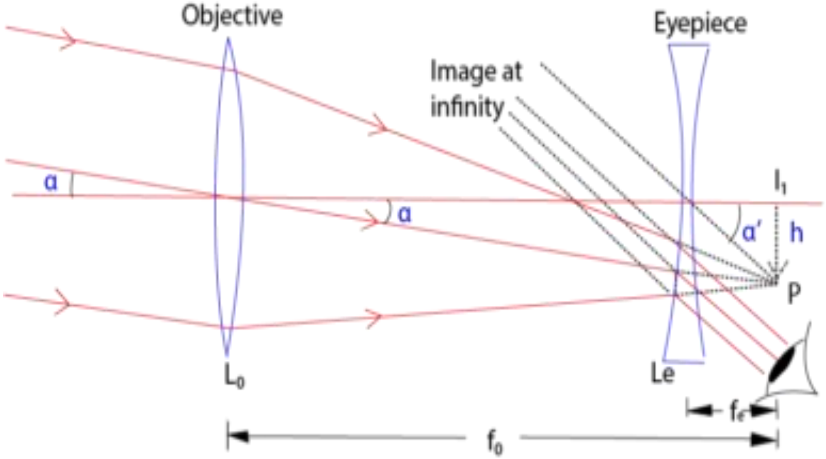
$$M = \frac{\alpha'}{\alpha} \text{ where } \alpha' \text{ and } \alpha \text{ are in radians}$$

(b) (i) Describe with the aid of a ray diagram, the operation of telescope made of a converging lens and a diverging lens when used in normal adjustment.



Galilean telescope

Light from distant object incident on objective lens is refracted to form real inverted image at its principal focus f_0. In normal adjustment, the principal focuses of both lenses coincide. The eye piece therefore forms the final image of the object at infinity.



Galilean telescope

To obtain the magnification, m, we assume the eye is very close to

$$m = \frac{\alpha'}{\alpha}$$

For small angles, α and α' are measured in radians

$$\alpha \approx \tan\alpha = \frac{h}{f_e} \text{ and } \alpha' \approx \tan\alpha = \frac{h}{f_o}$$

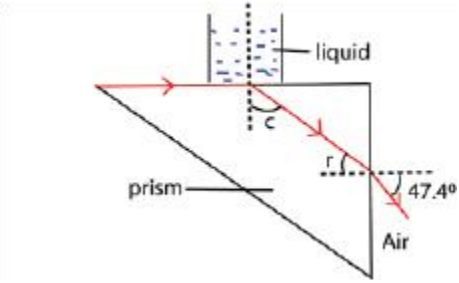
Substituting for α and α'

$$\text{Magnifying power, } m = \frac{\alpha'}{\alpha} = \frac{h}{f_e} \div \frac{h}{f_o} = \frac{f_o}{f_e}$$

(ii) State two limitations of this type of telescope.

- *it has virtual eye-ring*
- *It has a small field of view*
- *It produces less clear image*

(c) **The diagram in the figure below shows a path followed by a ray of monochromatic light through a right angled prism of refractive index 1.52. The light emerges in air at an angle of 47.4^0.**



Find the refractive index of the liquid.

Note: A ray on the boundary is grazing ray.

Let the refractive index of the liquid and air be and c is the refractive index of glass.

From

$n_g \sin i = na \sin 47.6^0$

$1.52 \sin r = 1 \sin 47.6^0$

$r = 29^0$

$r + c = 90^0$

$c = 61^0$

$n_L \sin 90^0 = ng \sin c$

$n_L = 1.52 \sin 61^0 = 1.33$

(d) Explain the following as applied to lenses.

(i) chromatic aberration

It is a failure of a lens to focus all colors to the same point due to different refractive indices for the different color wavelength.

(ii) spherical aberration

It is the failure of the lens to focus all rays through the lens to the same point leading blurred image

(e) Explain how chromatic and spherical aberration are minimized in a reflecting telescope

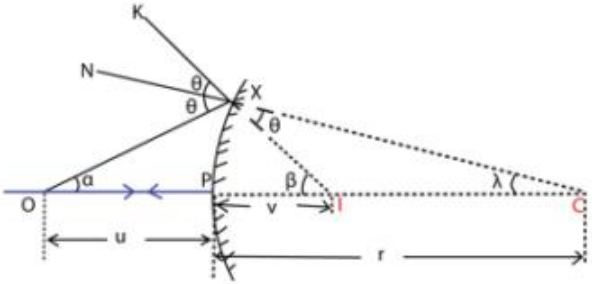
Correction of chromatic aberration

- *Use lenses made of low-dispersion glasses, especially those containing fluorite*
- *By using combination of lenses of opposite nature (convex & concave) or chromatic doublet such that the dispersion produced by one lens is reversed by another.*
- *Placing the eye close to the lens such that images due to different colours subtend the same angle at the eye.*

Means of reduction of spherical aberration

- *Using lenses with an aspheric surface*
- *Using lens of small aperture.*
- *Using a stopper such that only light incident on the middle of the lens pass, but this method reduces the brightness of the image since it reduces the amount of light energy passing through the lens.*

13. (a) Derive an expression relating the focal length, f, of a convex mirror to the object distance, u and image distance, v.
Consider the incidence of ray **OX** on to a convex mirror from a point object **O** placed along the principle axis and then suddenly reflected in the direction **XK** making an angle q with the normal **XN**.



From triangle XIC, $\theta + \lambda = \beta$

$\Rightarrow \quad \theta = \beta - \lambda$ ..... (i)

From triangle OXI, $\alpha + \beta = 2\theta$ ..... (ii)

Substituting (i) into (ii)

$\alpha + \beta = 2(\beta - \lambda)$

$\Rightarrow \quad \alpha - \beta = -2\lambda$ ..... (a)

If X is very close to P. then

$\alpha \approx \tan\alpha = \frac{XP}{u}$, $\beta = \frac{XP}{-v}$ (I is virtual) and $\lambda \approx \tan\lambda = \frac{XP}{-r}$ (C is virtual)

Equation (a) becomes

$$\frac{XP}{u} - \frac{XP}{-v} = \frac{-2XP}{-r}$$

$$\frac{1}{u} + \frac{1}{v} = \frac{2}{r}$$

But 2 = 2f

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

(c) **A convex mirror forms an image half the size of the object. The object is then moved towards the mirror until the image is three quarter that of the object. If the image is moved by a distance of 0.6cm, calculate**

(i) focal length of the mirror

Using $\frac{v}{f} = m + 1$

Initially, $\frac{v}{f} = \frac{1}{2} + 1 = \frac{3}{2}$ ..... (i)

When the object was displaced

$\frac{v+0.6}{f} = \frac{3}{4} + 1 = \frac{7}{4}$ ..... (ii)

Eqn. (i) and Eqn. (ii)

$\frac{0.6}{f} = \frac{7}{4} - \frac{3}{2} = \frac{1}{4}$; f= 2.4cm

(ii) new potion of the object (03marks)

$v + 0.6 = \frac{7}{4} x f = \frac{7}{4} x 2.4 = 4.2$ cm

$\frac{4.2}{u'} = \frac{3}{4}$

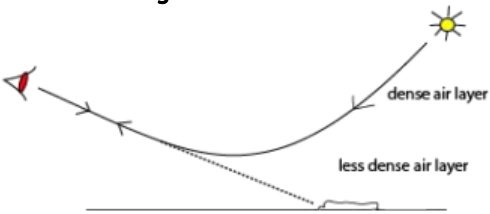
u' = 5.6cm

The object is 5.6 cm from the mirror.

(d) (i) What is critical angle?

Critical angle is the angle of incidence in the dense medium for which the angle of refraction in the less dense medium is 90^0.

(ii) Explain how mirage is formed



On a hot day, layer on air near the ground are hotter and lens dense than layers above. This leads to total internal reflection of rays of light from the sky. And mirage is the image of the sky to the eye by total internal reflection

(e) State four applications of total internal reflection

- in radio broadcasting
- determination of refractive index if material
- in optical fiber transmission
- in refracting prisms in binoculars and periscopes

(b) (i) The deviation, d, by small angle prism of refractive angle A and refractive index, n, is given by

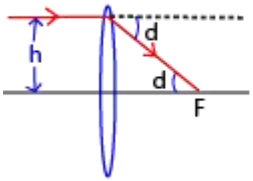
$d = A(n-1)$

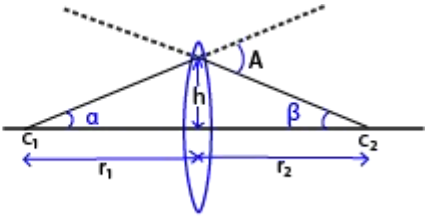
Use this expression to show that the focal length, f, of a thin converging lens of refractive index, n, is given by

$$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right),$$

where r_1 and r_2 are radii of curvature of the lens surfaces

Consider a ray close and parallel to the principal axis, incident at height, h.





$\tan d = \frac{h}{f}$ d is small in radian, $d = \frac{h}{f}$ ..... (i)

For small angle prisms d = (n-l) A ..... (ii)

From the diagram above, $\alpha + \beta = A$ ..... (iii)

For small angle

$A \approx \tan\alpha = \frac{h}{r_1}$ and $\beta \approx \tan\beta = \frac{h}{r_2}$

Substitution α and β in equation (iii)

$\left(\frac{h}{r_1} + \frac{h}{r_2}\right) = A$ ..... (iv)

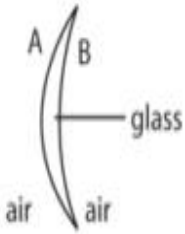
Substituting equation (i) and (iv) in equation (ii)

$\frac{h}{f} = (n-1)\left(\frac{h}{r_1} + \frac{h}{r_2}\right)$

Dividing by h

$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$

(ii) The figure below is a glass convex lens in air with surfaces A and B having radii of curvature 10cm and 15cm respectively.



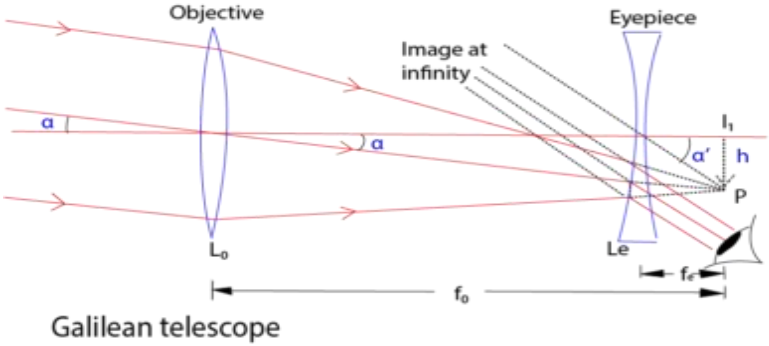
If the refractive index of the glass material is 1.50. Calculate the power of the lens. (03marks)

$r_1 = 10cm = 0.1m$, $r_2 = -15cm = -0.15m$

Using $\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right) = (1.5-1)\left(\frac{1}{0.1} + \frac{1}{0.15}\right) = 1.67D$

(c) (i) **With the aid of a ray diagram, describe the structure and action of a Galilean telescope in normal adjustment.**

Light from distant object incident on objective lens is refracted to form real inverted image at its principal focus f_0. In normal adjustment, the principal focuses of both lenses coincide. The eye piece therefore forms the final image of the object at infinity.



Galilean telescope

(d) Explain the disadvantage of a Galilean telescope over refracting type.

- *Eye-ring is virtual*
- *Image less bright and less clear*

15. (a) (i) State the laws of refraction of light

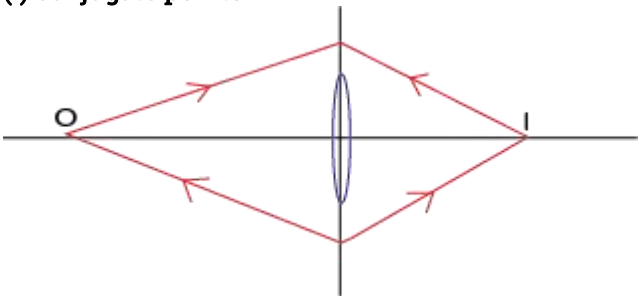
- *The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane*
- *The ratio of the sine of angle incidence to the angle of refraction is constant for a given pair of the media.*

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

- *Angle of incidence must be greater than the critical angle.*
- *Light must be moving from a denser to less dense medium*

15. (a) with the aid of ray diagram, explain the following as applied to lenses

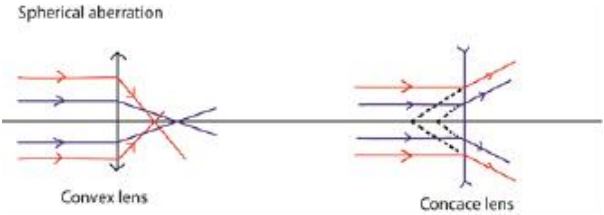
(i) conjugate points.



These are two points; O and I, on the opposite side of a convex lens such that an object and its image at these points are interchangeable.

(ii) spherical aberration

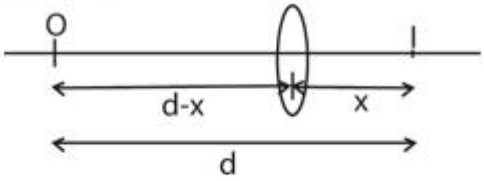
Spherical aberration occurs when the lens fails to focus all rays falling on it to the same point. Thus images formed by the lens at large apertures are therefore unsharp or blurred at the edges.



(b) An object, O, placed in front of a converging lens forms a real image, I, on the screen. The distance between the object and its real image is d. while that of the image from the lens is x.

Derive the expression for the least possible distance between the object and its real image

Solution



$u = d-x \qquad v = x$

From $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$$\frac{1}{f} = \frac{1}{d-x} + \frac{1}{x} = \frac{d}{dx - x^2}$$

$$x^2 - dx + fd = 0$$

$$x = \frac{d \pm \sqrt{d^2 - 4fd}}{2}$$

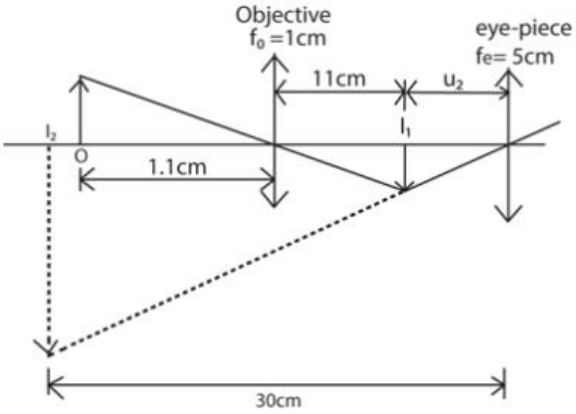
for real roots, $d^2 > 4fd$ or $d > 4f$

(c) Give the properties of lenses in achromatic combination.

- *One lens should be concave and the other convex*
- *The lenses should be of different materials*

- *The dispersion caused by the concave lens should be completely cancelled by the convex lens.*
- *The radii of curvature of concave and convex lenses should be numerically equal*

(d) A compound microscope consists of two converging lenses of focal lengths 1.0cm and 5.0cm respectively. An object is placed 1.1cm from objective and the microscope is adjusted so that the final image formed 30cm from the eye- piece. Calculate (i) the separation of the lenses



Objective lens

From $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{1.0} = \frac{1}{1.1} + \frac{1}{v}$; v = 11cm

Eye piece

$\frac{1}{5.0} = \frac{1}{u_e} - \frac{1}{30}$; $u_e = 4.3$cm

$Separation = v + u_e = 11 + 4.3 = 15.3$cm

(ii) **the magnifying power of the lenses.**

$$m = \left(\frac{v_e}{f_e} - 1\right)\left(\frac{v_o}{f_o} - 1\right)\frac{D}{v_e} = \left(\frac{-30}{5.0} - 1\right)\left(\frac{11}{1} - 1\right)\frac{25}{-30} = 58.3$$

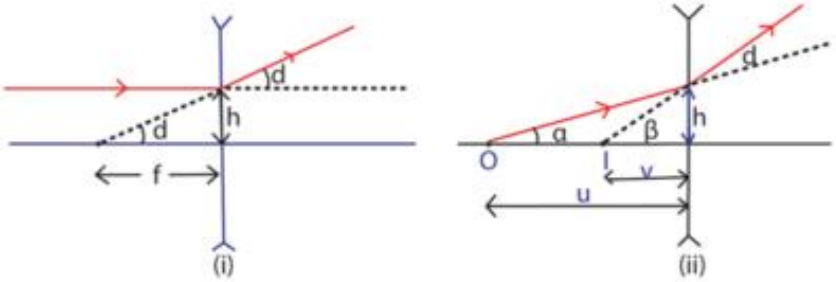
(e) **State two differences between a compound microscope and an astronomical telescope.**

Compound microscope	*Astronomical telescope*
– view near objects	*– views distant objects*
– objective lens has smaller focal length	*– objective has longer focal length*
– in normal adjustment, final image is at near point	*– in normal adjustment final image is at infinity*
– has greater resolving power	*-has smaller resolving power*

17. (a) Define the following terms as applied to a concave lens:
(i) principal focus'
it is appoint on principal axis where rays of light originally parallel and close to principal axis appear to diverge from after reflection by the lens.
(ii) radii of curvature
are radii of the sphere of which the lens surfaces form part
(b) **A point object is placed at a distance u in front of a diverging lens of focal length, f, to form an image at a distance, v, from the lens.**

Derive an expression that relates u. v. and f.

Consider in each case a ray incident on the same lens at a small height ***h*** *above the principal axis as shown:*



From Fig (i), the close and parallel to principal axis ray appears to diverge from the focal point and suffers a small deviation **d**; since h is very small

Thus $d \approx \tan d = -\frac{h}{f} =$ ---------- (i) (F is virtual)

From Fig (ii), the ray from a point object **O** suffers the same small deviation **D** to give rise to a point image **I**.

From geometry, $\beta = \alpha + d$ or $d = \beta - \alpha$

Since α and α are small; $\alpha \approx \tan\alpha = \frac{h}{u}$ and $\beta \approx \tan\beta = -\frac{h}{v}$ (image is virtual)

$$d = -\frac{h}{v} - \frac{h}{u} \quad \text{---------- (ii)}$$

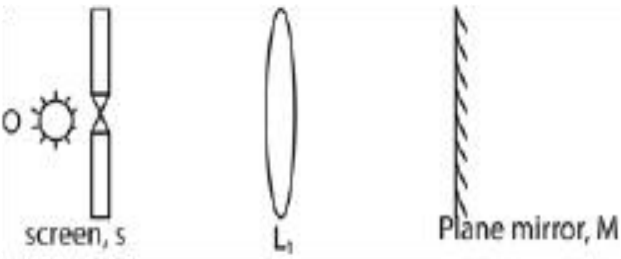
Equating equations (i) and (ii) gives

$$-\frac{h}{f} = -\frac{h}{v} - \frac{h}{u}$$

Thus $\frac{1}{f} = \frac{1}{u} + \frac{1}{u}$

(c) Describe an experiment to determine the focal length of a concave lens using a plane mirror, converging lens and illuminated object.

Setup



- *The apparatus is shown above*
- *The wire gauze is illuminate with a bulb and the position of lens L_1 is adjusted until a sharp image of the wire gauze is formed on the object screen, S.*
- *The distance SL_1 is measured and recorded as f_1.*
- *The test lens L_2 is now cemented of L_1 and again placed between O and M.*
- *The position of the combined lens is adjusted until a sharp image of the wire gauze is formed on S.*
- *The distance SL_2 is measured as f_2.*
- *Focal length of the test lens, f, is then calculated from,*

$$\frac{1}{f} = \frac{1}{f_2} - \frac{1}{f_1}$$

(d) What is meant by a:

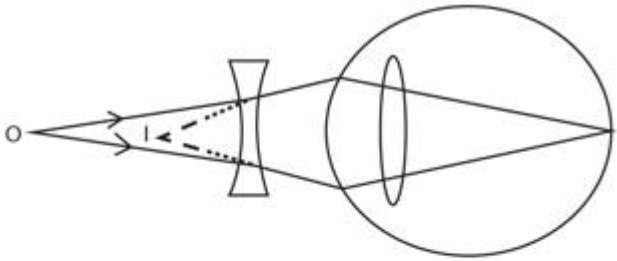
(i) visual angle

Visual angle is the angle subtended by an object or image at the eye.

(ii) near point

The near is the point at which the eye is able to view the object clearly with the greatest details.

(e) **A person with a normal near point distance of 25cm wears spectacles with a diverging lens of focal length 200cm in order to correct the far point distance to infinity. Calculate the near point when viewing using the spectacles.**



The object at O appear to be at I, the near point for the eye.

Now v= -25 cm and f = -200cm

Thus using $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

$$\frac{1}{u} = \frac{1}{-200} + \frac{1}{25}$$

u = 28.6cm

18. (a) What is meant by the term:

(i) refraction

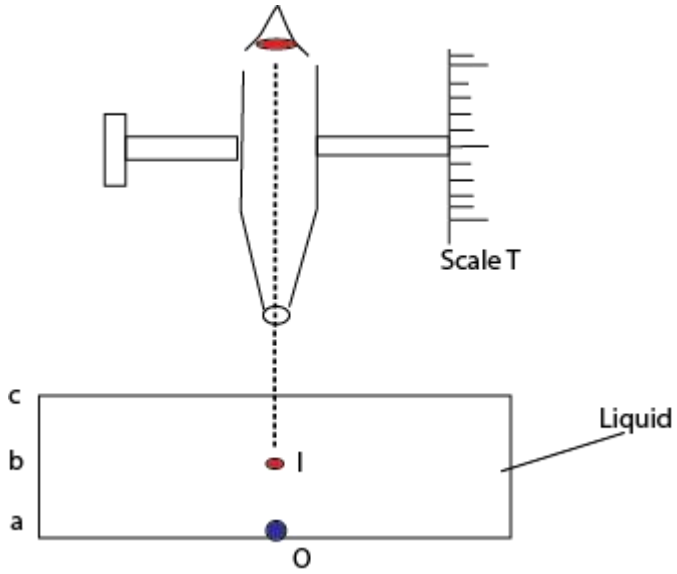
Refraction is the change in direction of propagation of light as it travels from one medium to another.

(ii) absolute refractive index?

Absolute refractive index of a medium is the ratio of speed of light is vacuum to the speed of light in the medium.

(b) Describe an experiment to determine the refractive index of a liquid using a travelling microscope

Measurement of refractive index of a liquid using travelling microscope or by apparent depth method.

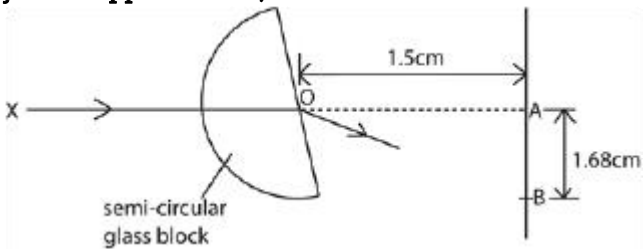


*A vertically traveling microscope having a graduated scale **T** besides it is focused on sand particles placed at **O** on bottom of the container. The scale reading **a** on **T** is noted.*
*A liquid whose refractive index is required is filled in a container and the microscope is raised until the particles are refocused at **I**. The scale reading **b** is again noted.*
Finally the traveling microscope is focused on the liquid surface giving a scale reading c.

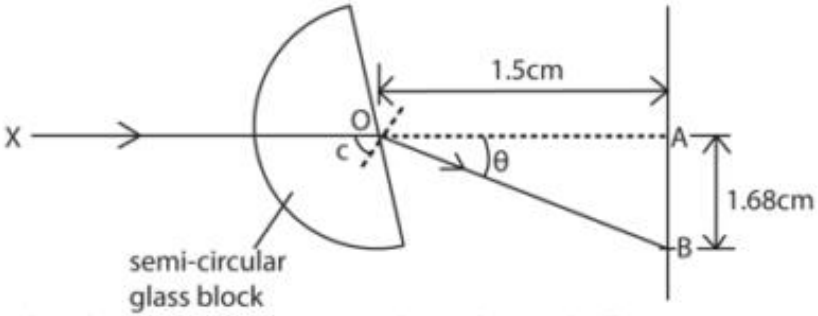
$$\text{Thus } n_L = \left[\frac{c-a}{c-b}\right]$$

(c) The figure below shows monochromatic light X incident towards A on vertical screen.

When the semicircular glass block is placed across the path of light with its flat face parallel to the screen, a bright spot is formed at A. When the glass block is rotated about a horizontal axis through O, the bright sport moves from A to B and then just disappears. At B, distance 1.68cm from A.



(i) Find the refractive index of the material of the glass block. (04marks)



When the spot just disappear at B, the total internal reflection just occurs

$n = \frac{1}{\sin c}$ where $c = 90 - \theta$

but $\tan \theta = \frac{1.68}{1.5} = 1.2$; $\theta = 48.2$

$c = 90 - 48.2 = 41.8$

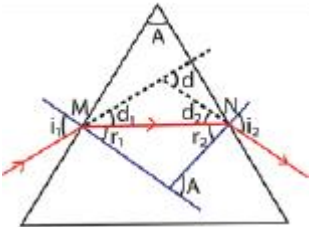
$n = \frac{1}{\sin 41.8} = 1.5$

(ii) Explain whether AB would be longer or shorter if the block of glass of higher refractive index was used.

When the refractive index is high the ray is refracted more, AB becomes longer.

(d) (i) A ray of monochromatic light is incident at a small angle of incidence on a small-angle prism in air. Obtain the expression, d= (n-1)A, for the deviation, d, of light by the prism, where A is the refracting angle of the prism and n, is the refractive index. (04marks)

Solution



The small refracting angle of this prism causes the angle i_1, r_1, r_2 and i_2 to be small such that sin $i_1 \approx i_1$, sin $r_1 \approx r_1$ sin $r_2 \approx r_2$ and sin $i_2 \approx i_2$

From the diagram, $d = d1 + d_2$

But $d_1 = i_1 - r_1$ and $d_2 = i_2 - r_2$

=> $d = (i_1 - r_1) + (i_2 - r_2)$

On simplifying $d = i_1 + i_2 - (r_1 + r_2)$

but $r1 + r_2 = A$

=> $d = i_1 + i_2 - A$ ....(a)

At M Snell's law becomes.

$na \sin i_1 = n \sin r_1$

For small angles this gives $i_1 = nr_1$ .....(b)

Similarly at N Snell's law becomes $i_2 = nr_2$ .....(c)

Substituting equation (b) and (c) in (a) gives

$d = nr_1 + nr_2 - A$

$d = n (r_1 + r_2) - A$

but $r_1 + r_2 = A$

=> $d = nA - A$

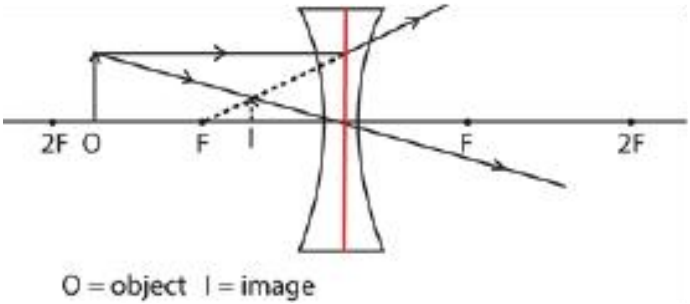
$d = (n - 1)A$

(ii) Calculate the minimum deviation produced by a 60^0 prism if the refractive index of the glass is 1.50.

$$\text{Using } n = \frac{\sin\left(\frac{D_{min}+A}{2}\right)}{\sin A/_2}$$

$$1.5 = \frac{\sin\left(\frac{d_{min}+60}{2}\right)}{\sin\frac{60}{2}}$$

$$d_{min} = 37.18^0$$



O = object I = image

State any two applications of total internal reflection.

- *Transmission of light by optical fiber*
- *Reflecting prisms in binoculars, periscopes*

19. (a) (i) Define principal focus of a concave lens.

Principal focus of a concave lens is the point on the principal axis where rays of light parallel and close to principal axis appear to diverge from after refraction through the lens.

(ii) Draw a ray diagram to show formation of an image of finite object in a concave lens

(iii) Describe the image formed in (a)(ii)

– it is virtual and diminished.

(iii) Explain what would happen if the lens was replaced with a similar one but of much smaller focal length.

If the lens was replaced with one of a smaller focal length, the final image would have been smaller. This is because the power of a lens = ; therefore a lens of smaller focal length has a larger magnifying power.

(b) **Explain how spherical aberration is minimized in a photographic camera**

Spherical aberration in a photographic camera is minimized

- *by the diaphragm. The diaphragm only allows central beam which forms a sharp image.*
- *using composite lens*

20. (a) Define refractive index.

Refractive index of a medium is the ratio of the speed of light in vacuum to the speed of lght in a medium.

21. A prism of refractive angle 60^0 has refractive indices 1.515 and 1.529 for red and violet respectively. When white light is incident on one face of the prism, red light undergoes minimum deviation. Calculate the angle of

(i) incidence for white light

At minimum deviation

$$n_r = \frac{\sin\left(\frac{D+A}{2}\right)}{\sin\frac{A}{2}} = \frac{\sin i}{\sin\frac{A}{2}}$$

$$\sin i = 1.51 sin\frac{60}{2}$$

i = 49.03

(ii) emergence for violet light

At the first face, $\sin i = n \sin r$

$$\text{Sin } r = \frac{\sin 49.03}{1.529}$$

$$r = 29.6^{0}$$

$$r_1 + r_2 = 60$$

$$r_2 = 60 - 29.6 = 30.4$$

At the second face

$$1.529 \sin 30.4 = \sin i$$

$$i = 50.7^{0}$$

(d) Describe the adjustment that have to be made before a spectrometer can be used.

- *The collimator is adjusted to produce parallel rays of light*
- *The turn table is levelled*
- *The telescope is adjusted to receive light from the collimator on its cross wire.*

(ii) **A compound lens consists of two lenses in contact having powers of +12.5D and -2.5D. Find the position and nature of the image of an object placed15.0cm from the compound lens.**

$f_1 = \frac{1}{12.5} = 0.08m = 8cm$

$f_2 = \frac{1}{-2.5} = 0.4m = -40cm$

From $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{8} - \frac{1}{40}$

Combined focal length f = 10cm

From $\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$

$\frac{1}{v} = \frac{1}{10} - \frac{1}{15}$; v = 30cm

The image is real (v is +ve) and magnified (v greater than u)

(c) What is meant by magnifying power of optical instrument?

Magnifying power of optical instrument is the ratio of the angle subtended by the final image at the eye when using optical instrument to the angle subtended by the object at the naked eye.

(ii) Why should the objective and eye piece of a compound microscope have short focal length?

To achieve a bigger magnification

CHAPTER SEVENTEEN

WAVES

1. Define the following terms
    a) *Amplitude - The measure of the displacement of the wave from its rest position. The higher the amplitude of a wave, the higher its energy.*
    b) *Crest - The crest is the highest point of a wave. The opposite of the crest is the trough.*
    c) *Diffraction - Diffraction is when a wave remains in the same medium, but bends around an obstacle.*
    d) *Electromagnetic Waves - Electromagnetic waves are waves that can travel through a vacuum. They do not need a medium. Light is a type of electromagnetic wave.*
    e) *Frequency - The frequency of a wave is the number of times per second that a wave cycles. The frequency is the inverse of the period.*
    f) *Intensity - A measurement of the strength of a sound wave that is equal to the power divided by the area.*
    g) *Interference - Interference is when one wave comes into contact with another wave.*
    h) *Light wave - A light wave is a special type of electromagnetic wave that has a frequency in the visible spectrum.*
    i) *Longitudinal - A longitudinal wave is a wave where the disturbance travels in the same direction as the wave. Sound waves are longitudinal.*
    j) *Mechanical Waves - A mechanical wave is a wave that must travel through some sort of matter called a medium. Mechanical waves cannot travel through a vacuum like outer space.*
    k) *Medium - The medium is the matter that a wave travels through.*

l) Period - The period of a wave is the time between wave crests. It is the inverse of the frequency.

m) Polarization - Polarization is when a wave oscillates in one particular direction. Light waves are sometimes polarized by a special polarizing filter.

n) Reflection - Reflection occurs when a wave bounces off a boundary, changing direction but remaining in the same medium.

o) Refraction - The change in direction and wavelength when a wave moves from one medium to another.

p) Refractive Index - The refractive index is a number that describes how light travels through a specific medium. Different mediums have different refractive indexes. The refractive index of a vacuum is defined to be 1.

q) Resonance - Resonance is the tendency for a system to oscillate with greater amplitude at some frequencies than at others.

r) Resting position - The resting position is the position the medium would take if there were no wave. It is represented on a graph by a line through the center of the wave.

s) Sound wave - Sound waves are mechanical waves that are caused by a vibration. Sound waves can be heard by our ears.

t) Speed - The speed of a wave is a measure of how fast the disturbance of the wave is moving. The speed can be dependent on the type of medium that a wave is moving through.

u) Standing wave - A standing wave is a wave that remains in a constant position.

v) Transverse - A transverse wave is a wave where the disturbance moves perpendicular to the direction of the wave.

w) *Wave - A wave is a traveling disturbance that moves through space and matter. Waves transfer energy from one place to another, but not matter.*

x) *Wavelength - The wavelength of a wave is the distance between two corresponding points on back-to-back cycles of a wave. For example, between two crests of a wave.*

y) *Trough - The trough is the lowest part of the wave. The opposite of the trough is the crest.*

2. A vibrator produces water waves in a ripple tank . the distance between the first and the fifth crest is 200mm. The waves travel 300mm in 1.5sec

a. Determine the wavelegth of the wave

b. The velocity of the wave

c. The frequency of the vibrator

3. **(a) (i) Distinguish between stationary and progressive waves**

Stationary wave:- waveform do not move through the medium and therefore energy is transferred from the source to the same point away.

Progressive wave- wave forms more though the medium and therefore energy is transferred form the source t the same point away.

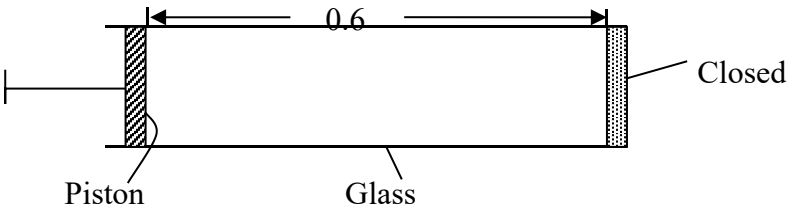
b) **Differentiate between constructive and destructive interference of light waves**

Constructive and destructive interference are phenomena that take place when several waves meet. Constructive interference happens when two waves overlap in such a way that they combine to create a larger wave. Destructive interference happens when two waves overlap in such a way that they cancel each other out. . The main difference between constructive and destructive interference is that constructive interference occurs when the displacements of the waves that meet are in the same direction, whereas destructive interference occurs when displacements of the waves that meet are in the opposite directions.

4. State a reason why a closed tube or pipe produces less quality sound than an open one

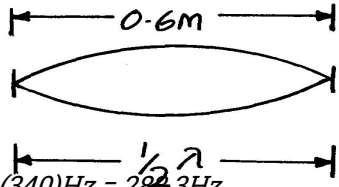
Open pipe has both odd and even harmonics.

(b) The figure below shows a piston inside a glass tube



Air inside is made to vibrate producing a fundamental note. Find the fundamental frequency to be produced

(b) (i) For closed pipe



½ λ = 0.6

λ = 1.2m

λ V= f_o, f_o = V = (340)Hz = 283.3Hz

λ 1.2

(c) If the glass tube is made open by removing the piston and opening the other end, what is the new fundamental frequency?

End correction ignored,

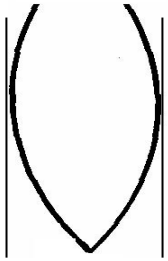
If ¼ λ = 0.6

λ = 0.6 x 4 = 2.4m

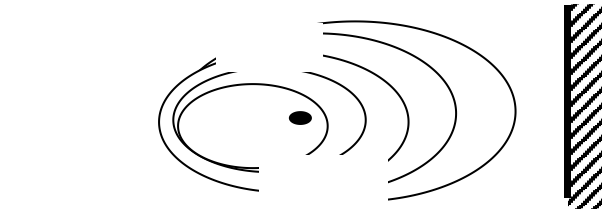
f_o = V = (340)Hz

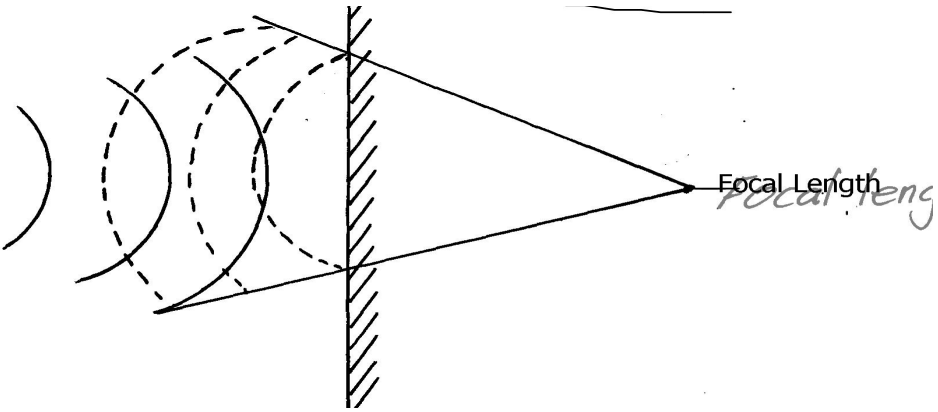
2.4

= 141.7Hz



2. The figure below shows circular waves approaching a straight reflector. Complete the sketch to show what happens when the waves hit the reflector.





5. (a) State one difference between the way sound waves and electromagnetic waves are transmitted.

6. i) Sound is transmitted as a longitudinal wave electromagnetic is transmitted as a transverse wave.

4.(I) A mine worker stands between two vertical cliffs 400 m from the nearest cliff. The cliffs are X distance apart. Every time he strikes the rock once he hears two echoes, the first one comes after 2.5 sec. while the 2nd follows 2sec. later. From this information;

Calculate;

(i) Speed of sound in air.

(ii) $S = \frac{2d}{t}$

$= \frac{2 \times 400}{2.5} = \frac{800}{2.5}$

$= 320 m/s$

(ii)The value of **X**.

Let distance from mine worker be furthest cliff by y. then

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

$320 = \frac{2y}{2 \times 2.5}$

$2y = 320 \times 4.5$

$2y = 1440$

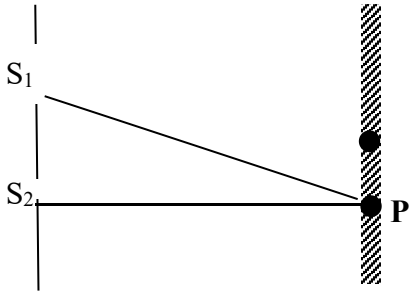
$y = \frac{1440}{2}$

$= 720 m^2$

total distance = 720 + 400

$x = 1120m$

(b) The figure below shows waves starting from two coherent sources S_1 and S_2.



What would be observed at P if the waves are

(i) **light waves.**

Bright fringe.

(ii) Sound waves.

Loud sound.

(c) State the conditions for diffraction of light to occur.

slat must be very narrow (less than the wavelength of light)

4. **The diagram below represents plane wave fronts produced in a ripple tank.**

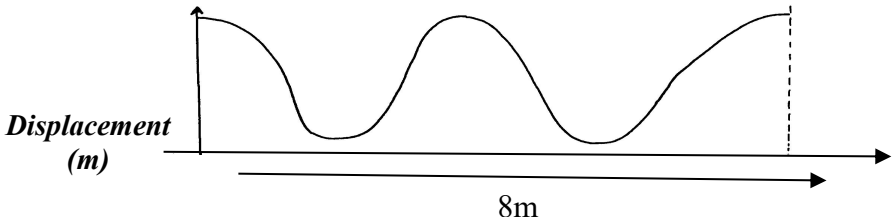
Given that the distance **AB** is 15 cm, determine the wavelength of the wave

$6\lambda = 15\ cm$

$1\lambda = \frac{1 \times 15}{6}$

$= 2.5\ cm.$

6. (a) **The figure below shows a wave profile with velocity 340m/s**



Determine:

*(a)*The frequency of the wave

i) $= {}^{8}/_{2} = 4m$

$f = {}^{V}/_{X}$

$= {}^{340}/_{4}$

$= 80H_Z$

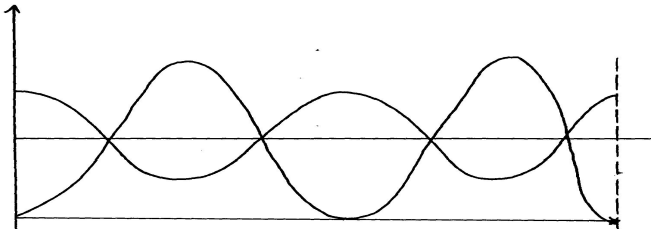
(ii) The period of the wave

ii) $T = {}^{1}/_{F}$

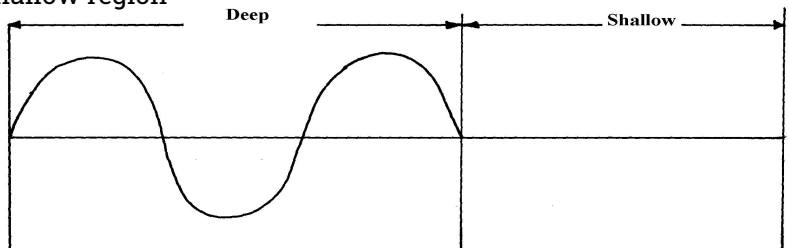
$= {}^{1}/_{80}$

$= 0.0125\ seconds$

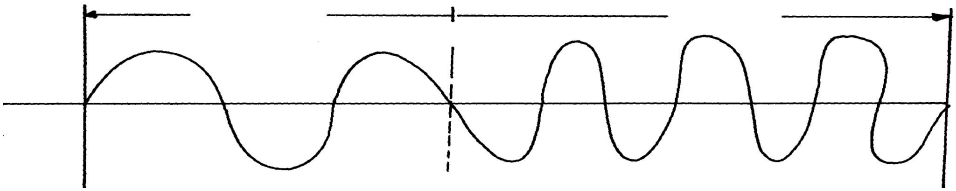
(b) **On the same diagram in (b) above sketch a wave profile of another wave with same frequency, greater amplitude but 180° out of phase with the one in (b)**



6. Figure 3 shows the displacement of a particle in a progressive wire incident on a boundary between deep and shallow region



Complete the diagram to show what is observed after bounding. (Assume no loss of energy)



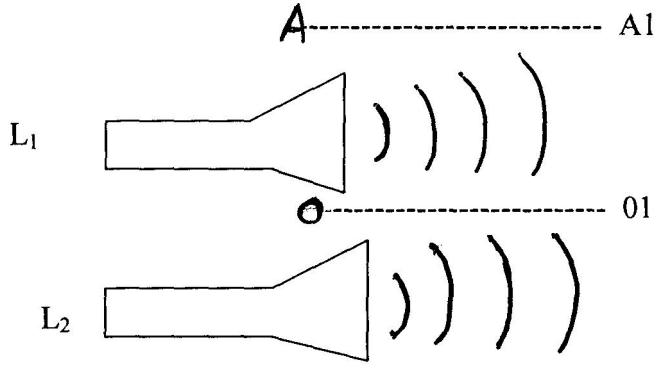
8. (a) Explain the difference between progressive waves and stationary waves

(a) In a progressive wave, all particles have the same amplitude and each particle is out of phase with the particle next to it. In stationary wave, vibrations of particles at points between successive nodes are in phase and the amplitude of particles between nodes is different

(b) State any two conditions necessary for the establishment of a stationary wave

Must have:- (i) Same speed
(ii) Same frequency
(iii) Same of nearly equal amplitudes

(c) (i) The figure below shows two loudspeakers L_1 and L_2 connected to a signal generator



An observer walks along the line 0-01 (equidistant from L_1 and L_2) and another along the Line AA_1.Explain the observation made by each and give reasons to your answer

OO_1 – Loud sound (constructive interference) waves arrive in phase

AA_1 – Loud and soft sound (Destructive and constructive interference)

(d) If a wave is propagated at a velocity of 50m/s; determine its frequency if the distance travelled by the wavelength in 2 cycles is 1.25m

$$f = \frac{V}{\lambda}$$

$$\lambda = \frac{1.25}{2} = 0.625$$

$$f = \frac{50}{0.625}$$

= 80HZ

(f) State **one** condition necessary for interference to occur

– Constant phase difference

- Nearly same amplitude

9. Give conditions necessary for diffraction of waves to occur

The width of the opening must be smaller than the wavelength of the wave.

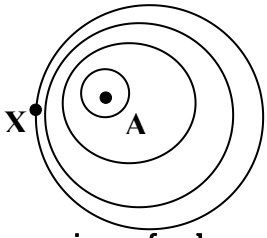
9 Distinguish between diffraction and refraction of waves

- Diffraction- is the spreading waves beyond obstacle openings

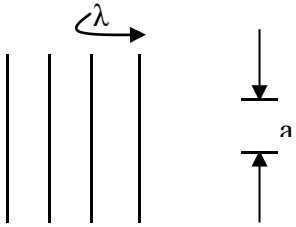
- Refraction- is the bending of waves when they change the medium

13.A student touches the surface of water in a big pan at point A at regular intervals and observes the ripples as in the diagram below. Explain the pattern of the ripples observed.

Figure 2



14. In the figure below shows a series of plane wires approaching a gap. Complete the diagram to show the wire after passing through the gap if



15 (a) (i) State the difference between mechanical and electromagnetic waves

Electromagnetic waves travel though a vacuum while mechanical waves need a medium

***(ii)*Give one example of each of the above waves**

Mechanical waves – sound waves

- water waves

- shock

- electromagnetic waves – light waves

- radio waves

-X-rays, gamma rays

CHAPTER EIGHTEEN

RADIOACTIVITY

1. **(a) Define radioactive decay**

Radioactive decay is the spontaneous random emission of particles from the nucleus of an unstable nuclide ✓

(b) A radioactive element decays to $^{1}/_{128}$ of its original activity after 49 days. Determine its half –life

There are 7 half lives ($t_{½}$)

$7t_{½} = 49$ *days*

$t_{½} = \frac{49}{7}$

$= 7$*days*

2. State one use of radioisotope

radioactive isotopes are used as

(h) fuel for nuclear reactors,

(i) a method for treating cancer,

(j) a way to make food safer to eat.

3. What is meant by radio active decay?

a) Spontaneous disintegration of unstable atoms in order to gain stability

4. Arrange the following in order of increasing frequency: Red light, Infrared radiation, X-rays, UV radiation, Short –radio waves, TV and Fm radio waves, Am radio waves and Long radio waves.

Long radio waves, AM radio waves, T.V and FM Radio waves, short Radio waves, infra red radiation, red-light , Uv radiation and X-rays.

5. **Differentiate between alpha .beta and gamma particles**

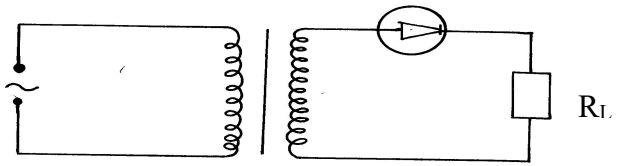
There are three main types of particles that can be emitted as radiation. They are alpha (α) particles, beta (β) particles, and gamma (γ) particles. The main difference between alpha, beta and gamma particles is that alpha particles have the least penetration power while beta particles have a moderate penetration power and gamma particles have the highest penetration power.

Property	Alpha ray	Beta ray	Gamma ray
Nature	Positive charged particles, 2He 4 nucleus	Negatively charged particles (electrons).	Uncharged , electromagnetic radiation
Charge	+2e	−e	0
Mass	6.6466×10^{-27} kg	9.109 × 10−31 kg	0
Range	~10 cm in air, can be stopped by 1mm of Aluminium	Upto a few m in air, can be stopped by a thin layer of Aluminium	Several m in air, can be stopped by a thick layer of Lead
Natural Sources	By natural radioisotopes e.g.92U236	By radioisotopes e.g.29Co68	Excited nuclei formed as a result of Gamma decay

6. (a) You are provided with the following:-
- One diode

-A load resistor
- An a.c. source
- One transformer

(i) Using the above apparatus draw a circuit arrangement for half wave rectification



(ii) Explain how the circuit drawn in (a)(i) above achieves half wave rectification

During the first half cycle, the diode is forward biased so it conducts.

- Current flows through R_2 building a voltage which decreases as the first half cycle comes to an end.

- During the second half cycle, the diode is traverse biased so it does not conduct.

(b) (i) Determine the value of x and y in the nuclear equation below:-

$$^{238}_{92}U \longrightarrow {}^{y}_{x}Z + 4\beta$$

y =238-4(1) = 242

X = 92

(iii) **The half life of a radioactive element is 20minutes. The mass of the element after 12 minutes is 0.03125g. Determine the original mass of the element**

$\frac{120}{20}$ = 6 half lives

0.03125 x 26 = 2g

(iv) **What evidence supports the fact that gamma rays are not charged**

They are deflected by both electric and magnetic fields

(v) Alpha particles have low penetrating power as opposed to beta particles. Give a reason for this

Alpha particles are heavy (massive)

7. **A manufacturer wishes to check the thickness of steel sheets he produces. Explain how this can be done using a radioactive source and a counter**

(v) – The sheets are brought in turns between radioactive source and the counter.

- The count rate is a measure of the thickness of the metal sheet.

8. Uranium 235 was bombarded with a neutron and fission took place in the following manner:

$$_{92}U + {}^{1}_{0}n \xrightarrow{235} {}_{38}Rn + {}_{b}X + 10({}_{0}n)^{90}_{a} \quad 1$$

Determine the values of a and b

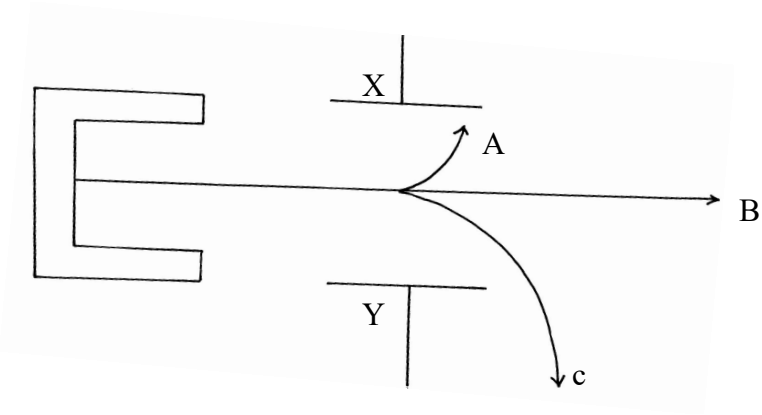
i) a = 236 – 91= 145

ii) b = 92- 38 = 54

9. When carrying out experiments with radio active substance one is instructed that the source should never held with bare hands but with forceps. Give a reason for the instruction

radioactive substances are harmful to the body when ingested

10. The diagram below shows the paths taken by three radiations A, B and C from a radio active isotope through an electric field



i) **State the charge on plate Y**

i) Negative

iii) **Identify the radiation A and C**

A – Beta radiation

C – Alpha radiation

iii) Give a reason why C deviates move A

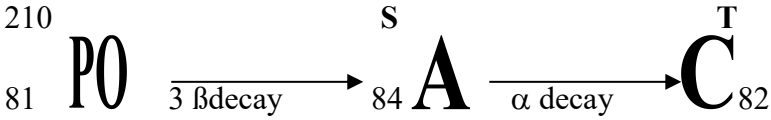
C – more massive than A

11. **One of the application of Beta emission (B) is controlling thickness gauge. Explain how they are used for this purpose?**

– a beta source is placed on one side of a moving sheet of paper and a G.N detected on the other side

- If the material is too thin, the count rate at the detector will be too high and vice versa

12 **The following is a nuclear reaction for a fusion process resulting from the reaction of polonium with loss of beta particles**



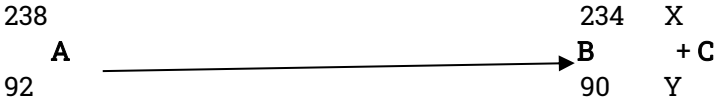
(i) Determine the values of S and T

(i) S – 210 T – 206

(ii) State the source of the energy released

The splitting of a heavy nuclide to lighter particles (fission process)

12. **The expression below is an equation for radioactive element A. Element B and C are the daughter nuclides. A, B and C are not the actual symbols of any of the elements**



(a) State what type of radioactive decay this is.

Alpha decay

(b) What is the value of:

X....*4*..... **Y**.....*2*.....

13. **Radium -222 is a radioactive element with a half-life period of 38 sec. What fraction of the mass of a sample of this element remain after 380 sec.**

No. of half lifes = 380 = 10

38

$N = N_o (½)$

$$\frac{380}{38} = (½)^{10} = \frac{1}{1024}$$

14 (a) **Define the term half-life of a radioactive material**

Time taken for the activity of a sample of a radioactive material to reduce to half of the original value

CHAPTER NINETEEN

X-RAY

1. **Differentiate between hard and soft X-ray**

The X-rays of low wavelengths are called hard X-rays and those of larger wavelengths are called soft X-rays.

Soft X-rays are produced at comparatively lower potential difference than hard X-rays. They have a wavelength of 4◦ A or above. They also have lower frequencies and hence lesser energy. Following is the major difference between soft x-ray and hard x-ray.

- ✓ *Hard X-rays will have higher energy where as Soft X-rays will have lower energy.*
- ✓ *Hard X-rays will have shorter wavelength where as Soft X-rays will have longer wavelength.*

2. State two application of X –rays in medicine

Treatment of cancer, tumors

3. **State the factor that affects:-**

(i) The intensity of X-rays

Size of heater current/filament current

(ii) The strength of X-rays

Accelerating potential/kinetic energy of elctrons/anode Voltage

4. **An x-ray tube must be highly evaluated. Give a reason for this**

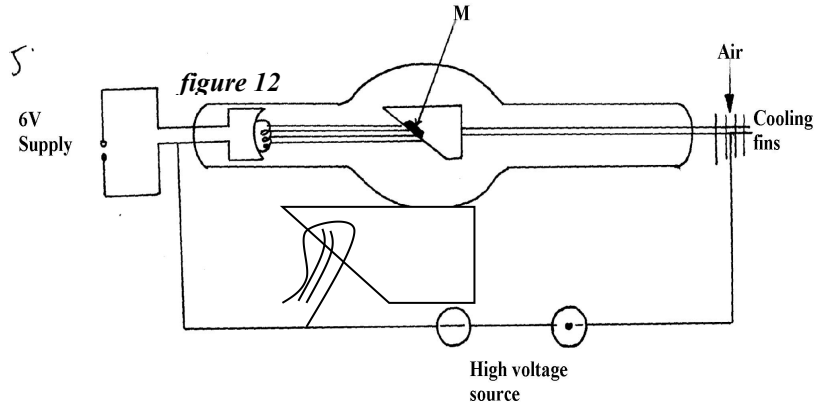
To avoid collisions between the moving electrons and air particles

5(a) In the production of X- rays, electrons are directed at a tungsten target. State a reason why the target is made of tungsten

a) – Tang stein has high melting point and therefore it would not met at elevated temperatures

f) How can the intensity of the X-rays tube be increased? *b) – Increasing filament voltage or heating current*

7. *Figure 12* below shows an x-ray tube:



(a) Indicate on the diagram the path of x-ray beam supplied by the tube

(b) Why is M set at angle of 45° relative to the electron beam? *To direct x-rays out of the tube through the window on the shield.*

(c) Name a suitable metal that can be used for part M and give a reason for your choice

Tungsten or molybodenum.

- High melting point thus it can withstand high temperature

(d) State how the following can be controlled:-

(i) Intensity

i) Heater current (Filament current)

(ii) Anode potential (operating potential)

(ii) Penetrating power -

Covering with protective materials where x-rays are not required

(iii) The exposure to patients

- Minimize exposure time as much as possible

- Reduce number of exposure as much as possible

(e) An x-ray tube is operating with an anode potential of 12Kv and a current of 10.0m.A:

(i) Calculate the number of electrons hitting the anode per second

$$Q = Jt = 10 \times 10\text{-}3C \qquad (= 1.6 \times 10\text{-}19C)$$

$$10 \times 10^{-3}C = 1.6 \times 10^{-19} \times n$$

$$n = \frac{10 \times 10^{-3}}{1.6 \times 10^{-19}} = 6.25 \times 10^{16} \text{ electrons}$$

(ii) Determine the velocity with which the electrons strike the target

$$\tfrac{1}{2} m_e V^2 = eV$$

$$V = \frac{2eV}{me}$$

$$= \sqrt{\frac{2 \times 1.6 \times 10\text{-}19 \times 12000}{9.1 \times 10\text{-}31}}$$

$$= \sqrt{4.2198 \times 10^{15}}$$

$$= 6.496 \times 10^{7} m/s$$

(iii) State one industrial use of x-rays

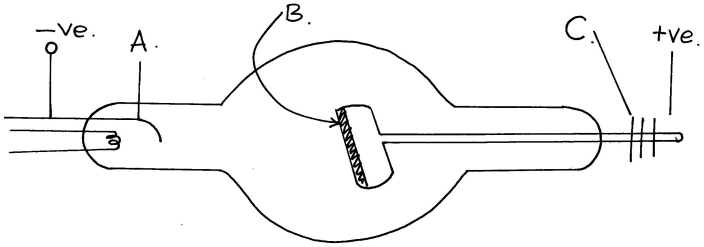
- Detecting fault in metals or other structures.

- Controls quality of manufacturer items e.g tyres, thickness of sheets, papers e.t.c.

- Analysis of gem stones.

7.(i) The diagram below shows simplified diagram of an x-ray tube,

Figure 8



(a) **Name the parts A, B, and C.**

A – cathode

B – Anode

C – Cooling fins

(b) What adjustments would be made to

(i) Increase the penetrating power of the x-rays produced. *increase the p.d at the anode*

(ii) Increase the intensity of the rays produced.

increase the cathode heater current

(c) Name a suitable material for the part marked B and give a reason for your choice.

Tungsten:- It has a high melting point so the heat produced will not melt it easily

d.Name a suitable material for the part marked C and sate its purpose.

Copper – it is used to cool/conduct heat away from the anode

(g) Why is it necessary to maintain a vacuum inside the tube?

So that the electrons do not collide with gas molecules which could result in loss of energy.

(f) State one use of x-rays in the following areas; -

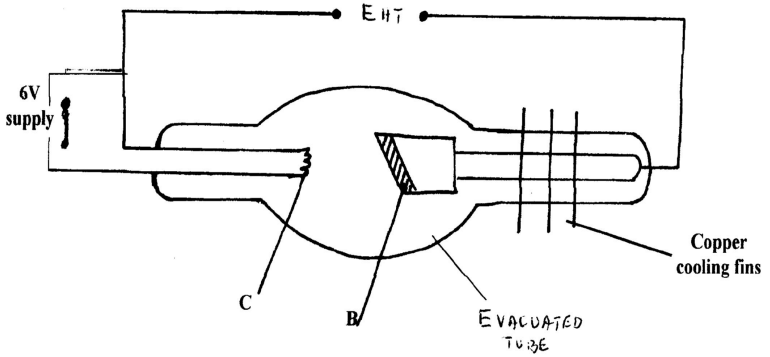
(i) In medicine

Detecting fracture in bones

(ii) In Industry.

Detecting flaws in metals

8. **a) The figure shows the circuit of a modern X-ray tube**



i) Indicate the path of the X-ray beam supplied by the tube

ii) Name the part labeled C and state its function

C is the cathode.

It produces electron thermionically

iv) **If the tube above is operated at an accelerating potential of 100kV and only 0.05% of the energy of the electrons is converted to X – rays, calculate the wave length of the generated X-rays. (Take electric charge e = 1.602 x10^{-19}C, planks constant h = 6.63 x 10^{-34} Js, and speed of light c = 3.0 x 10^{8}m/s)**

Energy of X –rays

f = 8.01 X 10^{-16}

£ = 5/100 X 100 kV X 1.602 X 10^{-19} c

6.63 X 10^{-34}

= 8.01 X 10^{-16} j

= 1.208 X 10^{18} HZ

λ = c

λ = 3.0 X10^{8} m/s

f 1.208 X 10^{18}HZ

= 2.483 X10^{-10}m

8. **State two properties of X-rays**

They penetrate matter

-They obey properties of electromagnetic waves

- *Diffraction*
- *Reflection*
- *Obey inverse square law*

v) State one industrial application of X-rays

Used to detect defects in metals in industries

-Used to sterilize medical equipment.

9. ***Name four properties of X rays***
   - ✓ *They have a shorter wavelength of the electromagnetic spectrum.*
   - ✓ *Requires high voltage to produce X-Rays.*
   - ✓ *They are used to capture the human skeleton defects.*
   - ✓ *They travel in a straight line and do not carry an electric charge with them.*
   - ✓ *They are capable of travelling in a vacuum.*