Contents

Chapter 1

Mechanics

Contents

1.1 Measurements

Section A (Objectives)

1. The following readings were recorded when measuring the density of a stone:

Mass of stone = 25g,

Volume of water = 25cm^3.

Volume of water and stone = 35cm^3.

What is the density of the stone?

A. $\frac{25}{10}$g cm^{-3}

B. $\frac{35}{30}$g cm^{-3}

C. 10 g cm^{-3}

D. $\frac{25}{35}$ g cm^{-3} **A**

$$\begin{aligned} V &= 35 - 25 \\ &= 10cm^3 \\ D &= \frac{M}{V} \\ &= \frac{25}{10} gcm^{-3} \end{aligned}$$

2. Three of the fundamental physical qualities are

A. density, mass and time.

B. length, time and mass.

C. length, time and weight. **B**

D. volume, temperature, mass.

3. Which one of the following groups consists of vectors only

A. momentum, acceleration, work, energy.

B. speed, velocity, displacement, energy. **C**

C. displacement, velocity, acceleration, force.

D. velocity, work, power, momentum

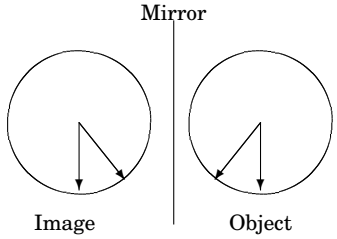
4. The hands of an image of an unnumbered clock face in a plane mirror indicates the position of 6.20. the actual time is

A. 5.40.

B. 6.20.

C. 6.40.

D. 7.40. **C**



5. Liquid Y of volume 0.40m^3 and density 900kgm^{-3} is mixed with liquid Z of volume 0.35m^3 and density 800kg m^{-1}.

Calculate the density of the mixture.

A. 800kg m^{-3}

B. 840 kg m^{-3}

C. 850kg m^{-3}

D. 900kg m^{-3} **C**

$$\begin{aligned} D &= \frac{\text{total mass}}{\text{total volume}} \\ &= \frac{0.4 \times 900 + 0.35 \times 800}{0.4 + 0.35} \\ &= \frac{360 + 280}{0.75} \\ &= \frac{640}{0.75} \\ &= 853.33 \approx 850 \end{aligned}$$

6. A tank 2m tall and base area 2.5m^2 is filled to the brim with a liquid which exerts a force of 40,000N at the bottom. Calculate the density of the liquid.

A. $\frac{4{,}000}{25\times2\times10}$ kgm^{-3}

B. $\frac{40{,}000}{2.5\times2\times10}$ kgm^{-3}

C. $\frac{40{,}000}{25\times2\times10}$ kgm^{-3}

D. $\frac{40{,}000}{2.5\times2}$ kgm^{-3} **B**

$$\begin{aligned} F &= W = mg \\ &= 40,000 \\ m &= \frac{F}{g} = \frac{40,000}{10} \\ D &= \frac{M}{V} \\ &= \frac{\frac{40,000}{10}}{2 \times 2.5} \\ &= \frac{40,000}{10 \times 2 \times 2.5} kgm^{-3} \end{aligned}$$

7. A piece of material of mass 200grams has a density of 25kgm^{-3}. Calculate its volume in m^3.

A. $\frac{200}{25}$

B. $\frac{200}{1000\times25}$

C. $\frac{1000\times25}{200}$

D. $\frac{1000\times200}{25}$ **B**

$$\begin{aligned} V &= \frac{M}{D} \\ &= \frac{200}{1000} kg \div 25 kgm^{-3} \\ &= \frac{200}{1000 \times 25} m^3 \end{aligned}$$

8. A tin containing 6×10^3 m^3 of paint has a mass of 8kg. If the mass of the empty tin with the lid is 0.5kg, calculate the density of the paint in Kgm^{-3}.

A. $\frac{8\times0.5}{6\times10^{-3}}$
B. $\frac{7.5}{6\times10^{-3}}$
C. $\frac{8\times10^6}{6\times10^{-3}}$
D. $\frac{8.5\times10^6}{6\times10^{-3}}$ **B**

$$\begin{aligned} D &= \frac{m}{v} \\ &= \frac{8-0.5}{v} \\ &= \frac{7.5}{6\times10^{-3}} \end{aligned}$$

9. Length, mass and current are

A. units of measurement
B. derived quantities
C. fundamental quantities
D. measured in metres, newtons and amperes respectively **C**

10. Convert 25cm^3 into m^3

A. 2.5×10^5
B. 2.5×10^2
C. 2.5×101
D. 2.5×10^{-5} **D**

$$\begin{aligned} 25cm^3 &= 25cm \times 1cm \times 1cm \\ &= \frac{25}{100}m \times \frac{1}{100}m \times \frac{1}{100}m \\ &= 2.5 \times 10^{-5}m^3 \end{aligned}$$

11. Two solid cubes have the same mass but their edges are in the ration 4:1 What is the ratio of their densities?

A. 1:4
B. 1:8
C. 1:16
D. 1:64 **D**

$$\begin{aligned} \frac{D_1}{D_2} &= \frac{\frac{M}{V_1}}{\frac{M}{V_2}} \\ &= \frac{V_2}{V_1} = \frac{l_2^3}{l_1^3} \\ &= \left[\frac{l_2}{l_1}\right]^3 \\ &= 4^3 = 64 \end{aligned}$$

hence the ratio is 64:1 or 1:64

12. A box of dimensions 0.2m by 0.3m by 0.5m is full of a gas of density 200kg/m^3. The mass of the gas is

A. 3×10^{-2}kg
B. 6.0×10^0kg
C. 2×10^2kg
D. 6.7×10^3kg **B**

$$\begin{aligned} M &= \rho \times v \\ &= 200 \times 0.2 \times 0.3 \times 0.5 \\ &= 6.0 \times 10^0 kg. \end{aligned}$$

13. A set of apparatus that is suitable for measurement of the volume of an irregular object includes:

A. overflow can, measuring cylinder, irregular object and string.

B. measuring cylinder, irregular object, overflow can, flask.

C. overflow can, irregular object, string, retort stand and burette.

D. Burette, overflow can, irregular object, string, measuring cylinder, retort stand. **B**

14. Which of the following can be used to measure the diameter of a bicycle spoke accurately?

A. Metre rule.

B. Vernier caliper.

C. Tape measure.

D. Micrometer screw gauge. **D**

15. A rectangular block of tin is 0.5m long and 0.01m thick. Find the width of the block if its mass and density are 0.45kg and 9000kgm^{-3} respectively.

A. $0.005 \times 0.45 \times 9000$m

B. $\frac{0.45}{9000 \times 0.005}$m

C. $\frac{0.005}{0.44 \times 9000}$m

D. $\frac{0.45 \times 0.005}{9000}$ m **B**

$$
\begin{aligned}
V &= \frac{m}{d} \\
&= \frac{0.45}{9000} \\
\text{But } V &= L \times W \times h \\
w &= \frac{V}{h \times L} \\
&= \frac{\left(\frac{0.45}{9000}\right)}{0.5 \times 0.01} \\
&= \frac{0.45}{9000 \times 0.005}
\end{aligned}
$$

16. The width of a metre rule is accurately measured by a

A. micrometer screw gauge

B. vernier caliper

C. tape measure

D. metre rule **A**

17. A piece of metal of mass 120 g is placed in a 100 ml measuring cylinder containing 20ml of water. Find the density of the metal if the water level rises to the 50 ml mark.

A. 1.2 g cm^{-2}.

B. 2.4 gmc^{-3}.

C. 4.0 g cm^{-3}

D. 6.0 g cm^{-3} **C**

$$
\begin{aligned}
1ml &= 1cm^3 \\
m_{disp.water} &= (50 - 20) \cdot 1gcm^{-3} \\
&= 30g \\
m_{metal} &= 30g \\
D &= \frac{m}{v} = \frac{120}{4} \\
&= 4gcm^{-3}
\end{aligned}
$$

18. What is meant by mass of a body?

Mass is quantity of matter a body contains

1.2 Molecular properties

Section A (Objectives)

1. When water spreads on a glass plate, the forces between its molecules and glass molecules are due to

A. surface tension.

B. adhesion.

C. cohesion.

D. viscosity **B**

2. Surface tension in a liquid may be weakened by

A. Lowering the temperature

B. Adding soap solution

C. Increasing the amount of liquid

D. Increasing the density of the liquid **B**

3. When potassium dichromate dissolves at the bottom of a water container, it spread slowly throughout water by a process called

A. Evaporation

B. Diffusion

C. Capillarity

D. Convection. **B**

4. When a crystal of potassium permanganate is carefully placed at the bottom of a beaker containing water it spreads uniformly in the water after some days due to

A. diffusion.

B. capillarity.

C. surface tension.

D. Brownian motion. **A**

5. Soap is used to wash clothes because it

A. increase capillarity in the clothes.

B. reduces capillarity in the clothes

C. increases surface tension allowing water to penetrate the dirt easily.

D. reduces surface tension allowing water to penetrate the dirt easily. **D**

6. Brownian motion experiment shows that molecules of gases are

A. stationary.

B. in motion in one direction only.

C. in constant random motion.

D. more closely packed than molecul in liquid. **C**

7.

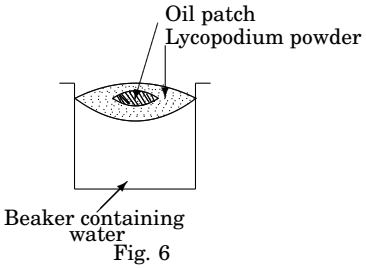


Fig. 6

An oil drop of volume 10^{-3}cm^3 forms a patch on water as shown in fig. 6. The area of the patch is 0.785 cm^2. If it is one molecule thick, what is the size of the molecule?

A. 4.06×10^4cm

B. 7.85×10^4cm

C. 9.53×10^4cm

D. 1.27×10^{-3}cm **D**

$$\begin{aligned} \text{thickness} &= \frac{\text{Volume}}{\text{area}} \\ &= \frac{10^{-3}cm^3}{0.785cm^2} \\ &= 1.274 \times 10^{-3}cm \end{aligned}$$

8. When mercury is spilt on glass it forms small spherical droplets because its

A. density is high.

B. surface tension makes its surface elastic.

C. molecules are small.

D. cohesive force is greater than adhesive force with glass. **D**

9. A blue copper sulphate crystal placed at the bottom of a beaker containing water is found to spread throughout the water after sometime due to

A. osmosis.

B. diffusion

C. capillarity

D. surface tension **B**

10. A needle may float on a clean water but sinks when some detergent is added to water because the detergent.

A. reduces the density of water

B. increase adhesive force between the needle and water molecules.

C. Lowers the surface tension of water.

D. makes water surface slippery.

11. The particles in a solid at room temperature are

A. close together and vibrating.

B. close together and stationary.

C. far apart and moving at random.

D. Close together and moving at random. **A**

12. Water wets glass because

A. adhesion forces between water and glass molecules are less than cohesion forces.

B. adhesion forces between water and glass molecules are more than cohesion forces.

C. surface tension forces between water and glass molecules are more than adhesion forces.

D. surface tension forces are less than cohesion forces. **B**

13. In a Brownian motion experiment, the

A. smoke particles are seen moving about with uniform velocity.

B. motion observed is caused by the air molecules colliding with the smoke particles.

C. size of particles are found to increase the motion.

D. smoke cell has a vacuum within it. **B**

14. The force which hold the molecules in a water drop together are called. . . .

A. Surface tension.

B. Adhesive forces.

C. Cohesive forces.

D. Electrostatic forces **C**

15. When smoke is introduced in a smoke cell and observed under a microscope, it is observed as particles moving at random. This is mainly because the particles.

A. are hot.

B. collide with one another

C. collide with air molecules.

D. collide with the walls of the smoke cell. **C**

Section B (Structured)

16. Give two observations which show the existence of surface tension.

1. *Some insects can walk on water*
2. *soap bubbles can be formed easily*
3. *a steel needle can be made to float on water.*

17. State two factors which affect surface tension of a liquid.

(1) *Temperature*
(2) *Impurities like camphor, soap, etc*

18. Distinguish between cohesion and adhesion

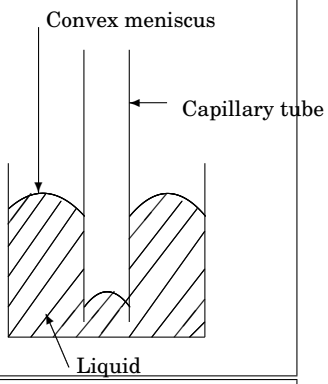
Cohesion in the force of attraction between molecules of the same kind while Adhesion is the force of attraction between molecules of different kind.

19. Sketch diagrams to show the level of liquid in a capillary tube that is immersed in a liquid which has greater.

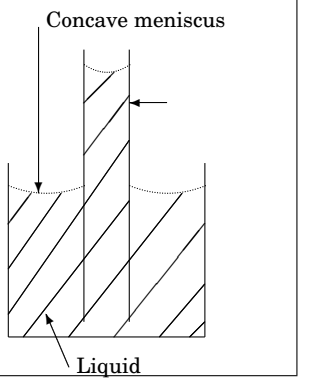
(i) Cohesion than adhesion

(ii) adhesion than cohesion

(i) for greater Cohesion than adhesion



(ii) for greater adhesion than cohesion



20. The diagram in fig. 9 shows an arrangement for observing Brownian motion.

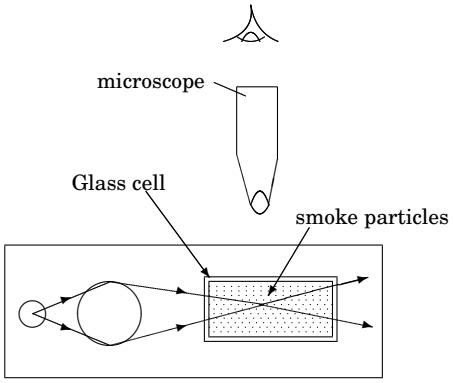


Fig. 9

(a) Explain

(i) the observations made.

(ii) What will be observed when the glass cell temperature is raised.

(i) *Smoke molecules are observed as white specks moving in a zigzag motion.*

(ii)*The zigzag motion becomes faster.*

21. State one factor which determines the rate of diffusion of a gas.

Density or molecular mass of the gas

22. Explain why in the Brownian motion experiment, smoke particles are observed to be in random motion.

This is due to the forces of attraction and repulsion between the smoke particles and air molecules.

23. ’

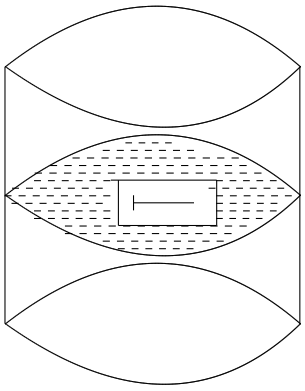


Fig. 9

A pin is placed on a bloating paper which is on the surface of water as shown in fig. 9. Explain what happen after some time.

The paper absorbs water and sinks leaving the pin floating on water.

24. Explain what happens when some soap solution is carefully added to the water.

It reduces surface tension hence it makes the pin sink.

25. The diagram in fig. 5 shows an arrangement for determining the size of an oil molecule.

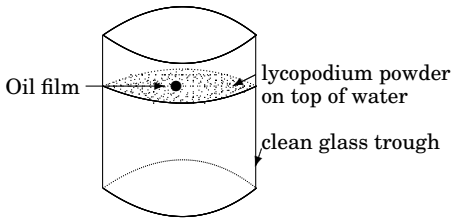


fig. 5

(a) State two assumptions made in the experiment.

- The oil films is monomolecular
- The oil film is circular

(b) If $1.8 \times 10^{-4} cm^3$ of oil spreads to form a patch of area $150 cm^2$, calculate the thickness of the patch.

$$\text{Thickness}, h = \frac{\text{Volume}}{\text{Area}}$$

$$h = \frac{1.8 \times 10^{-4} cm^3}{150 cm^2}$$
$$= 1.2^{-6} cm$$
$$h = 1.2 \times 10^{-8} m$$

Paper II (Essay)

26. (a) Describe a simple experiment to show the existence of surface tension in water and state two factors that affect it.

(b) **A solution is made by dissolving $1 cm^3$ of cooking oil in $199 cm^3$ of methanol. When $0.004 cm^3$ of the solution is dropped on the surface of water, an oil film of diameter 12cm is obtained.**

(i) **Estimate the thickness of a molecule of the cooking oil.**

(ii) **State any assumption made in b(i)**

(c) **Smoke confined in an illuminated cell is observed through a microscope.**

(i) **State what is observed.**

(ii) **What conclusions can be drawn from the observations in (c) (i) above?**

Solution

(a) An experiment to show the existence of surface tension in water.

- get a very thin copper wire and smear it with Vaseline or grease
- place the greased thin copper wire on a paper and place it in ice water or very cold water.

- The paper will absorb water and sink leaving the thin copper wire floating on water.

Since copper as a metal sinks in water and here this thin copper wire floats, then the surface of water acts like an elastic skin and this is surface tension.
Surface tension can be affected by

- Temperature i.e decreases with increase in temperature
- Detergents i.e. decreases surface tension of water when added to it.

(b) (i) $1cm^3$ of oil is dipped in $199cm^3$ of methanol to form $200cm^3$ of the solution

i.e $200cm^3$ of solution contains $1cm^3$ of oil

$1cm^3$ of solution contains $\frac{1}{200}cm^3$ of oil

$0.004cm^3$ of solution contains $\frac{0.004}{200}cm^3$ of oil

$0.004cm^3$ of solution contains $0.00002cm^3$ of oil

$0.004cm^3$ of solution contains $2.0\times 10^{-5}cm^3$ of oil

Volume of oil in $0.004cm^3$ of the solution is $2.0 \times 10^{-5}cm^3$

$$V = 2.0 \times 10^{-5}cm^3$$

The oil film is assumed to be a cylinder hence its volume is given by

$$V = \pi r^2 h$$

Where h is the thickness of the molecule

$$\begin{aligned} h &= \frac{V}{\pi r^2} \\ &= \frac{2.0 \times 10^{-5}cm^3}{3.14 \times (6cm)^2} \\ &= 1.77 \times 10^{-7}cm \\ &= 1.77 \times 10^{-7} \times 10^{-2}m \\ &= 1.77 \times 10^{-9}m \end{aligned}$$

(ii)One assumption made above is that the film formed is one molecule thick i.e. monomolecular.

(c) (i) What is observed is a random zigzag motion of bright specks (smoke molecules)

(ii)We conclude that the particles of gasses are ever in a state of motion colliding with each other, that is why we see the zigzag motion.

27. (a) (i) What is meant by the term diffusion?

(ii) **State factors on which diffusion depends.**

(b) **Describe an experiment to show diffusion in liquids.**

(c) **A porous pot containing air is connected to a water manometer. Explain**

what happens if hydrogens is let in the space surrounding the pot as showed in Fig. 1.

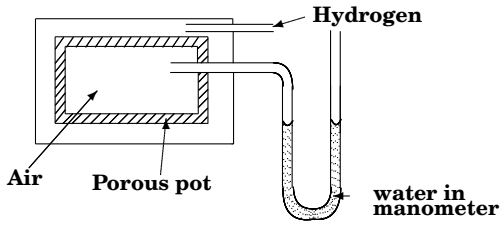


Fig. 1

Solution

(a) (i) diffusion is the movement of molecules from regions of high concentration to regions of low concentration.

(ii) diffusion depends on

- density of the diffusing materials
- temperatures

(b)Experiment to show diffusion in liquids

- Place water in a clean container
- Using a capillary tube, place a drop of potassium permanganate at one point at the bottom of the water.
- Leaving the system in that state for some time. You will find that the whole water has changed to blue, the colour of potassium permanganate which has diffused through the whole water

(c) Hydrogen has smaller molecules compared to those of air so the hydrogen molecules or the gas will enter to the interior of the porous pot at a faster rate increasing the gas pressure there hence the manome ter water is pushed out to show a pressure difference.

28. Smoke is confined in a smoke cell and observed through a microscope. Explain what is observed when the temperature of the smoke cell is raised.

Solution

What is observed, is the zigzag motion caused by the collision of the smoke molecules with air molecul This motion is called Brownian motion.

When the temperature is increased, the zigzag motion is more fast i.e. the molecules now move faster

29. (a) Describe an experiment to estimate the thickness of an oil molecule.

(b) Explain the following observations.

(i) When mercury and water are separately poured on glass, mercury does not wet glass but water does.

(ii) **When a detergent is added to a clean water**

surface, a needle floating on it (water surface) sinks.

(c) **A small steel ball is allowed to fall centrally down a tall cylinder containing lubricating oil.**

(i) **Sketch the velocity-time graph for the motion of the ball**

(ii) **Describe the features of the graph.**

Solution

(a)

- Get a 1cm cube fill it by counting the drops of the oil that can fill this 1cm cube,If they are N drops then;
  Volume of one oil drop, V is;

$$\begin{aligned} V &= \frac{1cm^3}{N} \\ &= \frac{1}{N}cm^3 \end{aligned}$$

- Place water on a tray and sprinkle lycopodium powder on it so as to enable a clear view of the oil patch.
- Let one drop of oil drop on the settled water in the tray. The oil patch will increase in area till it increases no more.
- Measure or estimate the area of the oil patch and call it Acm^3. The oil layer is assumed to be monomolecular.
- Then the thickness of the oil molecule is calculated as follows;

  From , Volume of oil drop, V, is equal to the product Area of Oil patch, A and thickness of the oil layer, h, then;

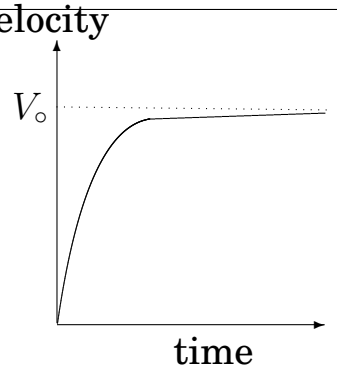
$$\begin{aligned} h &= \frac{V}{A} \\ &= \frac{\frac{1}{N}cm^3}{Acm^3} \\ &= \frac{1}{NA}cm \\ &= \frac{1}{NA} \times 10^{-2}m \end{aligned}$$

(b) (i) Mercury does not wet glass because it has a greater cohesional forces compared to its adhesional forces to glass. Water wets glass because it has a greater adhesion to glass compared to its cohesion.

(ii) this is because a detergent reduces the surface tension that is holding it, the floating needle to a value that can not support the needle which now sinks.

(c) a small steel ball falling in lubricating oil.

(i) its velocity time graph is;



Where $V_\circ$ is terminal velocity

(ii) the graph shows that the steel ball increases its velocity to a maximum constant value called its terminal velocity.

In the first case where the ball's velocity increases, there is a net force, F, acting on it given by

$$F = W - U - \text{Viscous drag}$$

where W and U are its weight and Upthrust respectively.

In the second case where the ball's velocity is constant (terminal velocity), the net force acting on it is zero i.e.

$$W = U + \text{Viscous drag}$$

1.3 Mechanical properties

Section A (Objectives)

14. A beam may be designed with much of its central part removed in order to improve on its

A. brittleness

B. stiffness

C. ductility

D. stability **C**

1. A material that can be rolled into sheet or drawn into wires without breaking is said to be

A. Strong

B. Elastic

C. Ductile

D. Brittle **C**

2. A rod of cross-sectional area 40cm^2 needs a tensile force of 2N to break it. What is its breaking stress?

A. 0.005N m^{-2}

B. 0.05N$_{-2}$m^{-2}

C. 5N m^{-2}

D. 500N m^{-2} **D**

$$\begin{aligned} A &= 40cm^2 \\ &= 40cm \times 1cm \\ &= \frac{40}{100}m \times \frac{1}{100}m \\ &= \frac{40}{10000}m^2 \\ \text{Stress} &= \frac{F}{A} \\ &= \frac{2N}{\frac{40}{10000}m^2} \\ &= 500Nm^{-2} \end{aligned}$$

3. A load of 4N stretches a spring by 0.5cm, calculate the extension when a load of 8N is applied.

A. 0.25cm.

B. 1.0cm.

C. 2.0cm.

D. 4.0cm **B**

$$\begin{aligned}\frac{F_1}{e_1} &= \frac{F_2}{e_2}\\ e_2 &= \frac{F_2 e_1}{F_1}\\ &= \frac{8N}{4N} \times 0.5cm\\ &= 1cm\end{aligned}$$

4.

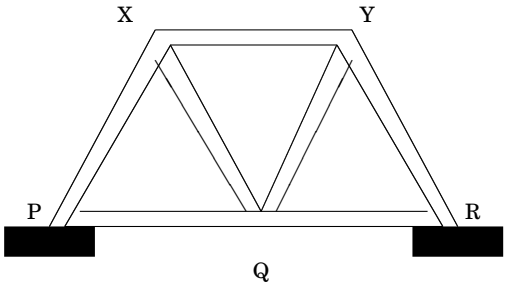


Fig. 6

The diagram in fig. 6 shows a framework of a bridge. Which of the girders are ties?

A. XQ, QY, PX, YR

B. PQ, QR, XY

C. XQ, QY

D. PX, YR **B**

5. Which of the following are all brittle materials?

A. Leather, rubber, thread.

B. Clay, glass, wood **C**

C. Glass, cast iron, stone

D. Rubber, polyester, copper wire

6. In a wire supporting a load, stress is given by

A. $\frac{\text{Strain}}{\text{Area}}$

B. $\frac{\text{Area}}{\text{Force}}$

C. Force $\times$ Area

D. $\frac{\text{Force}}{\text{Area}}$ **D**

7. Reinforced concrete is stronger than ordinary concrete because concrete and steel are

A. both brittle materials

B. both docile materials.

C. strong in tension and compression respectively.

D. strong in compression and tension respectively **D**

8.

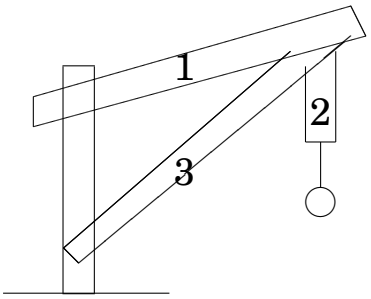


Fig. 4

Fig. 4 shows an arrangement of three planks on a vertical frame. Which planks can be replaced by ropes?

A. 1and 3

B. 1 and 2

C. 3 and 2

D. 1, 2 and 3. **B**

9.

The diagram shows three identical spring balances X, Y and Z arranged as shown in Fig. 5 supporting a load of 10N. Each balance weighs 10N. At equilibrium, the spring Z is extended by e metres. The extensions of X and Y are

	X(m)	Y (m)
A.	$\frac{e}{2}$	$\frac{e}{2}$
B.	e	e
C.	$2e$	$2e$
D.	$3e$	$3e$

A

10. Which of the following are brittle substances?

A. Dry clay, steel and wood. **D**

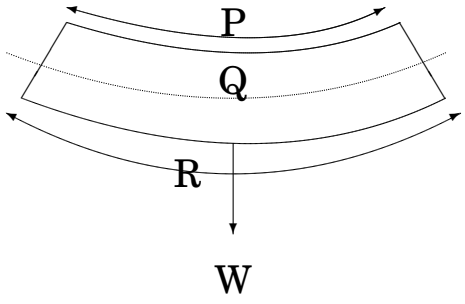
B. Chalk, steel, plastic and glass

C. Glass, chalk, concrete and steel

D. Dry clay, glass, chalk and concrete

Steel is not brittle

11.



The regions P, Q and R are respectively.

A. tension, compression, neutral axis.

B. Neutral axis, compression, tension.

C. Compression, neutral axis, tension.

D. Tension, neutral axis, compression. **C**

12. An object is said to behave elastically when

A. its elastic limit is exceeded.

B. its breaking point is reached.

C. equal increases in the force applied to it produce equal changes in length.

D. the potential energy stored in it is used to permanently deform the object. **C**

13. A ductile material is that which

A. is fragile. **C**

B. is not elastic.

C. can be moulded into any shape.

D. easily breaks under compression.

14. The purpose of threads in tyres is to make them

A. attractive.

B. stronger.

C. reduce friction.

D. grip the road surface. **B**

15.

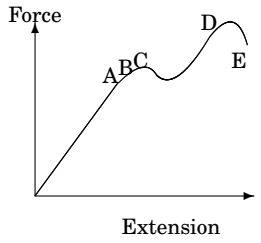


Fig. 4

Fig. 4 shows how the extension of a copper wire varies with the applied force. Point B represents

A. proportional limit.

B. Elastic limit.

C. Breaking stress.

D. Yield point.

16. The strength of a material depends on the

(i) nature of the material.

(ii) diameter of the material.

(iii) length of the material.

A. (i) only.

B. (i) and (ii) only

C. (ii) and (iii) only.

D. (i), (ii) and (iii). **A**

17. A mass of 0.2kg produces an extension of 8cm in a spring. The force required to produce an extension of 6 cm is

A. 0.75N.

B. 1.50N.

C. 2.70N.

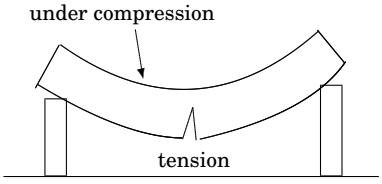
D. 24.00N. **C**

$$\begin{aligned}\frac{F_1}{x_1} &= \frac{F_2}{x_2}\\ F_2 &= \frac{F_1}{e_1}\times x_2\\ &= \frac{(0.2\times 10)\times 8}{6}\\ &= 2.667\end{aligned}$$

Section B (Structured)

18. Explain with the aid of a sketch diagram, how a notch weakens a beam of a brittle material.

A notch acts as a weak point when it is put under tension.



19. State two ways in which concrete may be made stronger.

1. *by adding to it iron bars which are strong under tension.*
2. *by adding in it more appropriate cement to make it more stronger under compression.*

20. Distinguish between a strut and a tie.

A strut is a girder under compression while a tie in a girder under tension.

21.

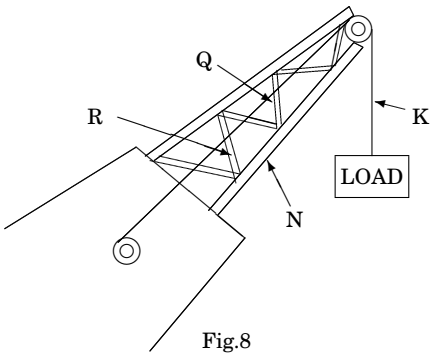


Fig.8

The diagram in fig. 8 shows the arm of a crane used for lifting heavy loads.
Name the force acting on structure;

K

N

Q

R

K - *Tension force*

N - *Compressional force*

Q - *Compressional force*

R - *Compressional force*

22. .

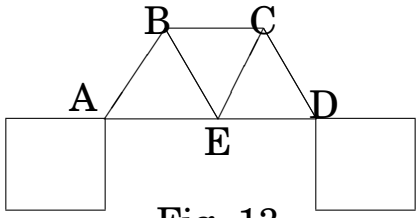


Fig. 13

Fig. 13 shows a frame work of girders. Identify any **two** girders which are in

(i) Tension

AE and ED

(ii) Compression

AB and BE(even EC,BC and CD)

23. Define the following terms

(i) Strain

(ii) Stress

(i) *strain is the ratio of extension to original length.*

(ii)*stress is the force per unit area*

24. The curve in Fig. 7 shows the force versus extension graph for a copper wire. Describe what is happening between points A and B.

The wire undergoes plastic deformation where its atoms or molecules slide over each other.

Paper II (Essay)

25. (a) State Hooke's law of elasticity

(b) **Different loads, W, are applied to the end of an elastic wire and the corresponding extension, e, of the wire recorded**

(i) **Sketch a labeled graph e against W**

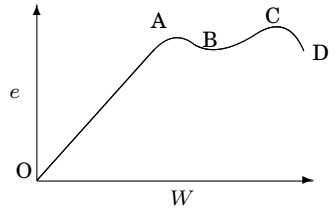
(ii) **describe briefly the features of the graph in (b) (i)**

(c) **A spring of natural length** $5.0\times10^{-2}m$ **extends by** $2.0\times10^{-3}m$ **when a force of 18N acts on it. Calculate the extension when a force of 10N is applied to the spring.**

Solution

(a) Hooke's law states that the extension of an elastic material is directly proportional to the force applied on it, provided the elastic limit is not exceeded.

(b) (i)



Where

$\begin{cases} A & \text{is elastic limit} \\ B & \text{is proportionality} \\ C & \text{is yield point and} \\ D & \text{is breaking point} \end{cases}$

(ii) the graph has two main parts; **The elastic region OA**; where Hooke's law is obeyed and **The inelastic region AD** where the material undergoes plastic deformation (Hooke's law is not obeyed)

(c) From the question we have;

$$\begin{aligned} l_0 &= 5.0\times10^{-2}m \\ e &= 2.0\times10^{-3}m \\ \text{When } F &= 1.8N \end{aligned}$$

From Hooke's law

Force F is proportional to extension e,

$$\begin{aligned} F &\ \alpha\ e \\ F &= ke \end{aligned}$$

where k is the spring constant or elastic constant.

$$\begin{aligned} \Rightarrow k &= \frac{F}{e} \\ &= \frac{1.8N}{2.0\times10^{-3}m} \\ &= 900N/m \end{aligned}$$

hence $F = ke$ becomes

$$F = 900e$$

If the force of $10N$ extends the spring by e

$$\text{From } F = 900e$$

$$
\begin{aligned}
10 &= 900e \\
\frac{10}{900} &= \frac{\not{9}00}{\not{9}00}e \\
\frac{10}{900} &= e \\
e &= \frac{10}{900} \\
e &\simeq 0.0111m \\
e &\simeq 1.11cm
\end{aligned}
$$

26. (a) With the aid of a diagram, describe the effect of a shear force on a body.

(b) (i) What is meant by strength as applied to a material?

(ii) **State the factors on which strength of a material depends.**

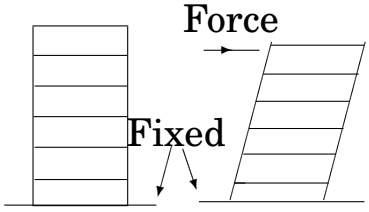
(c) **Describe a simple experiment to verify Hooke's law using a spring.**

(d) (i) What is concrete?

(ii) **State any three characteristics of concrete which make it a desirable building material.**

Solution

(a) the effect of a shear force on a body is, it makes the body slide along one of its sides e.g.



No shear force With shear force

Hence the body changes shape.

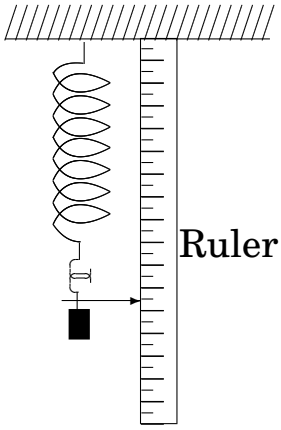
(b) (i) strength is the ability of a material to resist distortion when a force is applied on it.

(ii) strength of a material depends on

- the young's moduli of the material
- the surface texture i.e. does it easily develop a notch or is it smooth.

(c) an experiment to verify Hooke's law

- suspend a spring from a rigid support as shown below



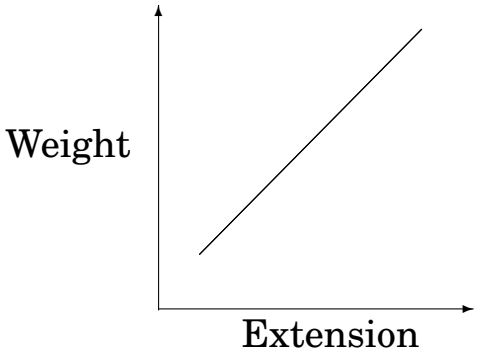
- read the initial position of the pointer on the ruler as $P_\circ$
- Hang a small mass, m, from the free end of the spring and measure the new position as P
- measure the extension x as $x = |P - P_\circ|$
- repeat the above procedures for various increasing val-

ues of masses, m, and record your results as shown

m	P	x	W

where;
P is new pointer position
x is extension in metres
$W = mg$ is weight and
m is mass in kg

- plot a graph of weight against extension, a straight line will be obtained.



This shows that the extension is proportional to the force (weight) applied which is Hooke's law.

(d) **(i)** Concrete is a stone-like material which is obtained by mixing sand, cement, water and gravel then left to dry.

(ii)
- It is a very strong material under compressional forces.
- It is fire resistant i.e. concrete can not burn like wood
- It can be moulded into any desired shape
- It is weather resistant i.e. it remains strong in wet and dry conditions.

1.4 Forces

1. Which of the following are true statements about friction?

(i) it does not oppose motion.

(ii) It causes wearing of surfaces.

(iii) It decreases as weight of a body increases.

(iv) It can be reduced by applying oil between surfaces.

A. (i) only.

B. (i) and (iii) only.

C. (ii), (iii) and (iv) only.

D. (i), (ii), (iii) and (iv) **C**

2. .

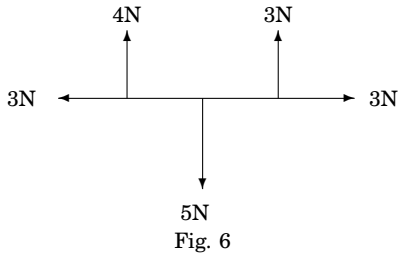


Fig. 6

Five forces of 5N, 3N, 4N, 3N and 3N act on a body as shown in

Figure 6. Find the resultant force on the body.

A. 2N

B. 7N

C. 12N

D. 18N. **A**

$\uparrow (4+3)-5=2N \rightarrow 3-3=0N$
resultant is 2N

3.

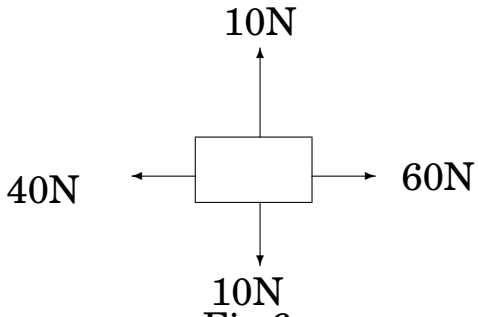


Fig.6

Forces of 60N, 10N, 40N and 10N act on a body as shown in Fig. 6. In which direction does the body move?

A. upwards.

B. downwards.

C. to the left.

D. to the right. **D**

4. Two forces of 5N and 12N act on a body at right angles. Find their resultant.

A. 7N

B. 13N

C. 17N

D. 169N **B**

If R is the resultant, then

$$\begin{aligned} R &= \sqrt{5^2+12^2} \\ &= \sqrt{25+144} \\ &= \sqrt{169} \\ &= 13 \end{aligned}$$

5.

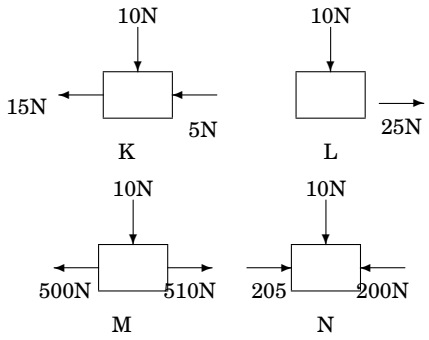


Fig. 3

Fig. 3 shows forces applied on each of the identical blocks of the same mass. The block which has the greatest net force is

A. K

B. L

C. M

D. N **A or B**

The vertical force in all the 4 diagrams is constant i.e. 10N, the horizontal forces are

$$\begin{aligned} K &= 15+5=25 \\ L &= 25 \\ M &= 510-500=10 \\ N &= 205-200=5 \end{aligned}$$

hence L and K had the maximum horizontal force and hence greatest net force

6.

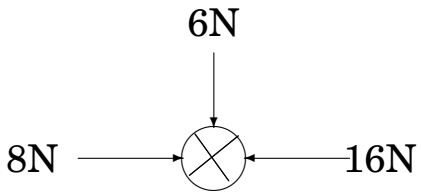


Fig. 5

The diagram in fig. 5 shows three forces of 8N, 6N and 16 N acting on a particle X. The magnitude of the resultant force is

A. 10N

B. 14N

C. 18N

D. 30N **A**

net horizontal force is $16 - 8 = 8$N

net vertical force = 6N

Magnitude of the resultant force R is

$$\begin{aligned} R &= \sqrt{6^2 + 8^2} \\ &= \sqrt{36 + 64} = \sqrt{100} \\ &= 10N \end{aligned}$$

7.

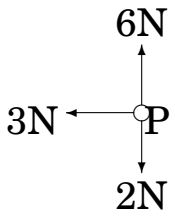


Fig. 1

In the diagram in Fig. 1, the magnitude of the resultant force acting on a body P. is

A. 1N

B. 5N

C. 7N

D. 11N **B**

$\uparrow 6 - 2 = 4$

$\longrightarrow 3N$

$R = \sqrt{3^2 + 4^2} = 5$

8. In which of the following situations is minimum frictional force required?

A. sliding down a slope.

B. walking along a road.

C. Leaning a ladder against a wall.

D. designing brake blocks for a bicycle. **A**

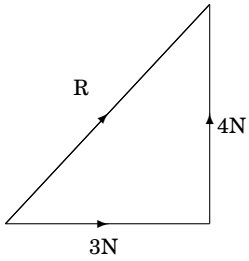
9. Two forces of 4N and 3N act at a point at right angles to each other. Find the magnitude of the resultant force.

A. 1N

B. 5N

C.7N

D. 12N = 5



$R = \sqrt{3^2 + 4^2} = \sqrt{25} = 5$ **B**

10. Which of the following is true for an object under shearing forces?

A. The object does not change in shape.

B. The layers of the object tend to slide on one another.

C. The object gets twisted.

D. The object tends to shorten.

B

Section B (Structured)

11. What is a vector quantity?

This is a quantity which shows both magnitude and direction.

12. Fig. 7 shows the resultant R of two forces P and Q. R makes an angle of 60^o with the horizontal and P is $50N$.

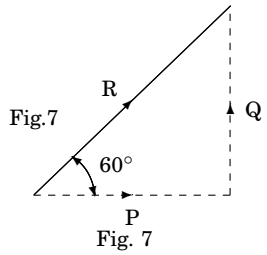


Fig.7

Fig. 7

Find the magnitude of:

(i) Q

(ii) R

Using trigonometric definitions of $\tan\theta$ and $\cos\theta$, we have;

(i) Q

$$\begin{aligned}\frac{Q}{P} &= \tan 60^0 \\ Q &= P\tan 60 \\ &= 50\times\sqrt{3} \\ &= 50\sqrt{3} \\ &= 50\times 1.732 \\ &\cong 86.6N\end{aligned}$$

(ii) R

$$\begin{aligned}\frac{P}{R} &= \frac{\cos 60}{1} \\ \frac{R}{P} &= \frac{1}{\cos 60} \\ R &= \frac{P}{\cos 60} \\ &= \frac{50}{0.866} \\ &= 57.74N\end{aligned}$$

13. .

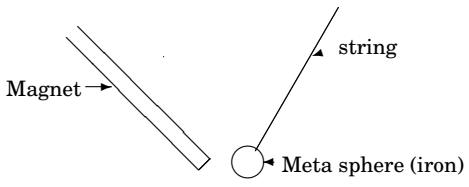
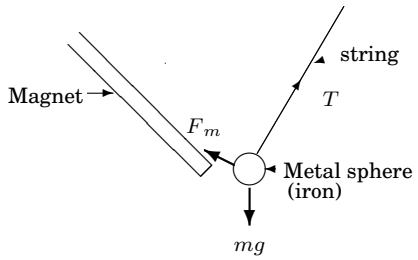


Fig. 7

The diagram in Fig. 7 shows a metal sphere of weight W in equilibrium. Complete the diagram to show the forces acting on the metal sphere.



where;

T is tension in the string

Mg is the weight of the metal sphere

F_m is magnetic force of attraction

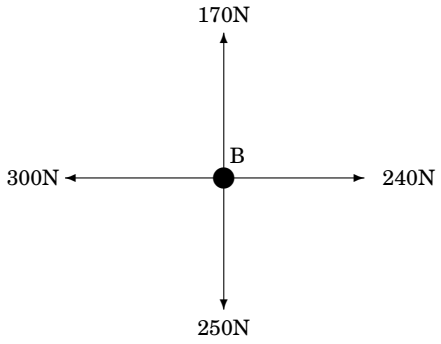
14. State two effects that a force can have on a body.

1. *It makes it move*
2. *It may deform it*

15. Give two examples of a vector.

- momentum and
- acceleration or
- velocity and
- force

16.



Four forces of $170N$, $240N$, $250N$ and $300N$ act on a body B, as shown in the diagram above. Determine the magnitude of the resultant force on B.

net upward force,

$$\begin{aligned} P &= 170 - 250 \\ &= -80N \end{aligned}$$

horizontal force,

$$\begin{aligned} Q &= 340 - 300 \\ &= -60N \end{aligned}$$

Resultant, R

$$\begin{aligned} R &= \sqrt{P^2 + Q^2} \\ R &= \sqrt{(-80)^2 + (-60)^2} \\ &= \sqrt{6400 + 3600} \\ &= 100N \end{aligned}$$

Paper II (Essay)

17. (a) What is meant by *dynamic friction*

(b)**Describe, with the aid of a diagram, an experiment to determine the limiting friction between two surfaces in contact**

(c)**State any one factor which affects friction**

(d) **Give one application of friction**

(e) **Describe an experiment to demonstrate friction com-**

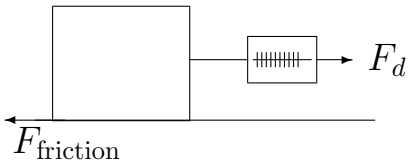
pensation using an inclined plane.

Solution

(a) Dynamic friction is the type of friction which acts on a body in motion.

(b)An experiment to determine the limiting friction between two surfaces in contact;

- let the two surfaces be that of the box and that of the surface where the box is resting
- place the box on the surface and tie a small weighing machine on it.
- Pull the box via the other end of the weighing machine as shown below;



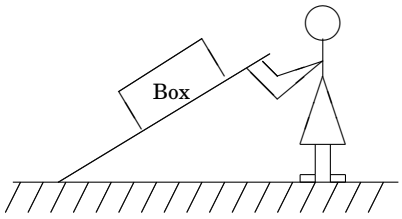
- when the box just starts to move, record the reading of the weighing machine. this reading is the value of the limiting friction between the two surfaces.

(c)Normal reaction on the surface or the nature of the surface (surface texture)

(d) Friction is used in writing, stoping and starting motion, etc

(e) An experiment to demonstrate friction compensation using an inclined plane.

- Place an object like a box on a horizontal plane.
- rise one side of it slowly till the box starts to slide, the angle of inclination just when it starts to slide is a measure of the force of gravity that is overcoming friction i.e. the angle of inclination is proportional to friction.



1.5 Energy

Section A (Objectives)

1. A body of mass m kg and at height h m from the ground has

   A. total gravitational potential energy = mh. **B**

   B. the greatest gravitational potential energy when at height, h.

   C. the greatest potential energy when it just drops to the ground.

   D. the least potential energy when at height $\frac{1}{2}$ h to the ground.

2. The energy transformations involved in a bicycle dynamo is

   A. electrical to chemical.

   B. potential energy to chemical energy.

   C. chemical to light energy. **D**

   D. kinetic energy to electrical energy.

3. The energy transformations involved in a bicycle dynamo is

   A. electrical to chemical.

   B. potential energy to chemical energy.

   C. chemical to light energy.

   D. kinetic energy to electrical energy. **D**

4. Which one of the following statements is true about energy transformation?

   A. A steam engine changes heat energy into mechanical energy.

   B. A thermopile changes electrical energy to heat energy.

   C. A dynamo changes electrical energy to mechanical energy

   D. A microphone changes electrical energy to sound energy.

   A

5. The diagram in fig. 3 shows an oscillating pendulum bob. Which of the following statements is true about its motion?

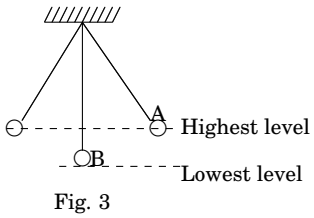


Fig. 3

   A. The kinetic energy at B is equal to the kinetic energy at A.

   B. The kinetic energy at B is less than the potential energy at A.

   C. The kinetic energy at B is equal to the potential energy at A. **C**

   D. The kinetic energy at B is greater than the potential energy at A.

6. Which of the following forms mechanical energy

   A. electrical energy and kinetic energy

   B. Potential energy and nuclear energy

   C. Nuclear energy and kinetic energy

   D. Potential energy and kinetic energy **D**

7. In which of the following devices is kinetic energy converted to electrical energy?

   A. an accumulator.

   B. An electric motor.

   C. A combustion engine

   D. A dynamo **D**

8. A body of mass 25kg falls freely from a height of 10 metres to the ground. Calculate its velocity as it hits the ground.

   A. 4.47 ms^{-1}

   B. 10.0 ms^{-1}

   C. 14.14 ms^{-1}

   D. 2500 ms^{-1} **C**

$$\begin{aligned} \frac{1}{2}mV^2 &= mgh \\ v &= \sqrt{2gh} \\ &= \sqrt{2 \times 10 \times 10} \\ v &= 14.14ms^{-1} \end{aligned}$$

9. The energy changes that take place when a stone falls freely from rest to the ground can be orderly arranged as:

   A. Kinetic energy Potential energy Sound energy Heat energy

   B. Sound energy Potential energy Kinetic energy Heat energy

   C. Potential energy Sound energy Kinetic energy Heat energy

   D. Potential energy Kinetic energy Heat energy Sound energy **D**

10.

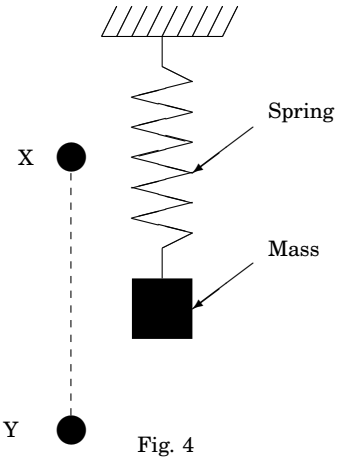


Fig. 4

A mass attached to the end of a spring moves up and down to maximum and minimum points X and Y as shown in fig. 4 above. When the mass is at X the

   A. kinetic energy is maximum, potential energy is minimum.

   B. kinetic energy is zero, potential energy is maximum.

   C. kinetic energy is equal to potential energy.

   D. kinetic energy and potential energy are both zero. **B**

11. Which of the following statements is true about an electric motor? It changes

   A. kinetic energy to electrical energy.

   B. electrical energy to light energy.

   C. electrical energy to kinetic energy.

   D. chemical energy to electrical energy. **C**

12. A ball of 1kg bounces off the ground to a height of 2m after falling from a height of 5 m, find the energy lost.

A. 5J

B. 20 J.

C. 30 J.

D. 50 J. **C**

$$\begin{aligned} E_{lost} &= mg\Delta h \\ &= 1 \times 10 \times (5-2) \\ &= 30J \end{aligned}$$

13. Which of the following is the correct order of energy changes or conversions in a generator?

A. Heat energy in cylinder $\Rightarrow$ Kinetic energy in pistons $\Rightarrow$ electrical energy.

B. Chemical energy from fuel $\Rightarrow$ Heat energy in cylinders $\Rightarrow$ Kinetic energy in pistons $\Rightarrow$ Rotational kinetic energy in the dynamo $\Rightarrow$ electrical energy

C. Chemical energy $\Rightarrow$ Rotational kinetic energy in the dynamo $\Rightarrow$ Rotational kinetic energy in pistons $\Rightarrow$ Electrical energy.

D. Electrical energy $\Rightarrow$ Rotational kinetic energy in dynamo $\Rightarrow$ Rotational kinetic energy in pistons $\Rightarrow$ sound energy. **B**

14. An electric motor of efficiency 90% operates a water pump. If it raises 0.9kg of water through 10m every second. Calculate the electrical power supplied to the motor.

A. 8.1W.

B. 81W.

C. 90 W.

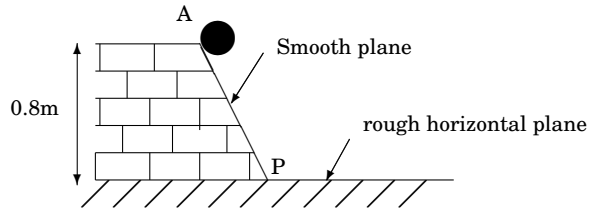
D. 100 W. **D**

if supplied power is x

$$\begin{aligned} 90\% \text{ of } x &= \frac{mgh}{t} \\ \frac{90}{100}x &= \frac{0.9 \times 10 \times 10}{1} \\ x &= \frac{100}{90} \times \frac{0.9 \times 10 \times 10}{1} \\ x &= 100 \end{aligned}$$

Section B (Structured)

15. A ball A of mass $2kg$ is released from a wall at a height of $0.8m$ above a rough horizontal surface along a smooth inclined plane as shown below;



(i) Find the velocity of the ball at point P.

From the law of conservatioon of energy, loss in potential energy is equal to the gain in kinetic energy.

$$\begin{aligned}\frac{1}{2}mv^2 &= mgh\\ v &= \sqrt{2gh}\\ &= \sqrt{2\times 10\times 0.8}\\ &= 4ms^{-1}\end{aligned}$$

(ii) Find the frictional force required to bring the ball to rest in a distance of $2m$ along the rough surface.

aqssuming that the 4m/s is along the horizontal plane, using the law of conservation of energy, we have;

$$\begin{aligned}\text{Kinetic energy} &= \text{work done by friction}\\ \frac{1}{2}mv^2 &= F\times d\\ \frac{1}{2}\times 2\times 4^2 &= F\times 2\\ 16 &= 2F\\ F &= 8N\end{aligned}$$

16. Define the Joule.

A joule is the work done in moving a force of 1N through a distance of 1m in the directions of the force.

17. The work done to move a body through a distance of 5 m is 30 J. Find the force that acts on the body. (03 marks)

$$\begin{aligned}W &= F\times D\\ F &= \frac{W}{D}=\frac{30}{5}\\ &= 6N\end{aligned}$$

Paper II (Essay)

18.

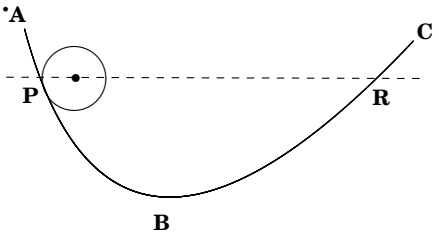


Fig. 1

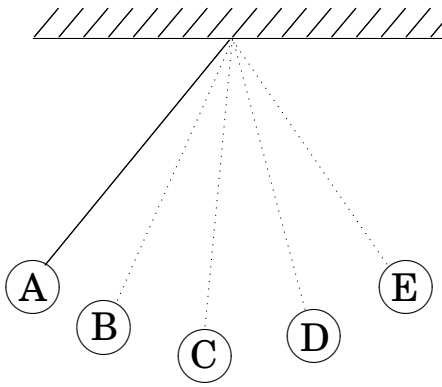
The diagram in Fig. 1 shows a large smooth bowl ABC. Explain what happens when a ball is released from P

Solution

When released from P it losses it potential energy as it gains kinetic energy which is maximum at B.
Past B it rises reducing in speed (kinetic energy) but gaining equivalent potential energy.
There is loss of energy due to friction with the bowl and air resistance.
The ball returns and repeats with decreasing height till when it comes to rest at B

19. (a) (i) State the principle of conservation of energy.

(ii) **Illustrate the principle in (a) (i) with reference to a simple pendulum in a vacuum.**



If we use $P.E$ to mean potential energy and $K.E$ to mean kinetic energy then;

The total mechanical energy at A i.e.

P.E at A + K.E at A

$$\begin{aligned} &= P.E \text{ at } B + K.E \text{ at } B \\ &= P.E \text{ at } C + K.E \text{ at } C \\ &= P.E \text{ at } D + K.E \text{ at } D \\ &= P.E \text{ at } E + K.E \text{ at } E \\ &= \text{Total energy} \end{aligned}$$

Or from A to B the body is losing potential energy and gaining kinetic energy.

From C to E it is loosing kinetic energy and gaining potential energy.

(b) **A ball of mass 3.0kg falls from rest at a height of 4.0m onto a horizontal surface and rebounds to a height of 2.0 m.**

(i) **Find the kinetic energy just before the ball hits the surface; and just after the collision. Explain the difference between the two energies.**

(ii) **What is its initial momentum?**

Solution

(a) (i) Principle of conservation of energy states that energy can neither be created nor be destroyed but it just changes from one form to another.

(ii) For a simple pendulum in avacuum its total energy (i.e. mechanical energy) remains constant at all points as it oscillates or swings. For the diagram below; Remember mechanical energy is the sum of potential energy and kinetic energy.

(b) from the question

$$\begin{aligned} m &= 0.3kg \\ \text{Initial height }, H &= 4.0m \\ \text{Rebound height }, h &= 2.0m \end{aligned}$$

(i) Just before the ball hits the ground, its kinetic energy, (K.E.) is equal to its initial poten-

tial energy i.e.

$$\begin{aligned} \text{K.E.} &= \frac{1}{2}mv^2 \\ &= mgH \\ &= 0.3 \times 10 \times 4 \\ &= 12 Joules \end{aligned}$$

Just after the collision, its kinetic energy (K.E.) is the same as its potential energy at the rebound height i.e.

$$\begin{aligned} \text{K.E.} &= \frac{1}{2}mv^2 \\ &= mgh \\ &= 0.3 \times 10 \times 2 \\ &= 6 Joules \end{aligned}$$

The difference between these two values of kinetic energy is the energy dissipated or lost as;

- Light, if sparks are formed
- Sound, it sound is heard at rebound
- Other forms of energy

Kinetic energy just before rebound is equal to the sum of Kinetic energy just after rebound and Energy losses

(ii) Its initial momentum is the product of mass and initial velocity of the body, i.e. mV
But initial kinetic energy, K.E.

$$\begin{aligned} K.E. &= \frac{1}{2}mV^2 \\ 12 &= \frac{1}{2}mV^2 \end{aligned}$$

$$\begin{aligned} \Longrightarrow V &= \sqrt{\frac{2 \times 12}{0.3}} \\ &= \sqrt{80} \\ &= 8.944 ms^{-1} \end{aligned}$$

Hence Initial momentum, mV, is;

$$\begin{aligned} mV &= 0.3Kg \times 8.944 ms^{-1} \\ &= 2.6832 Kgms^{-1} \end{aligned}$$

1.6 Pressure

Section A (Objectives)

1. Turbulent flow of a fluid in a pipe may be caused by

(i) Making the pipe narrow

(ii) Laying the pipe steeply

(iii) Making the fluid to flow and uniformly.

A. (i) only

B.(i) and (ii) only

C.(ii) and (iii) only

D.(i) , (ii) and (iii) **A**

2. In a liquid, pressure is

A. transmitted in a specific direction

B. transmitted in all directions.

C. decreased with depth.

D. decreased with density. **B**

3.

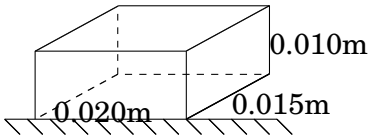


Fig. 5

A box is placed on top of a table as shown in Fig. 5, with the dimensions indicated. If its mass is 40kg, find the pressure it exerts on the table.

A. $\frac{40}{0.020\times0.015}$

B. $\frac{40}{0.015\times0.010}$

C. $\frac{40\times10}{0.020\times0.015}$

D. $\frac{40\times10}{0.020\times0.010}$ **C**

$$\begin{aligned} P &= \frac{F}{A} \\ &= \frac{mg}{A} \\ &= \frac{40\times10}{0.02\times0.15} \end{aligned}$$

4. Pressure in a liquid is independent of the

A. density of the liquid.

B. Depth below the surface of the liquid.

C. Pressure exerted on the surface of the liquid above.

D. Cross sectional area and the shape of the vessel containing the liquid. **D**

5. A rectangle block of metal weighs 3N and measures $(2\times3\times4)\text{cm}^3$. What is the greatest pressure it can exert on a horizontal surface?

A. 5.0×10^3 Nm^{-2}

B. $3.75\times10^{-2}\text{Nm}^{-2}$

C. 2.5×10^3 Nm^{-2}

D. $7.5\times10^{-1}\text{Nm}^{-2}$ **A**

$$\begin{aligned} P_{max} &= \frac{F}{A_{min}} \\ A_1 &= \frac{2}{100}\cdot\frac{3}{100} = \frac{6}{10000}m^2 \\ A_2 &= \frac{2}{100}\cdot\frac{4}{100} = \frac{8}{10000}m^2 \\ A_3 &= \frac{3}{100}\cdot\frac{4}{100} = \frac{12}{10000}m^2 \\ A_{min} &= \frac{6}{10000} \\ P &= \frac{3N}{\frac{6}{10000}m^2} \\ &= 5000 = 5.0\times10^3 \end{aligned}$$

6. The mass of a cuboid of dimensions 4m $\times$ 2m $\times$ 3m is 48kg. The minimum pressure it can exert is

A. 20 Nm^{-2}.

B. 40 Nm^{-2}

C. 60 Nm^{-2}.

D. 80 Nm^{-2} **B**

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

$$\begin{aligned} &= \frac{mg}{A_{max}} \\ &= \frac{48 \times 10}{4 \times 3} \\ &= 40 \end{aligned}$$

7. In a hydraulic machine

   A. an object displaces its own weight of fluid.

   B. the pressure transmitted in a fluid is the same in all directions.

   C. the volume of fluid compressed is proportional to the applied force.

   D. an object experiences an upthrust equal to the weight of fluid displaced. **B**

8. Which of the following is true about a manometer?

   (i) it uses mercury because mercury is a good conductor of heat.

   (ii) It is used for measuring gas pressures.

   (iii) The maximum height of mercury it can support is 760mm.

   A. (i) and (ii) only

   B. (i) and (iii) only.

   C. (ii) only

   D. (ii) and (iii) only.

9. What is 730mmHg in Nm^2?

   A. $\frac{13600\times100\times10}{730}$

   B. $\frac{13600\times730\times10}{1000}$

   C. $\frac{13600\times730}{1000\times10}$

   D. $\frac{13600\times10}{1000\times730}$ **B**

$$\begin{aligned} P &= h\rho g \\ &= \frac{730}{1000} \times 13600 \times 10 \\ &= \frac{730 \times 13600 \times 10}{1000} \end{aligned}$$

10. A metal cylinder contains a liquid of density 1100kgm^{-3}. The area of the base of the cylinder is 0.005m^2 and the height of liquid is 5 m. Calculate the force exerted by the liquid on the base of the cylinder.

    A. 27.5N

    B. 55N

    C. 220 N

    D. 275N **D**

$$\begin{aligned} F &= W = mg \\ &= \rho v g \\ &= \rho A h g \\ &= 1100 \times 0.005 \times 5 \times 10 \\ &= 275N \end{aligned}$$

11. Which one of the following statements is false? The pressure in a liquid

    A. at any one point in a liquid would not change even when more liquid is added.

B. at any one point depends only on the depth and density.

C. at any one point acts equally in all directions.

D. increases with depth. **A**

12.

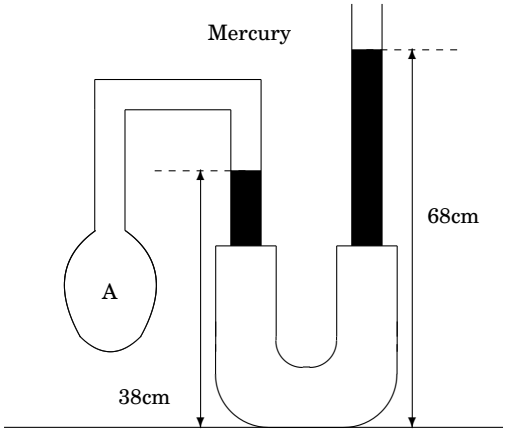


Fig. 5

In fig. 5, a fixed mass of dry air is trapped in bulb A. Calculate the total pressure of the air in A, given that atmospheric pressure is 76cm of mercury.

A. 30 cm Hg

B. 38 cm Hg

C. 46 cm Hg

D. 114 cm Hg **D**

$$\begin{aligned} P &= H + h \\ &= 76 + (68 - 38) \\ &= 76 + 30 \\ &= 106 cmHg \end{aligned}$$

There is no correct option but the answer close to it is 114cmHg

13. Which of the following is true about pressure in liquids? It

A. increases with the surface area of the liquid.

B. it directly proportional to the depth.

C. depends on the shape of the container.

D. is the same at equal depths in all liquids. **B**

14.

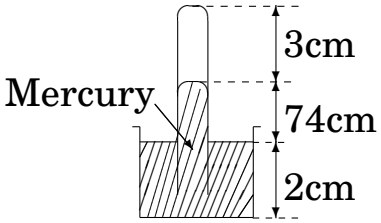


Fig. 3

The diagram in fig. 3 shows a mercury barometer. What is the value of the atmospheric pressure?

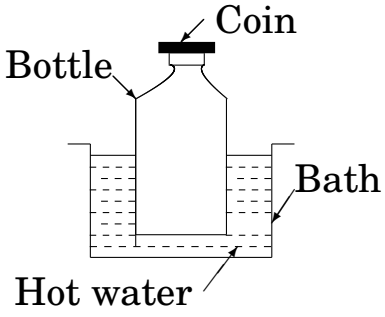
A. 74 cm.

B. 76 cm.

C. 77 cm.

D. 79 cm. **A**

15. An empty bottle is immersed in a hot bath and then closed with a coin as shown below.



The bottle is then immersed in a cold water bath and turned upside down. The coin...

A. does not fall off because the pressure inside the bottle is greater than that outside the bottle.

B. Does not fall off because the pressure outside the bottle is greater than that inside the bottle.

C. Will fall off because the pressure inside the bottle is equal to that outside the bottle.

D. Will fall off because the pressure inside the bottle is greater than that outside the bottle.

B

16. A rectangular block of dimension 4cm $\times$ 2cm $\times$ 1cm exerts a maximum pressure of 200Nm^{-2} when resting on a table. Calculate the mass of the block.

A. 4g.

B. 16g.

C. 40g.

D. 400g. **B**

$$\begin{aligned} P_{max} &= \frac{F}{A_{min}} \\ &= \frac{mg}{A} \\ 200 &= \frac{m \times 10}{\frac{4}{100} \times \frac{2}{100}} \\ m &= \frac{200 \times \frac{4}{100} \times \frac{2}{100}}{10} \\ &= 0.016kg \\ m &= 0.016 \times 1000g \\ &= 16g \end{aligned}$$

17. Calculate the increase in pressure which a diver experiences when he descends 30 m in sea water of density 1.2×10^3kg m^{-3}.

A. 3.0×10^2 Nm^{-2}

B. 1.2×10^4 Nm^{-2}

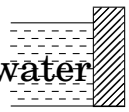
C. 3.34×10^4 Nm^{-2}

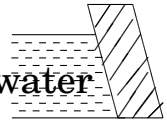
D. 3.34×10^5 N m^{-2} **D**

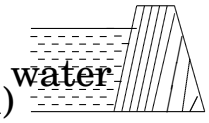
$$\begin{aligned} \Delta P &= \Delta h \rho g \\ &= 30 \times 1.2 \times 10^3 \times 10 \\ &= 3.6 \times 10^5 \end{aligned}$$

The value nearest to this is 3.34×10^5

18. The diagrams below show the possible shapes of water dams.

(i) 

(ii) 

(iii) 

Which shapes(s) is/are preferable?

A. (i) and (ii) only.

B. (ii) and (iii) only.

C. (i) and (iii) only.

D. (iii) only. **B**

Section B (Structured)

19. The diagram in fig. 8 below, shows an instrument used for measuring gas pressure in a laboratory.

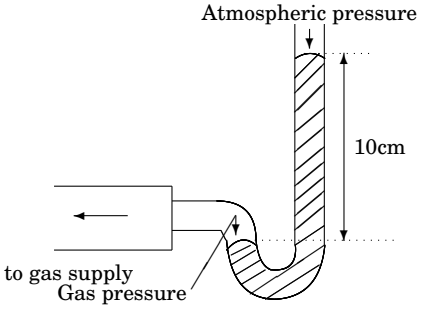


Fig. 8

Find the pressure in Nm^{-2} of the gas if atmospheric pressure is 76cmHg. [Density of mercury = $13.6\times10^3 kgm^{-3}$]

gas pressure, P

$$\begin{aligned} P &= P_\circ + h\rho g \\ &= H\rho g + h\rho g \\ &= (H+h)\rho g \\ &= (760+100)\rho g \\ &= (860mm)\,\rho g \\ &= \frac{860}{1000}\times 13.6\times 10^3 \times 10 \\ &= 116,960Pa \end{aligned}$$

20. State two factors which affect terminal velocity.

1. *Density of the fluid*
2. *Diameter, size or shape of the moving body.*

21. Explain briefly how a person is able to drink using a straw.

Atmospheric pressure acts on the surface of the drink pushing it up the straw to the drinker's mouth.

Paper II (Essay)

22. (a) (i) Explain why one feels more pain when pricked with a needle than when pricked with a nail.

(ii)**State the assumption made**

(b)**With the aid of a labeled diagram, explain how a force pump works.**

(c)**Calculate the pressure exerted on the ground by a box of mass $10kg$ when corresponding area of contact is $2m^2$.**

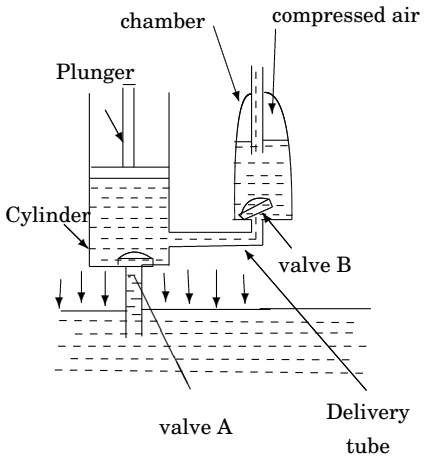
Solution

(a) (i) The needle has a tip with a smaller area compared to the nail hence under the same force, the needle exerts more or a much higher pressure $\left(P=\frac{F}{A}\right)$ compared

to the nail, therefore causing more pain.

(ii) The assumption made is the force acting on the two is assumed to be of the same magnitude and normal to the area of the contact.

(b) **How a force pump works**



This pump is operated by moving the plunger up and down manually or using a machine or engine (e.g. an electric motor).

During the up stroke:

Assuming it was empty, when the plunger is moved up;
Valve B closes due to;

- Its weight
- Weight of water above it(if it is there), and

Valve A opens due to:-

- The sucking nature of the empty space (nature abhors a vacuum) or we can say due to the low pressure region created.
- The atmospheric pressure acting on the water surface forces the water to rise up into the cylinder.

All in all, the water is transferred to the cylinder in the first stroke via valve A.

During the down stroke

On moving the plunger down:
Valve A closes due to;

- Its weight and
- Weight of water above it.

Valve B opens because the applied force below it, is greater than the force above it. When valve B opens, it allows water to flow from the cylinder to this chamber. When this chamber is full water rises in the exit pipe to a greater height depending on the force applied on the plunger.
When the up stroke is now performed and the cycle repeated, water flows up the cylinder.

(c)

$$\begin{aligned} \text{Pressure} &= \frac{\text{Force}}{\text{Area}} \\ P &= \frac{F}{A} \\ &= \frac{W}{A} \\ &= \frac{mg}{A} \\ &= \frac{10 \times 10}{2} \\ &= 50pa \end{aligned}$$

$$or P = 50Nm^{-2}$$

23. (a) Define the term pressure

(b) (i) Describe how a simple mercury barometer can be set up to measure the atmospheric pressure.

(ii) **The difference between the atmospheric pressure at the top and bottom of a mountain is** $1\times 10^4Nm^{-2}$ **if the density of air is** $1.25kgm^{-3}$**, calculate the height of the mountain.**

(c) (i) State the principle of transmission of pressure in fluids.

(ii) **Give one assumption on which the principle is based.**

(iii) **State two applications of the principle.**

(iv) **In fig. 1, piston A has diameter of 14cm while B has diameter of 280cm. If a force of 77N is exerted on piston A, calculate the force exerted by piston B.**

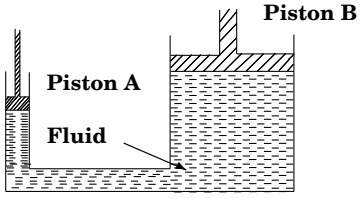


Fig. 1

Solution

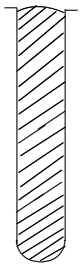
(a) pressure is the force acting normally or perpendicularly on an area of $1m^2$

OR

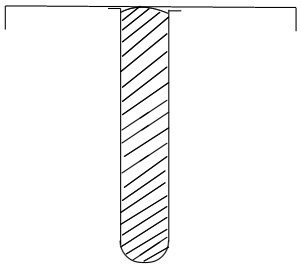
Pressure is the force acting normally per unit area.

(b) (i) how to set up a mercury barometer

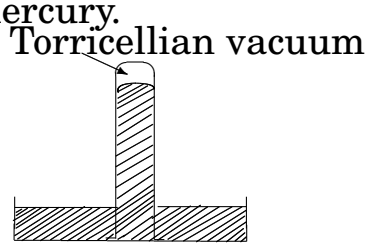
- fill a long thin test-tube closed at one end with mercury.



- Cover it with a short beaker ensuring that it is air-tight.



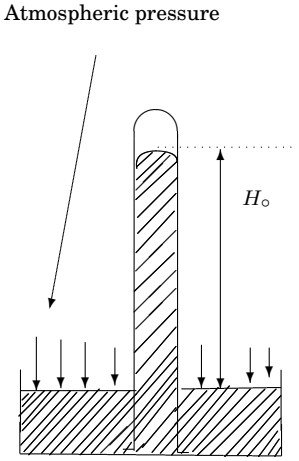
- Invert the set up such that the tube is on or in the beaker and pour in mercury.



- The mercury thread in the tube may touch the

top of the tube or not; if it does not touch the top, that space created is a vacuum[1].

The height of the mercury thread in the tube from the surface of the mercury in the beaker is a measure of the atmosphere pressure acting on the mercury surface this height is called the barometric height.



The value of the atmosphere pressure $P_\circ$ is obtained as

$$P_\circ = H_\circ \rho g$$

where
$H_\circ$ is barometric height
ρ is density of mercury used
g is the acceleration due to gravity.

(ii) height of a mountain,
Pressure difference in terms of the height of mercury is equal to pressure difference in terms of the height of air

$$\begin{aligned} \Delta P_{Hg} &= \Delta P_{air} \\ But P &= h\rho g \\ \Delta P &= (\Delta h)\rho g \\ H_{Hg}\rho_{Hg} g &= H_{air}\rho_{air} g \end{aligned}$$

but this pressure difference is known to be $1 \times 10^4 Nm^{-2}$

$$\begin{aligned} \Delta P_{Hg} &= \Delta H_{air}\rho_{air} g \\ 10^4 Nm^{-2} &= \Delta H_{air} \times 1.25 \times 10 \end{aligned}$$

$$\begin{aligned} \Longrightarrow \Delta H_{air} &= \frac{1 \times 10^4}{1.25 \times 10} \\ &= 800\text{metres} \end{aligned}$$

since this difference in height of air is from the top and bottom of a mountain, then the height of the mountain is 800 metres .

(c) (i) the principle of transmission of pressure in fluids states that; when a fluid (liquid or gas) is held in a container at rest and a force is applied at any point on the fluid, pressure is equally transmitted to all parts of the fluid in all directions.

(ii) The above principle assumes that all parts of the fluid are at the same height above the ground. Or it assumes pressure does not depend on depth.

[1]But it is not a true vacuum because it contains some mercury vapour

(iii) this principle is applied in

- Hydraulic brakes
- Hydraulic press
- Hydraulic jake

(iv) Applying Pascal's principle,
Pressure under piston A is equal to Pressure transmitted to piston B

$$\frac{\text{Force on } A}{\text{Area of } A} = \frac{\text{Force on } B}{\text{Area of } B}$$

$$\frac{F_A}{\text{Area of } A} = \frac{F_B}{\text{Area of } B}$$

$$F_B = \frac{F_A}{\text{Area } A} \times \text{ Area } B$$
$$= F_A \times \frac{\text{Area } B}{\text{Area } A}$$

$$\text{But } \frac{\text{Area } B}{\text{Area } A} = \frac{\pi r_B^2}{\pi r_A^2}$$
$$= \frac{r_B^2}{r_A^2}$$
$$= \frac{\left(\frac{d_B}{2}\right)^2}{\left(\frac{d_A}{2}\right)^2}$$
$$= \frac{d_B^2}{d_A^2}$$
$$= \left(\frac{d_B}{d_A}\right)^2$$

$$\text{hence } F_B = F_A \times \left(\frac{d_B}{d_A}\right)^2$$
$$= 77 \times \left(\frac{280cm}{14cm}\right)^2$$
$$= 30800N$$

hence the force exerted by piston B is 30800N

24. (a) (i) Define pressure and state its units.

(ii) With the aid of a diagram, describe how you would show that the pressure of a liquid is independent of cross-sectional area and shape

(b) **Two manometers P and Q contain a liquid X, and water respectively at the same level. They are then connected to a thistle funnel covered with a rubber membrane as shown in fig. 3.**

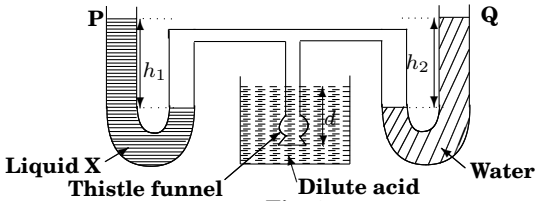


Fig. 3

When the thistle funnel is lowered into a beaker containing a dilute acid of density $1200kgm^{-3}$, the heights h_1 and h_2 are 15cm and 12cm respectively, Find the:

(i) ratio of the density of liquid x to that of water,

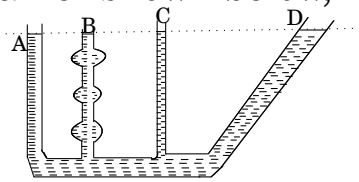
(ii) depth d of the thistle funnel below the surface of the dilute acid.

Solution

(a) (i) Pressure is the force acting normally on an area of 1 m^2 or pressure is the force acting normally per unit area.
its units are Nm^{-2} or pascals

(ii) an experiment to show that pressure in a liquid is independent of cross-sectional area and shape of a container.

- poor water in the container shown below,



The water level will be at the same height from the bottom for all the tubes A, B, C and D. This shows that;

- Pressure does not depend on cross sectional area otherwise the level of water in A would not be the same as that in C.
- Pressure does not depend on the shape of the container otherwise the level of water in tube B would not be the same as that in C.

(b) From question h_1 =15cm, h_2 =12cm

(i) for the manometer, considering the pressure at the points which are at the same depth in liquid x and water;

$$\begin{aligned} P_\circ + h_1\rho_x g &= P_\circ + h_2\rho_w g \\ h_1\rho_x g &= h_2\rho_w g \\ h_1\rho_x &= h_2\rho_w \\ \frac{\rho_x}{\rho_w} &= \frac{h_2}{h_1} \\ &= \frac{12cm}{15cm} \\ &= 0.8 \end{aligned}$$

The ratio of the density of liquid x to that of water is 0.8.

(ii) the depth, d;

$$\begin{aligned} P_\circ + d\rho_{dil}g &= P_\circ + h_2\rho_w g \\ d\rho_{dil.}g &= h_2\rho_w g \end{aligned}$$

$$\begin{aligned} d &= \frac{h_2\rho_w g}{\rho_{dil.}g} \\ &= \frac{h_2\rho_w}{\rho_{dil.}} \\ &= \frac{\frac{12}{100}m \times 1000}{1200} \\ &= 0.1m \\ &= 10cm \end{aligned}$$

hence the depth d is 10cm.

25. (a) Explain each of the following observations.

(i) **An inflated bicycle tube may burst when left in a hot place.**

(ii) **Large water reservoirs are much wider at the base than at the top.**

(b) **Fig. 3 shows the structure of a force pump.**

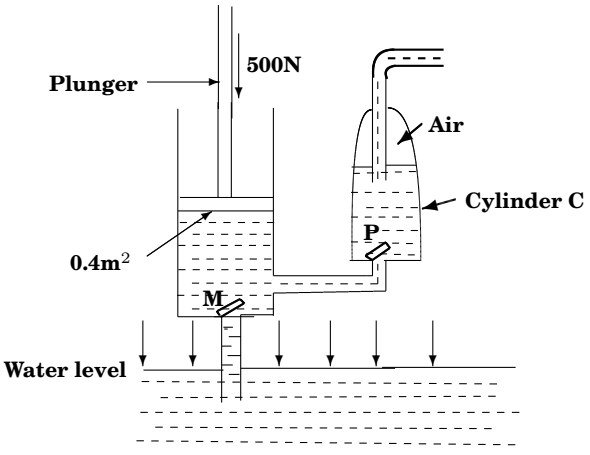


Fig. 3

(i) **Describe the action of the pump.**

(ii) **If a downward force of 500N is exerted on the plunger whose surface area is 0.4m^2 calculate the pressure which forces water into cylinder C .**

Solution

(a) (i) this is because when this bicycle tube is heated, the molecules of the gas in it begin to move with a greater speed, this lead to higher pressure which results into the bursting of the tube.

(ii) large water reservoirs are much wider at the base than at the top so as to ensure that their centre of gravity is near the ground making it more stable otherwise the tank will not be stable and it can easily be overturned by the water.

(b) (i) when the plunger is moved up, valve P closes due to weight of water above it. And valve M opens due to higher atmospheric pressure allowing water to enter into the first cylinder. When the plunger is moved down valve M closes and P opens due to the higher pressure exerted by the plunger, allowing the water prevoiusly lifted to enter cylinder C. The effect is, water from the well has been pumped to cylinder C.

(ii)

$$\begin{aligned} F &= 500N \\ A &= 0.4m^2 \\ P &= ? \\ \text{But } P &= \frac{F}{A} \\ &= \frac{500N}{0.4m^2} \\ &= 1250Nm^{-2} \\ P &= 1250Pa \end{aligned}$$

1.7 Motion

Section A (Objectives)

1. Which of the following physical properties changes when a body is moved from the earth to the moon?

   A. Mass

   B. Volume

   C. Weight

   D. Density **C**

2. A car of mass 1200kg moving with a velocity of 60ms^{-1} collides head-on with another car of mass 1000kg at rest and they stick together. Calculate their velocity after collision.

   A. $\frac{1200+1000}{1000\times60}$ ms^{-1}

   B. $\frac{1200+1000}{1200\times60}$ ms^{-1}

   C. $\frac{1000\times60}{1200+1000}$ ms^{-1}

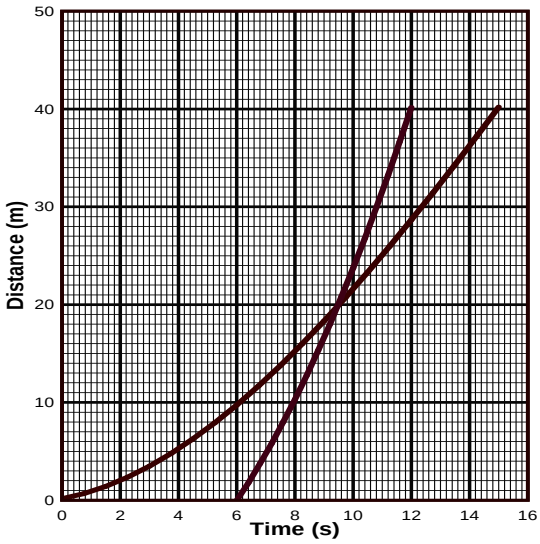
   D. $\frac{1200\times60}{1200+1000}$ ms^{-1} **D**

   momentum after collision ie equal to momentum before collision

$$\begin{aligned}(m_1+m_2)V &= m_1U_1+m_2U_2\\ V &= \frac{m_1U_1}{m_1+m_2}\\ &= \frac{1200\times60}{1200+1000}\end{aligned}$$

3. A man runs a race against a dog. the distance-time graph for the race is shown below;

Missing graph



Which of the following statements are true?

(i)the dog's time for the race was 6s.

(ii)the dog overtook the man 9.6s after the man started running

(iii)the man's speed does not change after 10s.

(iv)the dog run as shorter distance than the man.

A. (i), (ii) and (iii)

B. (i) and (iii) only.

C. (ii) and (iv)

D. (iv) only. **A**

4. The product of mass and acceleration is

A. Force

B. Inertia

C. Velocity

D. Momentum **A**

5. The ticker-time tapes below show the motion of four trolleys trolleys moving from left to right. Which one of them is accelerating?

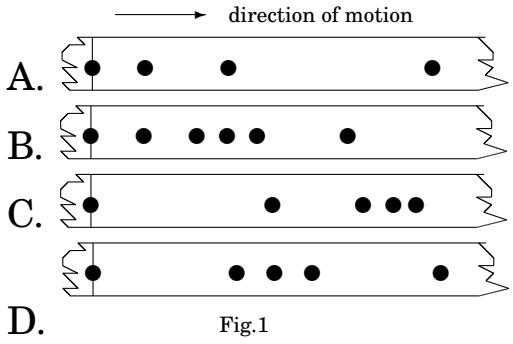


Fig.1 **A**

6. A body of mass 2 kg initially moving with a constant velocity of 10ms $^{-1}$ is subjected to a force of 5N for 2s. The change in momentum of the body in kgm^{-1}is

A. 10.

B. 20

C. 30

D. 50 **A**

$$\begin{aligned}\Delta(mv) &= Ft = 5 \times 2 \\ &= 10Ns \\ &= 10kgms^{-1}\end{aligned}$$

7. A straight line through the origin of a velocity-time graph shows that the

A. Velocity is uniform.

B. Distance is increasing uniformly.

C. Acceleration is uniform.

D. Motion is a retardation. **C**

8. When a steadily increasing force is applied to a moving object, all the following change except

A. Acceleration

B. Momentum

C. Speed

D. Mass **D**

9. When a car is suddenly brought to rest, a passenger jerks forward because of

A. inertia

B. friction

C. gravity

D. momentum **A**

10. A body moves with uniform acceleration if

A. its momentum remains constant.

B. it covers equal distances in equal times.

C. the velocity changes by equal amount in equal times.

D. the net force on the body is zero. **C**

11. Which one of the following statements is true when a stone of mass 2kg and that of 1kg are released from the same point at the same time?

A. both masses will hit the ground at the same time.

B. the 2 kg mass will hit the ground first.

C. the 1kg mass will hit the ground first.

D. they fall with different speeds.

A

12. A cyclist traveling at a constant acceleration of 2ms^{-2} passes through two points A and B in a straight line. If the speed at A is 10ms^{-1} and the points are 75m apart, find the speed at B.

A. 15.8ms^{-1}.

B. 17.3ms^{-1}.

C. 20.0ms^{-1}.

D. 400.0ms^{-1}. **C**

$$\begin{aligned} V &= \sqrt{U^2 + 2as} \\ &= \sqrt{10^2 + 2 \times 2 \times 75} \\ V &= \sqrt{400} \\ &= 20 \end{aligned}$$

13. A body moves with a uniform acceleration of P ms^{-2}. If its initial velocity is x ms^{-1} and it travels for t s to attain a final velocity of y ms^{-1}, find the value of P in terms of x, y and t.

A. $x + yt$

B. $\frac{y-x}{t}$

C. $\frac{y+x}{t}$

D. $y + xt$ **B**

Using the first equation of motion $V = U + at$

$$\begin{aligned} V &= U + at \\ \Rightarrow a &= \frac{V - U}{t} \\ P &= \frac{y - x}{t} \end{aligned}$$

14. A car of mass 1200kg moving with a constant velocity of 60ms^{-1} is retarded uniformly to rest in 12s. Calculate the retarding force.

A. $(1200 \times 12)\text{N}$

B. $(1200 \times 5)\text{N}$

C. $(1200 \times 10)\text{N}$

D. $(1200 \times 60)\text{N}$ **B**

$$\begin{aligned} F &= ma \\ &= 1200 \times a \\ &= 1200 \times \left[\frac{V - U}{t}\right] \\ &= 1200 \times \frac{0 - 60}{12} \\ &= 1200 \times -5 \\ &= -(1200 \times 5) \end{aligned}$$

15. The gradient of a velocity-time graph represents the

A. speed of the body.

B. velocity of the body

C. acceleration of the body.

D. the distance covered by the body. **C**

16. A Newton is defined as the

A. unit of force

B. force which produces an acceleration of 1ms^{-2}.

C. Force which gives a mass of 1kg an acceleration of 1ms^{-2}.

D. Force which gives any mass an acceleration of 1ms^{-2}. **C**

17. An object thrown from an aeroplane reaches a constant velocity known as terminal velocity because the

A. weight of the body at a given place does not vary.

B. sum of the upthrust and the viscous force will be equal to the weight of the body.

C. sum of the upthrust and the viscous force on the body is constant.

D. upthrust experienced by the body is constant. **B**

18. The ticker tape shown in fig. 4 was pulled through a ticker timer which makes 50 dots per second.

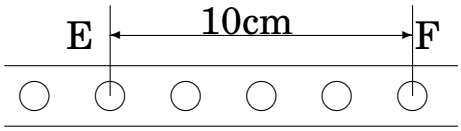


Fig. 4

The speed at which the tape was pulled is

A. 10cm s^{-1}

B. 25cm s^{-1}

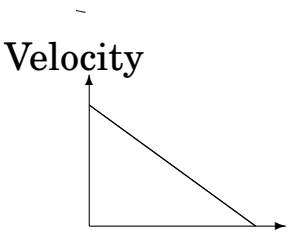
C. 50cm s^{-1}

D. 100cm s^{-1} **D**

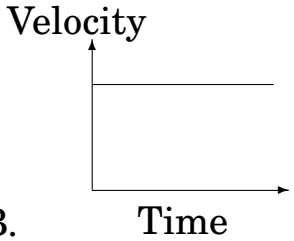
$$\begin{aligned} v &= \frac{d}{t} \\ &= \frac{10cm}{4T} \\ &= \frac{10cm}{\frac{4}{50}s} \\ &= \frac{500}{4} \\ &= 125cms^{-1}. \end{aligned}$$

The only answer near to this is 100cm/s

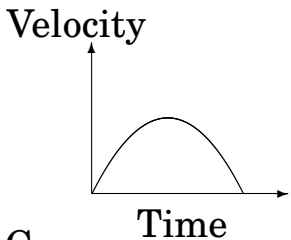
19.



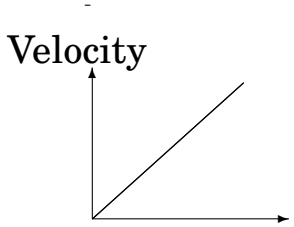
A.



B.



C.



D.

Which one of the above sketches represents uniformly accelerated motion? **D**

20. A body is said to be moving with uniform velocity when the rate of change of

    A. acceleration with time is constant.

    B. velocity with time is constant.

    C. distance with time is constant.

    D. displacement with time is constant. **D**

21. A force of 1N acts on a mass of 0.05kg initially at rest. Its acceleration is

    A. 0.05m s^{-2}

    B. 0.5 m s^{-}

    C. 2 m s^{-2}.

    D. 20 m s^{-2} **D**

$$\begin{aligned} a &= \frac{F}{m} \\ &= \frac{1}{0.05} \\ &= 20 \end{aligned}$$

22. A tape is pulled through a ticker timer which has frequency of 50Hz. If the distance between successive dots is 2cm, calculate the speed of the body.

    A. 0.01cms^{-1}

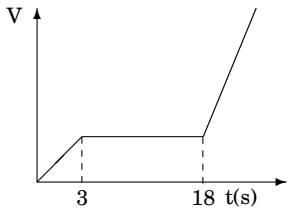
    B. 50cms^{-1}

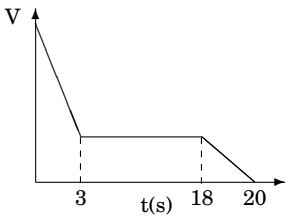
    C. 100cms^{-1}

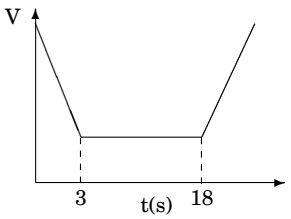
    D. 250cms^{-1} **C**

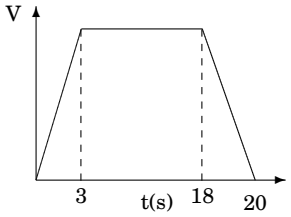
$$\begin{aligned} T &= \frac{1}{f} = \frac{1}{50} = 0.02s \\ D &= 2cm = 0.02m \\ v &= \frac{\text{distance}}{\text{time}} \\ v &= \frac{0.02m}{0.02s} = \frac{1m}{1s} = \frac{100cm}{1s} \\ v &= 100\text{cms}^{-1} \end{aligned}$$

23. A lift accelerates uniformly from rest for 3 s. It then moves at uniform velocity for 15s then decelerates uniformly for 2s before coming to rest. Which of the following velocity-time graphs represents the motion of the lift

A.


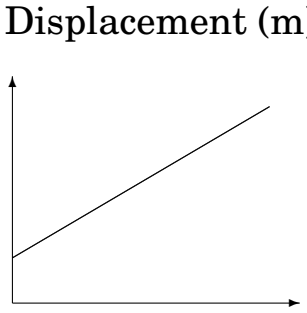
B.


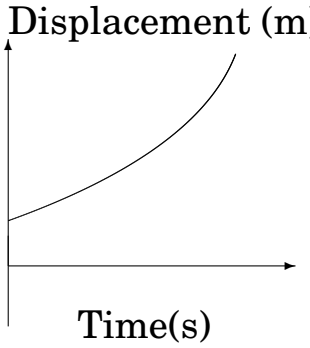
C.


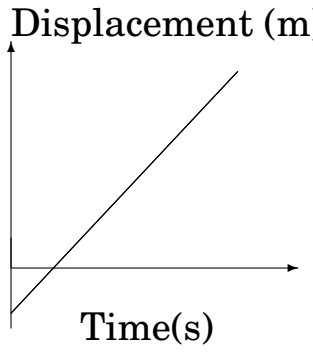
D. 

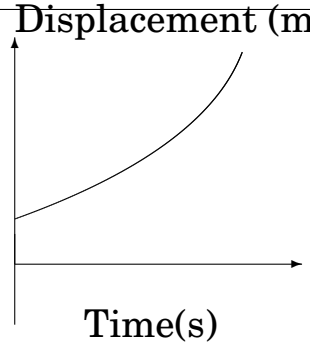
D

24. Which of the following displacement time graphs shows a car moving away from traffic lights at a steady speed?

A. 

B 

C. 

D. 

A

25. A ticker timer is connected to the mains supply of frequency 40H_Z. find the time it takes to print three consecutive dots.

A. 0.08s

B. 0.25s

C. 0.050s

D. 0.75s **C**

The space between 3 dots is 2.

$$\begin{aligned} t &= 2T \\ &= 2 \times \frac{1}{f} \\ &= \frac{2}{40} \\ &= 0.05s \end{aligned}$$

26. Fig. 4 shows a velocity-time graph for a moving body. Which of the following statements is true about the motion of the body?

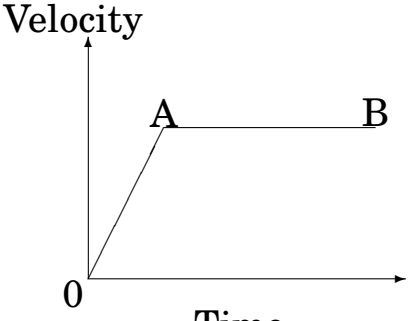


Fig. 4

A. Velocity of the body is constant between O and A.

B. Velocity of the body is constant between A and B.

C. The body is accelerating between A and B.

D. The body is not accelerating between O and A.

B

27. A boxer while training noticed that a punch bag is difficult to set in motion and difficult to stop. What property accounts for this observation?

A. size

B. Inertia.

C. Friction.

D. Weight of the bag **B**

28. A body of mass 25kg falls freely from a height of 10 metres to the ground. Calculate its velocity as it hits the ground.

A. 4.47 ms^{-1}

B. 10.0 ms^{-1}

C. 14.14 ms^{-1}

D. 2500 ms^{-1} **C**

$$\begin{aligned} \frac{1}{2}mV^2 &= mgh \\ v &= \sqrt{2gh} \\ &= \sqrt{2 \times 10 \times 10} \\ v &= 14.14ms^{-1} \end{aligned}$$

29. Find the force required to give a mass of 500g an acceleration of 2×10^{-2} ms^2.

A. 1×10^{-2} N.

B. 1×10^{1} N.

C. 1×10^{2}N

D. 1×10^{4} N. **A**

$$\begin{aligned} F &= ma \\ &= \frac{500}{1000} \times 2 \times 10^{-2} \\ F &= 1 \times 10^{-2}N \end{aligned}$$

30. The graph in fig. 1 describes the motion of a particle. Between which points is the particle at rest?

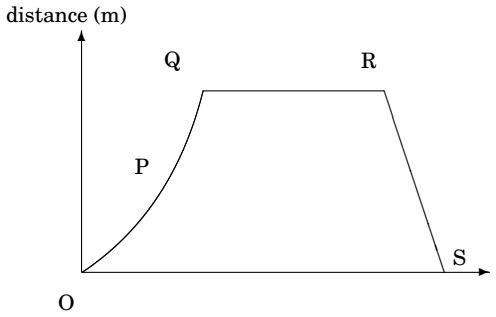


Fig. 1

A. 0 and P.

B. P and Q

C. Q and R

D. R and S. **C**

31. Eggs packed in a soft, shock-absorbing box are placed in a car. When the car suddenly starts or stops moving, the eggs do not crack because

A. no force acts on them.

B. the force acts on them for only a short time.

C. the force is small and acts for a longer time.

D. the force causes fast change of momentum. **C**

32. A bullet of mass 0.02kg is fired with a speed of 40 ms^{-1}. Calculate its kinetic energy.

A. 0.4J.

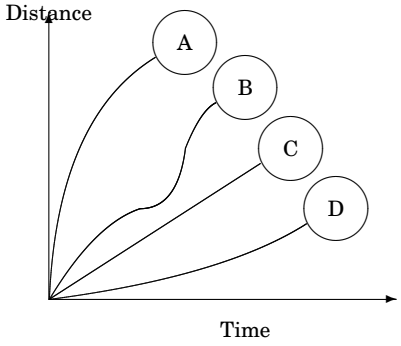
B. 0.8J.

C. 16J

D. 32J **C**

$$\begin{aligned} Ke &= \frac{1}{2}mV^2 \\ &= \frac{1}{2} \times 0.02 \times 40^2 \\ &= 16J \end{aligned}$$

33.



Which of the distance-time graphs above represents abody retarding? **A**

A because the slope of graph A which is velocity goes on decreasing as time increases and this means retardation.

34. A body of mass 20kg moves with a uniform velocity of 4 ms^{-1} from rest. Find its momentum.

A. 5kg ms^{-1}

B. 80kg ms^{-1}

C. 160kg ms^{-1}

D. 320kg ms^{-1} **B**

$$\begin{aligned} \text{Momentum} &= \text{mass} \times \text{velocity} \\ &= 20kg \times 4ms^{-1} \\ &= 80kgms^{-1} \end{aligned}$$

35. A car starts from rest and accelerates uniformly at the rate of 2 ms^{-2} for $\frac{1}{4}$ of a minute. Find the velocity of the car after this time.

A. 0.5 ms^{-1}

B. 12 ms^{-1}

C. 15 ms^{-1}

D. 30 ms^{-1}. **D**

$$\begin{aligned} V &= U + at \\ &= 0 + 2 \times (\frac{1}{4} \times 60) \\ &= 0 + 2 \times 15 \\ &= 30 \end{aligned}$$

36. The graph in figure 1 shows a speed-time graph of a body

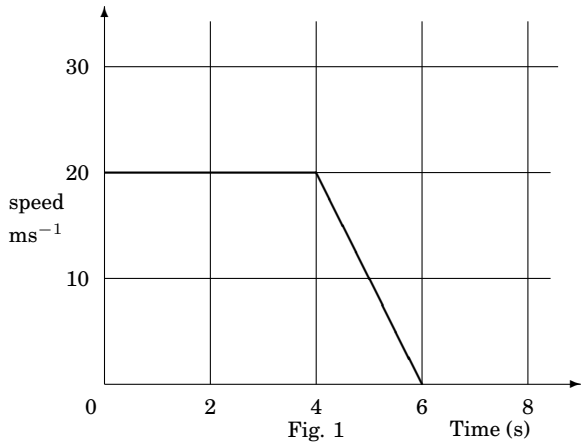


Fig. 1

Calculate the distance traveled during retardation

A. 20 m.

B. 40 m.

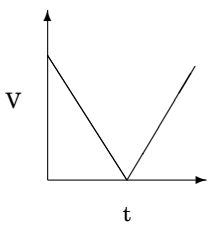
C. 80 m

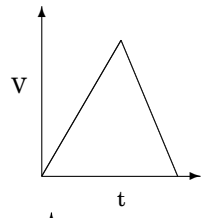
D. 100 m. **A**

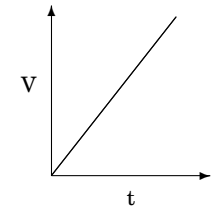
distance is equal to area below the velocity-time graph, the retardation region is a triangle.

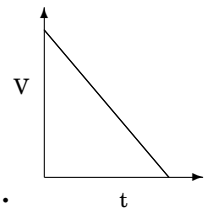
$$\begin{aligned} d &= \frac{1}{2}bh \\ &= \frac{1}{2} \times (6-4) \times 20 \\ &= 20m \end{aligned}$$

37. A boy throws a ball up in the air and it goes up and falls back to his hand. Which one of the following sketches of velocity-time graphs represents the motion of the ball up to the time it is received back?

A. 

B. 

C. 

D. 

A

38. A force of 10N acts on a body and produces an acceleration of 2ms^{-2}. The mass of the body is

A. 0.2kg

B. 5.0kg.

C. 20.0kg

D. 50.0kg. **B**

$$\begin{aligned} \text{From } F &= Ma \\ m &= \frac{F}{a} \\ m &= \frac{10N}{2ms^{-2}} \\ &= 5kg \end{aligned}$$

39. The time period of a simple pendulum

A. decreases as the length of the pendulum decreases.

B. increases as the mass of the pendulum bob decreases.

C. increases as the mass of the pendulum bob increases.

D. decreases as the length of the pendulum increases. **A**

$$T = 2\pi\sqrt{\frac{l}{g}}$$

40. The velocity-time graph for a car is as shown in fig. 2.

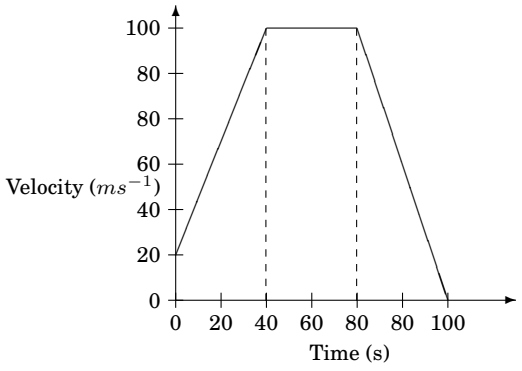


Fig. 2

Find the total distance the car travels

A. 2.0×10^3m.

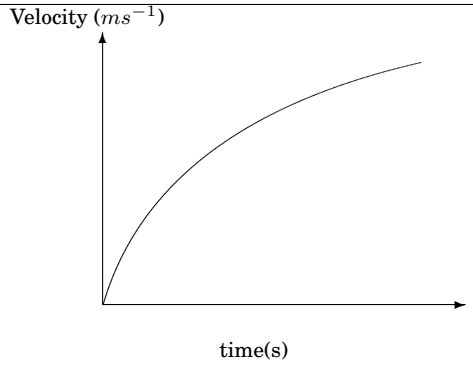
B. 3.0×10^3m.

C. 4.0×10^3m.

D. 7.0×10^3m **D**

$$\begin{aligned} d &= \frac{1}{2}40(120) + 40 \times 100 \\ &\quad + \frac{1}{2} \times 20 \times 100 \\ &= 2400 + 4000 + 1000 \\ &= 7,400 \\ &= 7.4 \times 10^3 \end{aligned}$$

41.



Which of the following best describes the motion represented by the velocity-time graphs shown in the diagram above?

A. decelerated motion.

B.Uniformly accelerated motion.

C.Non-uniformly accelerated motion.

D.Uniform velocity motion **C**

42. When a stone is thrown horizontally from a high tower, which of the following explains its motion.

(i) vertical acceleration is constant.

(ii) vertical acceleration is increasing.

(iii) horizontal velocity is constant.

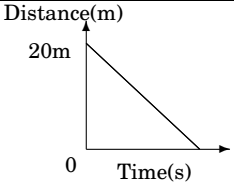
A. (i) only.

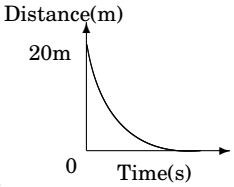
B. (i) and (ii) only.

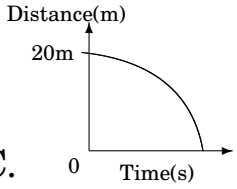
C. (iii) only.

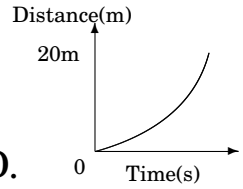
D. (i) and (iii) only. **D**

43. Which of the graphs below best describe the motion of a stone which falls freely from a height of 20m?

A. 

B. 

C. 

D. 

C

The slope which is velocity must be increasing, from a slope of zero at a height of 20m. and this is in figure C.

44. A car is uniformly accelerated from rest and after 10s, acquires a speed of 20 ms^{-1}. How far does it move during the eleventh second?

A 20m

B. 21m

C. 100m

D. 121m **B**

$$\begin{aligned} a &= \frac{V-U}{t} \\ &= \frac{20-0}{10} \\ &= 2ms^{-2} \end{aligned}$$

Duration of the eleventh second is 1s

$$\begin{aligned} S &= ut + \frac{1}{2}at^2 \\ &= 20 \times 1 + \frac{1}{2} \times 2 \times 1^2 \\ &= 20 + 1 \\ &= 21 \end{aligned}$$

45. A stone of mass 2.5g is thrown with an average force of 5.0N. Find the average acceleration in ms^{-1}

A. 5.0×10^4

B. 2.0×10^{-3}

C. $2.5m^{-1}$

D. 2.0×10^3 **D**

$$\begin{aligned} a &= \frac{F}{m} \\ &= \frac{5}{2.5 \times 10^{-3}} \\ &= 2 \times 10^3 \end{aligned}$$

46. An object of mass 2kg moving at 5 ms^{-1}, collides with another object of mass 3kg which is at rest. Find the velocity of the two bodies if they stick together after collision.

A. 1.0ms^{-1}

B. 2.0ms^{-1}

C. 2.5 ms^{-1}

D. 5.0 ms^{-1} **B**

$$\begin{bmatrix}\text{initial}\\ \text{momentum}\end{bmatrix} = \begin{bmatrix}\text{final}\\ \text{momentum}\end{bmatrix}$$
$$2 \times 5 = (3+2)V$$
$$V = 2$$

47. A bullet of mass 5g is fired at a speed of 400 ms^{-1} How much energy does it have?

A. $\frac{1}{2} \times 5 \times 10^2 \times 400$ Joules

B. $\frac{1}{2} \times 5 \times 10^3 \times 400$ Joules

C. $\frac{1}{2} \times 5 \times 10^{-3} \times 400 \times 400$ Joules

D. $\frac{1}{2} \times 5 \times 10^2 \times 400 \times 400$ Joules

C It has kinetic energy

$$ke = mv^2$$
$$= \frac{1}{2} \times 5 \times 10^{-3} \times 400 \times 400$$

48. A stone is released from a height of 20m above the ground. Find its height above the ground when its speed is 10 ms^{-1}

A. 5m

B. 10m

C. 15m

D. 20 m **C**

$$mg\Delta h = \frac{1}{2}mv^2$$
$$\Delta h = \frac{1}{2}\frac{v^2}{g}$$
$$= \frac{1}{2} \times \frac{100}{10}$$
$$= 5$$
$$h = H - \Delta h$$
$$h = 20 - 5$$
$$= 15$$

Section B (Structured)

49. An object of mass $2kg$ is moving with a velocity of $1ms^{-1}$. It is then acted on by a force of $5N$ through a distance of $16m$. Calculate;

(a) The acceleration produced by the force.

From $F = ma$
$$a = \frac{F}{m}$$
$$= \frac{5}{2}$$
$$= 2.5Nkg^{-1}$$
or $a = 2.5ms^{-2}$

(b) The final velocity of the object.

$V = ?$
$U = 1m/s$
$a = 2.5ms^{-2}$
$s = 16m$
$V^2 = U^2 + 2as$
$= 1^2 + 2 \times 2.5 \times 16$
$= 1 + 80$
$v^2 = 81$
$v = \sqrt{81}$
$v = 9m/s$

(c) the work done by the force.

$$\begin{aligned}\text{Work} &= F \times d \\ &= 5 \times 16 \\ &= 80J\end{aligned}$$

50. (a) What is meant by uniformly accelerated motion?

It is the motion where acceleration is constant or it is the type of motion where the rate of change of velocity with time is constant.

(b) Fig. 10 shows dots made on a ticker tape pulled by a trolley through a ticker-timer.

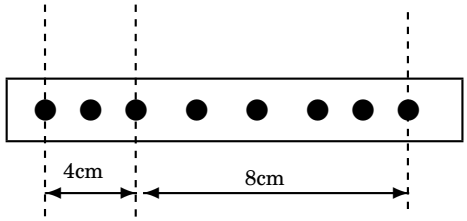


Fig.10

Describe the motion of the trolley, if the frequency is $50Hz$.

The trolley accelerates at a rate a given by $a = \frac{V-U}{t}$, calculated as follows;

$$\begin{aligned}U &= \frac{d}{t} \\ &= \frac{\left(\frac{4}{100}m\right)}{\left(\frac{2}{50}s\right)} \\ &= 1ms^{-1}\end{aligned}$$

$$\begin{aligned}V &= \frac{d}{t} \\ &= \frac{\left(\frac{8}{100}m\right)}{\left(\frac{5}{50}s\right)} \\ &= 0.8ms^{-1}\end{aligned}$$

The time taken is measured from the middle of the 4cm length to the middle of the 8cm length

$$\begin{aligned}t &= 3\tfrac{1}{2} \times \frac{1}{50} \\ &= 0.07s \\ a &= \frac{V-U}{t} \\ &= \frac{0.8-1}{0.07} \\ a &\approx -2.857ms^{-2}\end{aligned}$$

It is deceleration because it is negative.

51. An object is released from rest at a height of 20cm above the ground

(i) Describe the energy charges which take place.

It has potential energy which changes to kinetic energy as it falls, on hitting the ground it becomes sound, light and other energy forms.

(ii) Calculate the speed with which the object hits the ground.

Kinetic energy gained is equal to the potential energy lost

$$\begin{aligned}\frac{1}{2}mv^2 &= mgh \\ v &= \sqrt{2gh} \\ &= \sqrt{2\times 10\times 20} \\ &= 20ms^{-1}\end{aligned}$$

52. (a) What is uniform velocity?

This is the rate of change of displacement with time which is constant

(b) A car traveling at 20ms^{-1}is accelerated for 10s at 2ms^{-2}. Calculate the total distance covered during this time.

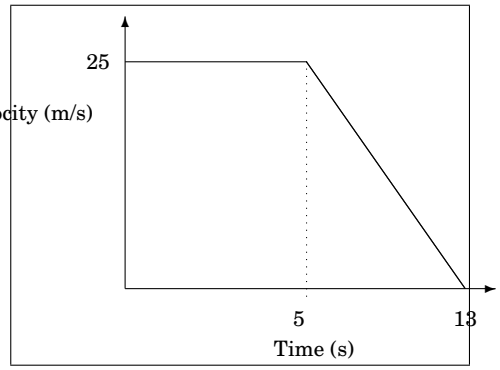
$$\begin{aligned}S &= Ut+\frac{1}{2}at^2 \\ &= 20\times 10+\frac{1}{2}\times 2\times 10^2 \\ &= 200+100 \\ &= 300m\end{aligned}$$

53. (a) What is meant by uniform velocity?

it is the rate of change of displacement with time which is constant.

(b) a car traveling with a uniform velocity of 25ms^{-1} for 5s brakes and then comes to rest under a uniform deceleration in 8 s.

(i) Sketch a velocity –time graph of the motion.



(iii) Find the total distance traveled.

$$\begin{aligned}D &= LW+\frac{1}{2}bh \\ &= 5\times 25+\frac{1}{2}\times 25\times 8 \\ &= 225m\end{aligned}$$

Paper II (Essay)

54. (a) **State Newton's laws of motion**

(b) **A block of mass** $50kg$ **is pulled from rest along a horizontal surface by a rope tied to one face of the block as shown in Fig.** 1**.**

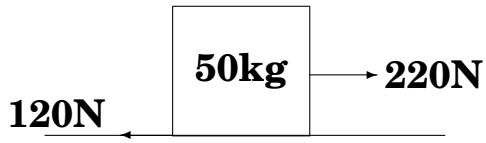


Fig. 1

(i)**Find the acceleration of the block**

(ii)**Calculate the distance moved by the block in** $4.0s$.

(iii)**What is the reaction of the surface on the block.**

(iv)**Compare the work done by the tension in the rope during the** 4.0**s interval with kinetic energy gained.**

Solution

(a) Newton's laws

- First law states that a body will stay in its state of rest or uniform motion in a straight line unless a force acts on it.
- Second law states that the rate of change of momentum is directly proportional to the force acting on the body.
- Third law of motion states that all forces exist in opposite pairs or for every action there in an equal and opposite reaction.

(b) (i) The tension in the rope is $220N$. The friction force between the block and the horizontal surface is $120N$. Net force, F

$$\begin{aligned} F &= 220N - 120N \\ F &= 100N \\ \text{But } F &= ma \\ ma &= 100N \\ 50kg \times a &= 100N \\ a &= \frac{100N}{50kg} \\ &= 2N/kg \\ ora &= 2ms^{-2} \end{aligned}$$

(ii) Using $S = ut + \frac{1}{2}at^2$

$$\begin{aligned} S &= 0 \times 4 + \frac{1}{2} \times 2 \times 4^2 \\ &= 0 + 4^2 \\ &= 16m \end{aligned}$$

(iii) From third law of motion

$$\begin{aligned} \text{Reaction} &= -\text{weight} \\ &= mg \\ &= 50 \times 10 \\ &= 500N \end{aligned}$$

(iv) Work done by tension in the rope, W_R

$$\begin{aligned} W_R &= \text{Tension} \times \text{distance} \\ &= 220 \times 16 \\ &= 3520\text{Joules} \end{aligned}$$

$$\text{Kineticenergy} = K.Eg$$

$$\begin{aligned} K.E.g &= \frac{1}{2}mV^2 \\ \text{but} V &= u + at \\ &= 0 + 2 \times 4 \\ &= 8m/s \\ K.Eg &= \frac{1}{2}mv^2 \\ &= \frac{1}{2} \times 50 \times 8^2 \\ &= 1600Joules \end{aligned}$$

(v) The tension in the rope does more work than the gain in the kinetic energy, the difference is the work done against friction or work done by friction

$$\begin{aligned} W_{\text{f}} &= 3520 - 1600 \\ &= = 1920J \end{aligned}$$

or

$$\begin{aligned} W_{\text{f}} &= \text{F} \times \text{D} \\ &= 120 \times 16 \\ &= 1920J \end{aligned}$$

55. (a) Define the following:

(i) Velocity

(ii) **Momentum**

(b) **A small iron ball dropped from the top of a vertical cliff takes 2.5s to reach the bottom of the cliff. Find**

(i) **the speed with which it strikes the bottom.**

(ii) **the height of the cliff.**

(c) **Explain briefly why a person feels heavier than usual at the instant a lift starts accelerating upwards.**

(d) **A valve of a cylinder containing 12kg of compressed gas is opened and the cylinder empties in 90s. If the gas flows out of the nozzle at an average speed of $25ms^{-1}$, find the average force exerted on the cylinder.**

Solution

(a) (i) Velocity is the rate of change of displacement with time

(ii) Momentum is the product of mass and velocity of the body in the direction of the body.

(b) An iron ball dropped from a cliff takes 2.5s to reach the bottom of the cliff.

(i) The speed with which it strikes the bottom
Using the first equation of motion

$$V = U + at$$

But $U =, 0m/s$ it was dropped, i.e. dropped from rest.
$a = 10ms^{-2}$ because it is falling down. Remember that if it was thrown up it would be $-10ms^{-2}$ and $t = 2.5s$
hence

$$\begin{aligned} V &= U + at \\ &= 0 + 10 \times 2.5 \\ &= 25ms^{-1} \end{aligned}$$

(ii) height of the cliff is the distance moved by the iron ball. We can use the second equation of motion or the third equation of motion.

Using the second equation of motion

$$\begin{aligned} h &= Ut + \frac{1}{2}at^2 \\ &= Ut + \frac{1}{2}gt^2 \\ \text{But} U &= 0ms^{-1} \\ h &= 0 + \frac{1}{2}gt^2 \\ &= \frac{1}{2}gt^2 \\ &= \frac{1}{2} \times 10 \times (2.5)^2 \\ &= 0.5 \times 10 \times 6.25 \\ &= 5 \times 6.25 \\ h &= 31.25m \end{aligned}$$

OR

Using the third equation of motion, we have

$$\begin{aligned} V^2 &= U^2 + 2as \\ \Longrightarrow s &= \frac{V^2 - U^2}{2a} \\ &= \frac{25^2 - 0^2}{2 \times 10} \\ &= \frac{625}{20} \\ s &= 31.25m \end{aligned}$$

(c)When a lift starts accelerating up with acceleration, a, the net force acting on the floor of the lift due to our weight increases from mg to $m(g+a)$ hence one feels heavier.

(d)From the question mass of compressed air , $m = 12kg$

time taken to empty the cylinder, $t = 90s$

speed of gas at nozzle, $V = 25ms^{-1}$

To get the average force acting on the body, we use the second law of motion, which states that the rate of change of momentum of a body is equal to the force acting on it i.e.

$$\text{Force} = mV - mU$$

but initially the gas in the container is at rest hence initial momentum is zero

$$\begin{aligned} \text{Average force} &= \frac{mV}{t} \\ &= \frac{12 \times 25}{90} \\ &= 3.33N \end{aligned}$$

56. (a) State the principle of conservation of linear momentum.

(b) **A trolley P of mass 150g moving with a velocity of $20ms^{-1}$ collides with another stationery trolley Q of mass 100g. If P and Q move together after collision, Calculate:**

(i) **the momentum of P before collision,**

(ii) **the velocity with which P and Q move after collision.**

(c)

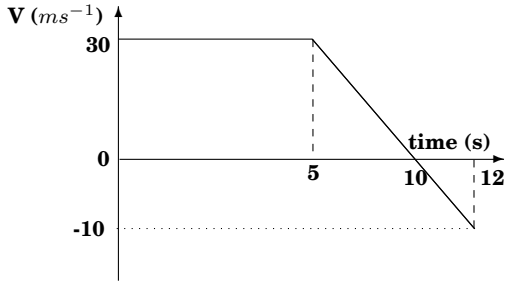


Fig. 1

Fig. 1 represents a velocity - time graph for the motion of a car. If the mass of the car is 500 kg, find;

(i) **the distance it traveled from the start of its motion.**

(ii) **The time it takes to get back to the starting point if its velocity is then maintained constant,**

(iii) **The momentum of the car just before deceleration.**

Solution

(a) the principle of conservation of linear momentum states that when two or more bodies collide their total momentum before collision is equal to their total momentum after collision provided no external forces acts on them.

(b) from question ,

mass of trolley P, m_p

$$\begin{aligned} m_p &= 150g \\ &= \frac{150}{100}kg \end{aligned}$$

mass of trolley, Q, m_q

$$\begin{aligned} m_q &= 100g \\ &= \frac{100}{1000}kg \\ &= \frac{1}{10}kg \end{aligned}$$

Initial velocity of trolley P, $U_p = 20ms^{-1}$

let the common velocity be Vms^{-1}

(i) Momentum of P

$$\begin{aligned} &= \text{mass } \times \text{velocity} \\ &= m_p \times U_p \\ &= \frac{150}{1000}kg \times 20ms^{-1} \\ &= 3kgms^{-1} \end{aligned}$$

(ii) Total momentum before collision is equal to total momentum after collision
Total momentum before collision is

$$\begin{aligned} &= m_qU_q + m_pU_p \\ &= \frac{100}{1000} \times 0 + \frac{150}{1000} \times 20 \\ &= 3 \end{aligned}$$

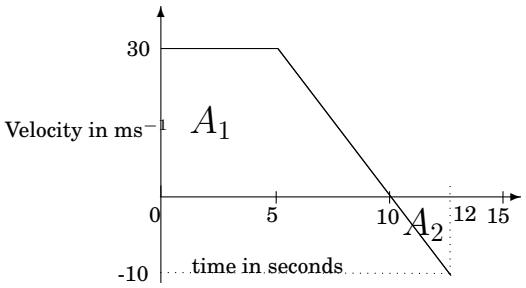
total momentum after collision is

$$\begin{aligned} &= (m_q + m_p)\, V \\ &= \left(\frac{100}{1000} + \frac{150}{1000}\right) \times V \\ &= \frac{250}{1000}V \\ &= \frac{1}{4}V \end{aligned}$$

equating the two, we have

$$\begin{aligned} 3 &= \frac{1}{4}V \\ 3 \times 4 &= V \\ V &= 12ms^{-1} \end{aligned}$$

(c) (i) Distance traveled is equal to Area below the velocity time graph for the given figure we have the areas A_1, A_2 and A_3 as shown below



Total distance, d

$$\begin{aligned} d &= \text{area } A_1 + \text{ area } A_2 \\ &= \frac{1}{2}h(a+b) + \frac{1}{2}bh \\ &= \frac{1}{2} \cdot 30 \cdot (10+5) + \frac{1}{2} \cdot 10 \cdot 2 \\ &= 225 + 10 \\ &= 235\text{metres} \end{aligned}$$

hence the total distance traveled is 235 metres
Note that the Area A_2would be negative if we were obtaining displacement, but here distance, a scalar quantity, should not be negative, so we take its magnitude.

(ii)

$$\begin{aligned} \text{Time} &= \frac{\text{Total distance}}{\text{velocity}} \\ &= \frac{235m - 10m}{10s} \\ &= \frac{225}{10} \\ &= 22.5\text{seconds} \end{aligned}$$

(iii)Momentum

$$\begin{aligned} &= \text{ mass} \times \text{velocity} \\ &= 500kg \times 30ms^{-1} \\ &= 15000kgms^{-1} \end{aligned}$$

57. (a) Define displacement.

(b) **Two vehicles A and B accelerate uniformly from rest. Vehicle A attains a maximum velocity of 30ms^{-1} in 10s while vehicle B attains a maximum velocity of $40ms^{-1}$ in the same time. Both vehicles maintain these velocities for 6s. They are then decelerated such that A comes to rest after 6s while B comes to rest after 4s.**

(i) **Sketch on the same axes a velocity-time graph for the motion of the vehicles.**

(ii) **Calculate the velocity of each vehicle 18s after the start.**

(iii) **How far will the two vehicles be from one an-**

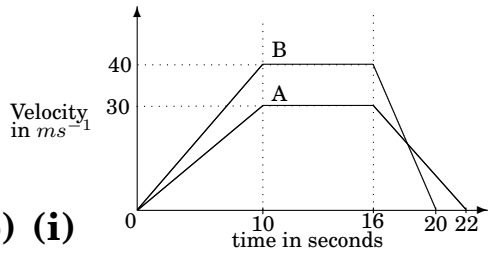
other during this moment in (ii) above?

(d) **Describe a simple experiment to measure the acceleration due to gravity.**

Solution

(a) Displacement is the distance moved in a given direction

(b) (i)



(ii) deceleration of A, a_a

$$\begin{aligned} a_a &= \frac{V-u}{t} \\ &= \frac{-30}{6} \\ &= -5ms^{-2} \end{aligned}$$

deceleration of B

$$\begin{aligned} a_b &= \frac{V-u}{t} \\ &= \frac{0-40}{4} \\ &= -10m/s^2 \end{aligned}$$

using the first equation of motion.
the velocity of vehicle A after $18s$ from start is; using

$$\begin{aligned} t &= 18-16 \\ &= 2 \text{ seconds} \end{aligned}$$

$$\begin{aligned} V &= U+at \\ &= 30+-5\times 2 \\ &= 30-10 \\ &= 20ms^{-1} \end{aligned}$$

velocity of vehicle B after 18s from the start is; using

$$\begin{aligned} t &= 18-16 \\ &= 2 \text{ seconds} \end{aligned}$$

$$\begin{aligned} V &= U+at \\ &= 40+-10\times 2 \\ &= 40-20 \\ &= 20ms^{-1} \end{aligned}$$

(iii) how far these vehicles will be from the one another, is obtained as the difference in the distance moved by the two vehicles. Distance moved by vehicle A in 18 s, d_A is equal to area below the velocity-time graph

$$\begin{aligned} d_A &= \frac{1}{2}h(a+b) \\ &= \frac{1}{2}\cdot 30\cdot(22+6) \\ &= 420 \text{ metres} \end{aligned}$$

Also distance moved by vehicle B in 18 s, d_B is equal

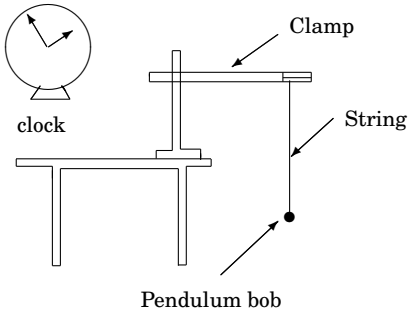
to area below the velocity-time graph

$$\begin{aligned} d_B &= \frac{1}{2}h(a+b) \\ &= \frac{1}{2}\cdot 40\cdot(20+6) \\ &= 520 \text{ metres} \end{aligned}$$

distance between the two vehicle after 18s $= 520 - 420 = 120$ metres

(c) An experiment to determine acceleration due to gravity using a simple pendulum

- **Apparatus**: a thread, a bob, clock, clamp, metre ruler.
- **Diagram**; the apparatus is arranged as shown below.



Method

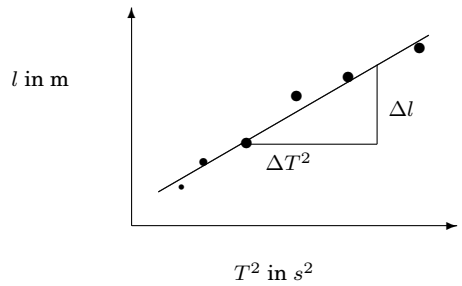
- Measure the length (l) of the pendulum bob (from the centre of the bob).
- Push the bob slightly, it will begin to oscillate.
- Note, when it is on one side and start the stop clock and begin counting the oscillations till it makes about 20 oscillations.
- When you lastly count the twentieth oscillation stop the stop clock.
- Read and record the time for twenty oscillations i.e. 20T.
- Repeat the procedure for various lengths of the pendulum, measure and record time for twenty oscillations (20T) for various lengths of the pendulum bob e.g. when length is 0.8m, 0.7m, 0.6m, 0.5m, 0.4m, 0.3m etc.
- Record your results in a suitable table as shown below.

l/m	$20T$/s	T/s	T^2/s^2
0.9			
0.8			
0.7			
0.6			
0.5			
0.4			
0.3			

where
l is length in metres, $20T$ time for 20 oscillations and T is the period

- plot a graph l against T^2 , a graph like this below will be obtained;

Graph of l agianst T^2



- obtain the slope (s) as

$$s = \frac{\Delta l}{\Delta T^2}$$

- calculate the value of acceleration due to gravity (g) from $g = 4\pi^2 s$

58. (a) Define the term acceleration.

(b) **A body attached to a string is swung in a vertical circular path in air as shown in fig. 1.**

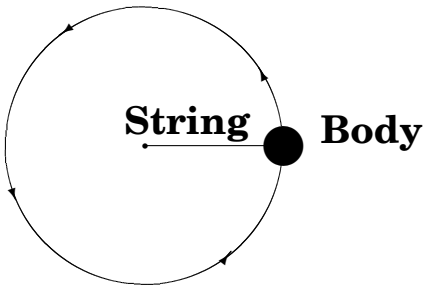


Fig. 1

Copy the above diagram and on it indicate and name all the forces acting on the body if the body is moving in an anti-clockwise direction.

(c) **Explain why the weight of an object on the Earth's surface may vary from one place to another.**

(d) **A ball of mass 0.25kg is dropped from rest at a height of 20m above the ground.**

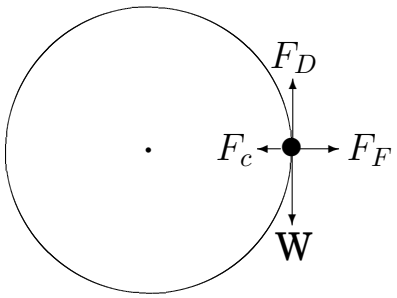
(i) **Calculate the time it takes to reach the ground.**

(ii) **If the ball bounced once on hitting the ground and lost 20% of its original energy, calculate the maximum height the ball reached again.**

Solution

(a) Acceleration is the rate of change of velocity with time

(b)



where

F_D - is the driving force or tangential driving force

F_C - is the centripetal force

F_F - is the centrifugal force

W - is weight of the body

(c) weight varies;

- because the earth is not a uniform sphere, some parts on its surface are close to its centre than others
- due to the rotation of the earth.

(d) from question $m = 0.25kg$ and $h = 20m$

(i) time it takes to hit the ground when dropped. Using the second equation of motion;

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

But $U = 0ms^{-1}$ initially at rest

$$\begin{aligned} h &= 0 + \frac{1}{2}gt^2 \\ h &= \frac{1}{2}gt^2 \\ \Longrightarrow t^2 &= \frac{2h}{g} \\ t &= \sqrt{\frac{2h}{g}} \\ &= \sqrt{\frac{2 \times 20}{10}} \\ &= \sqrt{4} \\ &= 2 \text{ seconds} \end{aligned}$$

hence it takes 2 seconds

(ii) new maximum height, if 20% of its original energy is lost.
Initial Energy, P.E

$$\begin{aligned} P.E. &= mgh \\ &= 0.25 \times 10 \times 20 \\ &= 50J \end{aligned}$$

If 20% is lost, then 80% is available.

New available energy is equal to

$$\begin{aligned} &= 80\% \text{ of initial energy} \\ &= \frac{80}{100} \times 50 \\ &= 40 \text{ Joules} \end{aligned}$$

Then we can now obtain the new height using the expression for potential energy, P.E.;

$$\begin{aligned} P.E. &= mgh \\ 40 &= 0.25 \times 10 \times h \\ 40 &= 2.5h \\ \frac{40}{2.5} &= h \\ 16 &= h \\ h &= 16 \text{ metres} \end{aligned}$$

hence the new maximum height is 16 metres

59. (a) Distinguish between the weigl and mass of a body.

(b) **The force of gravity on the moon is one-sixth of that on the earth. Determine the weight of a 12kg mass on the moon.**

(c) (i) Sketch the distance-time graph for a body falling freely from rest.

(ii) **An object is released from rest at a height of 0.5km. How long does it take to reach the ground**

Solution

(a) Mass is the quantity of matter a body contains while weight is the force exerted by a body on a support where it is freely suspended.

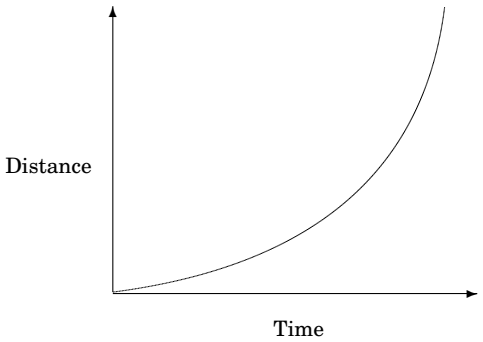
(b) acceleration due to gravity at the moon g_m

$$\begin{aligned} g_m &= \frac{1}{6}g_{earth} \\ &= \frac{1}{6} \times 10 \\ &= \frac{10}{6}ms^{-2} \end{aligned}$$

Weight of the 12kg mass at the moon is

$$\begin{aligned} W &= mg_m \\ &= 12 \times \frac{10}{6} \\ &= 20N \end{aligned}$$

(c) (i) distance - time graph for a body falling freely from rest



(ii) from question

$$\begin{aligned} h &= 0.5km \\ &= 0.5 \times 1000m \\ &= 500m \end{aligned}$$

Using the second equation of motion

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

But $U = 0ms^{-1}$ since it started at rest

$$\begin{aligned} h &= 0 + \frac{1}{2}gt^2 \\ h &= \frac{1}{2}gt^2 \\ \Longrightarrow t^2 &= \frac{2h}{g} \\ t^2 &= \sqrt{\left(\frac{2 \times 500}{10}\right)} \\ t &= 10 \text{ seconds} \end{aligned}$$

Hence it takes 10 seconds

60. The table below shows the variation of velocity with time for a body which has been thrown vertically upwards from the surface of a planet.

Velocity(m/s)	**8**	**6**	**4**	**2**	**0**	**-2**
Time(s)	**0**	**1**	**2**	**3**	**4**	**5**

(i)**What does the negative velocity mean?**

(ii)**Plot a graph of velocity against time**

(iii)**use the graph in b(ii) to find the acceleration due to gravity on the planet.**

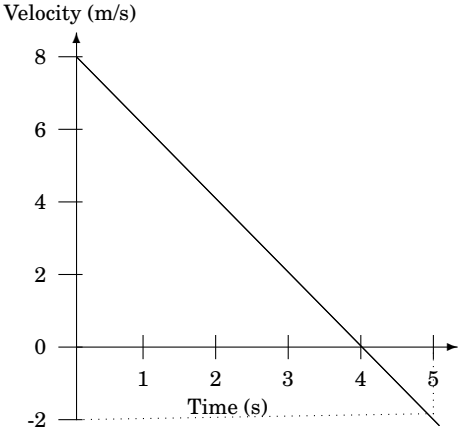
(iv) **Use the graph in b(ii) to find the total distance travelled.**

(v)**If the body weighs 34N on earth, what is its weight on the planet?**

Solution

(i) negative velocity meant that the body is moving in the opposite direction

(ii) The graph of velocity against time is



(iii)

$$\begin{aligned} g &= \frac{V-U}{t} \\ \text{but } V &= -2m/s \\ U &= 8m/s \\ t &= 5s \\ g &= \frac{-2-\ -8}{5} \\ g &= \frac{-10}{5} \\ g &= -2ms^{-2} \end{aligned}$$

it is negative because the body is moving upwards against gravity or opposite the direction of the force of gravity, hence $g = -2ms^{-2}$

(iv) Total distance, d

$$\begin{aligned} d &= \texttt{area below} \\ d &= \frac{1}{2}bh + \frac{1}{2}bh \\ d &= \frac{1}{2}\cdot 4\cdot 8 + \frac{1}{2}\cdot 1\cdot 2 \\ d &= 16+1 \\ d &= 17m \end{aligned}$$

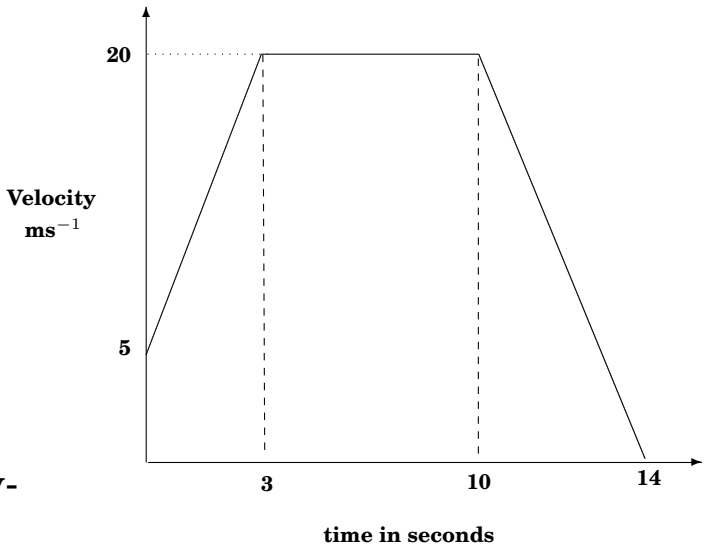
(v) On earth

$$\begin{aligned} W &= mg \\ 34 &= m\times 10 \\ m &= 3.4kg \end{aligned}$$

on the planet

$$\begin{aligned} W &= mg_{\texttt{planet}} \\ W &= 3.4\times 2 \\ W &= 6.8N \end{aligned}$$

61. .



The figure above shows a speed-time graph of a cyclist.

(i) **Find the acceleration of the cyclist between A and B**

(ii) **Describe the motion of the cyclist between B and C**

(iii) **Explain what is happening along CD**

(iv) **Calculate the distance traveled by the cyclist during the first ten seconds.**

Solution

From the graph

(i) Acceleration a

$$\begin{aligned} a &= \frac{V-U}{t} \\ &= \frac{(20-5)ms^{-1}}{3s} \\ &= \frac{15ms^{-1}}{3s} \\ &= 5ms^{-2} \end{aligned}$$

(ii) Between B and C the cyclist is moving at a constant speed of 20m/s for 7 seconds (i.e. between 10s and 3s).

(iii) Along CD the speed of the body is decreasing at a rate of

$$\begin{aligned} a &= \frac{V-U}{t} \\ &= \frac{0-20}{(14-10)} \\ &= \frac{-20}{4} \\ &= -5ms^{-2} \\ &= -5ms^{-2} \end{aligned}$$

(iv) Distance traveled in the first ten seconds, is equal to the area below the velocity-time graph with in those 10 seconds which is equal to;

$$\begin{aligned} &= \text{Area of trapezium} + \text{Area of rectangle} \\ &= \tfrac{1}{2}h(a+b) + L \times w \\ &= \tfrac{1}{2}(3.0)(5+20) + 20 \times (10-3) \\ &= \tfrac{1}{2} \times 3(25) + 20 \times 7 \\ &= 37.5 + 140 \\ &= 177.5 \text{ metres} \end{aligned}$$

62. Fig. 5 shows dots produced on a tape pulled through a ticker-timer by a moving body.

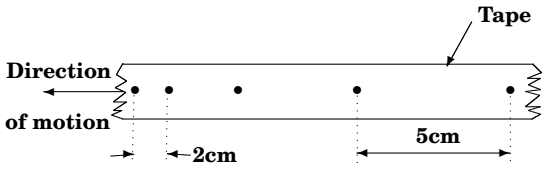


Fig. 5

The frequency of the ticker-timer is 50Hz Calculate the acceleration of the body.

Solution

Frequency, $f = 50Hz$

Period, T

$$\begin{aligned} T &= \frac{1}{f} \\ &= \frac{1}{50} \\ &= 0.02 \text{ seconds} \end{aligned}$$

The time taken is equal 3 periods i.e. $3T$

$$\begin{aligned} t &= 3T \\ &= 3 \times 0.02s \\ &= 0.06 \text{ seconds} \end{aligned}$$

Final velocity, V

$$\begin{aligned} V &= \frac{d_2}{t_2} \\ &= \frac{5cm}{T} \\ &= \frac{\frac{5}{100}m}{T} \\ &= \frac{0.05m}{0.02s} \\ &= 2.5ms^{-1} \end{aligned}$$

Initial velocity , U

$$\begin{aligned} U &= \frac{d_1}{t_1} \\ &= \frac{2cm}{T} \\ &= \frac{\frac{2}{100}m}{T} \\ &= \frac{0.02m}{0.02s} \\ &= 1ms^{-1} \end{aligned}$$

Acceleration, a

$$\begin{aligned} a &= \frac{V-U}{t} \\ &= \frac{(2.5-1)ms^{-1}}{0.06s} \\ &= \frac{1.5}{0.06}ms^{-2} \\ &= 25ms^{-2} \end{aligned}$$

63. (a) **What is the difference between speed and velocity?**

(b) **The graph in fig. 4 show the variation of distance with time for a body. Describe the motion of the body.**

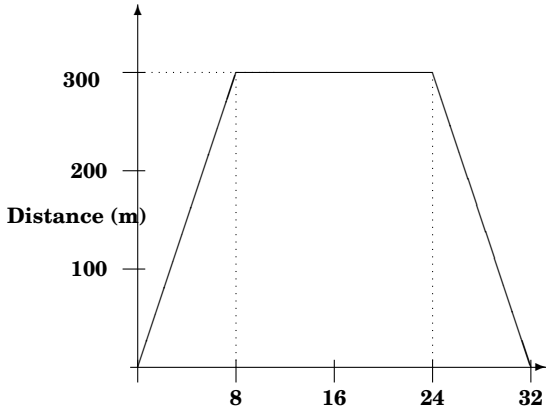


Fig. 4

Solution

(a) Differences between speed and velocity are;

Speed is a scalar quantity while velocity is a vector quantity

speed is the rate of change of distance with time while velocity is the rate of change of displacement with time

(b) Description of its motion; The body starts from rest and accelerates to a speed of $300ms^{-1}$ in 8 seconds. Then it maintains that speed for 16 seconds and finally comes to rest in the next 8 seconds.

64. (a) **A bullet of mass 20g is fired into a block of wood of mass 400g lying on a smooth horizontal surface. If the bullet and the wood move together with speed of 20ms^{-1}, calculate,**

(i) **the speed with which the bullet hits the wood,**

(ii) **the kinetic energy lost.**

(b) **State the energy changes involved in (c) above.**

Solution

(a) from the question

Mass of bullet

$$\begin{aligned} ,m_b &= 20g \\ &= \frac{20}{1000}kg \\ &= \frac{1}{50}kg \end{aligned}$$

Mass of wooden block

$$\begin{aligned} m_w &= 400g \\ &= \frac{400}{1000}kg \\ &= \frac{2}{5}kg \end{aligned}$$

Final common speed

$$v = 20ms^{-1}$$

(i) the speed with which the bullet hits the wood;

Using the law of conservation of momentum,

let

w - mean the wooden block

b - mean the bullet

V - velocity after collision and

U - velocity before collision

Total momentum before collision is equal to the total momentum after collision, provided no external force acts on the two bodies

$$m_wU_w + m_bU_b = m_wV_w + m_bV_b$$

But $U_w = 0ms^{-1}$. because the wooden block was at rest. and $V_w = V_b = V$ because after collision the bullet and the wooden block moved together with a common velocity, V.

hence the above equation becomes;

$$\begin{aligned} m_wU_w + m_bU_b &= m_wV_w + m_bV_b \\ 0 + m_bU_b &= m_wV + m_bV \\ m_bU_b &= (m_w + m_b)\,V \end{aligned}$$

$$\begin{aligned}\frac{1}{50}U_b &= \left(\frac{2}{5}+\frac{1}{50}\right)\times 20\\ \frac{1}{50}U_b &= \frac{21}{50}\times 20\\ \Longrightarrow U_b &= 21\times 20\\ &= 420ms^{-1}\end{aligned}$$

hence the velocity with which the bullet hits the wood is $420ms^{-1}$

(ii) Kinetic energy (K.E.) lost

$$= \begin{pmatrix}\text{initial}\\ \text{K.E}\end{pmatrix} - \begin{pmatrix}\text{Final}\\ \text{K.E}\end{pmatrix}$$

before collision only the bullet was moving, i.e. total kinetic energy before collision is that of the bullet. After collision the bullet and the wooden block were moving together as one body of mass (400+20)g

kinetic energy lost is equal to

$$\begin{aligned}&= \frac{1}{2}m_bU_b^2 - \frac{1}{2}(m_b+m_w)V_b^2\\ &= \frac{1}{2}\times\frac{1}{50}\times 420^2\\ &\quad -\frac{1}{2}\times\left(\frac{2}{5}+\frac{1}{50}\right)\times 20^2\\ &= 1764-84\\ &= 1680 \text{ Joules}\end{aligned}$$

hence the lost kinetic energy is 1680 Joules

(b) the energy changes involved, are;

From kinetic energy to;

- Sound energy
- Light energy if sparks are formed
- Kinetic energy of the bullet and the block when moving together
- Energy used to overcome friction

65. (a) Define inertia of a body.

(b) **Explain why a passenger standing on the floor of a lorry jerks backwards when the lorry starts moving forwards.**

(c) **A 7-tonne truck initially moving at a velocity of 50ms^{-1} accelerates to 80ms^{-1} is 3 seconds. Calculate the force on the truck that caused the velocity change.**

Solution

(a) Inertia is the tendency of a body to stay at rest if it has been at rest or to stay in motion in a straight line if it has been moving, when a force is applied on it.

(b) This is because of inertia; the passenger tends to remain at rest when the lorry moves, hence he/she has to jerk so as not to remain or so as to move with the lorry.

(c)

$$\text{Force} = ma$$

$$\begin{aligned} m &= 7 \text{ tonnes} \\ &= 7 \times 1000kg \\ &= 7000kg \\ a &= \frac{\text{change in velocity}}{\text{time}} \\ &= \frac{V-U}{t} \\ &= \frac{80-50}{3} \\ &= \frac{30}{3} \\ &= 10ms^{-2} \end{aligned}$$

$$\begin{aligned} F &= ma \\ &= 7000 \times 10 \\ &= 70,000N \end{aligned}$$

1.8 Power

Section A (Objectives)

1. A crane lifts 4 bricks per minute through a height of 1.5 m. find the power that is expended if each brick weight 100N.

A 2.5W
B. 10.0W
C. 150.0W
D. 600.0W **B**

$$\begin{aligned} P &= \frac{F \times d}{t} \\ &= \frac{100 \times (1.5 \times 4)}{60} \\ &= 10W \end{aligned}$$

2. A crane raises a mass of 500kg vertically upwards at a speed of 10ms^{-1}. Find the power developed.

A. 5.0×10^0
B. 5.0×10^1
C. 5.0×10^2
D. 5.0×10^4 **D**

$$\begin{aligned} P &= \frac{F \times d}{t} = F \times \frac{d}{t} \\ &= F \times v = mg \times v \\ &= 500 \times 10 \times 10 \\ &= 5.0 \times 10^4 W \end{aligned}$$

3. A girl whose mass is 50kg runs up a staircase 25m high in 4s. Find the power she develops.

A. $\frac{50\times4}{25}$
B. $\frac{50\times10}{25\times4}$
C. $\frac{50\times25}{4}$
D. $\frac{50\times10\times25}{4}$ **D**

$$\begin{aligned} P &= \frac{F \times d}{t} \\ &= \frac{mg \times d}{t} \\ &= \frac{50 \times 10 \times 25}{4} \end{aligned}$$

4. A train traveling at a constant speed of 200 m/s overcomes a resistive force of 8 kN. The power of the train is

A. (8×20) W.

B. $(8 \times 10 \times 20)$ W.

C. $(8 \times 100 \times 20)$ W.

D. $(8 \times 1000 \times 20)$ W **D**

$$\begin{aligned} P &= \frac{F \times d}{t} \\ &= F \times V \\ &= 8k \times 20 \\ &= 8 \times 1000 \times 20 \end{aligned}$$

5. A pump is rated at 400W. How many kilograms of water can it raise in one hour through a height of 72m?

A. 0.8kg

B. 5.6kg

C. 33.3kg

D. 2000kg **D**

$$\begin{aligned} Pt &= mgh \\ m &= \frac{Pt}{gh} \\ &= \frac{400 \times 3600}{10 \times 72} \\ &= 2000 \end{aligned}$$

6. Water flows over a large water fall of height 50m at a rate of 200kg s^{-1} and runs generator of efficiency 80%. The power of the generator in watts is

A. 2.5×10^4

B. 8.0×10^4

C. 2.5×10^5

D. 8.0×10^5 **B**

$$\begin{aligned} P &= 80\% \text{ of } \frac{mgh}{t} \\ &= \frac{80}{100} \times \frac{m}{t} \times gh \\ &= \frac{80}{100} \times 200 \times 10 \times 50 \\ &= 8.0 \times 10^4 \end{aligned}$$

7. An engine exerts a force of 2000N at a speed of 15 ms^{-1}. Find the power developed by the engine in Kw.

A. 30,000

B. 3,000

C. 300

D. 30 **A**

$$\begin{aligned} P &= Fv \\ &= 2000 \times 15 \\ &= 30,000 \end{aligned}$$

8. A constant force of 5N acts on a body and moves it through a distance of 20m in 10 seconds. calculate its power

A. 2.5W

B. 10W

C. 40W

D. 100W **B**

$$P = \frac{F \times D}{t} = \frac{5 \times 20}{10}$$
$$P = 10W$$

9. A mouse of mass 0.03kg climbs through a distance of 2 m up a wall in 4s. the power expended in watts is

   A. $0.03 \times 2 \times 4 \times 10$
   B. $\frac{0.03 \times 4 \times 2}{10}$
   C. $\frac{0.03 \times 4 \times 10}{2}$
   D. $\frac{0.03 \times 2 \times 10}{4}$ **D**

$$P = \frac{F \times d}{t} = \frac{0.03 \times 10 \times 2}{4}$$

10. A water pump raises 2000kg of water through a vertical height of 72m in one hour. Calculate the power of the pump.

    A. 40,000W.
    B. 4,000W.
    C. 400 W.
    D. 40 W. **C**

$$P = \frac{F \times d}{t} = \frac{mg \times d}{t} = \frac{2000 \times 10 \times 72}{3600} = 400W$$

11. A boy pulls a block of wood with a force of 30N through a distance of 300m in 2 minutes.

    Find the power he develops, if he pulls the block at constant speed.

    A. $\frac{30 \times 300}{2}$
    B. $\frac{30 \times 300}{2 \times 60}$
    C. $\frac{30 \times 2 \times 60}{200}$
    D. $\frac{300}{2 \times 60 \times 30}$ **B**

$$P = \frac{F \times d}{t} = \frac{30 \times 300}{2 \times 60}$$

Section B (Structured)

12. A man whose mass is $75kg$ climbs up a ladder of $6.5m$ high in $5s$. Calculate the

    (i) workdone,

$$w = F \times d = mg \times d = (75 \times 10) \times 6.5 = 4875J$$

    (ii) power expended

$$P = \frac{w}{t} = \frac{4875}{5} = 975Watts$$

13.

(a) Define Power

Power is the rate of doing work

(b) Find the power developed when a crane lifts a load of 3000N through 5m in 5s.

$$\begin{aligned} P &= \frac{F \times d}{t} \\ &= \frac{3000 \times 5}{5} \\ &= 3000Walts \end{aligned}$$

14. In a dam, $2.0 \times 10^3 kg$ of water falls every second through a height of $20cm$ to operate an electric generator.

(a) Calculate the power input to the generator.

Power, P

$$\begin{aligned} P &= \frac{\text{work done}}{\text{time}} \\ P &= \frac{mgh}{t} = \frac{m}{t}gh \\ &= 2 \times 10^3 \times 10 \times \frac{20}{100}m \\ &= 4000watts \end{aligned}$$

(b) State the energy changes which take place.

Potential energy → kinetic energy → electric energy

15.

(a) Define joule.

This is the mount of work done when a force of $1N$ moves through a distance of $1m$ from the point of application of the force in the direction of the force.

(b) A boy of mass $45kg$ runs up a flight of 60 steps. If each step is $12cm$, find the work done against gravity by the boy.

$$\begin{aligned} W &= F \times d \\ &= mg \times d \\ &= 45 \times 10 \cdot \left(\frac{12}{100}m \times 60\right) \\ &= 450 \times 7.2 \\ &= 3240J \end{aligned}$$

1.9 Archimedes/floatation

Section A (Objectives)

1. When an inflated balloon is released in air with its neck opened, it will

A. Rise up

B. Drop to the ground instantly

C. Move in the opposite direction to the escaping air **C**

D. Remain in one position

2.

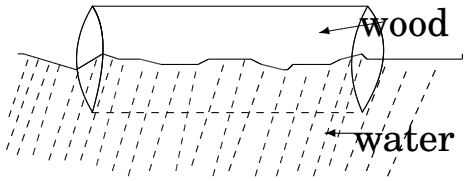


Figure 2 shows a bock of wood of volume 40cm^3 floating in water with only Half of its volume submerged. If the density of water is 1000 kgm^{-3}. Determine the mass of the wood under water.

A. 40×1000 kg.

B. 20×1000kg.

C. $40 \times 10^{-6} \times 500$ kg.

D. $20 \times 10^{-6} \times 500$kg. **D**

$$\begin{aligned} m_{dsp.wtr} &= \frac{1}{2} \times 20 \times 1gcm^{-3} \\ &= = 20g \\ m_{wd} &= \frac{1}{2} \times 20 = 10g \\ &= 10 \times 10^{-3}kg \\ &= 20 \times 10^{-6} \times 500kg \end{aligned}$$

3. A cork held under water rises to the surface when released because the upthrust on it is

A. greater than the weight

B. less than the weight

C. equal to the weight

D. equal to the weight of water displaced **A**

4. A solid, Q, sinks deeper in liquid, N, than in liquid, M, because the

A. upthrust on the solid is greater in liquid N than M.

B. density of liquid M is greater than that of N.

C. density of liquid N is greater than that of M.

D. surface tension of liquid N is less than that of M. **B**

5. Which of the following are true about a hydrometer?

(i) it measures density of liquid

(ii) its sensitivity is improved by narrowing its stem.

(iii)its readings increase upwards on the stem.

(iv)Its buoyancy is provided by the large bulb.

A. (i), (ii) and (iii) only.

B. (ii), (iii) and (iv) only.

C. (i), (ii) and (iv) only.

D. (ii) and (iv) only. **C**

6. A balloon is filled with hydrogen and released in the open air. It will rise

A. to a certain height and then float.

B. to a certain height and then drop.

C. to a certain height and then burst.

D. indefinitely. **A**

7. When a spherical ball falls through a column of oil with a steady velocity, the total

   A. downward force is greater than total upward force.

   B. upward force is greater than total downward force.

   C. upward force is equal total downward force.

   D. upward force is zero **C**

Section B (Structured)

8. (a) State the principle of floatation.

The weight of a floating body is equal to the weight of the fluid displaced.

(b) A cube of edge $0.1m$ floats in a liquid of density *1200kgm*$^{-3}$ with a third of it submerged, find the density of the material of the cube.

Using the law of floatation i.e. the weight of the cube, W_c, is equal to the weight of the liquid displaced, W_d.

$$\begin{aligned} W_c &= W_d \\ V\rho g &= \frac{1}{3}V\rho_L g \\ \rho &= \frac{1}{3}\rho_L \\ &= \frac{1}{3}\times 1200 \\ &= 400kg/m^3 \end{aligned}$$

9. (b) A solid weighs $25.0g$ in air and $19.0g$ when submerged in water. Find the density of the material of the solid.

$$\begin{aligned} \rho &= \text{Denisty} \\ \rho &= \begin{pmatrix}\text{Relative}\\ \text{density}\end{pmatrix}\cdot 1000kgm^{-3} \\ &= R.D\times 1000kgm^{-3} \end{aligned}$$

$$\begin{aligned} R.D. &= \frac{W_a}{W_a - W_w} \\ &= \frac{m_a g}{m_a g - m_w g} \\ &= \frac{m_a}{m_a - m_w} \end{aligned}$$

$$\begin{aligned} R.D. &= \frac{25\times 10^{-3}}{25\times 10^{-3} - 19\times 10^{-3}} \\ &= \frac{25}{6} \end{aligned}$$

hence,

$$\begin{aligned} \rho &= \frac{25}{6}\times 1000kgm^{-3} \\ &= 4166.67kgm^{-3} \end{aligned}$$

10. (a) State Archimedes' principle.

When a body is wholly or partially immersed in a fluid it experiences an upthrust or an upward force equal to the weight of the fluid displaced.

(b) A rubber balloon of mass $5\times 10^{-3}kg$ is inflated with hydro-

gen and held stationary by means of a string. If the volume of the inflated balloon is $5 \times 10^{-3} m^3$, calculate the tension in the string. (Density of hydrogen $= 0.080 kgm^{-3}$, Density of air $= 1.150 kgm^{-3}$)

At equilibrium, sum of upward forces is equal to the sum of downward forces acting on the balloon.

$$\begin{aligned} T &= U - mg_b - mg_{H_2} \\ &= \rho v_{air} g - mg_b - \rho v g_{H_2} \\ &= 1.15 \times \left(5 \times 10^{-3}\right) \times 10 \\ &\quad -5 \times 10^{-3} \left(5 \times 10^{-3}\right) \times 10 \\ &\quad -0.08 \times 5 \times 10^{-3} \times 10 \\ &= 0.0575 - 0.00025 - 0.004 \\ &= 0.05325 N \end{aligned}$$

11. A solid of volume $10^{-4} m^3$ floats in water (of density $10^3 kgm^{-3}$) with $\frac{2}{3}$ of its volume submerged.

(a) Find the mass of the solid?

mass of a floating body m_F is equal to the mass of the water displaced m_d

$$\begin{aligned} m_F &= m_d \\ &= \rho V g \\ &= 10^3 \times \frac{2}{3} \times 10^{-4} \times 10 \\ &= \frac{2}{3} kg \end{aligned}$$

(b) If the solid floats in another liquid with $\frac{4}{5}$ of its volume submerged, what is the density of the liquid.

$$\begin{aligned} \textit{mass of liquid displaced} &= \textit{mass of solid} \\ \rho V g &= \frac{2}{3} \\ \rho \times \frac{4}{5} \times 10^{-4} \times 10 &= \frac{2}{3} \\ 0.0008\rho &= \frac{2}{3} \end{aligned}$$

$$\begin{aligned} \rho &= \frac{2}{3} \times \frac{1}{0.0008} \\ &= 833.33 kg/m^3 \end{aligned}$$

12.

(a) Define density.

Density is mass per unit volume

(b) A balloon is filled with hydrogen and sealed. Explain what happens when the balloon is released in air.

It rises up in air if its total weight is less than the up-thrust acting on it.

13.

(i) A body whose weight in air is $52N$ experiences an upthrust of $12N$ in a fluid. Find its apparent weight.

(ii) What happens to the weight of the body at a much higher altitude?

(i) apparent weight, W_{App}

$$\begin{aligned} W_{App} &= W_{air} - \text{Upthrust} \\ &= 52 - 12 \\ &= 40N \end{aligned}$$

(ii) *at high altitude weight decreases because it is further away from the earth's centre.*

Paper II (Essay)

14. (a) (i) Describe an experiment to verify the law of flotation?

(ii) Give one example where the law of flotation is applied

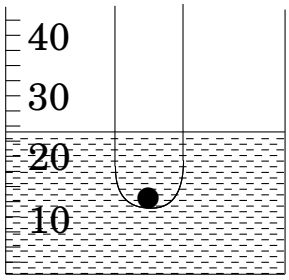
(b) (i) Define density.

(ii) A piece of glass weighs 0.5N in air and 0.30N in water. Find the density of glass.

Solution

(a) (i) An experiment to verify the law of floatation

- Apparatus: You should have a long test tube, small masses, measuring cylinder, and weighing scale.
- Weigh the mass of the test tube as M
- Place a known mass with mass, m, in it



- Read the level of water in the measuring cylinder as $V_\circ$
- Dip the test tube in the water in the measuring cylinder and leave it to settle. Take the new reading of the water level as V_m
- Get the volume $V$of water displaced as;

$$V = V_m - V_\circ$$

- Repeat the above procedure for various different masses in the test tube and tabulate your results as shown below;

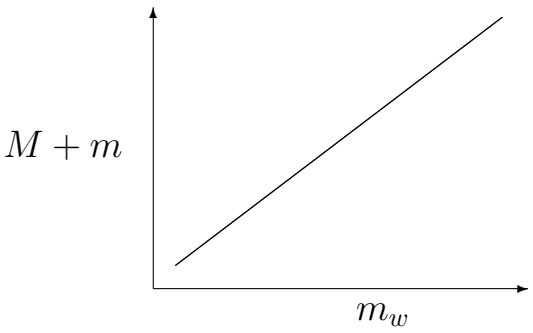
$M+m$	V	m_w

Where $M + m$ is the total mass of the floating body and $m_w = 1 \times V = Vg$, mass of water displaced.

The value of $M + m$ will be found to be equal to the mass m_w of water displaced

OR

If a graph of $M+m$ against m_w is plotted, a straight line with a slope of unity is obtained.



This shows that the mass of the floating body is equal to the mass of the fluid (liquid water) it displaces.

(ii) the law of floatation is applied in a ship. A ship is made of steel which sinks in water but this steel is made to ocupy a larger volume or space so that it displaces a larger quantity of water hence increasing the upthrust acting on it enabling it to float.

(b) (i) Density is mass per unit volume

(ii) Applying Archimedes principle, we say.
Relative density of a solid, R.d

$$R.D = \frac{\text{weight in air}}{\text{upthrust in water}}$$

$$= \frac{W_{air}}{W_{air} - W_{water}}$$
$$= \frac{0.5N}{0.5N - 0.3N}$$
$$= \frac{0.5N}{0.2N}$$
$$= 2.5$$

But

$$\text{density} = R.D. \times \begin{bmatrix}\text{density}\\ \text{of water}\end{bmatrix}$$

density of glass, ρ

$$\rho = 2.5 \times 1gcm^{-3}$$
$$= 2.5cm^{-3}$$
$$= 2.5cm^{-3}$$

OR

Density of glass, ρ

$$\rho = 2.5 \times 1000kgm^{-3}$$
$$= 2500kgm^{-3}$$
$$= 2.5 \times 10^3 kgm^{-3}$$

15. **A balloon is filled with $50m^3$ of hydrogen and tied to the ground. The balloon alone, and the container which it carries have a mass of 2.0kg. If the densities of hydrogen and air are $9.0\times10^{-2}kgm^{-3}$ and $1.29kgm^{-3}$ respectively, how much load can the balloon lift when released?**

Solution

in this question. we are to use Archimedes principle to obtain upthrust. From the question, we have;

volume of hydrogen, H_2, $V = 5m^3$

mass of balloon and container, $m_b = 2kg$

density of hydrogen $= 9.0\times10^{-2}kgm^{-3}$

density of air $= 1.29kgm^3$

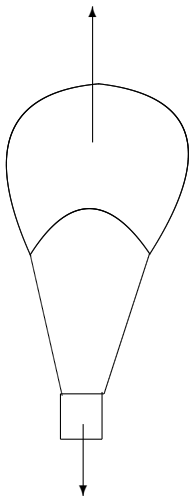
let the mass that can be lifted by the balloon be m

For the balloon to be in equilibrium, the net vertical force acting on it must be zero or

$$\underset{\text{forces}}{\text{Upward}} = \underset{\text{forces}}{\text{downward}}$$

but what are these forces?

Upthrust



Downward force

$$\text{Upthrust } = m_bg + mg + m_{H_2}g$$

but upthrust, U, is equal to weight, W, of the fluid (air) displaced i.e.

$$\begin{aligned} U &= W \\ &= mg \\ &= \rho Vg \\ &= \rho_{air}V_{H_2}g \\ &= 1.29 \times 5 \times 10 \\ U &= 64.5N \end{aligned}$$

$$\begin{aligned} \text{But } U &= m_bg + mg + m_{H_2}g \\ 64.5N &= m_b + mg + m_{H_2}g \end{aligned}$$

$$\begin{aligned} mg &= U - m_bg \\ &\quad -m_{H_2}g \\ &= U - 2 \times 10 - \rho_{H_2} \\ &\quad \times V_{H_2} \times g \\ &= U - 20 - 9.0 \times 10^{-2} \times 5 \times 10 \\ &= 64.5 - 20 - 4.5 \\ mg &= 40N \end{aligned}$$

Hence the balloon can lift a load of 40N.

16. **Explain why a ship floats in water although it is made mainly of metal.**

Solution

A ship made of a metal is made to float in water by making it have a large volume so that the volume of water it displaces is large,

so that the weight of water displaced is equal to the weight of the ship, for the ship to float according to the law of floatation. Or because the metal is designed to ocupy a larger volume hence reducing its average density to a value less than the density of water hence it floats on water.

1.10 Centre of gravity

Section A (Objectives)

1. Fig. 5 shows a uniform metre rule of 0.1kg pivoted at the 80cm mark. It balances horizontally when a mass P is hang at the 95cm mark. Find the value of P.

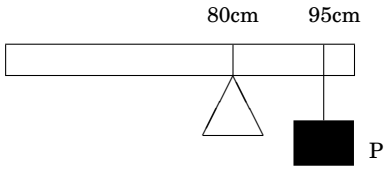


Fig. 5

A. 0.08kg
B. 0.2kg
C. 0.4kg
D. 1kg **B**

Principle of moments says

$$\begin{aligned} ACWM &= CWM \\ 0.1 \times (80-50) &= P \times (95-80) \\ 15P &= 3 \\ P &= \frac{3}{15} \\ &= 0.2 \end{aligned}$$

2. .

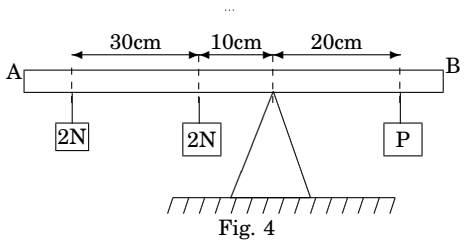


Fig. 4

A light beam AB is in equilibrium when forces of 2N, 2N and P act on it as shown in Fig. 4. Find the magnitude of P.

A. 5N
B. 4N
C. 2N
D. 1N **A**

$$\begin{aligned} 20 \times P &= 2 \times 40 + 2 \times 10 \\ 20P &= 100 \\ P &= 5N \end{aligned}$$

3.

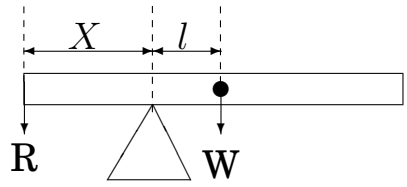


Fig. 5

Fig. 5 shows a uniform beam in equilibrium when a force R acts on it at one end. Find the weight, W, of the beam.

A. $\frac{X}{Rl}$
B. $\frac{Rl}{X}$

C. $\frac{l}{RX}$

D. $\frac{RX}{l}$ **D**

Taking moments at the pivot

$$\begin{aligned} R \times X &= W \times l \\ W &= \frac{RX}{l} \end{aligned}$$

4. A load of 500N is placed at 2m from a pivot of a sea saw. At what distance from the pivot should a weight of 250N be placed to balance the sea-saw?

A. 0.5m

B. 1.0m

C. 2.0m

D. 4.0m **D**

$$\begin{aligned} ACWM &= CWM \\ 500 \times 2 &= 250 \times x \\ x &= \frac{500 \times 2}{250} \\ &= 4m \end{aligned}$$

5. The diagram in Fig. 1 shows a uniform half metre rule suspended at point C.

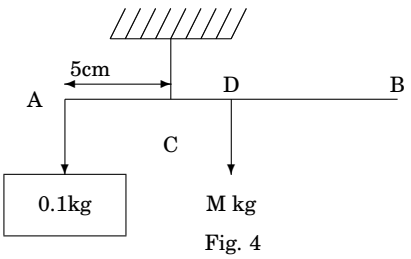


Fig. 4

The mass m of the rule is

A. 0.020kg.

B. 0.025kg.

C. 0.100kg.

D. 0.125kg. **A**

Taking moments at C

$$\begin{aligned} CWM &= ACWM \\ m \times (25-5) &= 5 \times 0.1 \\ 20m &= 0.5 \\ m &= \frac{0.5}{20} \\ &= 0.025kg. \end{aligned}$$

6.

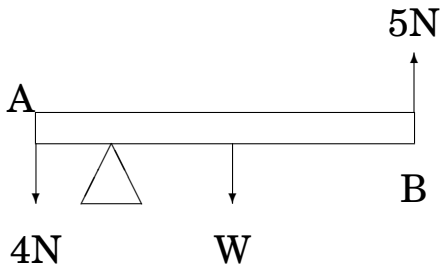


Fig. 3

A uniform wooden beam of weight W is pivoted at a distance $\frac{1}{5}^{th}$ of its length from the end A and kept in equilibrium by applying forces of 4N and 5N as shown in Fig. 3. the force exerted by the pivot on the beam is

A. 16

B. 15

C. 10

D. 8 **B**

Net force = 0N

$$\begin{aligned} 4 + W &= R + 5 \\ W &= R + 1 \end{aligned}$$

taking moments about the pivot

$$\begin{aligned}\frac{1}{5}l \times 4 + \frac{4}{5}l \times 5 &= \left[\frac{1}{2}l - \frac{1}{5}l\right] \times W \\ \frac{1}{5}l \times 4 + \frac{4}{5}l \times 5 &= \frac{3}{10}l \times W \\ \frac{24}{5} &= \frac{3}{10}W \\ W &= 16 \\ R &= W - 1 \\ &= 16 - 1 \\ &= 15\end{aligned}$$

7. Which of the following statements are true about two equal forces F acting on a bar of length L, shown in fig. 2

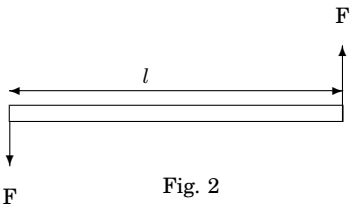


Fig. 2

(i) The resultant force on the bar is zero.

(ii) The forces cause a rotational effect.

(iii) The forces act in opposite directions.

(iv) The forces produce different turning effects.

A. (i) only

B. (i) and (ii) only

C. (i), (ii) and (iii) only.

D. (i), (ii) and (iv) only. **C**

8. A uniform metre-rule is pivoted at its centre as shown in fig. 2.

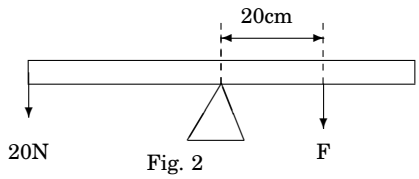


Fig. 2

If the rule is in equilibrium, find the value of F.

A. 4 N

B. 33.3 N

C. 50 N

D. 100 N **C**

$$\begin{aligned}ACWM &= CWM \\ 50 \times 20 &= 20 \times F \\ F &= 50\end{aligned}$$

9. The shaft in an engine is subjected to two parallel but opposite forces of 500 N each as shown in fig. 3.

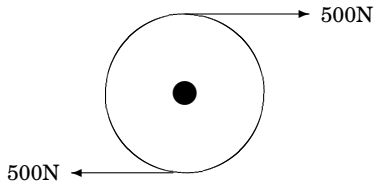


Fig. 3

The rotation is best stopped by applying.

A. two forces of 500 N acting at right angles to each other.

B. two parallel but opposite forces of 500 N.

C. a single force of 1000 N

D. a single force of 250 N **C**

Section B (Structured)

10. What is meant by the centre of gravity of a body.

This is a point where the net force due to the earth's attraction acts on a body.

11. A uniform metre rule, pivoted at the $10cm$ mark, balances when a mass of $400g$ is suspended at the $0cm$ mark as shown in fig. 7.

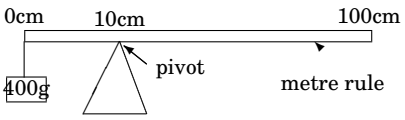


Fig. 7

Calculate the mass of the metre rule.

Let m be the mass of the meter rule, its weight acts at the 50cm mark. Using the principle of moments, we have;

$$\begin{aligned} m \times 40cm &= 400g \times 10cm \\ m &= \frac{400g \times 10cm}{40cm} \\ m &= 100g \end{aligned}$$

11. State the conditions for a body to bet in equilibrium.

i. *net moment acting on a body is zero i.e. the total sum of Anticlockwise moments is equal to the total sum of clockwise moments*

ii. *net force acting on it is zero i.e. net sum of upward forces are equal to the net sum of downward force or net sum of eastward forces is equal to the sum of westward forces*

12. What is meant by centre of gravity?

This is the point where the resultant force acting on a body due to the earth's attraction acts.

13. Define Moment of a force.

This is the product of force and its perpendicular distance from the turning point.

14. A uniform metre-rule is balanced at the 30cm mark when a load of 0.8N is hang at the zero-mark. Find the weight of the metre-rule.

Using the principle of moments, the sum of clockwise moments is equal to the sum of anticlockwise moments

$$\begin{aligned} W \times \frac{20}{100} &= 0.8 \times \frac{30}{100} \\ W &= \frac{0.8 \times 30}{20} \\ &= 1.2N \end{aligned}$$

15. A uniform beam of weight 2.5N is pivoted at its mid-point P, as shown in fig. 8. The beam remains in equilibrium when force R and S act on it. If R is 5N. Find the:

(i) value of S.

(ii) reaction at the pivot.

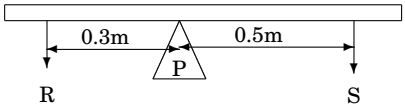


Fig. 8

Using the principle of moments;

$$\begin{aligned} S \times 0.5 &= R \times 0.3 \\ S &= \frac{5 \times 0.3}{0.5} \\ S &= 3N \\ \begin{bmatrix} \text{Reaction} \\ \text{at the pivot} \end{bmatrix} &= R + S \\ &= 5 + 3 \\ &= 8N \end{aligned}$$

Paper II (Essay)

16. **Briefly describe an experiment to locate the centre of gravity of an irregular lamina.**

Solution

An experiment to determine the centre of gravity of an irregular lamina using the **The plumb-line method**[2].

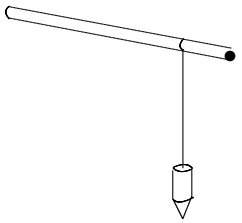
Apparatus;

In this experiment we need a lamina, a plumb line and a stand (or a rigidly fixed rod)

Method;

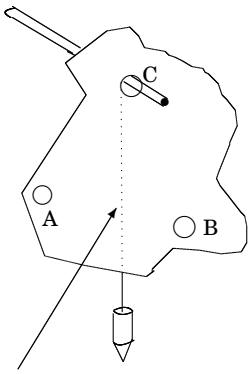
In this experiments you perform the following steps;

- Make three holes A, B, and C near the edges of the irregular lamina as shown below.
- Tie the plumb-line on a thin strong rod so that it suspends vertically

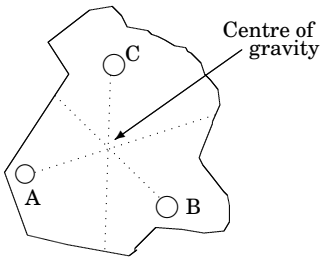


- Suspend the lamina on the same rod through the hole C as shown below.

[2]There is another method called the balancing method



- Trace the position of the vertical plumb-line string on the lamina, as a line called the meridian.
- Suspend the lamina now through the holes B and then A, drawing their corresponding meridians. The meridians will meet at a single point. This point of intersection of the meridian is the centre of gravity of the lamina?

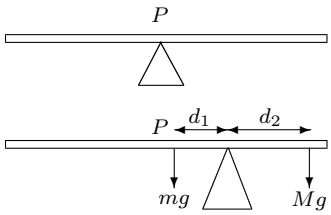


17. **Describe how you would measure the mass of a uniform metre rule using a known mass and a knife edge only.**

Solution

To measure mass of a uniform meter rule using a known mass and a knife edge only.

- Hold the rule horizontally on a knife edge.
- Move it slightly to its raised side on the edge until it rests horizontally
- Mark the position of the knife edge P on the rule when it rests horizontally.
- Tie a known mass with a string to one side of the rule.
- Change the position of the knife edge or the mass till the ruler rest horizontally again as shown below:



- Measure the distance of the mark P from the knife edge as d_1 and the distance of the string holding the known mass M from the knife edge as d_2 if m is the mass of the meter rule, from the principle of moments.

  Sum of clockwise moments, CWM is equal to the sum of anticlockwise moments, ACWM

$$\begin{aligned} CWM &= ACWM \\ Mg \times d_2 &= mg \times d_1 \\ \Longrightarrow m &= M \times \frac{d_2}{d_1} \end{aligned}$$

  substituting in for M , d_1, and d_2 the mass, m of the uniform rule is determined.

18. A uniform metre rule of weight 1N is pivoted on a wedge 5cm away from one end and suspended by a string 30cm from the other end.

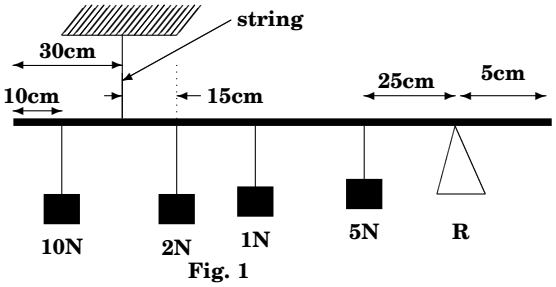


Fig. 1

If the metre is in equilibrium when weights of 10N, 2N and 5N are attached to it as shown in fig. 1, Calculate the;

(i) **tension in the string**

(ii) **normal reaction, R, at the wedge.**

Solution

(i) Taking moments at R,

$$\begin{aligned} T(100-35) &= 10(100-15) \\ &\quad +2\cdot 60 \\ &\quad +1(50-5) \\ &\quad +5\cdot 25 \end{aligned}$$

$$\begin{aligned} 65T &= 850+120 \\ &\quad +45+125 \end{aligned}$$

$$\begin{aligned} 65T &= 1140 \\ T &= \frac{1140}{65} \\ T &= 17.54N \end{aligned}$$

(ii) At equilibrium, the sum of upward forces is equal to the sum of downward forces, i.e.

$$\begin{aligned} T+R &= 10+2+1+5 \\ T+R &= 18 \\ R &= 18-T \\ R &= 18-17.23 \\ R &= 0.46N \end{aligned}$$

1.11 Machine

1. .

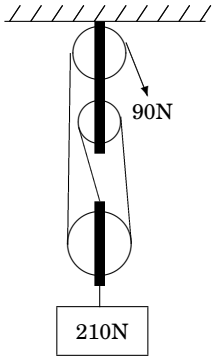


Fig. 1

Calculate the efficiency of the pulley system shown in Figure 1 if the minimum effort needed to raise a load of 120 N is 90N.

A. $\frac{90}{210\times 3\times 100}$

C. $\frac{210\times 3\times 100}{90}$

B. $\frac{90\times 3}{210\times 100}$

D. $\frac{210\times 100}{90\times 3}$ **D**

$$V.R. = 3$$

$$\begin{aligned} M.A. &= \frac{L}{E} = \frac{210}{90} \\ E &= \frac{M.A.}{V.R.} \times 100\% \\ &= \frac{\frac{210}{90}}{3} \times 100\% \end{aligned}$$

$$\begin{aligned} E &= \frac{210}{90} \div 3 \times 100\% \\ &= \frac{210}{90} \times \frac{1}{3} \times 100\% \\ &= \frac{210 \times 100}{90 \times 3} \end{aligned}$$

2.

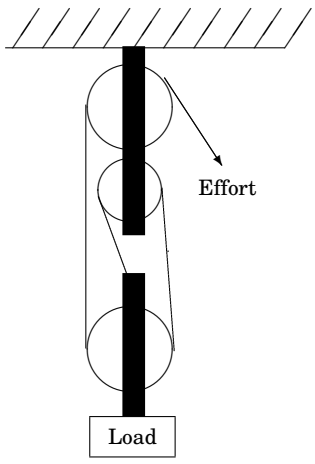


Fig.3

What is the velocity ratio of the pulley system shown in Fig. 3?

A. 1

B. 2

C. 3

D. 4 **C**

velocity ratio of a block and tackle system is equal to the number of strings holding the lower block, here Velocity ratio is 3.

3. The maximum efficiency that can be obtained with four pulleys and a mechanical advantage of 3 is

A. 100%

B. 75%

C. 12%

D. 1.33% **B**

$$\begin{aligned} VR &= 4 \\ E &= \frac{M.A.}{V.R.} \times 100 \\ &= \frac{3}{4} \times \\ &= 75\% \end{aligned}$$

4. Calculate the effort when a load 72N is raised using a block system of five pulleys and efficiency 80.

A. 11.52 N.

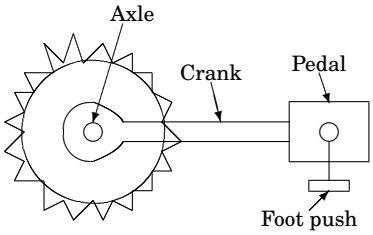
B. 18 N.

C. 57.6 N.

D. 288 N. **B**

$$\begin{aligned} \frac{MA}{VR} \times 100 &= E \\ MA &= \frac{E}{100} \times VR \\ &= \frac{80}{100} \times 5 = 4 \\ \frac{L}{E} &= 4 = \frac{72}{E} \\ E &= \frac{72}{4} \\ E &= 18N \end{aligned}$$

5.



CRANK OF A BICYCLE PEDAL

Fig. 2

Fig. 2 shows a crank of a bicycle pedal. The force a cyclist exerts on a pedal varies from a minimum to a maximum. When does the cyclist exert the maximum turning effect?

A. crank makes 90^0 with the foot push.

B. Crank makes 0^0 with the foot push.

C. Cyclist is climbing a hill.

D. Cyclist is turning a corner.

A

6. Which of the following statements is true of a wedge used as a simple machine?

A. A very small force is required to lift a big load.

B. Work done is always so much.

C. Effort on the wedge is applied vertically.

D. There is no frictional force.

A

7.

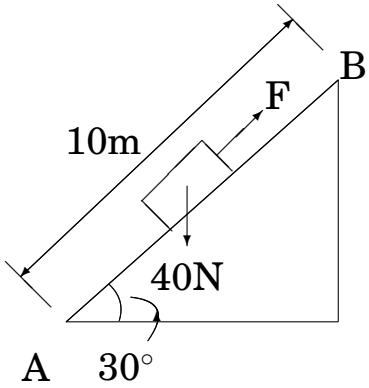


Fig. 5

A load of 40 N is pulled steadily from A to B along an inclined plane by a force F as shown in fig. 5. Find the velocity ratio of the system

A. 1.0.

B. 1.2.

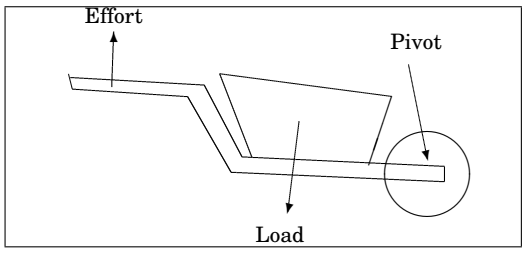
C. 2.0

D. 4.0 **C**

$$\begin{aligned} V.R. &= \frac{d_E}{d_L} \\ &= \frac{l}{h} \\ &= \frac{l}{l\sin 30} \\ &= \frac{1}{\sin 30} \\ &= \frac{1}{\left[\frac{1}{2}\right]} \\ &= 2 \end{aligned}$$

Section B (Structured)

8. Draw a labeled diagram to illustrate the lever principle as applied to a wheel barrow.



9. The graph in fig. 7 shows the variation of the efficiency of a pulley system with load.

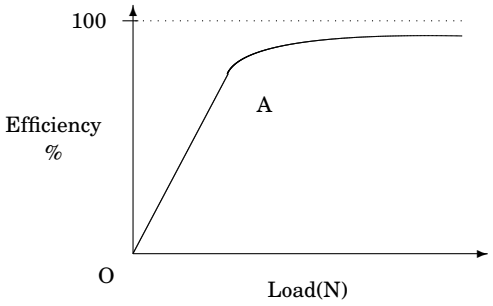


Fig. 7

Explain why;

(i) part OA of the graph is almost a straight line.

(ii) from A the graph curves and finally levels off before reaching 100%.

(i) *Because some energy is used to the moved parts of the machine and against friction is constant.*

(ii)*This is because always friction exists i.e. energy s used to overcome it and to move some parts of the machine hence the efficiency can not be equal to 100%*

10. ’

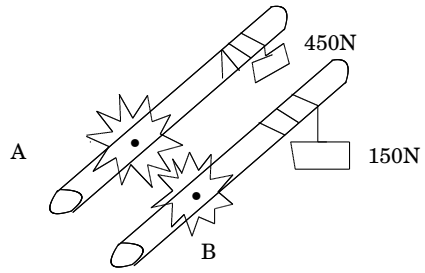


Fig. 8

Two gear wheels A and B with 80 and 20 teeth respectively lock into each other. They are fastened on axles of equal diameters such that a weight of 150N attached to a string wound around one axle raises a load of 450N attached to a string wound around the other axle as shown in fig. 8. Calculate;

(i) the velocity ratio,

$$\begin{aligned} VR &= \frac{\left(\begin{array}{c}\textit{number of teeth}\\ \textit{on driven wheel}\end{array}\right)}{\left(\begin{array}{c}\textit{number of teeth}\\ \textit{on driving wheel}\end{array}\right)} \\ &= \frac{80}{20} \\ &= 4 \end{aligned}$$

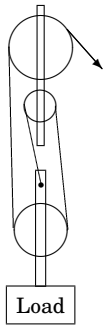
(ii) the efficiency, of the system.

$$\begin{aligned} M.A. &= \frac{L}{E} = \frac{450N}{150N} = 3 \\ \textit{Efficiency} &= \frac{M.A.}{V.R.} \times 100\% \\ &= \frac{3}{4} \times 100\% \\ &= 75\% \end{aligned}$$

11. What is meant by efficiency of a machine?

Efficiency is the ratio of work done by the machine to the work done on the machine.
Or efficiency is the ratio of the work done by the load to the work done by the effort

12. Draw a single pulley system of velocity ratio 3.



i.e the number of strings holding the lower block should be equal to 3

13. State one reason why the efficiency of a machine is always less than 100%.

This is because;

1. *Some energy is used to overcome friction.*
2. *some energy is used to lift parts of the machine.*

Paper II (Essay)

14. The graph in Figure 1.1on page 98 shows how load varies with effort in an experiment using a single pulley system of velocity ratio 5.

For a load of 450N, find the

(i) **effort**

(ii) **mechanical advantage**

(iii) **efficiency.**

Solution

from the graph, where load is $450N$

(i) the effort is $115N$

(ii) the mechanical advantage,

$$\begin{aligned} M.A. &= \frac{\text{Load}}{\text{Effort}} \\ &= \frac{\text{Change in load}}{\text{Change in effort}} \end{aligned}$$

Choosing the extreme points of the graph, i.e. (24,0) and (150,625)

$$\begin{aligned} M.A. &= \frac{\Delta L}{\Delta E} \\ &= \frac{(625-0)N}{(150-24)N} \\ &= \frac{625N}{126N} \\ &= 4.96 \end{aligned}$$

(iii) Efficiency, E,

$$\begin{aligned} E &= \frac{M.A}{V.R} \times 100\% \\ &= \frac{4.96}{5} \times 100\% \\ &= 99.2\% \end{aligned}$$

15. (a) Define the following terms:

(i) **mechanical advantage,**

(ii) **velocity ratio.**

(b)

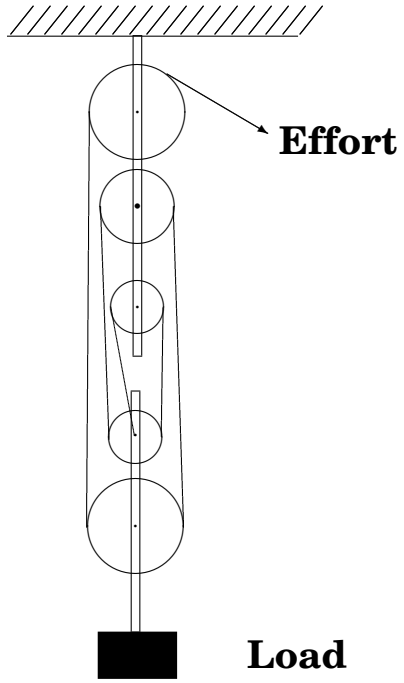


Fig. 2

The diagram in fig. 2 shows a pulley system used to raise a load.

(i) **What is the velocity ratio of the system?**

(ii) **Find how far the load is raised, if the effort moves down by 4m.**

(iii) **Calculate the effort required to raise a load of 800N, if the mechanical advantage of the system is 4.**

(iv) **Calculate the efficiency of the system.**

(c) **Explain what happens to the efficiency of the system in (b) above, if the load is much.**

(i) **less than 800N**

(ii) **more than 800N**

(d) **Draw a sketch graph to show how mechanical advantages of the system in (b) varies with load.**

(e) **Give two practical applications where pulley systems are used.**

Solution

(a) (i) mechanical advantage is the ratio of load to effort.

(ii) velocity ratio is the ratio of the distance moved by the effort to the distance moved by the load in the same time.

(b) (i) Velocity ratio is the number of strings holding the lower block.

$$= 5$$

(ii) Since

$$\begin{aligned} V.R. &= \frac{d_e}{d_l} \\ \text{But } d_e &= 4m \text{ and} \\ V.R. &= 5 \\ \Longrightarrow 5 &= \frac{4}{d_l} \\ 5d_l &= 4 \\ d_l &= \frac{4}{5} \\ &= 0.8 \text{ metres} \end{aligned}$$

hence the load is raised by 0.8 metres

(iii) from

$$\begin{aligned} M.A &= \frac{L}{E} \\ \text{But } M.A &= 4, \text{ and} \\ L &= 800N \\ \text{Hence }, 4 &= \frac{800}{E} \\ \Longrightarrow 4E &= 800 \\ E &= \frac{800}{4} \\ &= 200N \end{aligned}$$

hence the required effort is 200 N

(iv) Efficiency, E_f

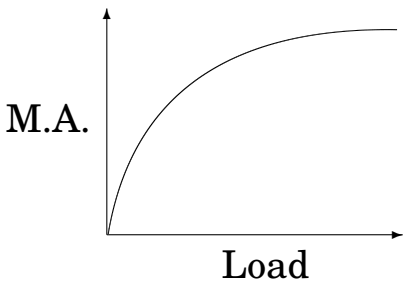
$$\begin{aligned} E_f &= \frac{M.A.}{V.R.} \times 100\% \\ &= \frac{4}{5} \times 100\% \\ &= 80\% \end{aligned}$$

hence the efficiency is 80%

(c) (i) If the load in (b) above is less than 800N, the efficiency reduces or the efficiency is lower.

(ii) if the load in (b) above is more than 800N, the efficiency increases or the efficiency is higher.

(d) graph of mechanical advantage, M.A. against load.



(e) Two practical application where pulleys are used are

- In cranes; to lift building material to high level when constructing high storeyed buildings
- In lifts that transport people to rooms at high or low levels in high storeyed buildings
- In running conveyor belts that move objects in industries and factories like moving crates of sodas when they are being bottled.

16. In a pulley system, the distance moved by an effort is five (5) times the distance moved by a load. Calculate the efficiency of the system if an effort required just to move a load of 60 N is 20 N.

Solution

From the question

velocity ratio

$$V.R. = 5$$

mechanical advantage

$$\begin{aligned} M.A. &= \frac{L}{E} \\ &= \frac{60N}{20N} \\ &= 3 \end{aligned}$$

hence from

$$\begin{aligned}\textbf{Efficiency} &= \frac{M.A.}{V.R.} \times 100\% \\ &= \frac{3}{5} \times 100\% \\ &= 60\%\end{aligned}$$

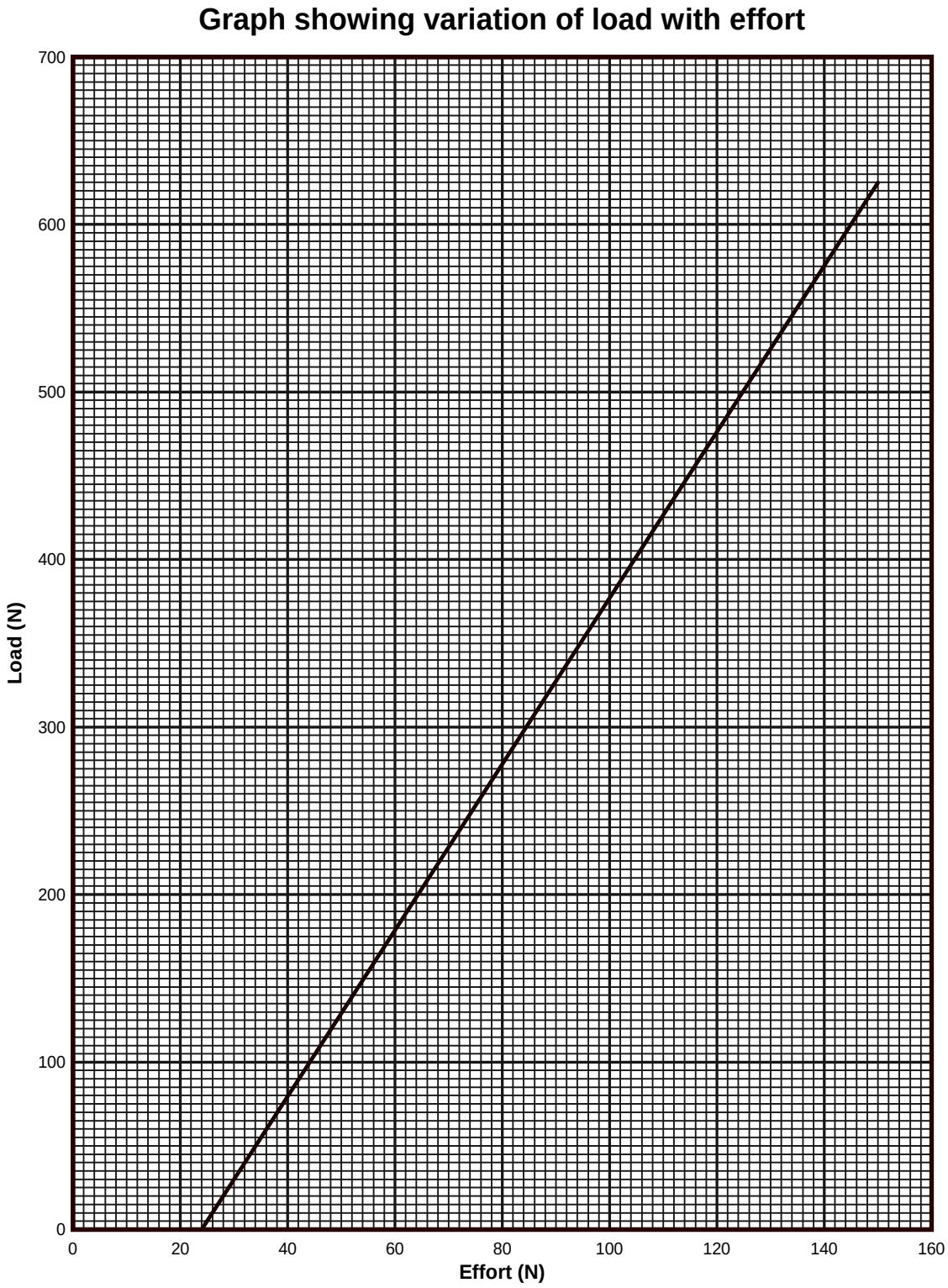


Figure 1.1: Graph of Load against Effort

1.12 Waves

Section A (Objectives)

1. The basic difference between transverse and longitudinal waves is in

A. Amplitude **C**

B. Wavelength

C. Direction of vibration

D. Medium through which the waves travel.

2. In a ripple tank, constructive interference occurs when

A. The wave is stationary

B. A crest overlaps with a trough

C. A crest overlaps with a crest

D. The wave strikes a barrier. **C**

3. .

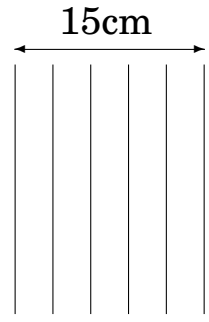


Fig. 8

Fig. 8 represents straight waves A, B, C, D, E and F. if after 5s, A occupies the position now occupied by F, find the wavelength of the wave.

A. 1 Hz

B. 3 Hz

C. 9Hz

D. 15Hz **A**

$$\begin{aligned}\lambda &= \frac{15cm}{5} = 3cm \\ v &= \frac{d}{t} = \frac{15cm}{5s} = 3cms^{-1} \\ f &= \frac{v}{\lambda} = \frac{3cms^{-1}}{3cm} \\ f &= 1Hz\end{aligned}$$

4. Which one of the following bands has a wavelength greater than that of visible spectrum?

A. Gamma

B. X-rays

C. Ultra-Violet

D. Infrared **D**

5. A vibrator produces a sound wave that travels 900m in 3s. if the wave length of the wave is 10m, find the frequency of the vibrator.

A. 30Hz

B. 270Hz

C. 300Hz

D. 3000Hz **A**

$$f = \frac{V}{\lambda} = \frac{1}{\lambda} \times V$$

$$\begin{aligned} &= \frac{1}{\lambda} \times \frac{d}{t} \\ &= \frac{1}{10} \times \frac{900}{3} \\ &= 30 \end{aligned}$$

6.

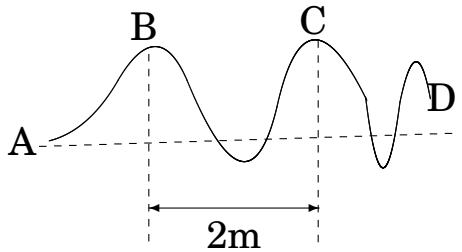


Fig.2

Fig. 2 shows a wave produced in a string. If the frequency is 2Hz, at what speed do the waves travel along the string?

A. 0.5ms^{-1}

B. 1.0ms^{-1}

C. 2.0ms^{-1}

D. 4.0ms^{-1} **D**

$$\begin{aligned} V &= f\lambda \\ &= 2 \times 2 \\ &= 4 \end{aligned}$$

7. The electromagnetic radiation which causes the body temperature to rise is called

A. X-rays.

B. gamma rays.

C. infrared

D. ultra violet **C**

8. A longitudinal wave is one in which the

A. direction of propagation is parallel to that of the vibration producing it.

B. particles of the medium through which it travels move opposite to the direction of propagation.

C. direction of propagation is perpendicular to that of the vibration producing it.

D. particles of the medium through which it travels move together with it.

A

9. Which of the following can be detected by an ordinary antenna?

A. Microwaves.

B. Infra-red rays.

C. Ultra violet rays.

D. Gamma rays **A**

10. A man standing in front of a tall wall makes a loud sound and hears the echo after $1\frac{1}{2}$ s. How far is he from the wall if the velocity of sound in air is 330ms^{-1}?

A. 110m

B. 247.5m

C. 440m

D. 990m. **B**

$$\begin{aligned} d &= \frac{Vt}{2} \\ &= \frac{330 \times 1.5}{2} \\ &= 247.5m \end{aligned}$$

11. Which of the following are longitudinal waves?

A. water waves

B. light waves

C. sound waves

D. radio waves **C**

12. In forced vibrations, resonance occurs when the forcing

A. frequency is equal to the natural wavelength.

B. velocity is equal to the natural velocity.

C. frequency is equal to the natural frequency.

D. frequency exceeds the natural frequency. **C**

13. The number of complete oscillations made per second is referred to as

A. periodic time

B. amplitude.

C. Wavelength.

D. frequency. **D**.

14. Points on a stationery wave which are permanently at rest are called

A. crests.

B. troughs.

C. nodes

D. anti-nodes. **C**

15. The velocity of sound in air, at constant pressure

A. increases with loudness.

B. decrease with loudness.

C. increases with temperature.

D. decrease with temperature.

D

16. Which one of the following radiations undergoes the largest diffraction when passed through a narrow aperture?

A. Radio waves

B. Gamma rays

C. Yellow light

D. Infra red rays. **A**

Radio waves because they have a very large wave length.

17. A source produces waves which travel a distance of 140cm in 0.08 s. If the distance between successive crests is 20cm, find the frequency of the source.

A. 0.875Hz

B. 8.750Hz

C. 87.500Hz

D. 8750Hz **C**

$$v = \frac{d}{t} = \frac{140cm}{0.08s}$$
$$v = \frac{1.4m}{0.08s} = 17.5ms^{-1}$$
$$\lambda = 20cm = \frac{20}{100}m = 0.2m$$
from $v = f\lambda$
$$f = \frac{v}{\lambda} = \frac{17.5ms^{-1}}{0.2m}$$
$$f = 87.5s^{-1} = 87.5Hz$$

18. A man sees the flash from a gun fired 1020m away and then later hears a bang. How long does the bang take to reach him? (Take the speed of sound as 340ms^{-1})

A. $\frac{1020}{340\times10}$ s
B. $\frac{340}{1020}$ s
C. $\frac{1020}{340}$ s
D. 340×1020 s **C**

$$\text{Time} = \frac{\text{Distance}}{\text{speed}} = \frac{1020}{340}$$

19. Which of the following shows the order in increasing wavelength of the members of the electromagnetic spectrum?

A. Ultra-violet, x-rays, radio waves, infra-red
B. radio waves, infra-red, x-rays, ultra-violet
C. x-rays, ultra-violet, infra-red, radio waves
D. Gamma rays, ultra-violet, radio waves, infra red **C**

20. .

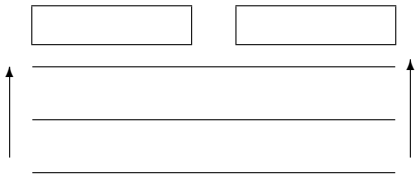


Fig. 6

The diagram in fig.6 shows parallel wavefronts approaching a narrow gap. waves passing through the gap are likely to undergo

A. reflection
B. refraction
C. diffraction
D. interference **C**

21. The effect produced when many echoes merge into one prolonged sound is known as

A. noise.
B. harmonics.
C. reverberation
D. pitch **C**

22. Fig. 3 shows waves spreading out from a point. The wavelength of the waves is

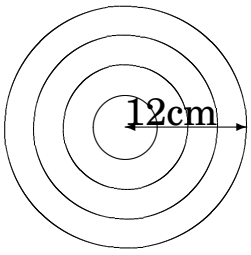


Fig. 3

A. 3cm

B. 6cm

C. 9cm

D. 12cm **A**

$$\begin{aligned}\lambda &= \frac{12}{4}\\ &= 3cm\end{aligned}$$

23. A man standing 85 m from a tall wall fires a gun and hears the echo from the wall after 0.5 s. Calculate the speed of sound in air.

A. 340 ms $^{-1}$

B. 170 ms^{-1}

C. 85 ms^{-1} **A**

D. 43 ms^{-1}

$$\begin{aligned}V &= \frac{2d}{t}\\ &= \frac{2\times 85}{0.5}\\ &= 340\end{aligned}$$

24.

Vibrator	Wave length	Frequency
Wave P	1,500 m	0.2 MHz
Wave Q	500m	.....

The table above shows readings obtained by using a vibrator which produces waves of a constant velocity. Find the frequency of the wave Q.

A. 0.07 MH$_Z$

B. 0.3 MH$_Z$

C. 0.6 MH$_Z$

D. 1.2 MH$_Z$ **C**

$$\begin{aligned}\text{velocity} &= f\lambda\\ f_1\lambda_1 &= f_2\lambda_2\\ 1500\times 0.2M &= 500\times f\\ f &= 0.2\times 3M\\ &= 0.6MHz\end{aligned}$$

25. Which of the following are transverse waves only?

A. Radio, sound, ultra-violet.

B. Ultra-violet, x-rays, water waves.

C. Infrared, gamma rays, sound wave.

D. Sound waves, ultra-violet, x-rays. **B**

26. A boy standing 150m from a vertical cliff claps his hands and hears an echo 0.85 seconds later. Find the speed of sound in air.

A. 128 ms^{-1}

B. 176 ms^{-1}

C. 255 ms^{-1}

D. 353 ms^{-1} **D**

$$\begin{aligned}V &= \frac{2d}{t}\\ &= 2\times\frac{150}{0.85}\\ &= 352.94ms^{-1}\approx 353ms^{-1}\end{aligned}$$

27. In a sound wave the particles of the medium

A. are stationary

B. move along with the wave.

C. vibrate in the same direction as the wave.

D. vibrate at right angles to the direction of the wave. **C**

28. Which of the following statements is true about the wave traveling from one medium to another?

(i) Its frequency and wavelength change.

(ii) Its frequency and velocity change.

(iii) Its velocity and wavelength change.

(iv) Only its frequency remains unchanged.

A. (i) only

B. (i) and (ii).

C. (i), (ii) and (iii).

D. (iii) and (iv). **D**

29. Which of the following statements are true about sound waves?

(i) They are longitudinal.

(ii) They are transverse.

(iii) They are produced by vibrations.

(iv) They can travel through empty space.

A. (ii) and (iv) only.

B. (i) and (iii) only.

C. (i), (iii) and (iii) only.

D. (ii), (iii) and (iv) only. **B**

30. Fig. 5 below shows circular waves incident on a plane reflector. Which of the following patterns represents the reflected wave?

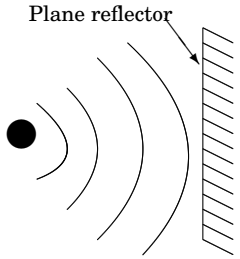
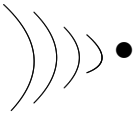


Fig. 5

A. 

B. 

C. 

D. 

A

31. Which of the following are not electromagnetic waves?

A. X-rays.

B. Radar waves.

C. Micro waves.

D. Sound waves. **D**

32. A vibrator produces waves which travel a distance of 12 m in 4s. If the frequency of the vibrator is 2Hz, what is the wavelength of the waves?

A. 1.5 m.

B. 3 m.

C. 6 m.

D. 24 m. **A**

$$\begin{aligned} V &= \frac{12m}{4s} \\ V &= 3m/s \\ \lambda &= \frac{V}{f} \\ &= \frac{3}{2} \\ &= 1.5 \end{aligned}$$

33. A girl stands in between two tall cliffs, and claps her hands. She bears the first echo after 1s and the second echo after 2s. If the speed of sound is 300 ms^{-1}, the distance between cliffs is

A. 300 m.

B. 450 m.

C. 900 m.

D. 1200 m **B**

$$\begin{aligned} \text{from } V &= \frac{2d}{t} \\ d_1 &= \frac{vt}{2} \\ &= \frac{300 \times 1}{2} \\ &= 150m \\ d_2 &= \frac{vt}{2} \\ &= \frac{300 \times 2}{2} \\ &= 300m \\ d &= d_1 + d_2 \\ &= 150 + 300 \\ &= 450 \end{aligned}$$

34. Which of the following statements is true?

A. Light waves, radio waves and sound waves will all travel through a vacuum.

B. Light waves and radio waves will travel through a vacuum.

C. Light waves and sound waves will travel through a vacuum, radio waves will not.

D. Sound waves and radio waves will travel through a vacuum, light waves will not

B

35. Sound waves

A. do not pass through a vacuum.

B. Travel through solids at lower speed than in air.

C. Do not travel through liquids

D. Travel at the highest speed in air **A**

Sound always travels faster in solids and can not travel in a vacuum.

36. Which one of the following does not change when water travel from deep to shallow water?

A. Frequency.

B. Amplitude.

C. Velocity.

D. Wavelength. **A**

Frequeny of a wave can only be changed by its source.

37. Sound travels much greater through

A. Steel.

B. Wood.

C. Water.

D. Nitrogen gas. **A**

38. Which of the following statements are true about refraction of waves?

(i) The speed of waves changes.

(ii) The wavelength changes.

(iii) The direction of travel changes.

(iv) The frequency changes.

A. (i) only.

B. (i) and (iii) only.

C.(i), (ii) and (iv) only.

D.(i), (ii) and (iii) only. **D**

39. An echo is produced as a result of sound waves being

A. absorbed by objects.

B. transmitted by objects.

C. deflected back by objects.

D. bent around corners by objects. **C**

40. Water waves are produced at frequency of 5Hz and the distance between 10 successive crests is 18cm. Calculate the velocity of the waves in ms^{-1}.

A. 9 ms^{-1}

B. 0.09 ms^{-1}

C. 0.1 ms^{-}

D. 1 ms^{-1} **B**

$$\begin{aligned} V &= f\lambda \\ \text{but } \lambda &= \frac{18}{10} \\ &= 1.8cm \\ &= \frac{1.8}{100}m = \frac{18}{1000} \\ V &= f\lambda \\ &= 5 \times \frac{18}{1000} \\ &= 0.09ms^{-1} \end{aligned}$$

41. The particles of the medium through which a longitudinal wave travels

A. vibrate parallel to the direction of the propagation of the wave.

B. vibrate perpendicular to the direction of the propagation of the wave.

C. move along with the wave.

D. move in the opposite direction to the wave. **A**

42. A girl standing 300m away from a high vertical wall makes a loud sound of frequency 60Hz. Calculate the wave length of the sound wave if the girl hears the echo after 2s.

A. 0.2m

B. 2.5m

C. 5 m

D. 10m **C**

$$\begin{aligned} V &= \frac{2d}{t} \\ &= \frac{2 \times 300}{2} \\ &= 300 \\ \text{from } V &= f\lambda \\ \lambda &= \frac{V}{f} \\ &= \frac{300}{60} \\ &= 5 \end{aligned}$$

Section B (Structured)

43. The end Q of a rope is tied to a pole while the end P is moved up and down as shown in fig. 9?

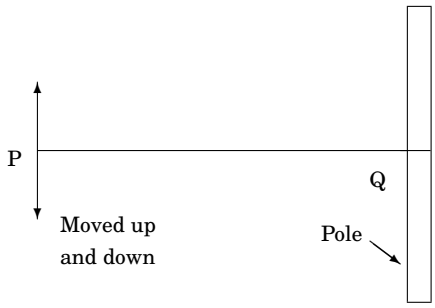
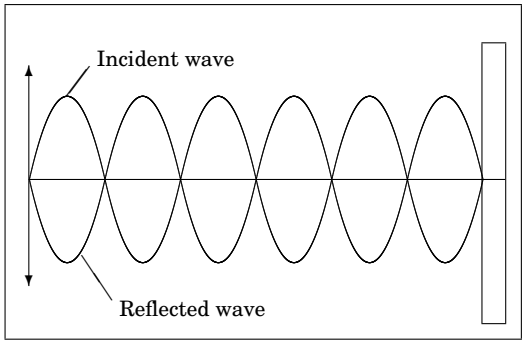


Fig.9

Sketch the resultant wave pattern between P and Q.



44. (i) Name the type of wave produced in (a) above.

(ii) Name one musical instrument which produces this type of wave.

(i)*Stationery wave or transverse wave*

(ii)*a violin or a quitar i.e. any stringed instrument*

45. What is meant by refraction?

Is the bending of waves or light when they move from one media to another.

46. .

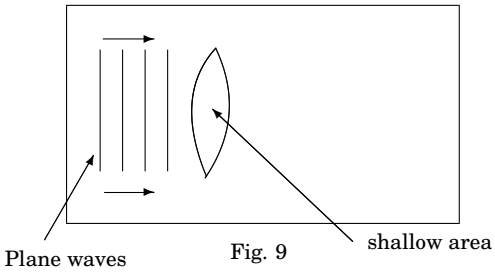
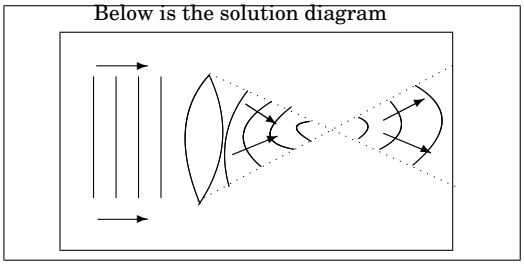


Fig. 9

Plane waves are generated at one end of a ripple tank. The waves travel towards the other end through a shallow region having the shape shown in fig. 9. Complete the diagram to show the wavefronts.

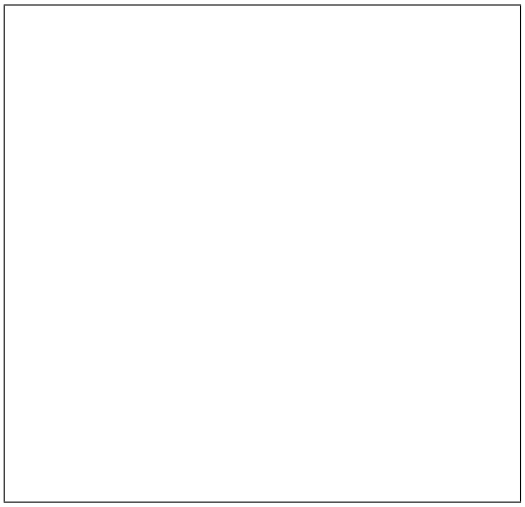
Below is the solution diagram



47. .

1. They travel at a speed of $3 \times 10^8 m/s$
2. They can travel in a vacuum i.e. they need no material media to propagate
3. They exhibit all wave properties i.e. they can be reflectd, refracted, diffracted, polarised and undergo interference.

A stick is dipped in water as shown in figure 10. Draw a ray diagram to show how the stick will appear to an observer at O.



48. State two properties of electromagnetic radiations.

49. The diagram in fig. 7 shows a section of a transverse wave of wave-length $4.0cm$.

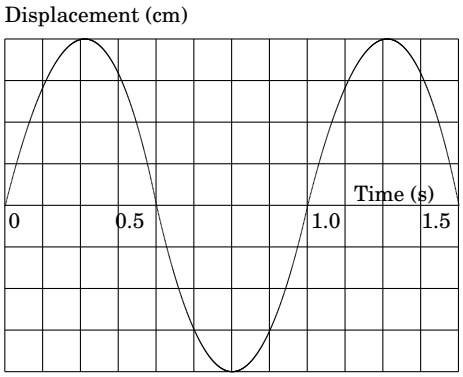


Fig. 7

Find its

(i) frequency

$$\begin{aligned} T &= 1 \text{ second} \\ f &= \frac{1}{T} = \frac{1}{1s} = 1s^{-1} \\ &= 1Hz \end{aligned}$$

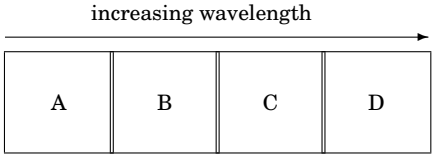
(ii) amplitude ?

it is 4cm

(iii) velocity

$$\begin{aligned} v &= f\lambda \\ &= 1Hz \times 4cm \\ &= 4cm/s \\ &= 0.04ms^{-1} \end{aligned}$$

50. The figure below shows part of the electromagnetic spectrum consisting of gamma rays radio waves, infrared and visible light.



Identify the bands to which these radiations belong.

A

B

C

D

A - *Gamma rays because it has the lowest wavelength or highest frequency*

B - *Visible light*

C - *Infra red*

D - *Radio wav*es

51. State one application of radiation above in

(i) Band A

(ii) Band B

(i) Band A - *to measure thickness of paper*

(ii) Band B - *to enables us to see near and far objects*

52. What is meant by a standing wave?

This is the resulting wave or the new wave formed when two similar waves moving in opposite directions interfere or travel together in the same media.

53 Fig. 11 below shows plane waves approaching a gap in a barrier.

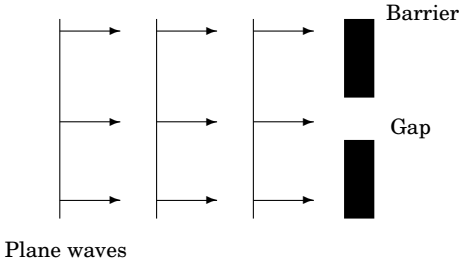


Fig. 11

(i) Show on the diagram , the appearance of the waves after the barrier.

(ii) What is the effect of reducing the size of the gap?

(i)

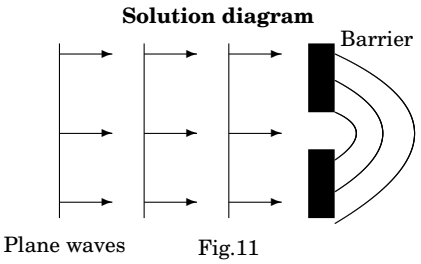


Fig.11

(ii)*The waves become more circular or get diffracted more*

54. The diagram in fig. 10 represents a wave traveling in water.

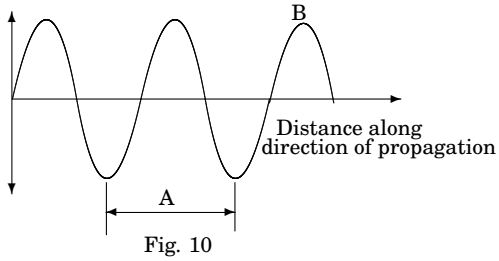


Fig. 10

(i) Name the part labeled B:

(ii) If the distance represented by A is 20cm and the speed of the waves is 8.0ms^{-1}, what is the frequency of the wave?

(i) *a crest*

(ii)

$$\begin{aligned} f &= \frac{v}{\lambda} \\ &= \frac{8ms^{-1}}{\frac{20}{100}m} = 40s^{-1} \\ &= 40Hz \end{aligned}$$

55. Describe how a straight wave is produced in a ripple tank.

By dipping plane sheet or material in the water in the ripple tank continuously.

56. State the conditions for the occurrence of destructive interference of waves.

1. *the waves must be out of phase or with a phase difference of 180°.*
2. *the waves must have equal wavelength and frequency*

57. Two identical loudspeakers A and B are placed near each other as shown in fig. 19. The speakers vibrate with same frequency.

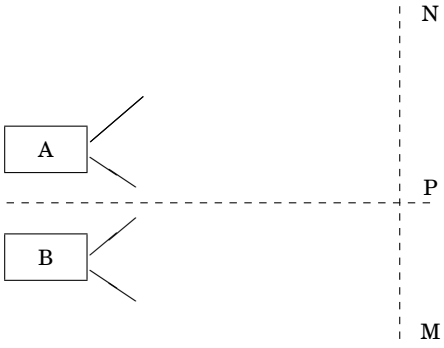


Fig. 10

Explain what will be observed on a sound detector moved from N to M

The loudness of sound (amplitude) increases and decreases regulatory due to interference of sound from the two speakers.

58. What is meant by the term reverberation?

Reverberation is the repetitive reflection of sound on surfaces.

59. State two factors which affect frequency of a vibrating string.

1. *tension in the string*
2. *length of the librating string or mass of the string*

60. A sound wave of frequency $440Hz$, has a velocity of $330ms^{-1}$. Calculate its wavelength.

$$\begin{aligned} \text{from } v &= f\lambda \\ \lambda &= \frac{v}{f} \\ &= \frac{330}{440} \\ &= 0.75m \end{aligned}$$

61. What is an echo?

An echo is reflected sound.

62. An echo sounder on a boat sends down a pulse through the water and receives its echo $0.9s$ later. If the velocity of sound in the water is $1450ms^{-1}$, calculate the water depth.

$$\begin{aligned} t &= \frac{2d}{v} \\ 2d &= tv \\ d &= \frac{tv}{2} \\ &= \frac{0.9 \times 1450}{2} \\ &= 652.5m \end{aligned}$$

63. State **one** practical application of echoes

in determining depth of sea

Paper II (Essay)

64. (a) Define the following terms as applied to waves.

(i) Amplitude

(ii)**frequency**

(b) (i) What is meant by interference of waves?

(ii)**Using a labeled diagram, show how circular water waves are reflected from a straight barrier.**

(c) (i) Use a labeled diagram to show the main bands of an electromagnetic spectrum.

(ii) **Calculate the frequency of a radio wave of wavelength** $2m$

Solution

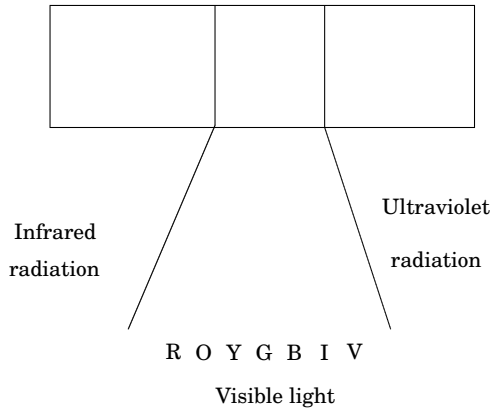
(a) (i) Amplitude is the maximum displacement of an oscillating particle from its rest or reference position.

(ii) Frequency is the number of cycles produced on oscillations made in 1 seconds.

(b) (i) Interference of waver is where two or more waves travel together in the same media simultaneously.

(ii)

(c) (i) The main bands of the electromagnetic spectrum are shown in the figure below;



(ii)

$$\begin{aligned} f &= \frac{c}{\lambda} \\ &= \frac{3 \times 10^8 m/s}{2} \\ f &= 1.5 \times 10^8 Hz \\ &= 150 MHz \end{aligned}$$

65. (a) Explain why the speed of sound is higher in solids than in air.

(b) **Two people X and Y stand in a line at distances of 330m and 660m respectively from a high wall. Find the time interval taken for X to hear the first and second sounds when Y makes a loud sound. (speed of sound in air = 330ms^{-1})**

(c) (i) What is meant by stationary waves?

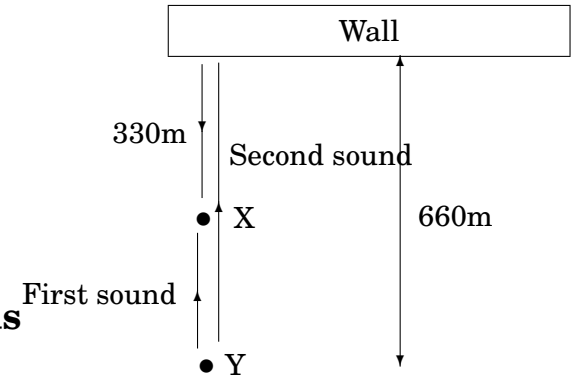
(ii) **Name one musical instrument which produces stationary waves.**

Solution

(a) The speed of sound is higher in solids than in air.

Since sound velocity depends on the density of the media through which it passes, then it will travel faster in solid that have a higher density than in air which has a lower density,

(b) Let us use this sketch below to show where the two echoes received by person X come from



the first echo is the direct sound heard from X.

If it takes time t_1, then;

$$\begin{aligned} t_1 &= \frac{\text{Distance moved}}{\text{Sound speed}} \\ t_1 &= \frac{660-330}{V} \\ &= \frac{330}{330} \\ &= 1 \text{ seconds} \end{aligned}$$

The second echo is the echo reflected from the wall, if it takes time, t_2, then

$$\begin{aligned} t_2 &= \frac{\text{Total distance travelled}}{\text{Sound speed}} \\ t_1 &= \frac{330\text{m to wall } + 660\text{m from wall}}{330} \\ &= \frac{990}{330} \\ &= 3 \text{ seconds} \end{aligned}$$

Hence the time interval taken for X to hear the first and the second sounds when Y makes a loud sound is;

$$\begin{aligned} t &= t_2 - t_1 \\ &= 3-1 \\ &= 2 \text{ seconds} \end{aligned}$$

c(i) a stationery wave is the resultant wave formed when two similar progressive waves are super imposed on one another (or interfere) when traveling in opposite directions in the same media.

c(ii) a guitar or violin

66. State any three effects of electromagnetic radiation on matter.

Solution

- they heat matter when they fall on it.
- They have a specific penetration depth in conductors.
- They cause ionisation in gasses

67. (a) State the conditions required for a stationary wave to be formed.

(b) **List the factor on which the frequency of a wave in a vibrating string depends.**

(c) **A child stands between two cliffs and makes a loud sound. If it hears the first echo after 1.5s and the second echo after 2.0s, find the distance between the two cliffs [speed of sound in air =** $320ms^{-1}$**]**

Solution

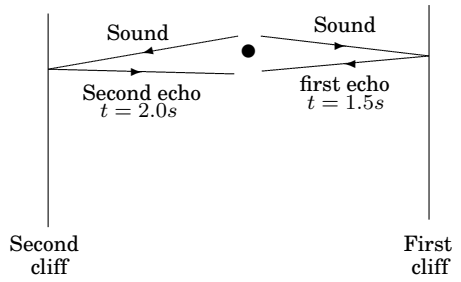
(a) For a stationary wave to be formed, the conditions are

- The waves must travel in opposite directions in the same media
- The waves must have the same wave-length and frequency

(b) frequency of a wave from a vibrating string depends on;

- Tension in it
- Length of the string that is vibrating
- The mass per unit length of the string

(c) from the question, we have
first echo heard after = 1.5s
second echo heard after = 2.0s
speed of sound in air = $320ms^{-1}$
Using the diagram below, we have;



$$\text{From speed } = \frac{2d}{t}$$

The distance of the first cliff from the child, d_1

$$\begin{aligned} d_1 &= \frac{\text{speed} \times \text{time}}{2} \\ &= \frac{320ms^{-1} \times 1.5s}{2} \\ &= 240m \end{aligned}$$

The distance of the second cliff from the child, d_2

$$\begin{aligned} d_2 &= \frac{\text{Speed} \times \text{time}}{2} \\ &= \frac{320ms^{-1} \times 2.0s}{2} \\ &= 320m \end{aligned}$$

hence the distance between the two cliffs is $(320+240)m$ which is 560 metres

68. (a) What is meant by sound?

(b) **Describe an experiment to show that sound waves requires a material medium for transmission.**

(c) **Explain briefly the following:**

(i) **a dog is more able than a human being to detect the presence of a thief tiptoeing at night.**

(ii) **an approaching train can easily be detected by human ears placed close to the rails.**

(d) **A sound of frequency 250Hz is produced 120m away from a high wall. Calculate the**

(i) **wave length,**

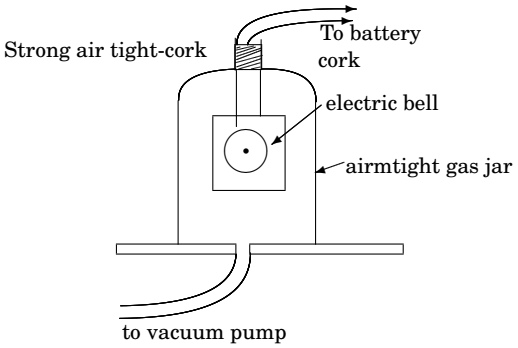
(ii) **time it takes the sound wave to travel to and from the wall. (Speed of sound air =** $330ms^{-2}$**)**

Solution

(a) Sound are the mechanical vibrations produced by any vibrating object in contact with air or any other media,

(b) an experiment to show that sound require a material media for transmission.

- Arrange the apparatus as shown below;



- When the electric bell is switched on, the sound can be heard.
- Switch on the vacuum pump connected to the gas jar, it sucks air out of the jar.
- When nearly all the air is removed, i.e. there is nearly a vacuum; the sound of the bell will not be heard. This confirms that sound requires a material medium for transmission.

(c) Let us explain the following;

(i) a dog's ears will detect a thief tip-toeing at night and not the human ear because it can detect sound with a higher frequency and sound of low intensity which the human ear can not detect.

(ii) an approaching train can easily be detected by human ears placed close to the rails because sound travels faster in solids (like the rails) compare to air (a gas)

(d) Sound of 250Hz is produced 120m away

(i) its wave length, λ is

$$\begin{aligned}\lambda &= \frac{V}{f} \\ &= \frac{330ms^{-1}}{250s^{-1}} \\ &= 1.32m\end{aligned}$$

Hence the wave length of sound is 1.32m

(ii)

$$\begin{aligned}\text{Time} &= \frac{2 \times d}{V} \\ &= \frac{2 \times 120}{330} \\ &= 0.7273 \text{ seconds}\end{aligned}$$

Hence sound takes 0.7273 seconds to travel to and from the wall.

69. (a) (i) Describe how the speed of waves in a ripple tank can be decreased.

(ii)**Explain the effect of decreasing the speed of the wave in (a) (i) on frequency.**

(b) **With the aid of sketch diagrams, explain the effect of size of a gap on diffraction of waves.**

(c) (i) Give two reasons why sound is louder at night than during the day.

(ii) **An echo-sounding equipment on a ship receives sound pulses reflected from the sea bed 0.02s after they were sent out from it. If the speed of sound in water is $1500ms^{-1}$, calculate the depth of water under the ship.**

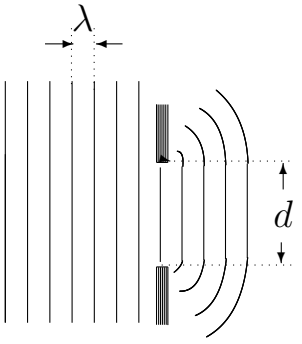
(d) **Identify two differences between water and sound waves.**

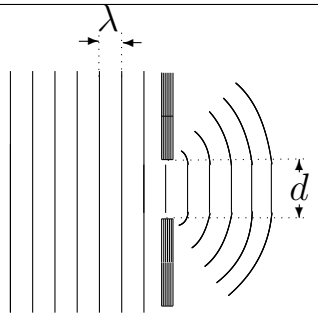
Solution

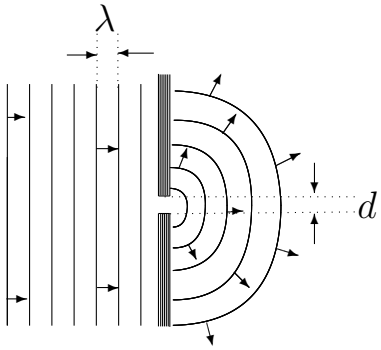
(a) (i) the speed of waves in a ripple tank can be decreased by reducing the depth of water in the ripple tank.

(ii) the effect of decreasing the speed of waves in a(i) above is that; the wave length of the water waves reduces, but frequency does not change. Frequency can only be changed by the source of the wave.

(b) the smaller the gap or size of the slit, the greater the degree of diffraction. This is shown in the diagrams below;

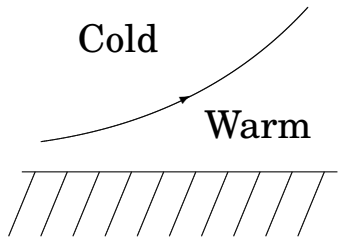




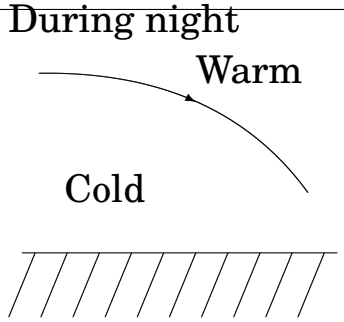


(c) (i) During the day, air near the ground is very hot and hence less dense, and that above it is warm (more dense) so sound produced on the ground is refracted upwards or towards the more dense meduim.

During day



But at night the ground is cold and the air above it is warm, hence sound produced is refracted towards the ground and hence it is louder.



(ii)Speed of sound, V

$$\begin{aligned} V &= \frac{\text{total distance moved}}{\text{time taken}} \\ V &= \frac{2 \times d}{t} \\ \Longrightarrow d &= \frac{Vt}{2} \\ &= \frac{1500 \times 0.02}{2} \\ &= 15 \text{ metres} \end{aligned}$$

(d) differences between water and sound waves

- Water waves traveled only on the surface of water and sound waves travel through the interior of any media
- Sound waves can be heard by the human ear and water waves can not be detected by the human ear.
- Water waves are transverse waves while sound waves are longitudinal waves.

70. (a) With aid of a diagram explain the terms amplitude and wavelength as applied to wave motion.

(b) (i) Derive an equation relating velocity V, frequency f, and wavelength, λ of a wave.

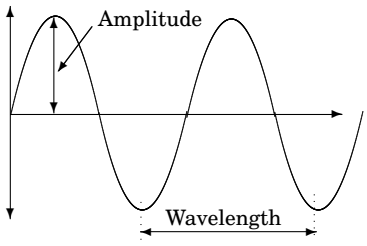
(ii) A radio wave is transmitted at a frequency of 150MHz Calculate its wavelength.

(c) (i) List four properties of electromagnetic waves.

(ii) **A long open tube is partially immersed in water and tuning fork of frequency 425Hz is sounde and held above it. The tube is gradually raised, find the length of the air column when resonance first occurs. [Neglect the end correction, Speed of sound in air = 340ms^{-1}]**

Solution

(a) Consider the wave below



Amplitude is the maximum displacement of a particle from its rest position when a wave passes through a media while wavelength is the minimum distance between 2 particles

in-phase in a media through which the wave is passing.

(b) (i) deriving an equation to relate velocity V, wave length λ and frequency f, of a wave
from

$$\text{Speed} = \frac{\text{distance moved}}{\text{time taken}}$$

if we consider a distance equal to one wavelength, this is covered in time equal to the period T of a wave

$$\begin{aligned} V &= \frac{\lambda}{T} \\ \text{But T} &= \frac{1}{f} \\ V &= \lambda \div T \\ &= \lambda \div \frac{1}{f} \\ &= \lambda \times \frac{f}{1} \\ &= f\lambda \\ \text{Hence } V &= f\lambda \end{aligned}$$

(ii) a radio wave is an electromagnetic wave, so it travels at a speed of $V = 3.0 \times 10^8 ms^{-1}$

$$\begin{aligned} \text{given } f &= 150MHz \\ &= 150 \times 1000000Hz \\ &= 150000000Hz \\ &= 1.5 \times 10^8 Hz \end{aligned}$$

$$\text{from } V = f\lambda$$

$$\begin{aligned} \Longrightarrow \lambda &= \frac{V}{f} \\ &= \frac{3.0 \times 10^8 ms^{-1}}{1.5 \times 10^8} \\ &= 2.0 \text{ metres} \end{aligned}$$

hence its wave length is 2.0 metres

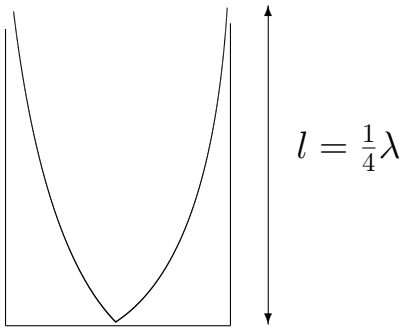
(c) (i) properties of electro-magnetic wave

- they travel at a speed of $3.0 \times 10^8 ms^{-1}$
- they need no material media to travel i.e. they can travel even in a vacuum.
- They exhibit all properties of waves i.e reflection, refraction, interference, diffraction and polarisation
- They are transverse waves

(ii)

$$\begin{aligned} f &= 425Hz \\ V &= 340ms^{-1} \end{aligned}$$

Consider the diagram below for the first position of resonance.



length of the first resonance position is $\frac{1}{4}\lambda$ but from $V =$

$f\lambda$

$$\begin{aligned}\lambda &= \frac{V}{f}\\ &= \frac{340ms^{-1}}{425s^{-1}}\\ &= 0.8 \text{ metres}\end{aligned}$$

first resonance position is l

$$\begin{aligned}l &= \frac{1}{4}\lambda\\ &= \frac{1}{4}\times 0.8m\\ &= 0.2m\\ &= 0.2\times 100cm\\ &= 20cm\end{aligned}$$

71.

(a) Name the electromagnetic radiation which

(i) **causes sensation of heat.**

(ii) **passes through a thin sheet of lead.**

(iii) **is used in satellite communication.**

(iv) **is used for remote control of a television receiver.**

Solution

(i) Infra-red radiations cause sensation of heat.

(ii) gamma-rays pass through a thin sheet of lead.

(iii) micro-waves are used in satellite communication

(iv) Ultra sound or x-rays are used in the remote control of a television receiver

72. (a) State three differences between sound and light waves.

(b) (i) Explain how stationery waves are formed.

(ii) **State three main characteristics of stationery waves.**

(c) (i) Define the terms frequency and wavelength as applied to sound.

(ii) **Describe an experiment to demonstrate resonance in sound.**

(d) **The velocity and frequency of sound in air at a certain time were** $320ms^{-1}$ **and 200Hz respectively. At a later time, the air temperature changed and the velocity of sound in air was found to be** $340ms^{-1}$**. Determine the change in wavelength of the sound.**

Solution

(a) differences between sound and light waves.

- Sound is a mechanical wave while Light is an electromagnetic wave
- Sound requires a material media to travel while Light

requires no material media for transmission i.e. can travel in a vacuum

- Sound can not be polarised because it is a longitudinal wave while Light can be polarised because it is a transverse wave.

(b) (i) Stationery waves are formed when two similar waves are made to travel in the same media in opposite directions. It is made up of nodes (of zero displacement) where the waves interfere destructively and antinodes where waves interfere constructively.

(ii) characteristics of stationery waves

- They appear not to move or appear to be stationery
- Their wavelength is half that of the interfering waves
- They always have a greater amplitude at some points due to constructive interference and a zero amplitude at points where there is destructive interference.

(c) (i) frequency is the number of cycles produced per second. Wave length is the minimum distance though which a wave repeats itself.

Or

Wavelength is the shortest distance between two particles in the media where the wave is passing, that are **in-phase**.

(ii) An experiment to demonstrate resonance in sound, using a closed tube

- Get a closed tube and a tuning fork
- With the open end of the tube facing upwards pluck the tuning fork and more it up and down along the axis of the tube.
- At a certain height, the tube will be heard producing some sound, hence the tube has been made to vibrate by the standing wave formed by the sound wave from the fork and echo in the tube. The tube is made to vibrate by another system, the tuning fork, and that is what we call resonance.

(d) Initial wave-length λ_1

$$\begin{aligned}\lambda_1 &= \frac{V_1}{f} \\ &= \frac{320ms^{-1}}{200Hz} \\ &= 1.6 \text{ metres}\end{aligned}$$

New wavelength, λ_2

$$\begin{aligned}\lambda_2 &= \frac{V_2}{f} \\ &= \frac{340ms^{-1}}{200Hz} \\ &= 1.7 \text{ metres}\end{aligned}$$

the change in the wave-length of the sound is 1.7 - 1.6 or 0.1 metres or 10 cm. i.e wave-length of sound increased.

73. (a) What is an echo?

(b) (i) Describe an experiment to measure the speed of sound in air.

(ii) **State any two likely sources of error in the experiment.**

(c) **Describe an experiment to determine how the frequency of a vibrating string depends on the length of the string.**

Solution

(a) An echo is reflected sound

(b) (i) An experiment to measure speed of sound in air
To measure velocity of sound in air let us use the echo method.
One needs a place with a clear space extending beyond 100m, from a high vertical wall. Here we determine the time taken by sound to travel to the wall and back to you.

- Clap your hand and wait for the echo which you will receive.
- Repeat this clap and measure the time t between clapping and receiving the echo using a watch or millisecond timer
- If the distance between you and the wall is, d, then velocity, V, of sound is

$$\begin{aligned}V &= \frac{2 \times d}{t} \\ &= \frac{2d}{t}\end{aligned}$$

The distance d can be measured using a tape measure.

(ii) Sources of errors in this experiment may be;

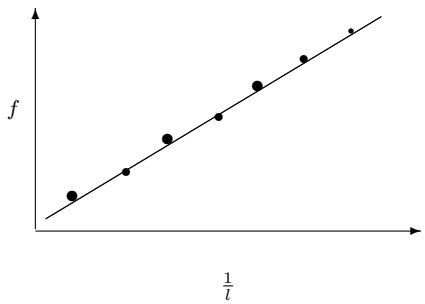
- wind, since it affects the speed of sound in air
- temperature or temperature changes of the surrounding air
- timing errors, i.e. one may not time well the time of sending and receiving the echo.

(c) An experiment to determine how the frequency of a vibrating string depends on the length of the string

- Here several different tuning forks, and a sonometer fitted with a steel piano wire are required.
- Adjust the tension in the wire so that its length is as long as possible when in unison with the lowest frequency tuning fork. This will ensure that the length corresponding to the remaining forks will be shorter than this.
- Keeping the tension constant, now tune the wire to each of the other forks in turn by altering the effective length of the vibrating wire by moving the wooden piece holding one end of the vibrating string.
- Corresponding values of frequency f and length l are recorded in the table as shown below.

Frequency f (in Hz)	Length l(in cm)	$\frac{1}{l}$	fl

- Plotting a graph of f against $\frac{1}{l}$, you will get a straight line.



This shows that frequency of sound produced by a vibrating string is inversely proportional to its length.

74. (a) List three differences between sound waves and radio waves.

(b) **Fig. 2 shows waves propagating towards a concave reflector.**

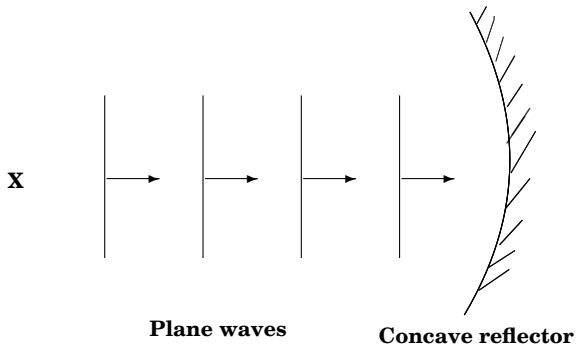


Fig. 2

(i) **Draw a diagram to show how the waves will be reflected.**

(ii) **If the velocity of the waves is 320ms^{-1} and the distance between two successive crests is 10cm, find the period of the waves.**

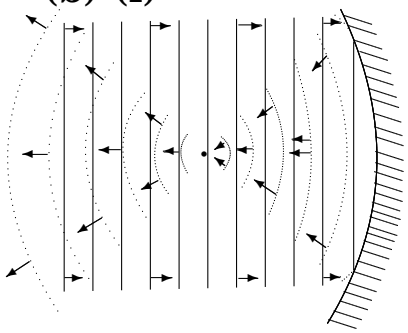
Solution

(a) Differences

- Sound waves can not be polarized and radio waves can be polarized

- sound waves are mechanical waves while radio waves are electromagnetic waves
- sound waves require a material media for transmission while radio waves require no material media for transmission

(b) (i)



Dotted lines are reflected waves
Full lines are the incident waves

(ii) from the question

$$\begin{aligned} V &= 320m/s \\ \lambda &= 10cm \\ &= \frac{10}{100}m \\ T &= ? \end{aligned}$$

from

$$\begin{aligned} V &= f\lambda \\ \Rightarrow f &= \frac{V}{\lambda} \\ &= \frac{320}{\left(\frac{10}{100}\right)} \\ &= \frac{320}{\left(\frac{1}{10}\right)} \\ &= 320 \times 10 \\ f &= 3200Hz \end{aligned}$$

period, T

$$\begin{aligned} T &= \frac{1}{f} \\ &= \frac{1}{3200} \\ &= 0.0003125s \\ T &= 3.125 \times 10^{-4}s \end{aligned}$$

75. (a) Two identical sources are made to produce circular waves in a ripple tank. With the aid of a diagram explain how interference fringes may be obtained.

(b)**State two similarities between water waves and electromagnetic waves**

(c)**Describe a simple method of detecting ultraviolet radiations.**

(d)**A radio station broadcast on 49metre band.**

(i) **what is meant by the above statement**

(ii)**calculate the frequency of the broadcast**

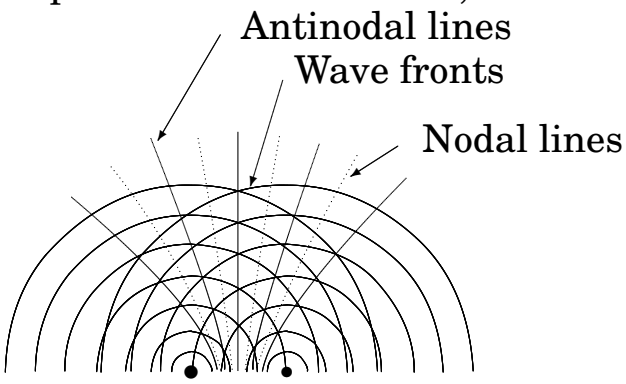
(iii) **Explain how radio waves are transmitted**

Solution

(a) The waves from the two sources interfere;

- Constructively at points called antinodes and
- destructively at points called nodes

the pattern is shown below;



(b) Similarities between water waves and electromagnetic waves;

- Both are transverse waves
- Both can be polarised

(c) How to detect ultraviolet radiations; We can use zinc sulphide to detect ultraviolet radiations because when it is exposed to ultraviolet radiations it glows with certain colours (Green).

(d) (i) It means that the radiowaves used by that radio station have a wavelength of 49m

(ii) Using the wave equation $V = f\lambda$

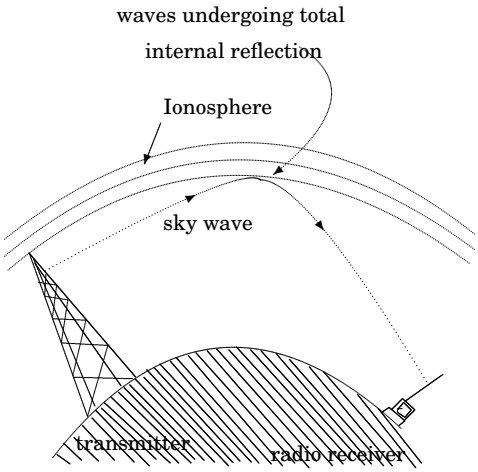
$$\begin{aligned} V &= f\lambda \\ f &= \frac{V}{\lambda} \\ &= \frac{3.0 \times 10^8}{49} \\ &= 6122448.98 \\ &= 6.122 \times 10^6 Hz \\ &= 6.122 MHz \end{aligned}$$

(iii) How radio waves are transmitted

They are produced by the transmitter up into the sky

They meet the ionosphere where that are totally internally reflected back to the earth

Then the reflected waves can be detected by the receivers (the radios, Televisions, Mobile phone antenas, e.t.c.)



Chapter 2

Light

Contents

2.1 Introduction

Section A (Objectives)

1. An Object 6 cm high is placed 24 cm from a tiny hole in a pinhole camera. If the distance from the hole to the screen is 8 cm. find the size of the image on the screen

A. 0.2cm

B. 2.0cm

C. 18.0cm

D. 32.0cm **B**

$$\begin{aligned} \frac{h_i}{h_\circ} &= \frac{V}{U} \\ h_i &= \frac{V}{U} \times h_\circ \\ &= \frac{8cm}{24cm} \times 6cm \\ &= 2cm \end{aligned}$$

2. When does the eclipse of the moon occur?

A. When the moon is between the sun and the earth

B. When the Earth is between the sun and the moon

C. When the sun is totally eclipsed by the moon

D. When a bright ring of sunlight shows round the edge of the moon. **B**

3. When a pin hole camera is moved nearer an object, the size of the image

A. remains the same.

B. becomes smaller.

C. becomes larger

D. becomes diminished. **C**

4. A man 1.75m tall stands at a distance of 7.0 m from the pinhole of pinhole camera. If the film is 0.20m behind the pinhole, find

the length of the image of the man formed on the film.

A. 8.75m

B. 4.00m

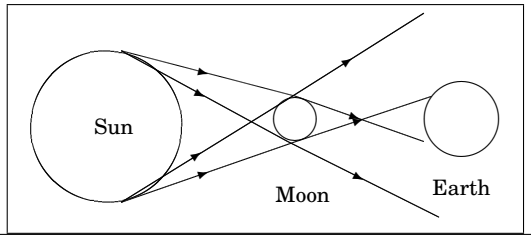
C. 0.80

D. 0.05m **D**

$$\begin{aligned}\frac{h_i}{h_o} &= \frac{V}{u}\\ h_i &= \frac{V}{u} \times h_o\\ &= \frac{0.2}{7} \times 1.75\\ &= 0.05m.\end{aligned}$$

Section B (Structured)

5. Sketch a diagram to show the formation of a solar eclipse.



Paper II (Essay)

6. (a) Describe an experiment to show that light travels in a straight line.

(b) **An object of height 4cm is placed 5cm away from a pinhole camera. The screen is 7cm from the pinhole.**

(i) **Draw to scale a ray diagram to show the formation of the image by the pinhole camera.**

(ii) **What is the nature of the image?**

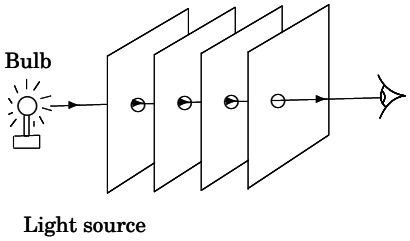
(iii) **Find the magnification.**

(iv) **Explain what happens to the image if the pinhole is made larger.**

Solution

(a) An experiment to show that light travels in a straight line; The following steps are taken;

- Drill holes in about four similar cardboards
- Arrange them as shown below;



- Place a candle at one end of the cardboards so that, one at the other end can see the light from the candle.
- When one of the cardboards is pulled out of the array or line then one can not see the light from the candle.

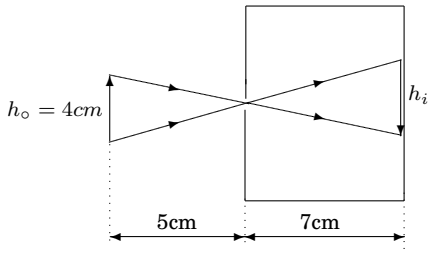
This shows that light travels in a straight line.

(b) (i) Diagram in figure 2.1 shows the formation of the image by the pin hole camera.

(ii) nature of the images formed by the pin hole camera

- They are inverted or upsidedown
- They are real
- They are laterally inverted
- They have an infinite depth of focus i.e. all parts of the image are equally sharp.

(iii)



Since the triangles formed by the two rays are similar, then

$$\begin{aligned} \frac{h_i}{V} &= \frac{h_\circ}{U} \\ \frac{h_i}{h_\circ} &= \frac{V}{U} \end{aligned}$$

since magnification

$$\begin{aligned} M &= \frac{h_i}{h_\circ} \\ &= \frac{V}{U} \\ &= \frac{7cm}{5cm} \\ &= 1.4 \end{aligned}$$

hence the magnification is 1.4

OR

from the accurate graphical construction, the height of the image is 5.6cm, hence magnification, M is

$$\begin{aligned} M &= \frac{\text{Image's height}}{\text{object's height}} \\ &= \frac{5.6}{4} \\ &= 1.4 \end{aligned}$$

(iv) when the pin hole is made larger, the image becomes blurred i.e. whitish not clear or less sharp.

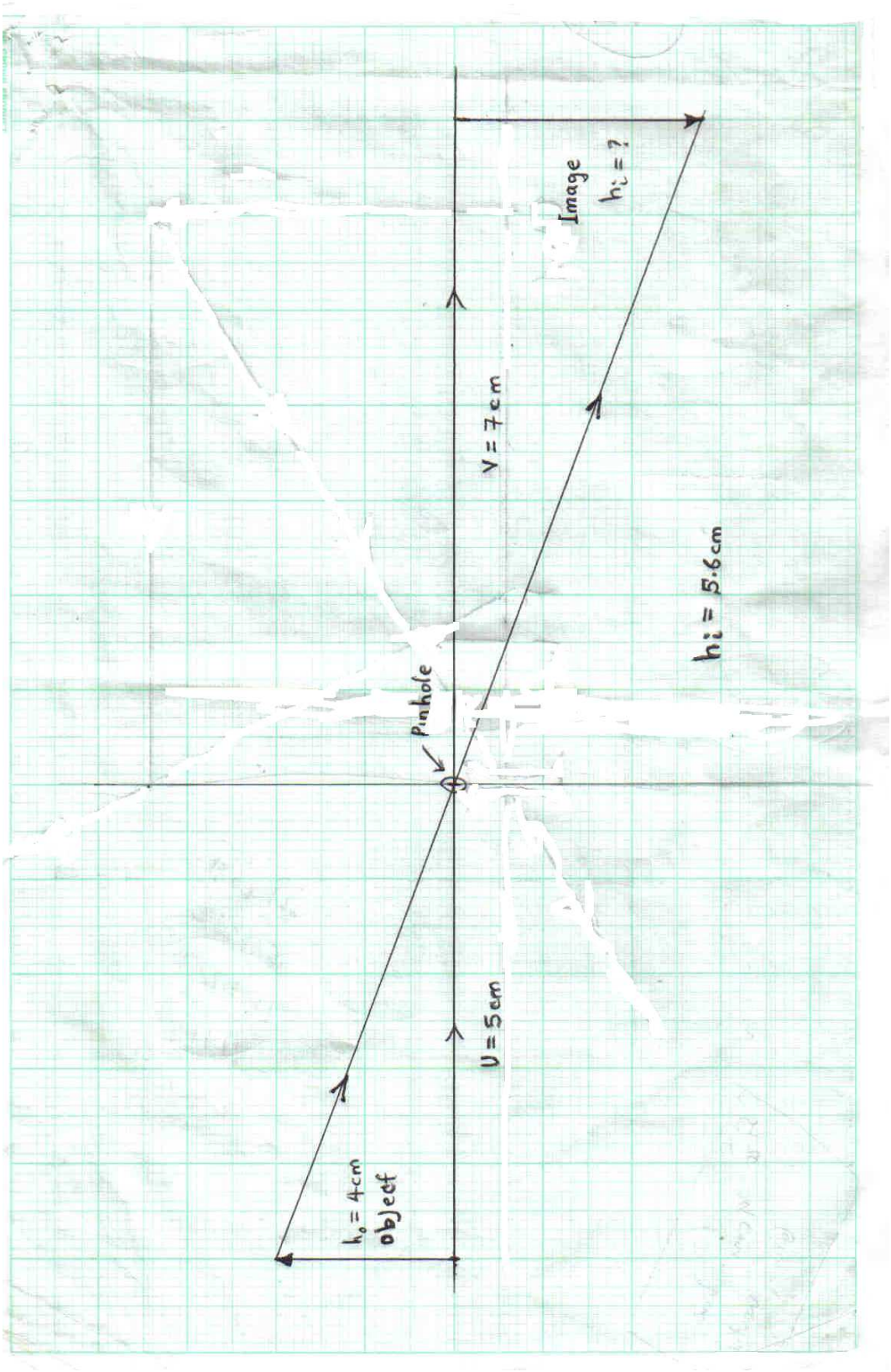


Figure 2.1: Scaled ray diagram: Pin hole camera

2.2 Reflection

Section A (Objectives)

1. A concave mirror can be used as a shaving mirror because when an object is placed between the focus and the pole, the image formed is

   A. magnified, virtual and erect.

   B. magnified, real and inverted.

   C. diminished, real and inverted.

   D. diminished, virtual and erect.

   A

2. Light energy is reflected when,

   A. angle of incidence is greater than angle of reflection.

   B. angle of incidence is equal to angle of refraction.

   C. angle of incidence is equal to angle of reflection.

   D. the normal at the point of incidence makes the same angle as the incident ray. **C**

3. An object is placed 30cm in front of a plane mirror. If the mirror is moved a distance of 6cm towards the object, find the distance between the object and its image.

   A. 24cm

   B. 36cm

   C. 48cm

   D. 60cm **C**

$$30 - 6 = 24$$
$$2 \times 24 = 48$$

4. An object is placed 6cm from a plane mirror. If the object is moved further by 2cm, find the distance between the object and its image.

   A. 16cm.

   B. 12cm.

   C. 8cm.

   D. 6cm. **A**

5. Which of the following information is true about concave and convex mirrors?

	Concave mirror	Convex mirror
A.	Converges light	Diverges light
B.	Diverges light	Converges light
C.	Refracts light	Reflects light
D.	Has a wide field of view.	Has a narrow field of view.

B

6. The focal length of a concave mirror is the

   A. distance between the pole of the mirror and the focal point.

   B. distance between the centre of curvature and the mirror.

   C. distance between the object and the image.

   D. diameter of the mirror. **A**

7.

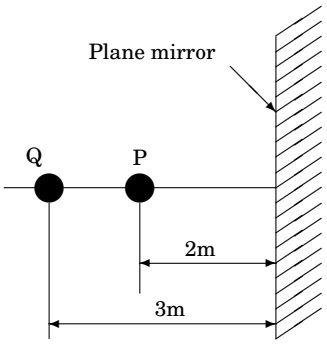


Fig. 7

Objects P and Q are placed at distances of 2 m and 3 m respectively from a plane mirror as shown in fig. 7. Find how far the image of P is from Q.

A. 1m.

B. 4m

C. 5m

D. 7m **C**

8. In a pin-hole camera, sharper and taller images are obtained by

A. widening the hole and moving the object farther.

B. narrowing the hole and moving the object nearer.

C. using a longer camera with a wider hole.

D. using shorter camera with a narrower hole **B**

9.

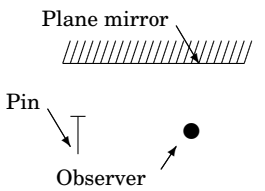


Fig. 4

A person observes the image of a pin placed in front of a plane mirror as shown in fig. 4 above. The reflected beam from the pin reaching the observer is a

A. virtual beam

B. divergent beam

C. parallel beam.

D. convergent beam **B**

10. A point object is 10cm in front of a plane mirror. When the object is moved 4cm towards the mirror, what is the distance between the object and the image?

A. 6cm

B. 8cm

C. 10cm

D. 12cm

New object distance from the mirror is $10 - 4 = 6$cm. distance between image and object is $6 \times 2 = 12$cm $(10 - 4) \times 2 = 12$ **D**

Section B (Structured)

11. Draw a ray diagram to show the formation of an image of the object O placed infront of a convex mirror shown in fig. 8. F is the principal focus of the mirror.

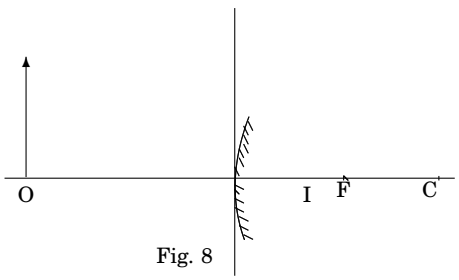
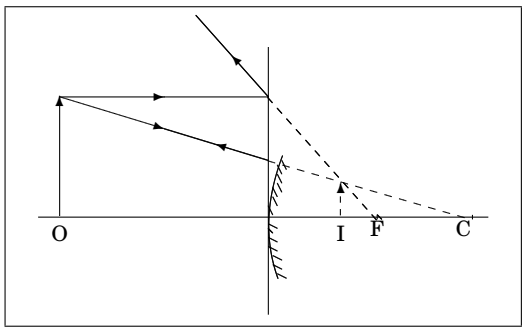


Fig. 8



12. State one application of a convex mirror.

In telescopes to observe distant objects and in super markets to supervise customers picking the goods they are to buy

13. Define the term lateral inversion as applied to mirrors

This is a property where the left of the image in the mirror is the right of the object and the images's right is the object's left.

14. State **two** properties of an image formed in a concave mirror when the object is placed between the focal point and the mirror.

- it is virtual
- it is magnified

Paper II (Essay)

15. (a) Explain the term virtual image as applied to optics.

(b) With aid of a ray diagram, explain why a convex mirror is used as a driving mirror.

(c) An object is placed $15.0cm$ **in front of a concave mirror. An upright image with magnification of four is produced. By graphical method, determine the:**

(i) nature of the image.

(ii) **focal length of the mirror.**

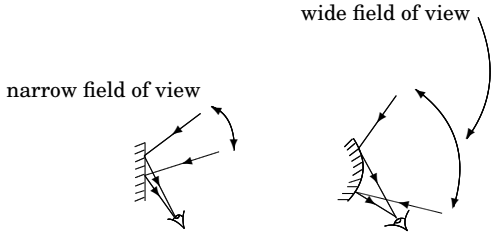
(iii) **distance of the image from the mirror.**

(d) **Name two applications of a concave mirror.**

Solution

(a) Virtual image is an image which cannot be formed on a screen.

(b)Because it has a high field of view.



(c)

$$\text{Magnification} = \frac{v}{u}$$
$$4 = \frac{v}{15}$$
$$v = 60cm$$

from the diagram in figure 2.3, it is;

(i)
- Upright
- Virtual
- Magnified

- Formed behind the mirror

(ii) From the ray diagram, $f = 12$cm.

(iii) Distance of the image from the mirror; v

$$\begin{aligned} v &= u \times M \\ v &= 15 \times 4 \\ v &= 60cm \end{aligned}$$

(d)
- Used by dentists to examine the patient's teeth
- Used in telescope to collect enough light ways for analysis
- Used in projectors to prevent loss of lights rays

16. (a) Describe an experiment to demonstrate the laws of reflection of light.

(b) **With the aid of a diagram illustrate how the shadows are formed when an opaque object is placed between an extended source of light, and a screen.**

(c) **An object 10cm high is placed at a distance of 25cm from a convex mirror of focal length 10cm.**

(i) **Draw a ray diagram to locate the position of the image.**

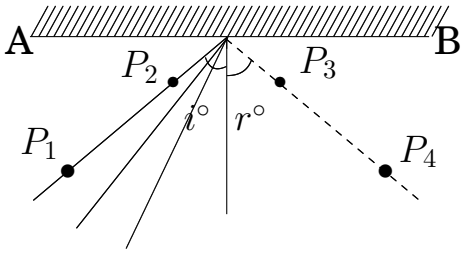
(ii) **Calculate the magnification**

(d) **Give reasons for use of convex mirrors in vehicles**

Solution

(a) An experiment to verify the laws of reflection of light

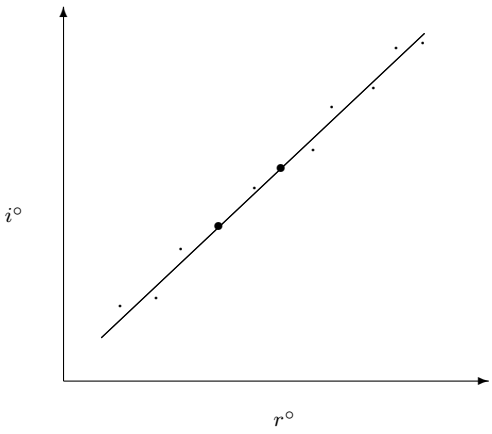
- get a white sheet of paper and pin it on the soft board.
- Draw a line AB (as mirror line) and lines at angles of 10, 20, 30, 40, 50, 60, 70 degrees as shown below.
- Pin two pins P_1 and P_2 on the line of angle 70° on one side of the paper and the mirror positioned on line AB as shown below;



- Observe the images of the pins P_1 and P_2 in the mirror and pin other pins P_3 and P_4 so that they are in line with the images of P_1 and P_2.
- Measure the angle of reflection, r
- Repeat the above procedures for the other lines and tabulate your results as shown below;

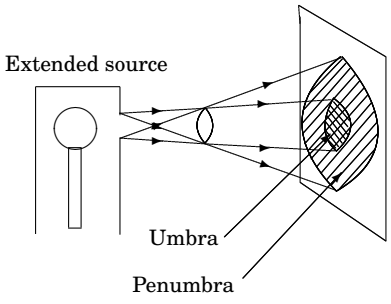
i°	r°
10	
20	
30	
40	
50	
60	
70	

- Plot a graph of i° against r°, you will get



A straight line with a gradient of unity. This shows that the angle of incidence, i°, is always equal to the angle of refraction, r° and that is the law of reflection.

(b)

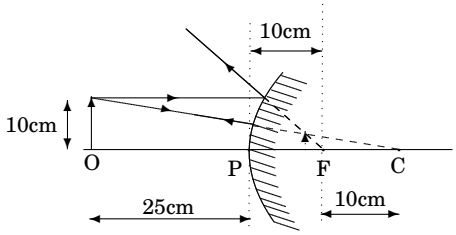


parts on the screen where no light from the sources reaches form the umbra (dark part of the shadow) and those that receive some light form the penumbra (the lighter part of the shadow).

(c) (i) from question

$$\begin{aligned} h_o &= 10cm \\ U &= 25cm \\ f &= 10cm \end{aligned}$$

The sketch is



the accurate ray diagram is shown in figure 2.2

(ii) from graph in figure 2.2

$$h_i = 3.4cm$$

hence

$$\begin{aligned} \text{magnification} &= \frac{h_i}{h_o} \\ &= \frac{3.4cm}{10cm} \\ &= 0.34 \end{aligned}$$

(d) Convex minors are used because they have a wider field of view.

17. (a) With the aid of diagrams, distinguish between diffuse and regular reflection.

(b)

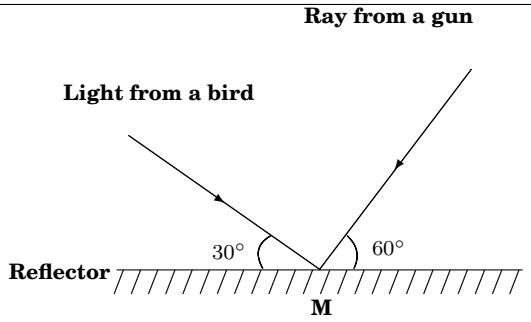


Fig. 2

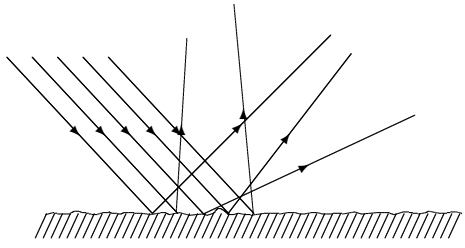
A ray from a bird makes an angle of 30° with a plane reflector and a ray from the barrel of the gun makes an angle of 60° to the same reflector at the same point. M as shown in fig. 2. Find the angle through which the reflector must be rotated about M such that the ray from the barrel of the gun falls on the bird.

(c) **With the aid of a diagram explain why a parabolic mirror is most suitable for use in car headlights.**

(d) **List three uses of a concave mirror.**

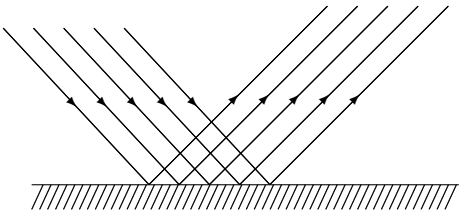
Solution

(a) Diffuse reflection is a type of reflection of light which occurs on the surface of a rough surface



Diffuse reflection

i.e. a parallel beam is reflected in all directions and regular reflection is when a wave (or light) is reflected on a smooth surface. Always a parallel beam is reflected as a parallel beam.



Regular reflection

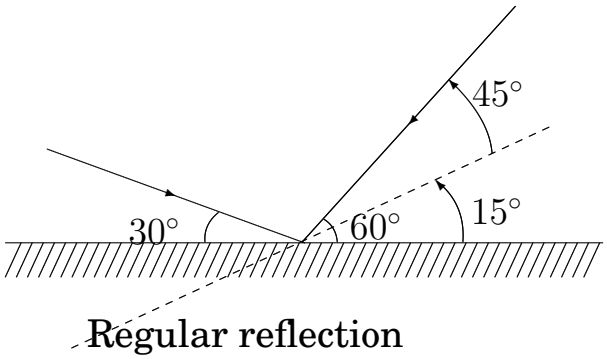
(b) for the ray from the barrel of the gun to fall on the bird, the sum of the angle of incident and angle of reflection should be equal to

$$180 - 60 - 30 = 90^\circ$$

but from the law of reflection.

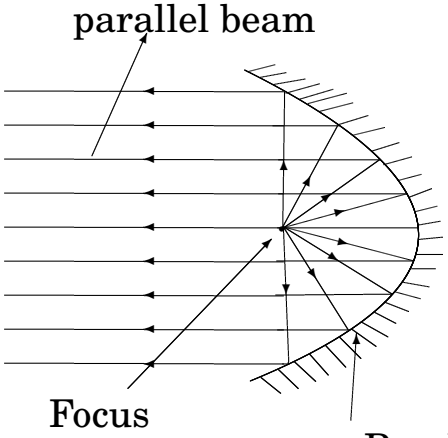
$$\begin{aligned} \textbf{Angle of incidence} &= \textbf{Angle of reflection} \\ i &= r \\ \text{But } i + r &= 90 \\ 2i = 2r &= 90 \\ i = r &= 45^\circ \end{aligned}$$

For this to be the case, the glancing angle of the ray from the gun should also be 45° this mean we must rotate the minor through 15° $(60^\circ - 45^\circ)$.



Regular reflection

(c) For a parabolic mirror, the a caustic surface can not be formed because all the rays are focused exactly to the focus or when a light source is placed at the focus, a parallel beam is produced.



Parabolic reflector

(d) Concave mirrors are used in

- Car head lamps and in search light to produce parallel beams of light
- In a projector to collect light that would be lost.
- In telescopes to collect enough light that can be ised to view astronomical bodies.

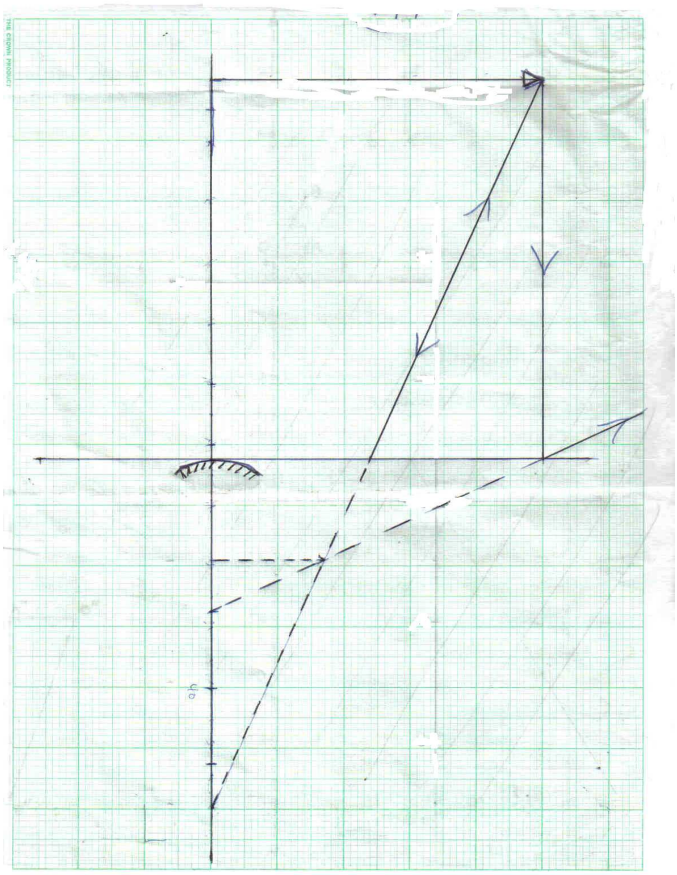


Figure 2.2: Scaled ray diagram: curved mirrors

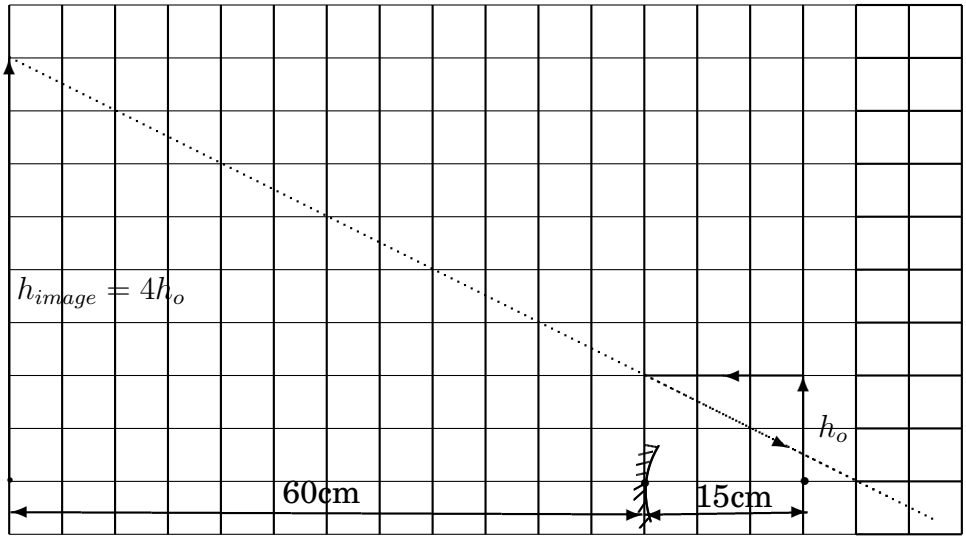


Figure 2.3: Scaled ray diagram: curved mirrors

2.3 Refraction

Section A (Objectives)

1. A pin is placed in front of a convex lens at a distance less than the focal length of the lens. What type of image is formed?

   A. Real, inverted, diminished.

   B. Virtual, erect, magnified.

   C. Real, erect, diminished. **B**

   D. Virtual, inverted, magnified.

2. A stick with one end immersed in a liquid appears bent at the liquid surface due to

   A. diffusion.

   B. reflection.

   C. interference.

   D. refraction. **D**

3. An object 2cm tall is placed 5cm infront of a convex lens. A real image is produced 20cm from the lens. Calculate the magnification of the lens.

   A. 4

   B. 2

   C. 0.5

   D. 0.25 **A**

   Magnification, M

$$M = \frac{V}{U} = \frac{20cm}{5cm}$$
$$M = 4$$

4. An object is placed between a converging lens and its principal focus. The image formed is

   A. real, magnified, upright.

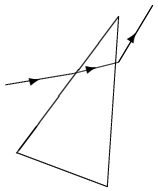
   B. real, magnified, inverted.

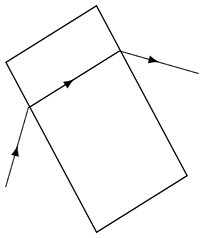
   C. virtual, diminished, upright.

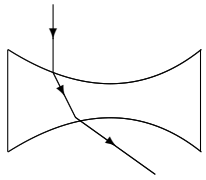
   D. virtual, magnified, upright.

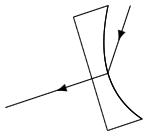
   D

5. Which of the following is a correct ray diagram?

   A. 

   B. 

   C. 

   D. 

   C

6. An object is placed at a distance of 20 cm from a convex lens of focal length 15cm. The type of image formed is

   A. inverted and magnified

   B. inverted and diminished

   C. upright and diminished.

   D. upright and magnified. **A**

   Using the lens formula

$$\frac{1}{V} = \frac{1}{f} - \frac{1}{U}$$

$$\begin{aligned}\frac{1}{V} &= \frac{1}{15} - \frac{1}{20} \\ &= \frac{1}{60} \\ V &= 60cm\end{aligned}$$

since $V > U$ it is magnified and the object is between F and C, for a convex lens the image is always inverted, since V is positive, then the image is real.

7. A stick with one end immersed in water appears bent at the water surface because of

   A. Diffraction.

   B. Reflection

   C. Interference.

   D. Refraction. **D**

8. A ray of light is incident on a glass block at an angle of incidence of 40° and the angle of refraction is 21°. Find the critical angle of the glass.

   A. 42.0°

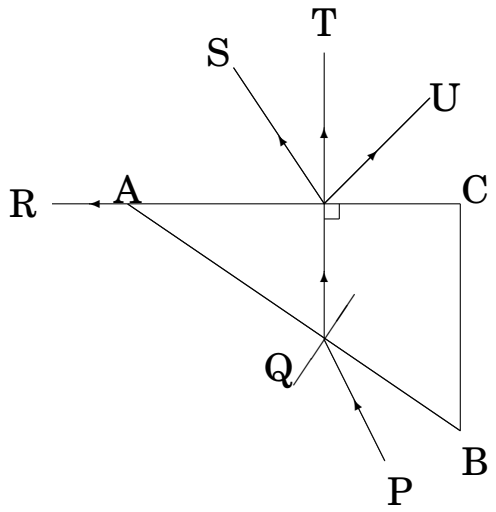
   B. 40.0°

   C. 33.8°

   D. 35.0° **C**

$$\begin{aligned}n &= \frac{\sin i}{\sin r} \\ &= \frac{\sin 40}{\sin 21} \\ \sin c &= \frac{1}{n} \\ &= \frac{\sin 21}{\sin 40} \\ &= \frac{0.3584}{0.64278} \\ &= 0.55752 \\ c &= \sin^{-1}(0.55752) \\ &= 33.885\end{aligned}$$

9. A ray of light PQ is incident on the face AB of a glass prism ABC as shown in the diagram in fig. 2



Which one of the rays, R, S, T, U indicates the correct direction of the emergent ray?

A. R

B. S

C. T

D. U **C**

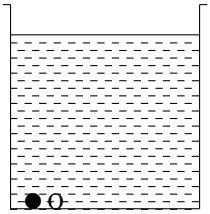
Section B (Structured)

10. State the laws of refraction.

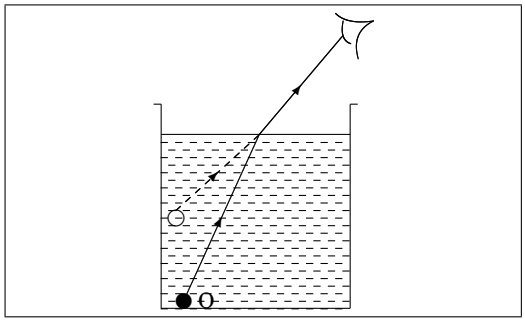
(i) The incident ray, refracted ray and the normal at the point of incident all lie in the same plane.

(ii)The ratio of the sine of the angle of incident to the sine of the angle of refraction for any two media, is always constant.

11. .



In the diagram below, an object O is placed at the botom of a clear pond. Draw rays to show how the object appears to an observer at E.



12. Fig. 13 shows refraction of light rays from a distant object by a human eye.

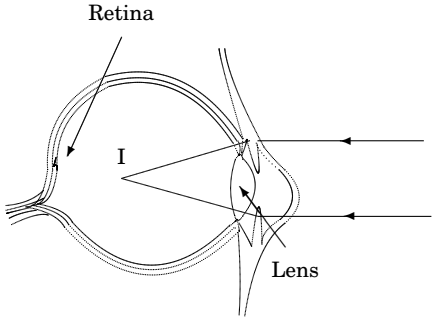


Fig.13

(a) Explain whether the eye is able to see the object clearly.

No because the image I is not formed on the retina.

(b) What is meant by accommodation?

This is the change of the eye's focal length by the ciliary muscle so as to form the image of an object in front of the eye, on the retina.

13. The refractive index of a glass block is 1.62. Calculate its critical angle.

from $n \sin C = 1$

$$\begin{aligned} C &= \sin^{-1}\left(\frac{1}{n}\right) \\ &= \sin^{-1}\left(\frac{1}{1.62}\right) \\ &= \sin^{-1}(0.617) \\ &= 38.12 \end{aligned}$$

14. Define focal length of a converging lens

It is the distance between the optical centre and the principal focus of a converging lens.

15. The focal length of converging lens is 10.0cm. What is its power.

$$\begin{aligned} P &= \frac{1}{f} \\ &= \frac{1}{\left(\frac{10}{100}m\right)} \\ &= 10\text{Dioptres} \end{aligned}$$

16. State any two properties of an image of a real object formed in a diverging lens.

1. *It is diminished*
2. *It is virtual*

17. .

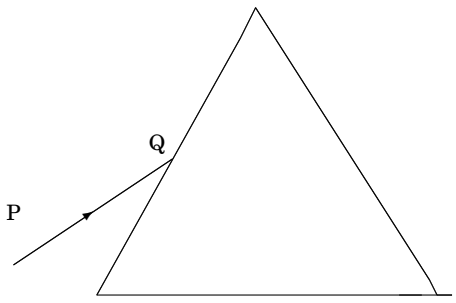
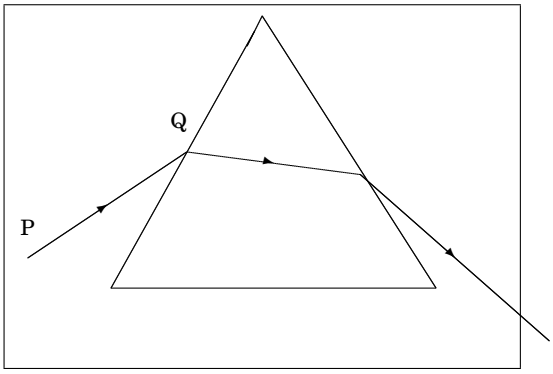


Fig. 10

Complete the diagram in fig. 10 to show the path of the light ray PQ through the prism.



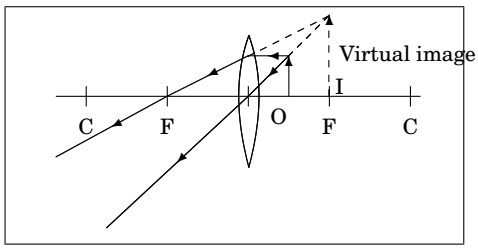
18. Light traveling in water is incident at a water-air surface at 30°. What is the angle of refraction if the refractive index from air to water is 1.33?

$$\begin{aligned} \frac{\sin i}{\sin 30} &= 1.33 \\ \sin i &= 1.33 \sin 30 \\ &= 1.33 \times 0.5 \\ &= 0.665 \\ i &= \sin^{-1}(0.665) \\ &= 41.68 \end{aligned}$$

19. What is meant by refractive index?

Refractive index is the ratio of the speed of light in a medium to speed of light in a vaccum or it is the ratio of sine of the angle of incidence in one media to the sine of the angle of refraction in the other media.

20. With the help of a ray diagram show how a converging lens can be used as a magnifying glass.



21. .

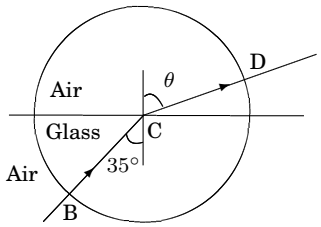


Fig. 8

Fig. 8 shows a ray of light incident on a semi-circular glass block of centre C.

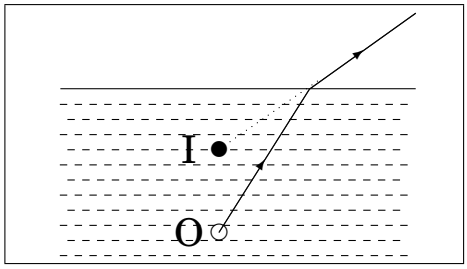
(a) Why is the ray not deviated?

Because it is normal to the surface at B i.e. the angle of incident is zero so even that of refraction has to be zero hence the ray is not deviated or refracted at B.

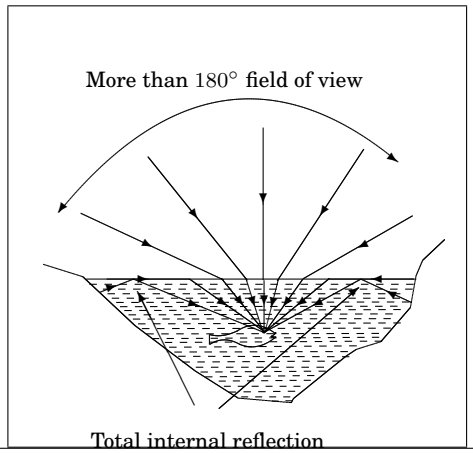
(b) Calculate the value of angle θ if the refractive index of glass is 1.52.

$$
\begin{aligned}
n_a \sin i_a &= \text{constant} \\
n_a \sin i_a &= n_g \sin i_g \\
\sin\theta &= 1.52 \times \sin 35^\circ \\
&= 1.52 \times 0.5736 \\
&= 0.8718 \\
\theta &= \sin^{-1}(0.8718) \\
&= 60.67
\end{aligned}
$$

22. Sketch a ray diagram to show how refraction of light makes a pond to appear shallower than it actually is.



23. Draw a diagram to show how a fish in water attains a wide field of view (2marks)



Paper II (Essay)

24. (a) Explain the causes of refraction of light.

(b) **Describe an experiment you would use to measure the refractive index of glass using a glass block.**

(c) (i) State the conditions for total internal reflection to occur

(ii) **State one application of total internal reflection.**

Solution

(a) causes of refraction are;

- change in the wave length of the light wave as it moves from one media to another or
- change in the speed of light wave as it moves from one media to another. If speed or wavelength of the waves could not change then there would be no refraction.

(b) An experiment to measure refractive index of glass

Using the Real-Apparent depth method;

- Place the glass block on the table
- measure the distance of the top of the glass block from the table and call it, real depth
- View the bottom of the glass block through the glass block, it appears raised, using an optical pin position it so that it coincides with the raised botto. Call this distance of the raised bottom to the top of the glass, apparent depth
- Obtain the refractive index, n, of the glass block using the expression; $n = \frac{\text{Real depth}}{\text{apparent depth}}$

(c) (i) Conditions for total internal reflection are

- the ray must be moving from a more optically dense media to a less optically dense media.
- The angle of incidence should be more than the critical angle.

(ii) Total internal reflection is applied in;

- Optical fibres
- Erecting prisms
- Reflecting prisms
- Transmission of radio waves via the ionosphere.

25. (a) Use a ray diagram to show how a virtual image may be formed by a converging lens.

(b) **A converging lens of focal length 20cm forms a real image 4cm high of an object which is 5cm high. If the image is 36cm away**

from the lens, determine by a graphical method, the position of the object.

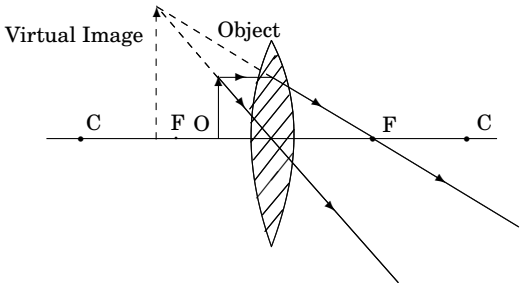
(c) **State two differences between a pin-hole camera and a lens camera.**

(d) **With the aid of a diagram explain why a pond appears shallower than it actually is.**

(e) **Using a labeled diagram show how two right-angled isosceles prisms may be used to produce an erect image of a distant object.**

Solution

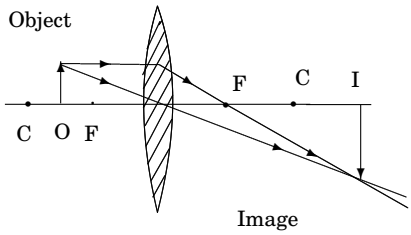
(a) a virtual image is formed by a converging lens, only when the object is between its optical centre and the principal focus. The diagram below shows this;



(b) from the question

$$\begin{aligned} f &= 20cm \\ h_i &= 4cm \\ h_\circ &= 5cm \\ v &= 36cm \end{aligned}$$

Sketch

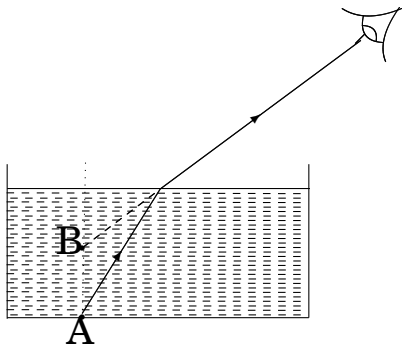


from the accurate graphical ray diagram labeled Figure 2.5 on page 148 the position of the object is 45cm from the pole of the lens.

(c) differences between a pinhole camera and a lens camera

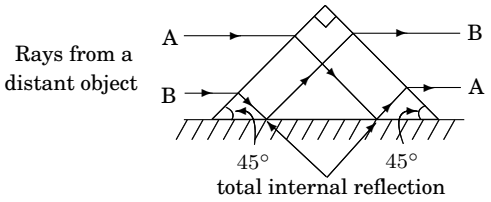
- The pin hole camera has no lens while the lens camera uses a lens
- The pin hole camera does not control light entering it while the lens camera controls light entering it using a diaphragm and a shutter

(d) a pond appears shallower than it actually is due to refraction, the diagram below shows this;



light from the deeper point A appears to be coming from the shallower point B

(e) how a right-angle isosceles prism can produce an erect image of a distance object.



since the angle of incidence is 45° which is more than the critical angle of glass (41.8°), then there is total internal reflection.

Hence the ray AB from a distant object is inverted to ray BA.

26. (a) What is meant by the following terms.

(i) **critical angle.**

(ii) **total internal reflection.**

(b) **Explain briefly how sky radio waves travel from a transmitting station to a receiver.**

(c) **State two applications of converging lenses.**

(d) **An object 8cm high is placed perpendicular on the principal axis 12cm away from a diverging lens. With the aid of a ray diagram, find the focal length of the lens, if the height of the image formed is 2cm**

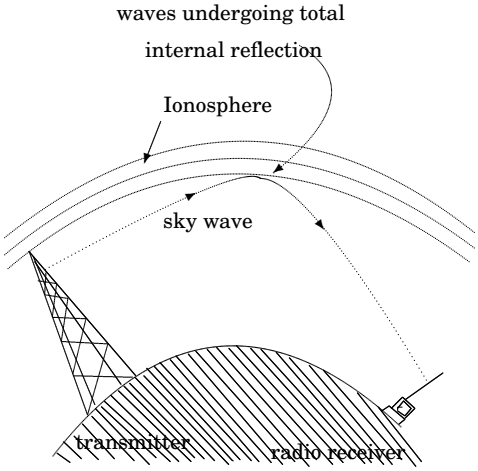
Solution

(a) (i) Critical angle is the angle of incidence in a more optically dense media for which the angle of refraction in the less optically dense media is 90°

(ii) Total internal reflection is the type of reflection a ray undergoes when moving from a more optically dense media to a less oprically dense media when the angle of incidence is more than the critical angle.

(b)They travel by total internal reflection on the ionosphere;

- the receiver produces the radio waves and sends them out in space.
- The waves meet the ionosphere and undergo total internal reflection and they are reflected back to the other part of the earth where the receiver (like a radio) receives them.



(c) Applications of converging lenses

- Used in projectors
- Used in lens camera
- Used in lens microscopes (not electron microscopes)

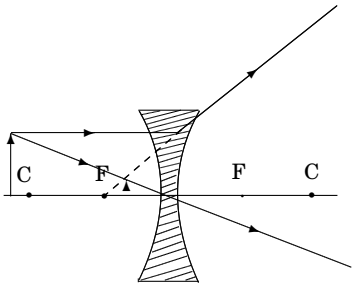
(d)

From the question

$$\begin{aligned} h_0 &= 8cm \\ U &= 12cm \\ h_i &= 2cm \end{aligned}$$

$$\begin{aligned} \text{magnification} &= \frac{h_i}{h_o} \\ &= \frac{V}{U} \\ \Rightarrow \frac{V}{U} &= \frac{h_i}{h_o} \\ \frac{V}{12} &= \frac{2cm}{8cm} \\ \frac{V}{12cm} &= \frac{2cm}{8cm} \\ V &= \frac{2}{8} \times 12cm \\ &= 3cm \end{aligned}$$

from the sketch



- Draw line from top of object to image to principle axis, at O. This gives the position of the lens,
- Draw a vertical line at O,
- Draw a horizontal line from the objects top to meet this vertical line at B.
- Draw a line from B to top of the image and continue till it touches the principal axis at a point F, the principal focus.
- Focal length is the distance FO.
  The ray diagram in figure 2.4 shows that.
- Next draw the arrows to show the direction of light and more so to make it a ray diagram (otherwise it is not), The constructed diagram is in figure 2.4

27. (a) The diagram in fig. 6 shows a ray of yellow light incident at an angle of 50° on one side of an equilateral triangular glass prism of refraction index 1.52

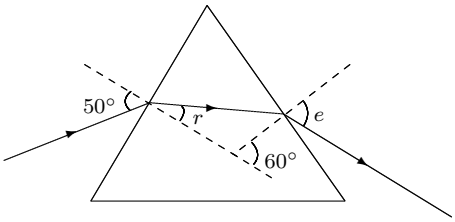


Fig. 6

(i) **Calculate the angles marke r and e.**

(ii) **State and explain what would be observed if the ray above were of white light.**

(b) **Explain with the aid of a diagram, why the writing on a piece of paper under a glass block appears raised when observed from above.**

Solution

(a) From the diagram

(i)

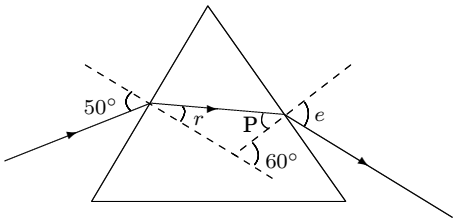


Fig. 6

from $n_a \sin i_a$ = Constant

$$
\begin{aligned}
n_{\text{air}} \sin i_{\text{air}} &= n_{\text{glass}} \sin i_{\text{glass}} \\
1 \times \sin 50 &= 1.52 \times \sin r \\
\sin 50 &= 1.52 \sin r
\end{aligned}
$$

$$
\begin{aligned}
1.52 \sin r &= \sin 50 \\
\sin r &= \frac{\sin 50}{1.52} \\
&= \frac{0.766}{1.52} \\
&= 0.504 \\
r &= \sin^{-1}(0.504) \\
&= 30.26^\circ
\end{aligned}
$$

for angle e recall that

$$
\begin{aligned}
P + r &= 60 \\
P &= 60 - r \\
&= 60 - 30.26 \\
&= 29.74
\end{aligned}
$$

Also

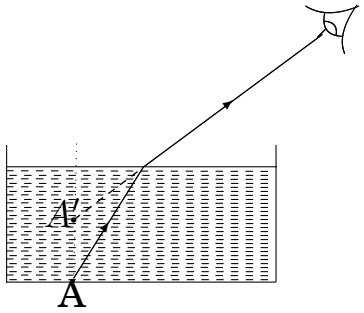
$$
\begin{aligned}
n_g \sin i_g &= n_a \sin i_a \\
1.52 \sin P &= 1 \times \sin e \\
1.52 \sin 29.74 &= \sin e
\end{aligned}
$$

$$
\begin{aligned}
\sin e &= 1.52 \sin 29.74 \\
&= 1.52 \times 0.496 \\
\sin e &= 0.754 \\
e &= \sin^{-1}(0.754) \\
&= 48.9^\circ
\end{aligned}
$$

Hence $r = 30.26^\circ$ and $e = 48.9^\circ$

(ii)If the ray above were of white light, it would get dispersed i.e. split into the seven colours of a rainbow (Red, orange, yellow, green, blue, indigo and violet), this is because each colour is refracted at a different angle of refraction or because each colour has its own refractive index for the same glass material.

(b) This is due to refraction when the ray from the writing on the paper passes through the glass, it gets refracted as shown below;



hence it appears as if it is coming from A' hence it appears raised.

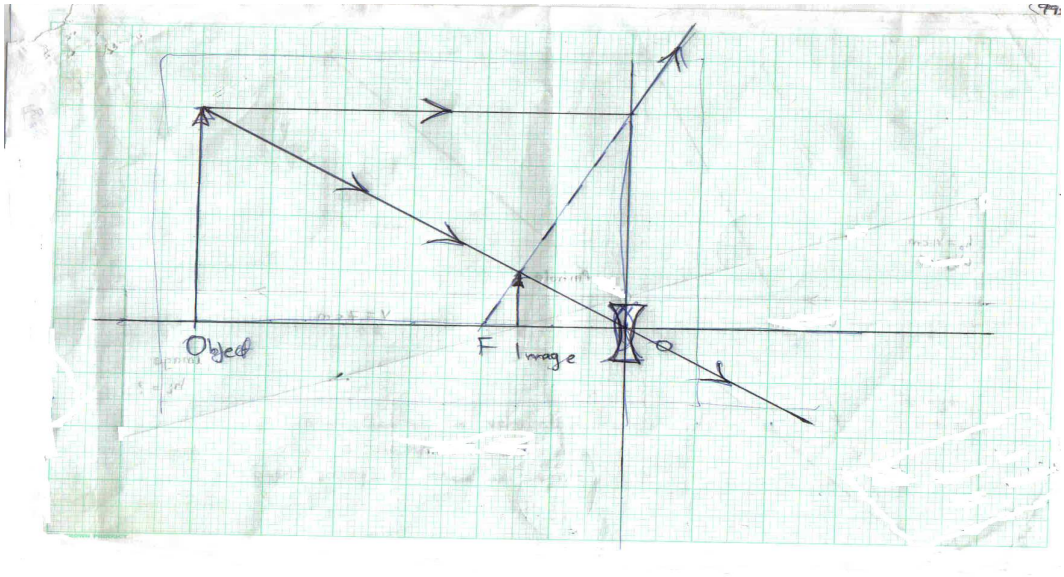


Figure 2.4: Ray diagram: Diverging lens

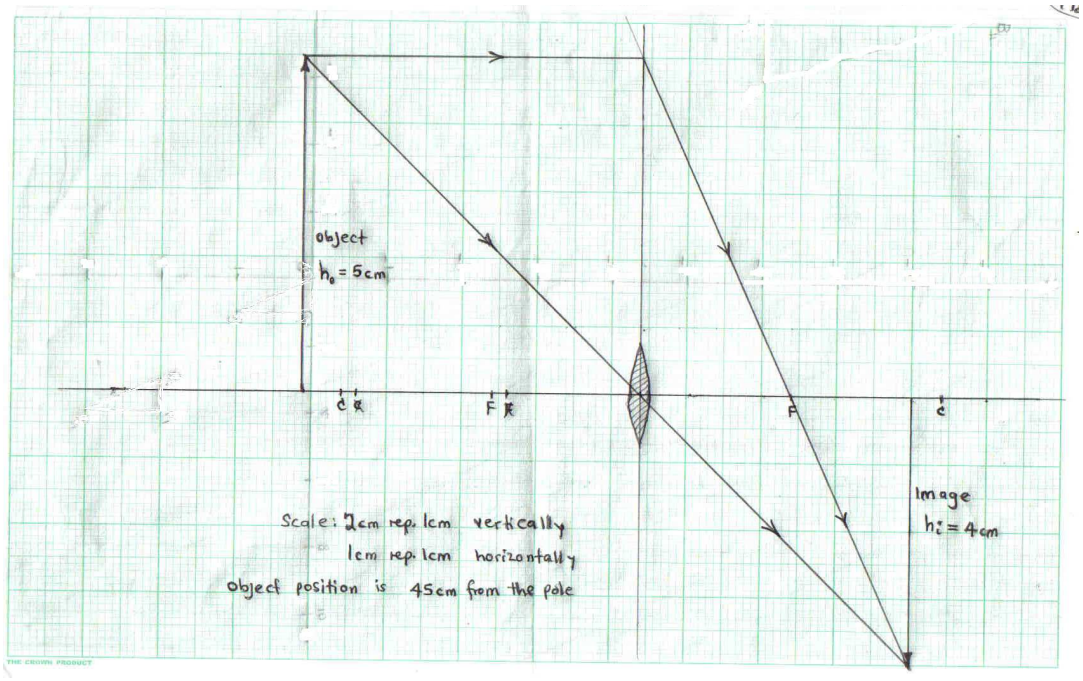


Figure 2.5: Ray diagram: converging lens

2.4 Dispersion

Section A (Objectives)

1. .

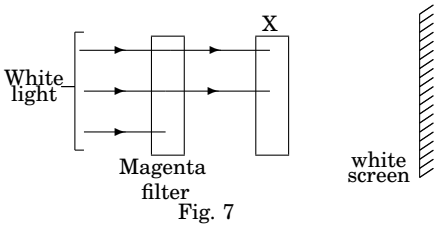


Fig. 7

Fig. 7 shows white light incident on a magenta colour filter. What colour filter should X be so that red is seen on the screen?

A. Cyan

B. Blue

C. Black

D. Yellow **A**

2. A piece of white cloth viewed through a blue glass looks blue because

A. blue light is absorbed by the glass.

B. the glass adds blue light to the light coming from the cloth.

C. the glass transmits only blue light and absorbs all the other colours.

D. the colour of the glass is reflected onto the cloth. **C**

3. A student is holding a white paper with green printing on it. If she enters a room with red light, she will see

A. Black printing on a red paper

B. Blue printing on a red paper

C. Yellow printing on a red paper

D. Red printing on a white paper **A**

Red is absorbed by green painting pigments

4. which of the following is correct?

(i) Green light shone on green surface is all absorbed

(ii) Green light added equally to red light appears yellow

(iii) Green light passes through a red filter

A. (ii) only

B. (i) and (ii) only

C. (ii) and (iii) only

D. (i), (ii) and (iii). **A**

5. Which of the following are secondary colours only?

A. Red, green and yellow.

B. Blue, yellow and magenta.

C. Yellow, cyan and magenta.

D. Red, green and blue.

C

6.

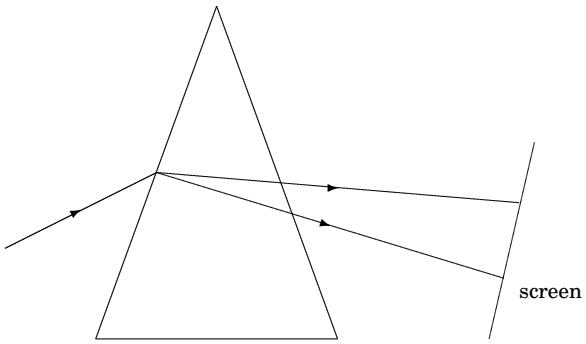


Fig. 8

Fig. 8 shows white light passing through a glass prism. Which colour is bent most?

A. Red

B. Yellow

C. Green

D. Violet **D**

7. The secondary colours of light are cyan, magneta and yellow. Which of the following sets of addition of colours of light will produce white light?

(i) Cyan + Blue and Magneta + Red.

(ii) Cyan + Red and Magneta + Green.

(iii) Yellow + Red and Magneta + Blue.

(iv) Cyan + Green and Yellow + Blue.

A. (i) only.

B. (ii) only.

C. (iii) only.

D. (iv) only **B**

Recall that

$$\begin{aligned} R + G + B &= W \\ R + C &= W \\ M + G &= W \\ B + Y &= W \end{aligned}$$

8. White light is separated into its component colours by a prism due to

A. absorption.

B. dispersion

C. reflection.

D. transmission. **B**

9. Which of the following statements are true?

(i) A magenta filter absorbs green light and transmits red and blue lights.

(ii) A magenta filter absorbs blue light and transmits red and green lights.

(iii) A cyan filter absorbs red light and transmits blue and green lights.

(iv) A cyan filter absorbs blue light and transmits red and green lights.

A. (i) only.

B. (ii) only

C.(ii) and (iv) only.

D.(i) and (iii) only. **D**

Recall that

$$\begin{aligned} M &= R+B \\ Y &= R+G \\ C &= G+B \end{aligned}$$

10. In this Question indicate the correct answer A, B, C or D according to the following;

A. If 1,2,3 only are correct

B. If 1,3 only are correct

C. If 2,4 only are correct

D. If 4 only is correct

Which of the following statements is/are true?

1. A glass prism disperses shorter wavelengths more than longer wavelengths.
2. A glass prism disperses longer wavelength more than shorter wavelengths.
3. A rod filter only allows red and longer wavelengths in the spectrum to pass **B**
4. A red filter allows all colours in the spectrum to pass except red.

Paper II (Essay)

11. (a) Explain what is meant by dispersion of light.

(b) **State why most hind car registration number plates are printed black on a yellow background.**

(c) **Explain why the sun appears red at sunrise and sunset.**

Solution

(a) Dispersion of light in the splitting of white light into its component colours i.e. red, orange, yellow, green, blue, indigo and violet.

(b) They are printed black on a yellow background to create a greater contrast so that the figures or letters are easily recognized by the human eye during day and night (by reflection of the light from car lamps).

(c) The degree of scattering of light depends on the wave length of light. Red has a longer wavelength of light hence it more scatted hence the light from the sun is red at sunrise and sunset because the scattered light is what can be seen at that time. Unlike during day when we see blue (short wave length light) i.e. the sky is blue.

12. (a) (i) What are primary colors? Name them

(ii) Explain briefly what happens when white light falls on a green body.

(b) **With the aid of a labeled diagram, describe how a**

lens camera works.

Solution

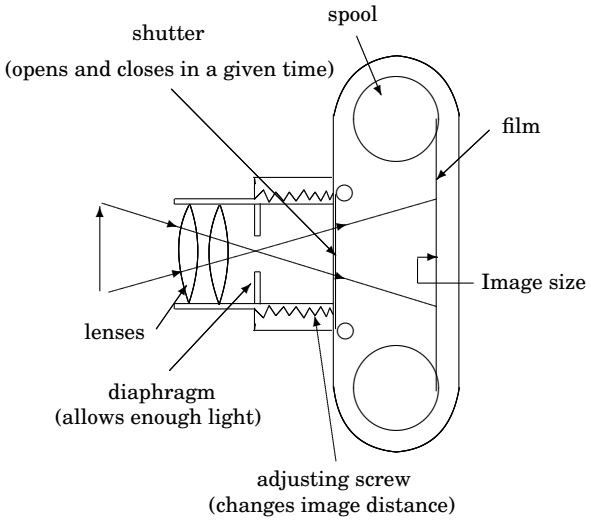
(a) (i) primary colours are colours which can not be obtained by mixing any other colours, they are red, green and blue.

(ii) When white light falls on a green body, the green body absorbs all colours a part from green which it reflects hence it appears green.

(b) how a lens camera works;

A lens camera is a light-tight box in which a convex lens in front of it forms a real inverted image on a photo sensitive film at the back.

Below is its diagram



light from an object in front of the camera is refracted through the lens and then the required amount of light passes through the diaphragm for a fixed short period of time when the shutter is open, Light meets the photographic film behind the camera where an image is formed, this film can then be developed into a photograph.

13. (a) Explain dispersion as applied to light

(b) (i) What is a pure spectrum?

(ii) **With aid of a labelled diagram, describe briefly how a pure spectrum is produced.**

(c) (i) Distinguish between a primary and a secondary colour.

(ii) **Fig. 2 shows colours mixed by addition. Name the colours represented by the parts labeled A, B, C and D.**

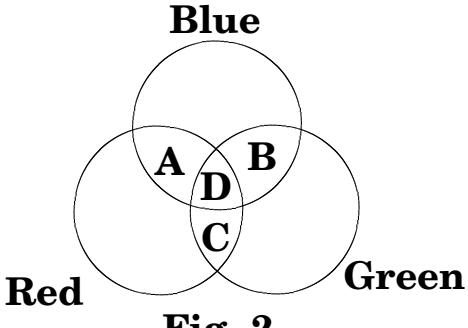


Fig. 2

(d) **State the colour of a yellow dress in green light.**

Solution

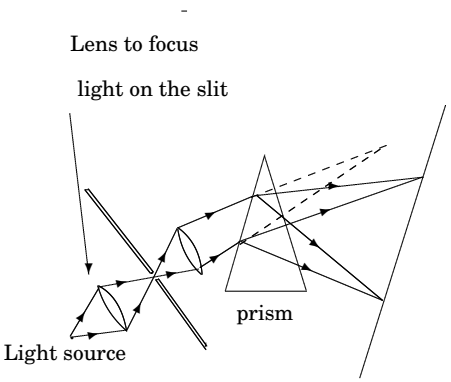
(a) dispersion is the splitting of white light into its component colours i.e. red, orange,yellow, green, blue, indigo and violet.

(b) (i) a pure spectrum is a group of pure or true colours of light.

For instance compound Yellow is not true yellow hence not a true or pure colour.

(ii) an experiment to produce a pure spectrum

A pure spectrum is produced from white light by dispersing light using a prism and a lens arranged as shown below;



The colours obtained are sharp or clear colours or do not overlap and hence they constitute a pure spectrums other wise if a lens is not used we would not have a pure spectrum but an overlap of colours.

(c) (i) a **primary colour** is a colour that can not be obtained by mixing any other colour, they are 3 red, green and blue while **secondary colours** are colours obtained by mixing primary colours.

Any other colour other than red, green and blue is a secondary colour.

(ii) The colour labeled in the diagram are'

A −Magnenta
B −Cyan
C −Yellow
D −White

(d) Colour of yellow dress in green light. Yellow is a secondary colour i.e.

yellow = red + green

hence a yellow dress reflects red, green and yellow lights

if a yellow dress is in green light and green is among the colours it reflects then in green light the yellow dress will reflect the green light to our eyes and hence it appear green.

But in this question they did not need the whole of this explanation but to just write Green because they said state.

Chapter 3

Heat

Contents

3.1 Thermometry

Section A (Objectives)

1. The interval between the ice and steam points on a thermometer is 192mm. Find the temperature when the length of the mercury thread is 67.2mm from the ice point.

   32.8°C
   35.0°C
   65.0°C
   67,2°C **B**

$$\begin{aligned}\theta &= \frac{x}{y} \times 100\% \\ &= \frac{67.2}{192} \times 100 \\ &= 35\end{aligned}$$

2. The lengths of the mercury column of a thermometer at ice point and steam point are 2.0cm and 22.0cm respectively. The reading of the thermometer when the mercury column is 9.0cm long is

   A. 45.0°C
   B. 40.9°C
   C. 35.0°C
   D. 31.8°C **C**

$$\begin{aligned}\theta &= \frac{l_\theta - l_0}{l_{100} - l_0} \times 100^\circ C \\ &= \frac{9-2}{22-2} \times 100 \\ &= \frac{7}{20} \times 100 \\ &= 35^\circ\end{aligned}$$

3. In order to make a mercury thermometer more sensitive the

A. degree markings must be further apart. **B**

B. diameter of the capillary tube must be reduced.

C. volume of the mercury bulb must be reduced.

D. capillary tube must be open to air.

4. The temperature at which all the heat energy is removed from a substance is called

A. Kelvin temperature.

B. Celsius temperature.

C. Freezing temperature.

D. Absolute zero temperature.

D

5. The distance between the lower and upper fixed points on the Celsius scale in an unmarked mercury-in-glass thermometer is 25cm. If the mercury level is 5 cm below the upper fixed point, then the temperature is

A. 5°C

B. 20°C

C. 80°C

D. 95°C **C**

$$\begin{aligned} \text{from } \theta &= \frac{l_\theta - l_0}{l_{100} - l_0} \times 100 \\ &= \frac{x}{y} \times 100 \\ \text{but } x &= 25 - 5 = 20cm \\ \text{and } y &= 25 \\ \theta &= \frac{20}{25} \times 100 \\ &= 80^\circ C \end{aligned}$$

Section B (Structured)

6. State any two factors which affect pressure in liquids.

1. *density of the liquid*
2. *depth*

7. Name any two physical properties which change with temperature.

1. *Pressure of a gas*
2. *Volume of a gas*
3. *Length of a metal bar*

8. Convert a temperature of $25^\circ C$ to Kelvin.

$$\begin{aligned} 25^0 C &= (25 + 273)\textit{Kelvin} \\ &= 298\textit{Kelvin} \end{aligned}$$

9. State **two** reasons why mercury is preferred to alcohol as a thermometric liquid.

1. it is opaque

2. it is a better conductor of heat

3. it has a higher fundamental interval

10. In a gas thermometer, the pressure of the gas at 0^0 C is 20 cmHg and at 100^0 C is 27 CmHg. Determine the room temperature if the pressure at this temperature is 21.4 cmHg.

$$\begin{aligned}\theta &= \frac{21.4-20}{27-20}\times 100^{\circ}C\\ &= \frac{1.4}{7}\times 100^{\circ}C\\ &= 20^{\circ}C\end{aligned}$$

Paper II (Essay)

11.

(a) What is meant by the terms

(i) temperature,

(ii) **heat?**

(b) **The fundamental interval of mercury in glass is** $192mm$. **find the temperature in degrees celcius when the mercury thread is** $67.2mm$**long.**

(c) **State two physical properties which change with temperature.**

Solution

a(i) Temperature is a measure of hotness or coldness of a number on some chosen scale.

a(ii) Heat is a form of energy that usually flows from a hot to cold body.

(b) Temperature, θ

$$\begin{aligned}\theta &= \frac{x}{y}\times 100^{\circ}C\\ &= \frac{67.2}{192}\times 100^{\circ}C\\ &= 35^{\circ}C\\ &= 35^{\circ}C\end{aligned}$$

(c)
- Length of a metal
- Volume of a gas
- Pressure by a gas
- Resistance of a metal

12. (a) (i) Describe the fixed points of a Celsius scale of temperature.

(ii) **Give two advantages of mercury over alcohol as a thermometric liquid.**

(iii) **Convert** -200° **C to Kelvin**

(b) Use the kinetic theory to explain the following:

(i) cooling by evaporation.

(ii) **why the temperature of a gas contained in a cylinder increases when it is compressed.**

(c) Explain briefly the transfer of thermal energy by conduction in metals.

Solution

(a) (i) Fixed point of the celcius scale of temperature are

- The lower fixed points i.e. the melting point of pure ice and
- The upper fixed point i.e. the boiling point of pure water at a pressure of 760 mmHg.

(ii)
- mercury is easily seen because it is opaque yet alcohol is colourless,
- mercury does not wet glass and alcohol wets glass
- mercury is a good conductor of heat compared to alcohol.
- Mercury does not easily boil (its boiling point in $357°$C) and alcohol boils easily i.e. has a lower boiling point of $78°$C.

(iii) Since

$$\begin{aligned} x^\circ C &= (x + 273)\text{K} \\ -200^\circ &= (-200 + 273)\text{k} \\ &= 73 \text{ Kelvins} \end{aligned}$$

(b) Using the kinetic theory we can explain;

(i) When a liquid evaporates, energetic molecules leave the liquid surface, this lowers the average kinetic energy of the molecules of the liquid, since this average is proportional to temperature of the liquid, then it cools.

(ii) When a gas is compressed, its molecules loose their kinetic energy since they do not have enough room to move. Since energy can not be destroyed, the lost energy is conducted to the sorrounding as heat hence the temperature of the liquid increases or is absorbed as its internal energy.

(c) heat transfer by conduction in metals;

When part of a metal is heated, the atoms of that part vibrate with a greater amplitude.

These vibrating molecules knock the neighbouring molecules which also begin to vibrate with a larger amplitude.

In this process also the loose electrons travel and knock the other atoms and hence heat is transferred by vibration of molecules and movement of electrons.

13.

(a) **Describe an experiment to determine the fixed points of a thermometer.**

(b) (i) Mention any three reasons for not using water as a thermometric liquid.

(ii) **When a celcius thermometer is inserted in a boiling liquid, the mercury thread rises above the lower fixed point by 19.5cm. Find the temperature of the boiling liquid if the fundamental interval is 25cm.**

Solution

(a)An experiment to determine the fixed points of a thermometer.

There are two fixed points for the celcius scale of temperature, let us describe each separately;

For lower fixed point

1. Place the thermometer in a funnel containing crushed blocks of pure ice.
2. Start the stop clock and note or record the length of the mercury thread in the thermometer.
3. This length will decrease with time. After some time this length becomes constant ($l_\circ$) and this is when ice is melting i.e. at ice point 0°C. This is marked as a point on the thermometer called ice point or lower fixed point.

For upper fixed point

Place the thermometer in steam from pure boiling water at a pressure of 760mmHg or **just** on the surface of boiling water. This is best done using a hypsometer shown below; When length of mercury thread remains steady for some time, the level of the surface of the mercury thread is marked on the thermometer as steam point or upper fixed point i.e. (100°C).

(b) (i) Three reason for not using water as a thermometric liquid,

- water does not expand uniformly in the range $0°$C to $4°$C
- water wets glass
- water easily evaporates

(ii)

$$\begin{aligned} x &= 19.5cm \\ y &= 25cm \\ Q &= \frac{x}{y} \times 100°C \\ &= \frac{19.5}{25} \times 100°C \\ &= 78°C \end{aligned}$$

3.2 Heat transfer

Section A (Objectives)

1. .

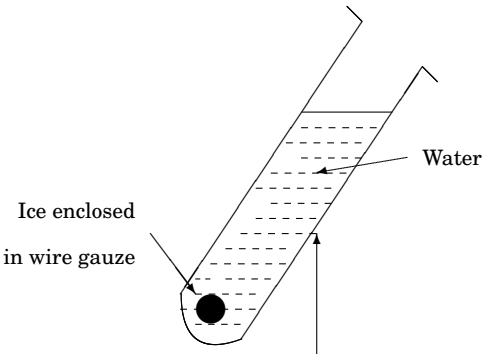


Fig. 6 HEAT

Which of the following is/are true about the experimental set up in fig. 6?

1. The ice takes long to melt because of the gauze.
2. The wire gauze keeps the ice at the bottom of the test tube.
3. The ice does not melt because the heating is from above
4. The ice takes long to melt because water is a poor conductor. **C**

2. Choose the corrrect option according to these instructions

A. if 1,2,3 only are correct.

B. If 1,3 only are correct.

C. If 2,4 only are correct.

D. If 4 only is correct.

A dull back surface is a good

(i) Absorber if heat energy

(ii) Emitter of heat energy

(iii) Reflector of heat energy

A. (i) Only

B. (i) and (ii) only

C. (ii) and (iii) only

D. (i) , (ii) and (iii). **B**

3. Radiation is the transfer of heat

A. In a liquid which involves the movement of the molecules

B. From one place to another by means of electromagnetic waves.

C. Through a fluid which involves the bulk movement of the fluid itself. **B**

4. The mode of transfer of heat between the boiler and the storage tank of a hot water supply system is

A. radiation

B. conduction

C. convention

D. evaporation **C**

5. The transfer of heat by the actual movement of molecules of matter takes place

A. only in liquids.

B. only in gases.

C. in solids and liquids.

D. in liquids and gases. **D**

6. A stone floor feels very cold to bare feet in cold weather, but a carpet in the same room feels comfortably warm. Why is this so?

A. the stone is a worse conductor of heat than a carpet.

B. the stone is a better conductor of heat than a carpet.

C. the carpet is a better conductor of heat than a stone.

D. the stone is a better reflector of heat than the carpet. **B**

7. Which one of the following fluids is the best conductor of heat?

A. Air

B. Alcohol

C. Water

D. Mercury **D**

8. The process of using a material of low thermal conductivity to prevent heat loss is called

A. cooling.

B. lagging

C. absorption.

D. contraction. **B**

9. Plants inside a green house emit radiations which cannot pass through the green house glass because the radiations are

A. of short wavelength.

B. of long wave length.

C. used to warm up the green house.

D. absorbed by the glass.

B

10. A dull black surface feels hotter even though it is at the same temperature as a shiny surface because it

A. has more heat than a shiny surface.

B. emits more heat than a shiny surface.

C. reflects more heat than a shiny surface.

D. conducts more heat than a shiny surface. **B**

11. Which of the following statements are true?

(i) Surfaces which reflect all colours of light appear white.

(ii) Red surfaces absorb all colours and reflects only red light.

(iii) Black surfaces appear black because they reflect all colours.

A. (i) only.

B. (i) and (ii) only.

C. (i) and (iii) only.

D. (ii) and (iii) only. **B**

12. A sea breeze occurs

A. when cool air blows towards the land.

B. when warm air blows towards the land.

C. during night.

D. when cool air blows towards the sea. **A**

13. Which of the following statements is/are true about heat radiation?

1. A cold body emits invisible radiation of long wavelength.
2. Very hot objects emit radiations of short wavelengths.
3. All good radiators of heat are good absorbers.
4. All radiations emitted by hot objects are invisible. **A**

Section B (Structured)

14. What is the use of a vacuum in a thermos flask?

To present heat loss by convection and conduction because these methods require a material media yet in a vacuum it is not there.

15. Explain why the sea remains cooler than land during day time and warmer than land at night.

Because water has a higher heat capacity i.e., it takes long to get heated during day and takes long to cool down during night.

16. State any **one** factor on which the rate of heat transfer along a metal bar depends.

The length of the metallic bar, its cross sectional area, temperature difference between its ends or nature of the material of the metal bar

17. Fig. 12 shows a thermos flask.

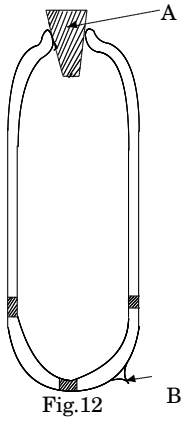


Fig.12

(a) name parts labeled

A

B

A - Cork

B - Vacuum seal

18. State the use of the part labeled A.

To prevent heat loss via conduction

19. Why do the contents of the flask ultimately get cold?

due to

1. *little radiation in the vacuum and*
2. *the loss of heat by conduction via the cork.*

Paper II (Essay)

20. Name two main features of a vacuum flask which enable it to keep a liquid warm.

Solution

- the vacuum in the double glass walls, this prevents conduction and convection
- the silvery surface on the inner sides of the double walls, this prevents or reduces heat loss by radiation.

21. (a) What is meant by conduction?

(b) **Draw a labeled diagram of a thermos flask and explain how it is able to keep a liquid cold for a long time.**

(c) **With the help of a diagram, describe how you would determine the upper fixed point of an uncalibrated thermometer.**

(d) **Explain the following observations;**

(i) a bare cement floor feels colder than a carpeted one.

(ii) **a beam with a notch; that is used for constructing a bridge, lasts longer when the notch is on its top surface than when the notch is on its lower surface.**

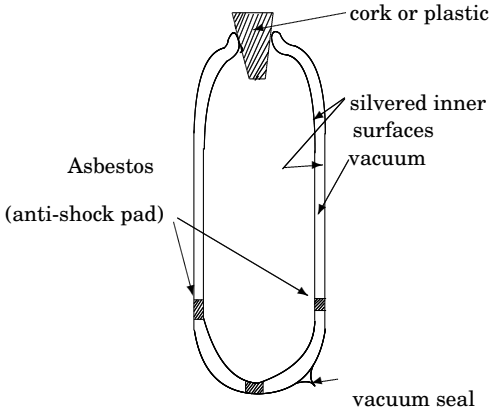
Solution

(a) Conduction is the process by which heat is transferred from regions at high temperature to regions at a low temperature by movement of electrons and vibration of atoms or molecules.

OR

Conduction is the process by which heat is transferred from regions at high temperature to regions at a low temperature without movement of matter.

(b)

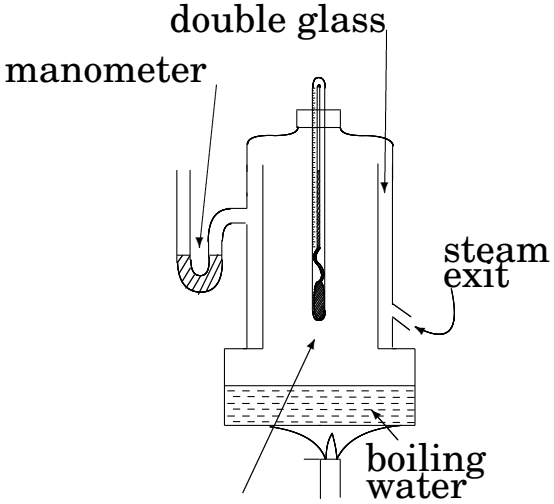


it is able to keep the liquid cold for a long time or preventing heat exchange by;

- the vacuum which does not have matter hence prevents heat loss by conduction and convention
- the silvered double-walls by reflecting the heat radiations on these walls.
- the cork which prevents heat loss by conduction since it is a poor conductor of heat.

(c) Place the thermometer in steam

from boiling water in the hypsometer as shown below;



wait till when the levels in the manometer are the same, then mark on the thermometer where the top of a mercury thread is, that is the upper fixed point.

(d) Explaining the phenomena;

(i) a bare cement floor feels colder than a carpeted one because carpet is a bad conductor of heat does not take heat from your body and cemented floor is a good conductor of heat so it takes the heat from your body which feels cold.

(ii) this is because the top the beam is under compression and this does not affect (or increase) a notch but below the beam it is under tension which widens and deepens the notch which may break the beam into two part i.e. the beam does not last longer.

3.3 Heat measurement

Section A (Objectives)

1. .

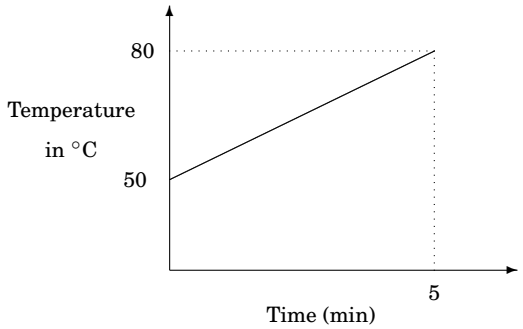


Fig. 3

A heater rated 6000 j/min is placed in 2 kg of a liquid. The temperature rise varies with time as shown in Fig. 3. The specific heat capacity of the liquid in J kg $^{-1}$K $^{-1}$ is

A. $\frac{6000\times2}{5\times30}$
C. $\frac{6000\times2\times5}{30}$
B. $\frac{6000\times2}{2\times30}$
D. $\frac{6000\times30}{2\times5}$ **B**

$$P = \frac{mc\Delta T}{t}$$
$$c = \frac{Pt}{m\Delta T}$$
$$= \frac{6000 \times 5}{2 \times 30}$$

2. The specific heat capacity of a substance is the amount of

   A. heat required to raise it through 1°C.

   B. heat required to raise the temperature of 1kg mass of the substance through 1°C.

   C. heat required to change 1kg mass of the substance into liquid at the same temperature. **B**

   D. heat required to raise its temperature a specific number of degrees.

3. Calculate the amount of heat required to change 100g of water at 100°C to steam at 100° C. [Specific latent heat of steam = 2.26×10^6 Jkg^{-1}]

   A. 2.26×10^8J

   B. 2.26×10^7J

   C. 2.26×10^5J

   D. $2.26 \times 10J$J **C**

$$\begin{aligned} E &= ml_v \\ &= \frac{100}{1000} \times 2.26 \times 10^6 \\ &= 2.26 \times 10^5 \end{aligned}$$

4. The amount of heat required to raise the temperature of 0.5kg of salt solution from -5°C to 15°C is (Specific heat capacity of salt solutions is 4000Jkg-1K^{-1})

   A. 8000J

   B. 20,000J

   C. 40,000J

   D. 160,000J **C**

$$\begin{aligned} H &= mc\Delta T \\ &= 0.5 \times 4000 \times 20 \\ &= 40,000J \end{aligned}$$

5. A 100g quantity of water at 24°C is added to 50g of water at 36°. The final temperature of the mixture is

   A. 28°C.

   B. 32°C.

   C. 30°C.

   D. 34°C. **A**

$$\begin{aligned} \text{heat loss} &= \text{heat gain} \\ m_1 c\Delta T &= m_2 c\Delta T \end{aligned}$$

But

$$\begin{aligned} m_1 &= 2m_2, c = c \\ \Rightarrow 2\Delta T &= \Delta T \\ 2 \times (T - 24) &= (36 - T) \\ 2(T - 24) &= 36 - T \\ 2T - 48 &= 36 - T \\ 3T &= 84 \\ T &= 28 \end{aligned}$$

6. The mount of heat required to raise the temperature of 0.5kg of iron from 25°C to 50°C is (Specific heat capacity of iron is 460 Jkg$^{-1}K^{-1}$)

   A. $\frac{0.5\times460}{25}$
   B. $\frac{460\times25}{0.5}$
   C. $0.5 \times 460 \times 25$
   D. $\frac{0.5\times25}{460}$ **C**

$$\begin{aligned} H &= mc\Delta T \\ &= 0.5 \times 460 \times (50-25). \\ &= 0.5 \times 460 \times 25. \end{aligned}$$

7. A block of lead of mass 1000g hits a hard surface without rebounding with a velocity of 23m s^{-1}. if its temperature rises from 15°C to 27°C, calculate the specific heat capacity of lead.

   A. 5.75JKg°C^{-1}
   B. 9.79JKg°C^{-1}
   C. 132.25JKg°C^{-1}
   D. 264.50JKg°C^{-1} **C**

$$\begin{aligned} \frac{1}{2}mv^2 &= mc\Delta T \\ c &= \frac{V^2}{2\Delta T} \\ &= \frac{23^2}{2\times(27-15)} \\ &= 132.25 \end{aligned}$$

8. 450g of water at 60°C is to be cooled to 35°C by addition of cold water at 20°C. How much cold water is to be added?

   A. 0.169kg
   B. 0.270kg
   C. 0.281kg
   D. 0.75kg **D**

$$\begin{aligned} H_{\text{Loss}} &= H_{\text{gain}} \\ 0.45\cdot(60-35) &= mc(35-20) \\ 0.45\times25 &= 15m \\ m &= \frac{0.45\times25}{15} \\ m &= 0.75kg \end{aligned}$$

9. Calculate the time required for a kettle taking 10A from a 240V supply, to heat 5kg of water through 80^0, assuming no heat loss.

   A. 700s.
   B. 292 s.
   C. 8.8 s.
   D. 1.7 s. **A**

$$\begin{aligned} P = VI &= \frac{mc\Delta T}{t} \\ t &= \frac{mc\Delta T}{IV} \\ &= \frac{5\times4200\times80}{10\times240} \\ &= 700 \end{aligned}$$

10. When 1kg of a certain liquid is heated for 10s its temperature rises by 25°C.

    If the power supplied is 1000 watts, find the specific heat capacity of the liquid.

    A. 40Jkg^{-1}K^{1}

    B. 400Jkg^{-1}K^{-1}

    C. 1000Jkg^{-1}K$^{-1=}$

    D. 2500Jkg^{-1}K^{1} **B**

$$\begin{aligned} Pt &= mc\Delta T \\ c &= \frac{Pt}{m\Delta T} \\ &= \frac{1000 \times 10}{1 \times 25} \\ &= 400 \end{aligned}$$

11. An electric heater is rated 240V, 400W. if the efficiency of the heater is 80%, find the amount of energy wasted per second.

    A. 48J.

    B. 80J

    C. 192J.

    D. 320J. **B**

    wasted energy is 20% i.e. (100-80) of the supplied energy. that is

$$\begin{aligned} &= 20\% \text{ of } 400 \\ &= \frac{20}{100} \times 400 \\ &= 80J \end{aligned}$$

12.

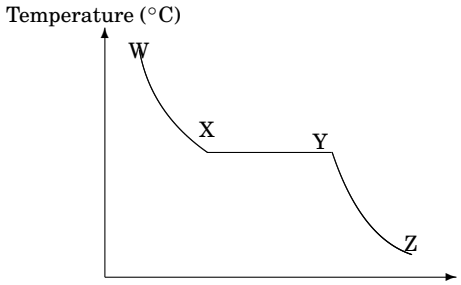


Fig. 4

The graph in fig. 4 shows a cooling curve of a pure substance. The substance is all in solid state between

A. W and X

B. W and Y

C. X and Y

D. Y and Z. **A**

13. Calculate the specific heat capacity of paraffin if 22000J of heat are required to raise the temperature of 2.0kg of paraffin from 20°C to 30°.

    A. 1100J kg^{-1}K^{1}

    B. 1200J kg^{-1}K^{-1}

    C. 2200J kg^{-1}K^{-1}

    D. 2100J kg^{-1}K^{-1} **A**

$$\begin{aligned} H &= mc\Delta T \\ c &= \frac{H}{m\Delta T} \\ &= \frac{22000}{2 \times (30-20)} \\ &= 1100Jkg^{-1}K^{1} \end{aligned}$$

14. An electric heater is immersed in 0.05kg of oil in a calorimeter of negligible heat capacity. The temperature of the oil rose from 20°C to 50°C in 100s. If the specific heat capacity of the oil is 2000J $kg^{-1}K^{-1}$, calculate the power supplied by the heater, assuming that there is no heat loss.

A. 30W.

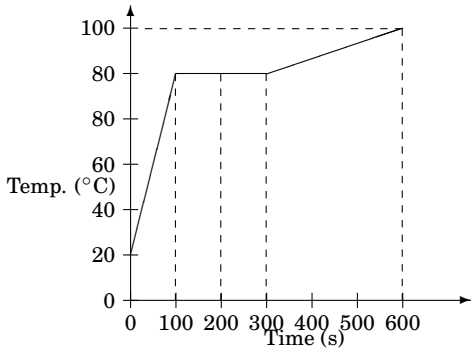
B. 50W.

C. 140W.

D. 600W **A**

$$\begin{aligned} P &= \frac{mc\Delta T}{t} \\ &= \frac{0.05 \times 2000 \times (50-20)}{100} \\ &= 30W \end{aligned}$$

15. When a 100W heater is used to heat 1kg of solid wax the temperature of the wax is observed to change with time as shown below



Find the specific latent heat of fusion of the wax.

A. 1.0×10^4Jkg^{-1}

B. 2.0×10^4J kg^{-1}.

C. 3.0×10^4Jkg^{-1}

D. 6.0×10^4 Jkg^{-1} **B**

Using the time when the temperature is constant,

$$\begin{aligned} Pt &= ml_f \\ L_f &= \frac{Pt}{m} \\ &= \frac{100 \times (300-100)}{1} \\ &= 20000Jkg^{-1} \\ &= 2 \times 10^4 Jkg^{-1} \end{aligned}$$

16. A heater with a power rating of 100W is placed in 0.5kg of ice at 0^0C. How long will it take the heater to melt all the ice? (Specific latent heat of fusion of ice $= 3.34 \times 10^5$ Jkg^{-1})

A. 1.67×10^{-3}

B. 1.67×10^3

C. 3.34×10^{-3}

D. 3.34×10^3 **B**

$$\begin{aligned} Pt &= mL_f \\ t &= \frac{0.5 \times 3.34 \times 10^5}{100} \\ &= 1.67 \times 10^3 \end{aligned}$$

Section B (Structured)

17. The specific heat capacity of water is 4200Jkg^{-1}k^{-1}. What is meant by the above statement?

It means that 4200 Joules of heat energy are required to increase the temperature of 1kg mass of water by 1 kelvin or 1 degree celcius.

18. State two reasons why water is used in the cooling system of a car engine?

(i) *besause water has a high specific heat capacity and*

(ii) *its boiling point is far above the working temperature of the car engine*

19. An immersion heater rated $1000W, 250V$ supplies heat to $80kg$ of a liquid in a tank. If the temperature of the liquid rises by$40°C$ in 48 minutes, what is specific heat capacity of the liquid?

From the law of conservation of energy,

heat gained by water = heat lost by heater

$$\begin{aligned} Mc\Delta T &= Pt \\ c &= \frac{Pt}{M\Delta T} \\ c &= \frac{1000 \times 48 \times 60}{80 \times 40} \\ &= 900Jkg^{-1}k^{-1} \end{aligned}$$

20. What is meant by specific heat capacity of a substance?

It is the amount of heat required to change the temperature of 1kg mass of that substance by 1kelvin or $1°C$.

21. When a block of iron of mass 2 kg absorbs 19KJ of heat, its temperature rises by 10^0C. Find the specific heat capacity of the iron.

From $H = mc\Delta T$

$$\begin{aligned} c &= \frac{H}{m\Delta T} \\ &= \frac{19000}{2 \times 10} \\ &= 950Jkg^{-1}K^{-1} \end{aligned}$$

22. Calculate the heat required to convert *0.8kg* of water at $100°C$ to steam. [Specific latent heat of vaporization of water = $2.26\times10^6Jkg^{-1}$

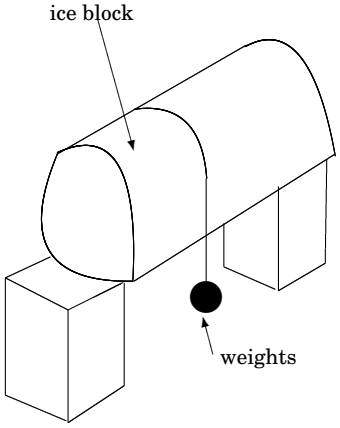
$$\begin{aligned} \text{Heat} &= Ml_v \\ &= 0.8 \times 2.26 \times 10^6 \\ &= 1.808 \times 10^6 J \end{aligned}$$

Paper II (Essay)

23. (i) Define latent heat of fusion.

(ii) Describe with aid of a labeled diagram, an experiment to show the effect of increase in pressure on the melting point of ice.

(iii) If the melting point of lead is $327°C$,find the amount of heat required to melt $200g$of lead initially at $27°C$. Specific heat capacity of lead is 140Jkg$^{-1}K^{-1}$ Specific latent heat of fusion of lead is 2.7×10^5Jkg^{-1}



Solution

(i) Latent heat of fusion is the amount of heat required to change to state of a substance from solid to liquid at constant temperature.

(ii) Effect of pressure on meeting point of ice. When a wire is tied to 2 masses and made to rest on the block of ice.

After sometime the wire if found to have entered into the ice block. Inside the ice block the temperature is not $0°C$ but may be $-2°c$. So inside the ice block, the pressure exerted by the wire makes ice melt at $-2°C$ have application of pressure on ice (something which expands on solidifying) lowers its meeting point.

(iii) Amount of heat required, H is

$$\begin{aligned} H &= mc\Delta T + ml_F \\ &= \frac{200}{1000}\cdot 140\cdot(327-27) \\ &\quad +\frac{200}{1000}\times 2.7\times 10^5 \\ &= 8400+54000 \\ &= 62400\text{Joules} \end{aligned}$$

24. (a) Define specific latent heat of vapourization

(b) **A calorimeter of mass 35.0g and specific heat capacity $840Jkg^{-1}k^{-1}$ contains 143.0g of water at $7°$C. Dry steam at $100°$ C is bubbled through the water in the calorimeter until the temperature of the water rises to $29°$C. If the mass of steam which condenses is 5.6g,**

(i) **Calculate the heat gained by the water and calorimeter**

(ii) **obtain an expression for the heat lost by the**

steam in condensing at 100°C and in cooling to 29°C.

(iii) **find the specific latent heat of vaporization of water.**

Solution

(a) Specific latent heat of vapourisation is the amount of heat required to change 1kg mass of a substance from liquid state to vapour state at its boiling point.

(b) from the question we have;
Mass of calorimeter,

$$\begin{aligned} m_c &= 35g \\ &= \frac{35}{1000}kg \end{aligned}$$

Its specific heat capacity, $C_c = 840Jkg^{-1}k^{-1}$ Mass of water in it,

$$\begin{aligned} m_w &= 143g \\ &= \frac{143}{1000}kg \end{aligned}$$

Temperature of water in it, $T_i = 7^{\circ}$
Temperature of steam, $= 100^{\circ}$
Final temperature of water, $T_f = 29^{\circ}$
Mass of condensed steam ,

$$\begin{aligned} m_s &= 5.6g \\ &= \frac{5.6}{1000}kg \\ &= 5.6 \times 10^{-3}kg \end{aligned}$$

(i) Heat, H gained by water and calorimeter, is given by;
$\Delta T = 29 - 7 = 22$

$$\begin{aligned} H_w &= m_w c_w \Delta T \\ &= \frac{143}{1000} \times 4200 \cdot 22 \\ &= 13213.2J \end{aligned}$$

$$\begin{aligned} H_{cal} &= m_c c_c \Delta T \\ &= \frac{35}{1000} \times 840 \cdot 22 \\ &= 646.8J \end{aligned}$$

$$\begin{aligned} H &= H_w + H_{cal} \\ &= 13213.2 + 646.8 \\ &= 13860J \end{aligned}$$

(ii) Heat lost by steam at 100°C and in cooling to 29°C
Heat lost is equal to heat required to condense heat required to cool it.

$$\begin{aligned} &= m_s l_v + m_s c_w \Delta T \\ &= m_s l_v + m_s c_w (100 - 29) \\ &= \frac{5.6}{1000} \cdot l_v + \frac{5.6}{1000} \cdot 4200 \cdot 71 \\ &= \frac{5.6}{1000} L_v + 1669.92 \end{aligned}$$

(iii) to find the specific latent heat of vaporization of water we equate the above two expression according to the law of conservation of energy.
Heat lost by steam is equal to heat gained by water and calorimeter

$$\frac{5.6}{1000}L_v + 1669.92 = 13860$$

$$\begin{aligned}
\frac{5.6}{1000}L_v &= 13860 - 1669.92 \\
\frac{5.6}{1000}L_v &= 12190.08 \\
5.6L_v &= 12190.08 \times 1000 \\
5.6L_v &= 12190080 \\
\frac{5.6L_v}{5.6} &= \frac{12190080}{5.6} \\
L_v &= 2176800 Jkg^{-1} \\
L_v &= 2.1768 \times 10^6 Jkg^{-1}
\end{aligned}$$

hence the specific latent heat of vaporization of water is $2.1768 \times 10^6 Jkg^{-1}$

25. (a) **Describe an experiment to determine the specific latent heat of vaporization of steam.**

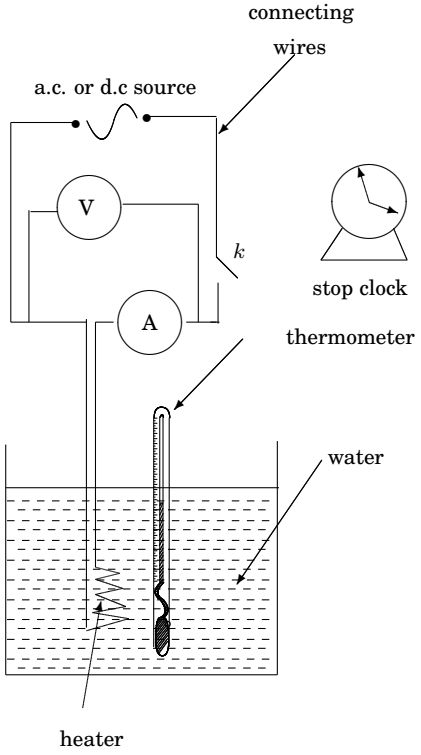
(b) **A copper container of heat capacity $60Jk^{-1}$ contains 0.5kg of water at $20°$C. Dry steam is passed into the water until the temperature of the container and water reaches $50°$C. Calculate the mass of steam condensed?**

Solution

(a) An experiment to determine the specific latent heat of vapourisation of steam.

This is an approximate method

- Pour water in the lagged container and dip in it a heater connected to the electric source as shown below;



- close the switch, k,
- When the water starts boiling Read and record the ammeter reading, I, and Voltmeter reading,V
- Measure the net mass of the lagged container with water , m_0 , start the stop clock. After a few minutes(about 10 minutes) and then open the switch.

- Record the time, t, for which the heater was on.
- Measure the mass m_1 of the system again, record the difference ,$m = (m_1 - m_0)$

Assuming no heat loss, heat used to vapourise the water, E_{vapour} is equal to the electric energy supplied, E_{supplied}

$$\begin{aligned} E_{\text{vapour}} &= E_{\text{supplied}} \\ ml_v &= Pt \\ ml_v &= VIt \\ l_v &= \frac{VIt}{m} \\ \text{or} \quad l_v &= \frac{VIt}{m_1 - m_0} \end{aligned}$$

where m is the mass in kg of water that evaporated.
I and V are the ammeter and Voltmeter readings in Volts and Amperes respectively. t is time taken for m kg of water to evaporate.

(b) Heat lost, H_l, by steam $ml_v + mc\Delta T$ is equal to the sum of heat, H_g gained by water $mc\Delta T$ and copper calorimeter $C\Delta T$

$$\begin{aligned} H_g &= mc\Delta T + C\Delta T \\ &= (mc + C)\Delta T \\ &= (0.5 \times 4200 + 60) \\ &\quad (50^\circ - 20^\circ) \\ &= (2100 + 60) \times 30 \\ &= 2160 \times 30 \\ H_g &= 64800 \end{aligned}$$

$$\begin{aligned} H_l &= ml_v + mc\Delta T \\ &= m(l_v + c\Delta T) \\ &= m(2.6 \times 10^6 + 4200 \times (100 - 50) \\ &= 2,810,000J \end{aligned}$$

since

$$\begin{aligned} H_l &= H_g \\ m &= \frac{64800}{2810000} \\ &= 0.023kg \\ &= 23g \end{aligned}$$

hence 0.023g of steam condensed.

26. (a) **The graph in fig. 1 shows a cooling curve of a liquid. Describe the main features of the curve.**

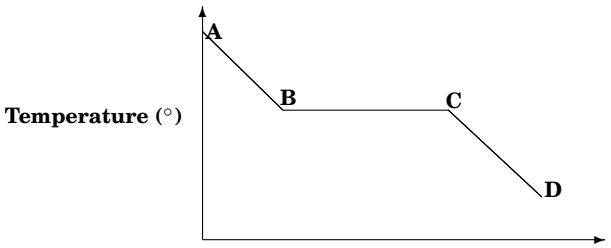


Fig. 1

(b) (i) Define the term specific latent heat of fusion?

(ii) **A copper can of mass 0.2kg contains 0.20kg of water at** 10°**C. The can and its contents are placed in a refrigerator. Calculate the quantity of heat given out if the temperature of the can and its contents falls to** -2°**C.**

Solution

(a) From the curve;

In the region AB, heat lost is the internal kinetic energy hence the temperature of the body decreases.

In the region BC, heat lost is the internal potential energy hence the temperature remains constant as the solid changes to liquid state.

In the region CD, heat lost is the internal kinetic energy hence the temperature of the body decreases.

(b) (i) specific latent heat of fusion is the amount of heat energy required to change the state of 1kg mass of a solid from solid state to liquid state at its melting point.

(ii)Heat lost by the copper can

$$\begin{aligned} H &= mc\Delta T \\ &= 0.2 \times 400 \times (10 - -2) \\ &= 0.2 \times 400 \times 12 \\ &= 960J \end{aligned}$$

heat lost by water, P

$$\begin{aligned} P &= mc_W\Delta T + ml_f \\ &\quad +mc_I\Delta T \\ &= m(c_w\Delta T + l_f \\ &\quad +c_I\Delta T) \\ &= 0.2\,(4200 \times 10 \\ &\quad +340,000 + 2100 \times 2) \\ &= 0.2(42000 + 340000 \\ &\quad +4200) \\ &= 0.2 \times 386200 \\ &= 77240J \end{aligned}$$

Total heat given out is

$$\begin{aligned} &= 960 + 77240 \\ &= 78200J \end{aligned}$$

Hence the total energy given out is 78200J

27. The graph in figure 3.1 on page 176 shows the variation of temperature of a metal with time

(i)**Using the graph explain what happens to the metal**

(ii) **What will the temperature of the metal be after 1000 seconds**

(iii) **If the metal absorbs heat at the rate of 2500**Js^{-1} **and the specific heat capacity is** $300Jkg^{-1}k^{-1}$**. calculate the mass of the metal?**

(iv) **Find the specific latent heat of the metal?**

Solution

(b) (i) the metal is being heated and it changes state from solid to liquid state

(ii) From the graph; when the metal is changing to the liquid state, its temperature is 1120°C

(iii)let heat absorbed be Q

$$\begin{aligned} Q &= mc\Delta T \\ \frac{\Delta Q}{\Delta t} &= mc\frac{\Delta T}{\Delta t} \\ \text{But } \frac{\Delta Q}{\Delta t} &= 2500Js^{-1} \end{aligned}$$

from graph,

$$\begin{aligned} \frac{\Delta T}{\Delta t} &= \frac{940-240}{400-0} \\ &= \frac{700}{400} \\ &= \frac{7^{\circ}}{4}Cs^{-1} \end{aligned}$$

$$\begin{aligned} \frac{\Delta Q}{\Delta t} &= mc\frac{\Delta T}{\Delta t} \\ 2500 &= mc\frac{7}{4} \\ 2500 &= m \times 300 \times \frac{7}{4} \\ 10000 &= 2100m \\ \frac{10000}{2100} &= \frac{2100m}{2100} \\ m &= \frac{10000}{2100} \\ &= 4.762kg \end{aligned}$$

(iv) Since the rate of heat absorption is the same, we say

$$\begin{aligned} H &= ml_f \\ Pt &= ml_f \end{aligned}$$

$$\begin{aligned} t &= 750-410 \\ &= 340s \\ P &= 2500Js^{-1} \\ m &= \frac{100}{21}kg \end{aligned}$$

substituting these into

$$\begin{aligned} Pt &= ml_f \\ l_f &= \frac{Pt}{m} \\ &= \frac{2500 \times 340}{\frac{100}{21}} \\ &= \frac{21 \times 2500 \times 340}{100} \\ &= 178,500Jkg^{-1} \end{aligned}$$

28. An electric heater of resistance 40Ω is connected to a 240V mains. How long will it take to raise the temperature of 4kg of water from 40°C to 100°C

Solution

(b) Using the law of conservation of energy, Heat supplied by heater , Pt is equal to the heat absorbed by water, $mc\Delta T$

$$\begin{aligned} Pt &= mc\Delta T \\ \frac{V^2}{R}t &= 4 \times 4200 \times (100-40) \\ \frac{240^2}{40}t &= 4 \times 4200 \times 60 \\ 1440t &= 1008000 \\ t &= \frac{1008000}{1440} \\ &= 700 \text{ seconds} \end{aligned}$$

hence it takes 700 seconds.

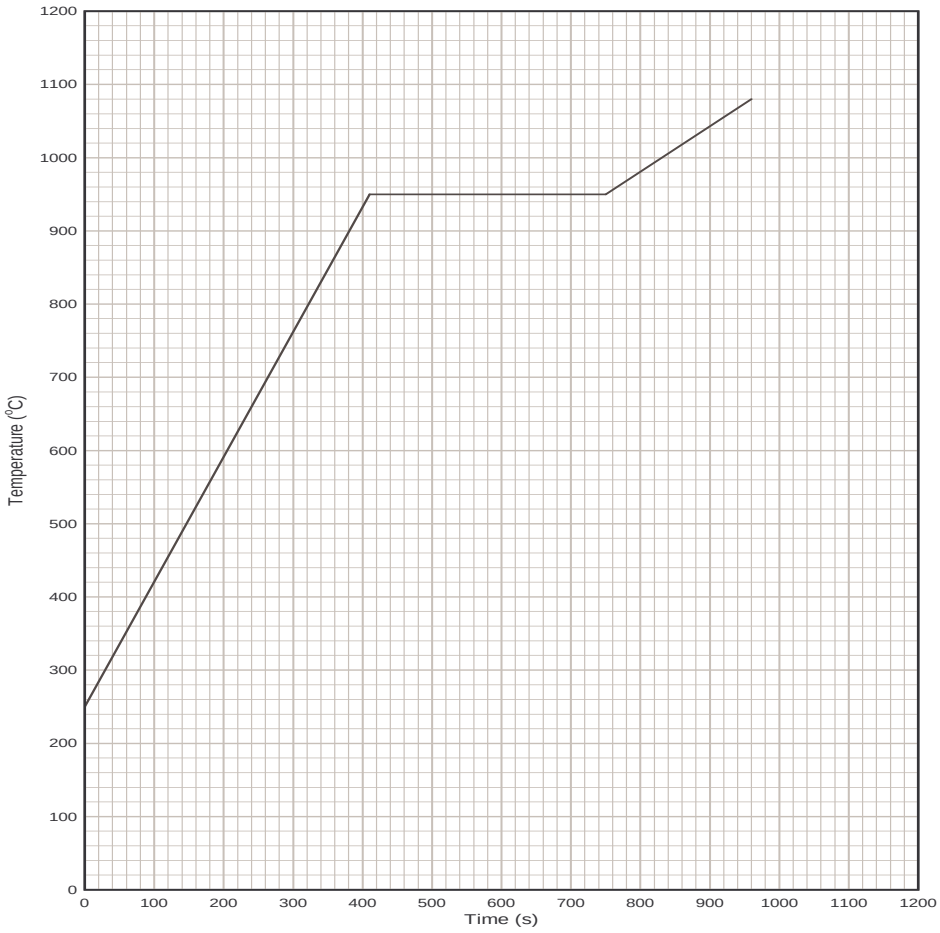


Figure 3.1: Graph of Temperature against time

3.4 Heat expansion

Section A (Objectives)

1. A bimetallic strip operates on the principle that metals

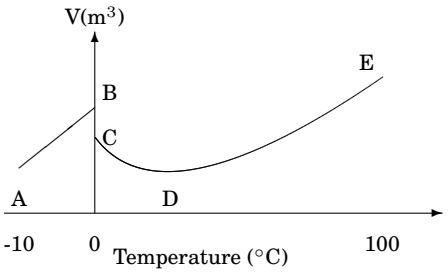
   A. are heat controllers

   B. are good heat conductors.

   C. have different rates of expansion

   D. have the same rates of expansion. **C**

2. The graph in fig. 6 shows ice being heated from -10° to 100°C.



   At what point does the substance have maximum density?

   A. E

   B. C

   C. D

   D. B **C**

3. Which of the following statements is incorrect when a tin containing air tightly sealed is heated?

   A. The average speed of molecules increases.

   B. The molecules of air hit the walls of tin harder.

   C. The molecules of air strike the walls less often.

   D. The pressure inside the time increases. **C**

4. A tight bottle top becomes easier to unscrew when hot water flows over it because the

   A. cap expands more than the glass.

   B. glass in the neck of the bottle contracts.

   C. hot water acts like oil between the glass and bottle.

   D. increased pressure of the air in the bottle causes the cap to expand. **A**

   (i) is very wrong also (iii) is not correct but there is no answer which does not contain (iii). Just to avoid (i) we choose bf C

5. Which of the following changes in volume, mass and density respectively occur when a metal block is heated?

   A. increases, remains the same, decreases

   B. increases, increases, increases

   C. remains the same, remains the same, decreases

   D. increases, remains the same, increases **A**

6. The unusual expansion of water when it is cooled between 4°C and 0°C is due to

A. water molecules coming closer together to form a compact structure.

B. formation of a new arrangement of molecules which requires a larger volume.

C. the increased repulsive forces between the water molecules.

D. differences in the sizes of water and ice molecules. **B**

Section B (Structured)

Paper II (Essay)

7. .

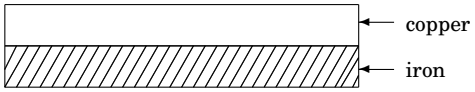


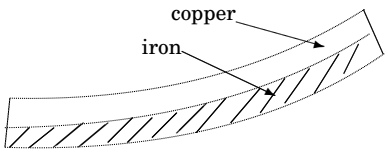
Fig. 10

fig. 10 shows strips of copper and iron bonded together.

(i) Redraw the diagram to show what happens when he strip is heated.

(ii) Why does the change you have shown in (a)(i) take place?

(i)



(ii) *Because copper and iron do not expand at the same rate.*

8. Explain why gaps are left between rails in a railway line.

To allow room for expansion when they are heated by the sun or friction between the rails and railway wheels.

9. Why do gases expand much more than solids for the same temperature change?

Because the gas molecules are free to move and they have weak molecular force compared to those in solids.

10. Name one application of a bimetallic strip.

to control temperature in thermostats.

11. Why is the freezing compartment of a refrigerator placed at the top?

To allow easy circulation of the coldness because cold air is dense so it goes down to the lower compartments.

3.5 Gas laws

Section A (Objectives)

1. An air bubble is introduced at the bottom of a jar containing mercury. Which one of the following explains what will happen to the bubble?

   A. It will be pressed by the mercury column and burst.

   B. it will rise to the surface while decreasing in size.

   C. It will rise to the surface while increasing in size.

   D. Nothing will happen to the bubble. **C**

2. A given mass of gas occupies a volume of 200 cm^3 at a temperature of 27^{o}c and a pressure of one atmosphere. Find the volume when its temperature rises to 54^{0}C at constant pressure .

A. $\frac{200\times1\times327}{300}$
C. $\frac{200\times300}{327\times1}$
B. $\frac{300\times327}{200\times1}$
D. $\frac{327\times1}{200\times300}$ **A**

$$\begin{aligned}\frac{V_1}{T_1} &= \frac{V_2}{T_2}\\ V_2 &= \frac{V_1T_2}{T_1}\\ T_1 &= 27+273=300k\\ T_2 &= 54+273=327k\\ V_2 &= \frac{200\times327}{300}\end{aligned}$$

3. When air is pumped in a tube at constant temperature, the pressure increases because

   A. the molecules are larger.

   B. the molecules are moving faster

   C. the molecules are closer together.

   D. more molecules are hitting the tube. **D**

4. The volume of a fixed mass of gas at 27.0°C and a pressure of 750mm of mercury is 300cm^3. What is its volume when the pressure is raised to 900mm mercury and the temperature is 327°C?

   A. 125cm^3

   B. 180cm^3

   C. 500cm^3

   D. 720cm^3 **C**

$$\begin{aligned}\frac{P_1V_1}{T_1} &= \frac{P_2V_2}{T_2}\\ V_2 &= \frac{P_1V_1T_2}{T_1P_2}\\ V_2 &= \frac{750\times300\times(327+273)}{(27+273)\times900}\\ &= \frac{750\times300\times600}{300\times900}\\ &= 500\end{aligned}$$

5. When the pressure of a fixed mass of a gas is reduced by half, its volume

   A. doubles at constant temperature.

   B. is halved at constant temperature.

   C. is halved if the temperature is also halved

   D. remains the same at constant temperature

   A

6.

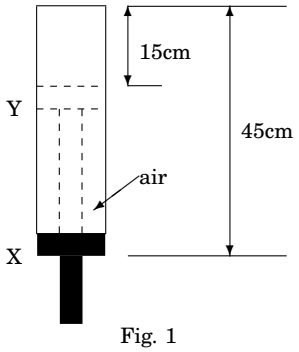


Fig. 1

In fig. 1 above the piston is moved from X to Y at constant temperature. The air pressure is

A. trebled

B. doubled

C. reduced by a third

D. unchanged **A**

Volume is made $\frac{1}{3}$ of the original volume then pressure is multiplied by 3 i.e trebled because at contant temperature Boyle's law holds i.e.

$$\begin{aligned} PV &= \text{constant} \\ PV &= \left[\frac{1}{3}V\right][3P] \\ &= PV \end{aligned}$$

7. The pressure of a fixed mass of a gas at 17^0C is 10^5pa. find its pressure at 27^0C if the volume remains constant.

   A. $\frac{27}{17} \times 10^5$pa.

   B. $\frac{17}{27} \times 10^5$ pa

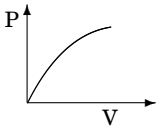
   C. $\frac{300}{290} \times 10^5$pa.

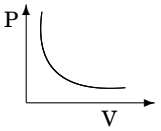
   D. $\frac{290}{300} \times 10^5$pa. **C**

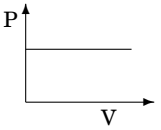
   For constant volume, pressure law holds.

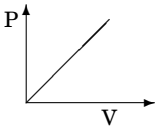
$$\begin{aligned} \frac{P_1}{T_1} &= \frac{P_2}{T_2} \\ P_2 &= \frac{P_1}{T_1} \times T_1 \\ &= \frac{10^5}{(17+273)} \times (27+273) \\ &= \frac{300}{290} \times 10^5 \end{aligned}$$

8. Which of the following graphs shows the variation of the pressure of a gas as the volume changes at a constant temperature?

A. 

B. 

C. 

D. 

B

9. The pressure exerted by a gas decreases when its volume is increased at a constant temperature because the molecules

A. move faster.

B. move closer to one another.

C. hit the walls more often.

D. hit the walls less frequently.

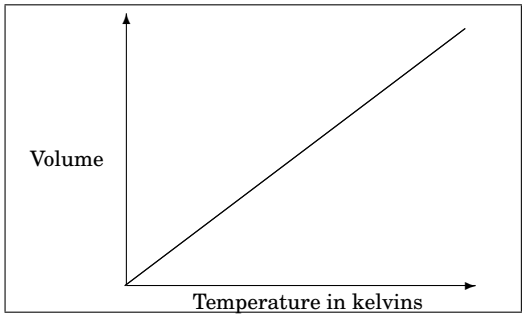
C

Section B (Structured)

10. Explain why increase in temperature increases the pressure of a gas.

Increase in temperature increases the speed of molecules which inturn undergo greater change in momentum when the gas molecules collide with the wall hence exerting greater force and pressure on the wall of the container.

11. Sketch the variation of volume with temperature in Kelvin, for a gas at constant pressure.



12 State Boyle's law

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

13. A volume of a fixed mass of a gas increases from $300cm^3$ to $500cm^3$ at a constant temperature. Find the new pressure if the initial pressure is $70cmHg$.

From Boyle's law

$$P_1V_1 = P_2V_2$$
$$P_2 = \frac{P_1V_1}{V_2}$$
$$P_2 = \frac{70 \times 300}{500}$$
$$= 42cmHg$$

Paper II (Essay)

14. (a) With the aid of a labeled diagram, describe an experiment to show how volume of a gas varies with pressure at constant temperature.

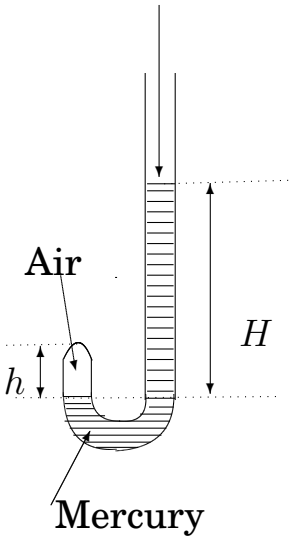
(b) **A gas of volume** $1000cm^3$ **at a pressure of** $4.0 \times 10^5 Pa$ **and temperature** $17°$**C is heate to** $89.5°$ **at constant pressure. Find the new volume of the gas.**

Solution

(a) An experiment to show how volume of a gas varies with pressure at constant temperature.

- Get a J-tube and pour mercury in it so as to trap some air in it as shown below;

  Atmospheric pressure, $P_\circ$



  the trapped air is at a pressure P, given by

$$\begin{aligned} P &= P_\circ + H\rho g \\ &= H_\circ \rho g + H\rho g \\ &= (H_\circ + H)\,\rho g \end{aligned}$$

  where ρ is density of mercury and g is acceleration due to gravity.

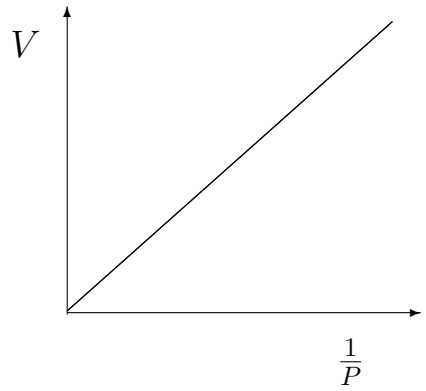
  Volume of air trapped = $V = Ah$

  Where A is the cross sectional area of the $J-$tube

- Add in more mercury in small quantities to obtain more values of h and H. And tabulate your results as shown below;

h	H	V	P	$\frac{1}{P}$

- Plotting a graph of V against $\frac{1}{P}$ we get



  this shows that the volume of a fixed mass of a gas is inversely proportional to the pressure it exerts provided its temperature remains constant.

(b) Since pressure is constant, we use Charles's law i.e.

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

from the question

$$\begin{aligned} V_1 &= 1000cm^3 \\ P_1 &= 4.0 \times 10^5 Pa \\ T_1 &= 17^\circ C \\ &= (17^\circ + 273) \\ &= 290 Kelvins \\ T_2 &= 89.5^\circ C \\ &= 89.5^\circ + 273 \\ &= 362.5 Kelvin \\ V_2 &= ? \end{aligned}$$

Using Charles's law

$$\begin{aligned}\frac{V_2}{T_2} &= \frac{V_1}{T_1}\\ \Longrightarrow V_2 &= \frac{V_1}{T_1}\times T_2\\ &= \frac{1000cm^3}{290k}\times 362.5k\\ &= 1250cm^3\end{aligned}$$

hence the new volume of the gas is $1250cm^3$.

15. (a) State the kinetic theory of matter.

(b) **State the law of volume and temperature (Charle's law).**
The volume of a fixed mass of a gas at a given pressure is 1.5m^3 at 300k. At what temperature will the volume of the gas be 0.5m^3 at the same pressure?

Solution

(a) Kinetic theory of matter states that, matter is made up of small particles (atoms or molecules) which are ever in a state of motion hence having kinetic energy and are ever in a state of attraction and repulsion hence having potential energy, the sum of their kinetic and potential energy constitute the heat energy or internal energy of the body.

(b) The law of volume and temperature states that the volume of a fixed mass of a gas at constant pressure is directly proportional to its absolute temperature;

from the question.

$$\begin{aligned}V_1 &= 1.5m^3\\ T_1 &= 300K\\ V_2 &= 0.5m^2\\ V_2 &= ?\end{aligned}$$

pressure is constant hence we use Charles's Law i.e.

$$\begin{aligned}\frac{V_1}{T_1} &= \frac{V_2}{T_2}\\ T_2V_1 &= T_1V_2\\ T_2 &= \frac{T_1}{V_1}\times V_2\\ &= \frac{300}{1.5}\times 0.5\\ &= 100K\end{aligned}$$

hence temperature will be 100k

16. (a) What is an equation of state of a gas?

(b) (i) With the aid of sketch graph, describe how absolute zero of temperature can be defined.

(ii) **Use the kinetic theory of gases to explain the existence of absolute zero of temperature.**

(c) **A volume of $2500cm^3$ of hydrogen gas is collected at 67°C at a pressure of 730mmHg**

Calculate the volume of the gas at S.T.P

Solution

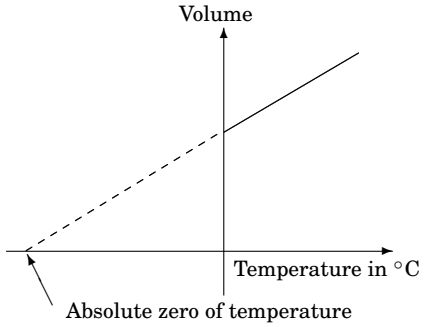
(a) the equation of state of a gas is

$$PV = nRT$$

Where P is the pressure it exerts, V is the volume it occupies, R is the universal gas constant, T its temperature and n is the number of moles

(b) (i) absolute zero of temperature.

For a graph of volume against temperature in °C for any gas, we have;



It is the temperature where the volume of an ideal gas is expected to be zero

(ii) According to the kinetic theory of gases, temperature is a measure of the average kinetic energy of the molecules of a gas,

If the temperatures of the gases is reduced also their amplitude of vibration reduces. This makes us conclude that if a gas is cooled further and further at a certain temperature, the molecules will have zero amplitude of vibration or zero kinetic energy and that temperature would be the absolute zero of temperature.

(c) from the question;

Let subscript 1 mean initial state and subscript 2 mean final state

$$\begin{aligned} \text{Then } V_1 &= 2500cm^3 \\ T_1 &= 67°C \\ &= (67 + 273)\,K \\ &= 340 \text{ Kelvins} \\ P_1 &= 730mmHg \\ \text{At S.T.P. } V_2 &= ? \\ P_2 &= 760mmHg \\ T_2 &= 273 \text{ Kelvins} \end{aligned}$$

Using the general gas equation because PV and T change, we have

$$\begin{aligned} \frac{P_1V_1}{T_1} &= \frac{P_2V_2}{T_2} \\ V_2 &= \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2} \end{aligned}$$

$$\begin{aligned} V_2 &= \frac{730 \times 2500}{340} \times \frac{273}{760} cm^3 \\ &= 1928.12cm^3 \end{aligned}$$

Hence the volume of the gas at S.T.P. is $1928.12cm^3$

(d) What is observed, is the zigzag motion caused by the collision of

the smoke molecules with air molecules. This motion is called Brownian motion.

When the temperature is increased, the zigzag motion is more fast i.e. the molecules now move faster

3.6 vapours

Section A (Objectives)

1. Which of the following can produce a cooling effect?

   (i) Compression of a gas.

   (ii) Expansion of gas

   (iii) Evaporation of a liquid

   A. (i), (ii) and (iii).

   B. (i) and (iii) only.

   C. (ii) and (iii) only.

   D. (iii) only. **C**

2. A domestic refrigerator uses a volatile liquid. Which of the following represents the order of the processes the liquid undergoes?

   A. Evaporation, cooling, compression, condensation, evaporation.

   B. Cooling, condensation, evaporation, compression, evaporation.

   C. compression, evaporation, condensation, cooling, evaporation.

   D. Condensation, cooling, evaporation, compression, evaporation. **A**

3. The rate of evaporation from a body is increased by

   (i) temperature

   (ii) pressure

   (iii) liquid with greater cohesive forces

   (iv) dryness of air around the body

   A. (i) and (ii) only

   B. (ii) and (iii) only

   C. (i) and (iv) only

   D. (iii) only **C**

Section B (Structured)

4. Explain why evaporation causes cooling.

Evaporation causes energetic molecules leave a substance. This reduces the average kinetic energy of the molecules of a substance which is proportional to temperature hence cooling it.

5. State two factors which affect the boiling point of water.

1. *Pressure (or external pressure)*
2. *Impurities in water*

6. .

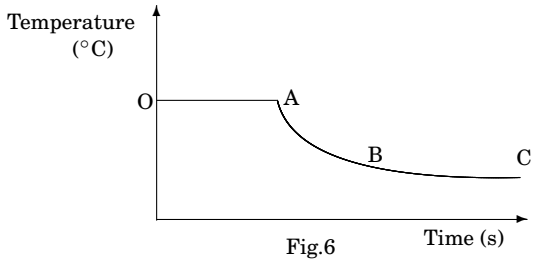


Fig.6

Fig. 6 shows temperature versus time curve for a liquid. State what is happening along BC.

The liquid which melted at OA attains room temperature

7. Use the kinetic theory of matter to explain what is happening along OA.

The liquid is losing its internal potential energy to the surrounding hence changing state from solid to liquid at constant temperature.

8. What is a saturated vapour?

It is a vapour in contact with its own liquid.

9. Equal volumes of water at the same temperature are poured in a basin and in a jug. State giving a reason which water will evaporate faster.

The one in the basin evaporates fast because it has a larger surface area exposed to air and the larger the surface area, the greater the rate of evaporation.

10. What are the functions of the following in a refrigerator

(i) Compressor

(ii) cooling fins?

(i) *to pump the evaporated vapour to the cooling fins to loss heat and cool.*

(ii) *To radiate the heat that has been extracted from the footstuff to the surrounding air.*

11. Distinguish between boiling and evaporation.

Boiling is the process by which a liquid changes to a vapour when its saturated vapour pressure is equal to the external pressure at constant temperature and evaporation is the process by which a liquid changes to a vapour at any temperature.

Paper II (Essay)

12. (i) What is meant by saturated vapour pressure?

(ii) **Explain what may happen when one is to cook food from a very high attitude.**

Solution

(i) Saturated vapour pressure is the pressure exerted by a vapour in contact with its own liquid.

(ii) Cooking food at a very high altitude, where atmospheric pressure is low, it takes long to be ready, this is because water boils at a much lower temperature due to low atospheric pressure.

13. (a) What is meant by latent heat of evaporation?

(b) **With the aid of a labeled diagram describe how a refrigerator works.**

(c) **The cooling system of a refrigerator extracts 0.7KW of heat. How long will it take to convert 500g of water at** 20°**C into ice?**

(d) **Explain how evaporation takes place**

Solution

(a) latent heat of evaporation is the amount of heat required to change a substance from liquid to gaseous state at its boiling point

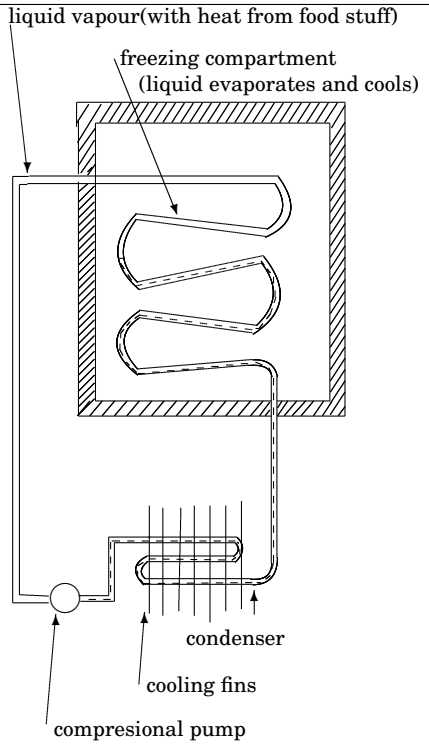
(b) how a refrigerator works;

A refrigerator is a device in which a volatile liquid is made to evaporate. It is made up of 3 parts.

- The pump
- The freezing box
- The condenser

The pump pumps the volatile liquid from one end to the other reducing the vapour pressure so as to enable the liquid to boil or evaporate.
the freezing box is the point where the volatile liquid actually evaporates and absorbs the required heat to evaporate from the foods and beverages near it.
The condenser is where the copper coils from the freezing box are connected to the cooling copper fins and the vapour compressed so as to condense and enable the vapour to loose the heat to the surrounding air via the cooling fins.

Diagram of refrigerator



(c) Power loss

$$\begin{aligned}\text{Power loss} &= 0.7kW \\ &= 0.7 \times 1000W \\ &= 700W\end{aligned}$$

To change $500g$ of water at $20°$C to ice at $0°C$ there are two process involved;

- To change temperature of water from $20°$C to $0°$C and
- to change the water at $0°$C to ice at $0°$C

heat required is equal to the sum of the two;

$$\begin{aligned}Pt &= mc\Delta T + ml_f \\ &= \frac{500}{1000} \times 4200 \times (20-0) \\ &\quad + \frac{500}{1000} \times 0.336 \times 10^6 \\ &= 42000 + 168000 \\ 700t &= 210000 \\ \frac{700t}{700} &= \frac{210000}{700} \\ t &= \frac{210000}{700} \\ &= 300 \text{ seconds}\end{aligned}$$

hence the refrigerator takes 300 seconds or 5 minutes

(d) evaporation takes place when liquid molecules have or are given high molecular speed by heating them and they escape from the attraction of their neighbouring liquid molecules to vapour or gaseous state. When this occurs for more liquid molecules at any temperature, then we say that the liquid is evaporating

14. (c) Explain, in terms of molecules, what is meant by a saturated vapour.

(d) Describe briefly one application of evaporation.

Solution

(c) a saturated vapour is a vapour that is in dynamic equilibrium with its own liquid or in contact with its own liquid. Interms of the molecules of the liquid, it the vapour in contact with its liquid such that the number of vapour molecules condensing to liquid state is equal to the number of liquid molecules changing to the vapour state.

(d) One application of evaporation is in the desalination of salty water.

Here the salty water is placed in an air tight container and then connected to a vacuum pump. This pump reduces the vapour pressure of water at room temperature hence all the water evaporates at room temperature leaving the salt behind.

OR

In seasoning wood i.e. drying wood.

3.7 Heat Engines

Section A (Objectives)

1. Which one of the following statements is true about energy transformation?

   A. A steam engine changes heat energy into mechanical energy.

   B. A thermopile changes electrical energy to heat energy.

   C. A dynamo changes electrical energy to mechanical energy

   D. A microphone changes electrical energy to sound energy.

   A

2. In a four-stroke combustion engine, the correct order of strokes is

   A. compression, power, exhaust, induction

   B. exhaust, compression, power, induction

   C. induction, compression, power, exhaust

   D. induction, power, compression, exhaust **C**

Section B (Structured)

3. Why is a petrol engine referred to as a four-stroke engine?

Because its cycle of operation is composed of 4 steps, induction, compression, ignition and exhaust.

4. State two reasons why the efficiency of a petrol engine is quite low.

1. *it has allow compression ratio*
2. *there is incomplete combustion of petrol*

Chapter 4

Electricity and magnetism

Contents

4.1 Electrostatics

Section A (Objectives)

1. When a charged body is brought near a cap of a negatively charged gold leaf electroscope, the

A. divergence of the leaf does not change

B. leaf falls if the body is negatively charged

C. leaf diverges if the body is positively charged.

D. Leaf diverges if the body is negatively charged. **D**

2. Which one of the following materials can be electrified by friction?

A. Plastic pen

B. Silver rod

C. Copper rod

D. Wet wood **A**

a dry insulator is reqiured like a plastic pen

3. A charged conductor usually loses charge gradually by a process called

A. induction

B. insulation

C. conduction

D. leakage **D**

4. A brass rod is rubbed with silk and then brought near a positively charged gold leaf electroscope. The divergence of the leaf will

A. increase.

B. decrease

C. not change **A**

D. increase slightly and fall back.

5. The result of rubbing a glass rod with silk and separating them is

   A. a negative charge on the rod and an equal positive charge on the silk.

   B. equal amounts of negative charge on both.

   C. a positive charge on the rod and an equal negative charge on the silk.

   D. no charge on both the rod and the silk. **C**

6. A metal rod gains a positive charge when rubbed with fabric. The fabric acquire.

   A. no charge

   B. a negative charge equal to that on the rod.

   C. a positive charge equal to that on the rod.

   D. a positive charge greater than that on the rod. **B**

7. When a rod is brought close to the cap of a negatively charged gold leaf electroscope and its leaf diverges, it shows that the rod is

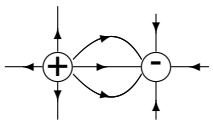
   A. negatively charged.

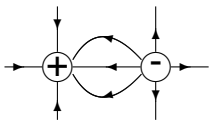
   B. Positively charged.

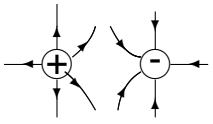
   C. Neutral.

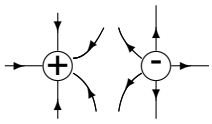
   D. Partially charged. **A**

8. Which one of the following diagrams represents the correct electric field pattern for two oppositely charged points?

   A. 

   B. 

   C. 

   D. 

   A

9. The laws of electrostatics induction state that

   A. like poles repel and unlike poles attract

   B. like poles attract and unlike pole repel

   C. like charges repel and unlike charges attract

   D. like charges attract and unlike charges repel **C**

10. Which of the following actions will cause the leaf of a negatively charged electroscope to fall?

    (i)Bringing a positively charged rod near the cap.

    (ii)Bringing a negatively charged rod near the cap.

    (iii)Connecting the can to the earth.

    A. (i) and (ii) only.

    B. (i) and (iii) only.

C. (ii) and (iii) only.

D. (i), (ii) and (iii). **B**

11. When polythene and wool are rubbed against each other and then separated, they acquire

A. no charge.

B. equal amount of same type of charge.

C. equal and opposite charges.

D. both acquire positive and negative charges **C**

12. A body can only be confirmed to be electrically charged when

A. another charged body attracts it.

B. it does not affect the leaf of a charged electroscope

C. it is repelled by another charged body.

D. it is found to have less protons than electrons. **C**

13. It is easier to charge insulators than conductors because

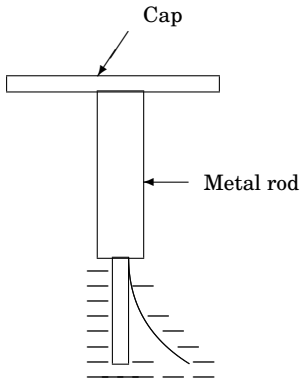
A. the insulators don't allow the charge to flow away but the conductors allow it to flow away

B. the conductors retain the charge by conduction but the insulators release it to the atmosphere

C. it is impossible to charge conductors under any condition.

D. insulators just receive the charge from the atmosphere without being rubbed. **A**

14.



The diagram above shows part of the gold leaf electroscope. What will happen to the leaf if a positively charged rod is brought near the cap of the electroscope? It will

A. increase in deflection

B. remain in the same position.

C. reduce in deflection

D. break off from the plate. **C**

The positive ions will attract the electrons from the plate and leaf, reducing the their total charge, reducing the force of repulsion, reducing the deflection.

15. Which of the following statement is true about a good electric insulator?

A. it acquires an electric charge when rubbed with suitable materials

B. all its electrons are loosely bound to its atoms.

C. Electric charge easily flows on its surface.

D. Some of its electrons are free to move about. **A**

16. An electroscope becomes negatively charged when it

A. Loses electrons.

B. Gains protons.

C. Gains electrons.

D. Loses protons. **C**

17. An insulating rod that can be charged positively, by rubbing with a piece of fabric is rubbed with fabric and left in contact for a long time then separated. What would you expect each one of them to have?

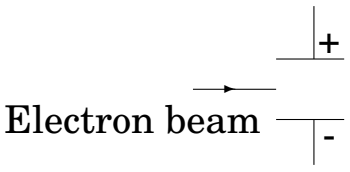
A. no charge.

B. equal number of opposite charges.

C. more positive charge on the rod than on the fabric.

D. more negative charge on the fabric than on the rod. **B**

18.



A beam of electrons is incident midway between two charged plates as shown above. The beam will

A. deflect upwards. **A**

B. deflect downwards.

C. move perpendicular to the plates.

D. pass through the plates undeflected

19.

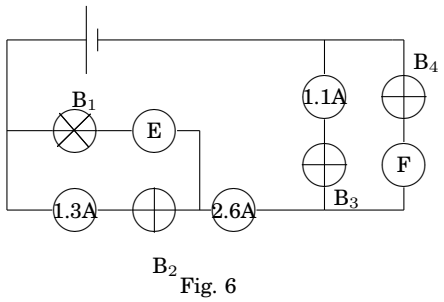


Fig. 6

In the above circuit B_1, B_2, B_3 and B_4 are bulbs. The readings of ammeters E and F are, respectively

A. 1.5A, 1.3A

B. 1.3A, 1.5A

C. 1.3A, 1.1A

D. 1.3A, 2.6A **B**

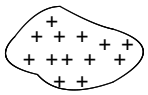
$$I_F = 2.6 - 1.1 = 1.5A$$
$$I_E = 2.6 - 1.3 = 1.3A$$

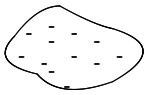
20. When a plastic rod is brought near a charged electroscope, the gold leaf is seen to diverge more. The possible charges on the rod and the electroscope are

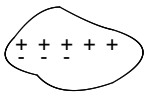
	Electroscope	Plastic rod
A.	positive	negative
B.	negative	positive
C.	Negative	negative
D.	Positive	uncharged **C**

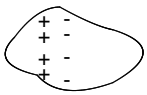
Divergence of the electroscope increases when they have the same charge i.e. positive and positive or negative and negative.

21. Which one of the following shows the correct distribution of electric charges generated in clouds due to violent movements within the thunder clouds?

A. 

B. 

C. 

D. 

D

The unequal distribution of electric charge in clouds is what causes the violent movements in thunder clouds. This is in **C**

Section B (Structured)

22. What happens to an insulator when it is rubbed by another insulator of different material?

One of the insulators losses electrons and becomes positively charged and the other gains them becoming negatively charged.

23. .

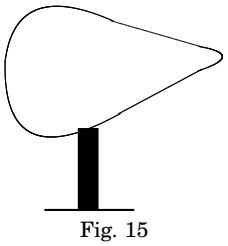
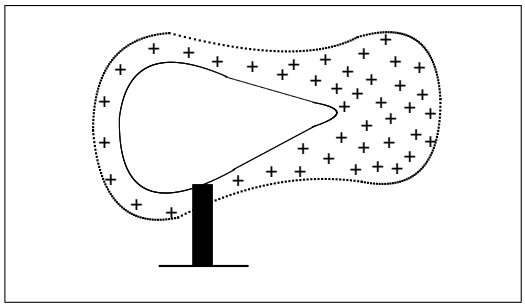


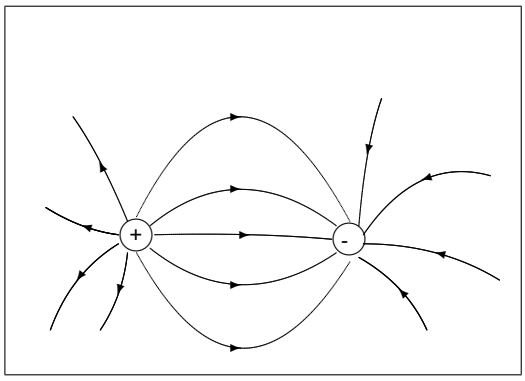
Fig. 15

Fig. 15 shows a conductor supported on an electrical insulator. The conductor is given some positive charge. Show how the charge is distributed on the conductor.



24 .

Sketch the electric field pattern due to two unlike charges P and Q above.



25. State the laws of electrostatics.

Like charges repel and unlike charges attract each other

26. Two insulting materials are rubbed together, describe what is observed if

(i) The two are brought near the cap of a gold leaf electroscope

(ii) Only one of them is brought near the cap.

(i) *The gold leaf will not diverge.*

(ii) *The gold leaf diverges*

27. Why is it difficult to perform experiments in electrostatics under damp conditions?

Because the charged bodies loose charge by corona discharge via the water vapour

28. A positively charged rod is brought near two conducting spheres A and B in contact as shown in fig. 9.

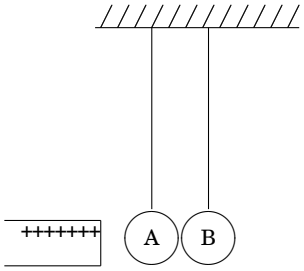
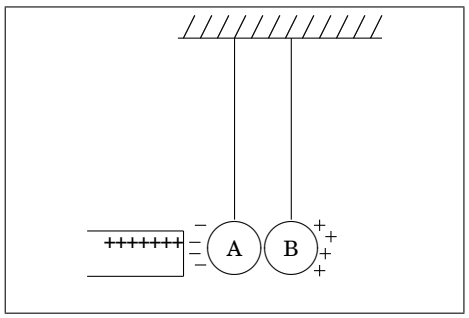


Fig. 9

(i) Show the charges on the spheres. (shown up)



(ii) Describe how the sphere may be given permanent charge

If they are separated when the charged rod is still in that position, they acquire opposite charges.

29. .

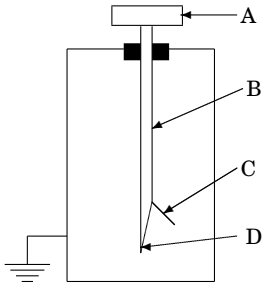


Fig.10

Fig. 10 shows the main parts of an electroscope. Name them.

A - metal cap

B - metal rod

C - gold leaf

D - metal plate

30. State two uses of an electroscope.

1. *to test for charge*
2. *to test for sign of charge*

31. .

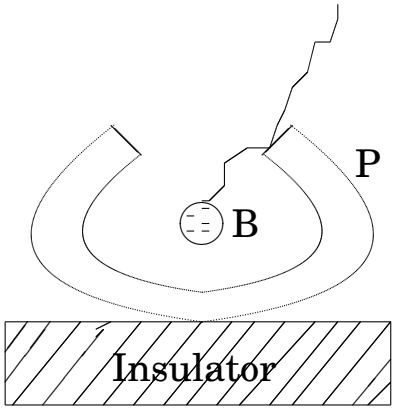


Fig. 10

Fig. 10 shows a negatively charged ball, B, inside a hollow metal conductor, P, resting on an insulator. Describe the distribution of charge on the metal conductor:

(i) Before B touches P.

inside P, it is positively charged and outside it is negatively charged with charge of same magnitude as that on B.

(ii) After B touches P.

B looses all its charge to P. The inside of P is not charged but its outside acquires a charge equal to that previously on B

Paper II (Essay)

32. (a) Describe how you would use a gold leaf electroscope to determine the sign of the charge on a given charged body.

(b) **Explain how an insulator gets charged by rubbing.**

(c) **Sketch the electric field pattern between a charged point and a metal plate.**

(d) **Describe how a lightening conductor safeguards a tall building from being struck by lightening.**

Solution

(a) To determine sign of charge on a given charged body.

- Get a positively charged electroscope (it's leaf is always diverged)
- Bring the charged body near its metal cap.
- If the leaf divergence increases then the body has the same sign of charge as that on the electroscope i.e. it is positively charged and
- If the leaf divergence deceases, then the body has a charge with sign opposite to that on the electroscope i.e. negatively charged.

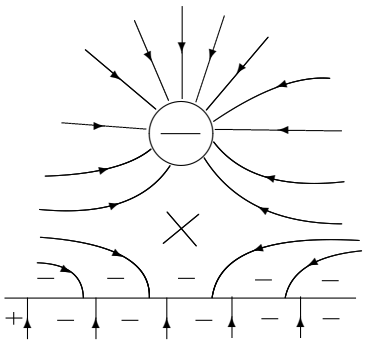
NB: You can also use a negatively charged electroscope to determine sign of charge on a charged body.

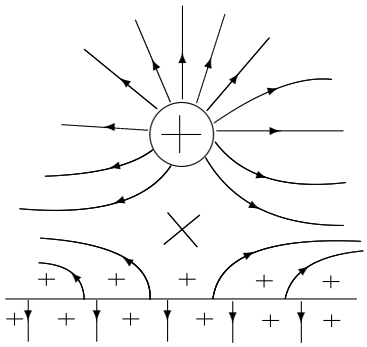
(b) How an insulator gets charged by rubbing; when two neutral insulators are rubbed against each other, one looses the electrons and the other gains them. The insulator that gains the electrons

becomes negatively charged and the one that looses the elections becomes positively charged.

(c) Electric field pattern of a charged point and a metal plate

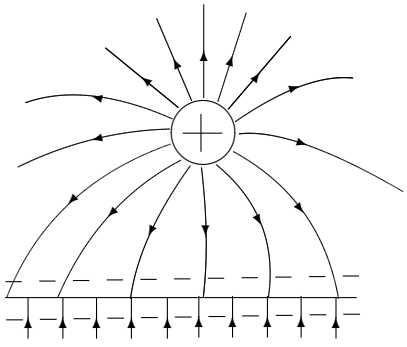
- If the plate and the point charge have the same charge, then we have

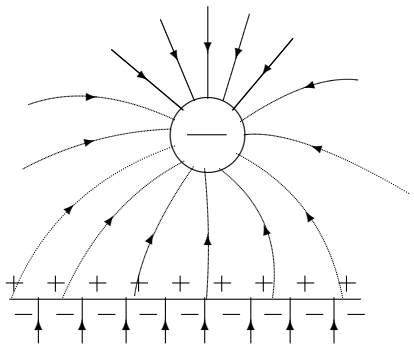




Where the $\times$ s are neutral points

- If the plate and the point charge have opposite charges, then we can have





Remember that this question is nor specific that is why i had to give all the possible answers to the question.

(d) The lightening conductor is a copper wire running from a plate burried in the ground to the top most point on the building ending in sharp spikes. When lightening strikes to such a building charges accumulate on it, the lightening conductor provides a low resistance path-way for the charges to or from the earth (the ground), otherwise they would pass through the walls of the building and water content in them would evaporate expand, drying, weakening the walls and hence the building collapses.

33. (a) What is meant by a conductor and an insulator? Give an example of each.

(b) (i) Explain briefly how you can charge a conductor negatively by induction.

(ii) **Describe how it can be confirmed that the**

conductor in (b) (i) is negatively charged.

Solution

(a) a conductor is a materials with loosely bound electrons on its atoms while an insulator is a material with firmly bound electrons to its atoms.

An example of a conductor is copper i.e. any metal

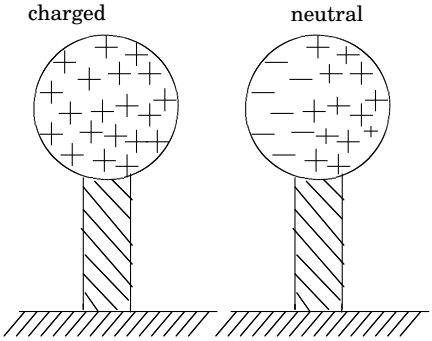
An example of an insulator is wood or rubber.

(b)

(i) charging a conductor negatively by electrostatic induction;

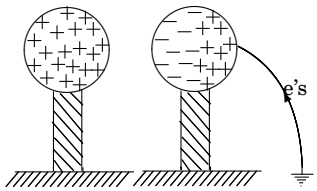
- Bring a positively charged body (or a rod) near a neutral body.

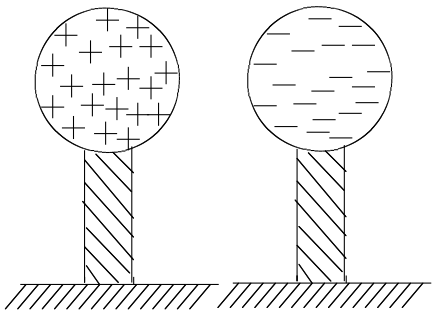
This makes the side near the charged body of the neutral body negatively charged and the other end positively charged (i.e. it causes unequal distribution of charge on the surface of the neutral conductor).



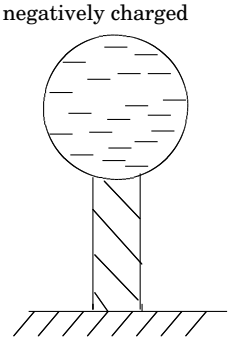
- Connect and disconnect (not very fast) an earth wire to the other side (positively charged side) of the neutral body.

This causes the electrons to flow from the earth to the electron deficient side (positively charged side) making the initially neutral body acquires an excess of negative charges





- Taking the positively charged body away, the initially neutral body is left with an excess of negative charges (electrons) which distribute evenly now on it, hence it has been charged negatively by electrostatic induction.



(ii) to confirm that the conductor in (b)(i) above is a conductor you may

EITHER take it near the metal cap of a positively charged electroscope and if its leaf divergency deceases then the body is negatively charged.

OR

If you take it near the metal cap of a negatively charged electroscope and its gold leaf divergency increases then the body is negatively charged.

34. Explain how leakage of charge occurs at the end of sharp conductors.

Solution

Sharp pointed charged conductors. At the sharp end, the electric field is very strong, this causes the air near it to get ionized and so the conductor repels the like charges in the ionized air and attract the unlike charges. These neutralize some charges on the charged conductor and that is the leakage of charge known as **Corona discharge**.

35. (a) What happens when a glass rod is rubbed with:

(i) **silk?**

(ii) **an identical glass rod?**

(b) **Describe how a gold leaf electroscope may be used to test the nature of the charge on an object.**

(c) **Draw the electric patterns for:**

(i) **an insulated negative charge.**

(ii) **two positively charged parallel plates at a small distance apart.**

(d) **Explain why it is not advisable to touch the copper strip of a lightening conductor when it is raining**

Solution

(a) (i) When a glass rod is rubbed with silk the glass rod losses electrons and the silk gains them hence the glass rod becomes positively charged and the silk becomes negatively charged.

(ii) when a glass rod is rubbed with an identical glass rod, one of them losses electrons becoming positively charged and the other gains electrons becoming negatively charged.

(b) Using a gold-leaf electroscope to test the nature of charge on an object.

You may use a negatively charged electroscope or a positively charged electroscope.

- Using negatively charged electroscope, always its leaf is diverged. When you bring this charged body near it, the divergence will change.

  If the divergence increases, then the body has the same charge as that on the electroscope, i.e. negatively charged

  If the divergence decreases, then the body has charged opposite to that on the electroscope, i.e. positively charged

OR

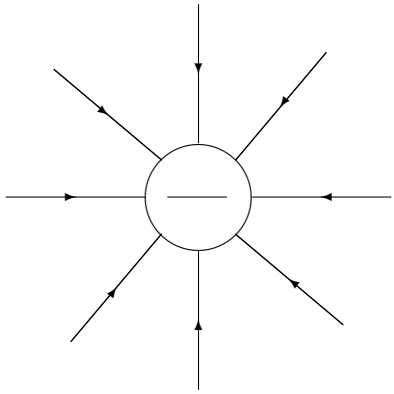
- Using positively charged electroscope, always its leaf is diverged. When you bring this charged body near it, the divergence will change.

  If the divergence increases, then the body has the same charge as that on the electroscope, i.e.positively charged

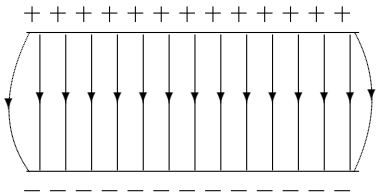
  If the divergence decreases, then the body has charge opposite to that on the electroscope, i.e. negatively charged

(c) Electric field pattern for

(i) an insulated negative charge



(ii) two positively charged parallel plates a small distance apart



(d) because lightening may strike you in the process of touching it. Since lightening involves the flow of electrons from the earth to the cloud or from the cloud to the earth, remebering that our body is a good conductor, when you touch it, you provide an easy or low resistance path to the flow of charges through your body hence be electrocuted.

36. (a) (i) What is a conductor?

(ii) **Give two examples of conductors.**

(b) **Describe how a gold leaf electroscope can be positively charged by electrostatic induction.**

(c) **Two polythene sheets A and B are both negatively charged with equal amounts**

of charge. One end of each polythene sheet is fixed into an insulator and the two sheets brought near each other as shown in figure 4.

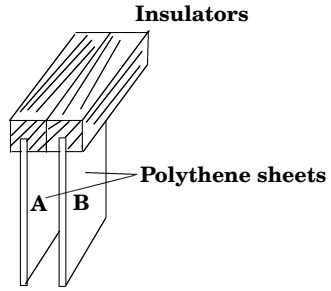


Fig. 4

(i) **Describe and explain what happens.**

(ii) **Describe and explain what happens it an earthed sheet of metal is inserted between the polythene sheets without touching them.**

(d) **Explain how thunder is produced during a rainstorm.**

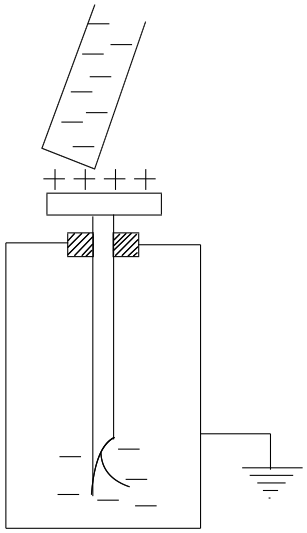
Solution

(a) (i) a conductor is a material that has free electrons on its surface. It easily conducts heat and electricity.

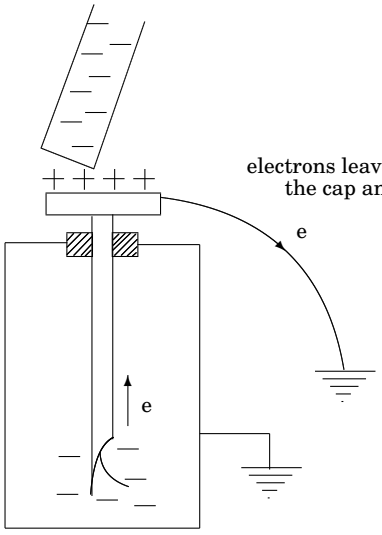
(ii) examples of conductor are;

- All metals like copper, iron, zinc ,etc
- Mercury

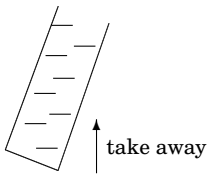
(b) how to change a gold-leaf electroscope positively by electrostatic induction Here you bring a negatively charged body near the metal cap of the electroscope

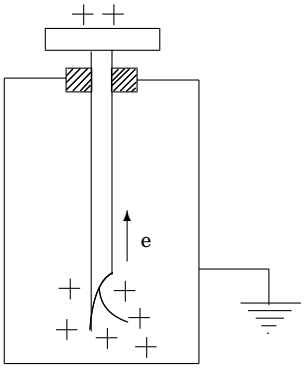


Connect an earth wire to the cap and then disconnect it.

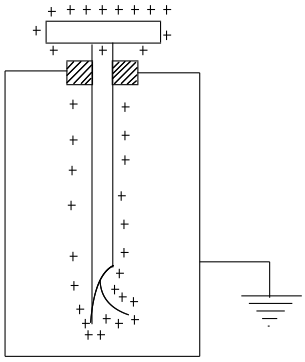


Taking away the negatively charged body,





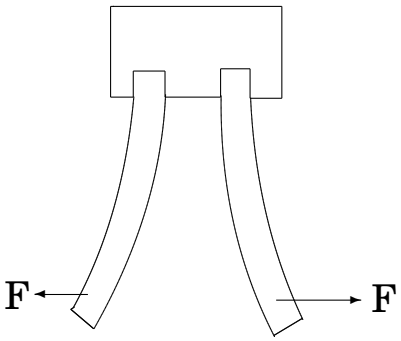
The electroscope will be left positively charged (i.e. with a deficiency of electrons).



Explanation

when a negatively charged body is brought near the metal cap, it repels the free electrons on the electroscope from the metal cap to the metal plate and the gold leaf. The metal cap is left with a deficiency of electrons i.e. positively charged and the metal plate with the gold leaf with an excess of electrons i.e. negatively charged hence the leaf diverges. At this point when an earth wire is connected to the metal cap, it provides an easy path or escape route for the repelled electrons on the metal plate and gold leaf to the earth [1]. The gold leaf collapses since it is now neutralized by the removal of the excess electrons (the metal cap is still electron deficient). Disconnecting the earth wire and taking away the negatively charged body respectively, the electroscope is generally left with a deficiency of electrons hence the electroscope is positively charged.

(c) (i) the negatively charged polythene sheets will repel each other hence they will bend like this



Forces of repulsion

(ii) then the negatively charged polythene plates will be attracted to the earthed sheet of metal.

(d) when lightening strikes, charge flows either from the cloud to the earth or from the earth to the

[1]The earth can never get filled up of electrons i.e has a high charge storing capacity or high capacitance

cloud or from cloud to cloud. This causes the air where the charge passes to expand very fast creating a compression sound wave, which we call thunder. That is how thunder is produced

4.2 Electric Cells

Section A (Objectives)

1. Which of the following statements is /are true?

(i) When identical cells are in parallel, the total e.m.f. is the sum of individual e.m.fs.

(ii) In a lead-acid accumulator, the lead peroxide acts as the positive pole.

(iii) The e.m.f. of a cell is the total p.d. across the external and internal resistances.

A. (i) only.

B. (i) and (ii) only .

C. (ii) and (iii) only.

D. (i), (ii) and (iii). **C**

2. In a dry cell, manganese (IV) oxide is used to

A. reduce the p.d. across it.

B. double its resistance.

C. increase its resistance.

D. keep the potential difference constant. **D**

3. The negative plate of a simple cell gradually goes into solution because of

A. polarization.

B. local action.

C. charging.

B. gassing. **B**

4. In a simple cell, the source of electrons which constitute the electron currents is

A. the zinc plate.

B. the copper plate.

C. dilute sulphuric acid

D. potassium dichromate. **A**

In a simple cell, current flows from copper plate to the zinc plate and electrons from the zinc plate to the copper plate hence the zinc plate is the source of electrons got from sulphate ions in the dilute sulphuric acid.

5. In a simple cell

A. polarization is caused by impure zinc.

B. potassium dichromate is used to prevent polarization.

C. the formation of hydrogen bubbles on the copper plate causes local action

D. hydrogen is produced on the zinc plate and causes polarization. **B**

Section B (Structured)

6. State two advantages of a nickel-iron accumulator over a lead acid accumulator.

1. *It can stay in discharged state for a longer period without any effect.*
2. *It can supply large currents without any ill effect.*

7. Name the gases evolved during the charging of lead acid accumulator.

Oxygen and hydrogen

8. Why is a dry cell called a primary cell?

Because when it is used up (discharged) it can not be recharged.

Paper II (Essay)

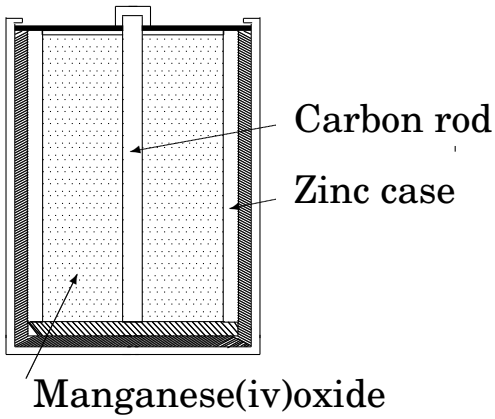
9. With the aid of a labeled diagram, explain how a dry cell works.

Solution

How a dry cell works

A dry cell is made up of manganese(iv)oxide as the electrolyte enclosed in a zinc case as the cathode.

The anode is a carbon rod dipped in the manganese(iv)oxide in the zinc case as shown below;



The manganese(iv)oxide dissociates and releases electrons to the zinc case and this creates a potential difference between the zinc case and the carbon rod. This can drive the current through a device connected across the cathode and anode.

The zinc used is pure zinc to prevent local action and the manganese(iv)oxide is an oxidising agent hence it prevents polarisation.

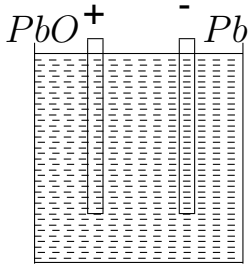
10. (i) Draw a labeled diagram of a lead acid accumulator.

(ii) List three precautions necessary to prolong the life of an accumulator.

(iii) State two disadvantages of a Nife cell over a lead acid cell.

Solution

(a) (i) a lead-acid accumulator



(ii) the following are the precautions to adhere to so as to prolong the life of an accumulator

- do not leave it in the discharge state for long.
- Do not short circuit the terminals i.e. connecting a wire to positive and negative terminals.
- Always give it a top-up charge monthly.

(iii) advantages of Nife cells over lead acid cells

- They can be left in the discharge state for a long period with no harm.
- They can provide large currents without ill-effects

4.3 Current electricity

Section A (Objectives)

1. A p.d. of 20 V is applied across two resistors of 4Ω and 6Ω connected in series. Determine the p.d. across the 6Ω resistor if the total circuit current is 2A.

A. 1.0V.

B. 2.0V.

C. 3.3V.

D. 112.0V. **D**

$$\begin{aligned} I &= \frac{20}{(4+6)} = 2A \\ V &= IR = 2 \times 6 \\ &= 12V \end{aligned}$$

2.

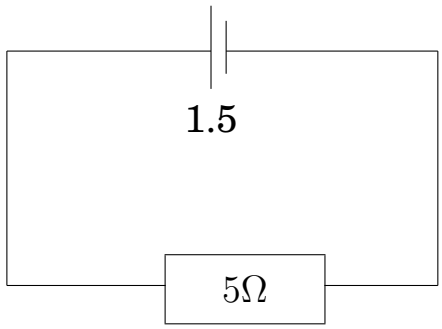


Fig. 1

A cell of e.m.f 1.5V and internal resistance, r, is connected in series with a 5Ω resistor as shown in Fig. 1. if the current in the circuit is 0.25A, find r.

A. 1Ω

B. 6Ω

C. 11Ω

D. 16Ω **A**

From

$$E = I(R+r)$$

$$\begin{aligned} r &= \frac{E}{I} - R \\ &= \frac{1.5}{0.25} - 5 \\ &= 6 - 5 \\ &= 1\Omega \end{aligned}$$

3.

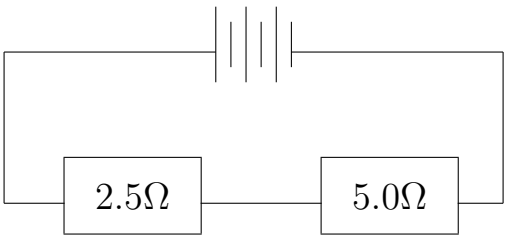


Fig. 1

If each cell shown in Fig. 1 has an internal resistance of 0.5Ω, find the effective resistance in the circuit.

A. 1.25

B. 7.50

C. 8.00

D. 9.00 **D**

$$\begin{aligned} R &= 2.5 + 5.0 + (0.5 \times 3) \\ &= 7.5 + 1.5 \\ &= 9.0 \end{aligned}$$

4. Two resistors of 2 ohms and 3 ohms are connected in series with a 10 volt battery of negligible internal resistance. The potential difference across a 3 ohm resistor is

A. 2V

B. 5V

C. 6V

D. 10V **C**

$$\begin{aligned} I &= \frac{V}{R} \\ &= \frac{10}{2+3} \\ &= 2 \\ V &= IR \\ &= 2 \times 3 \\ &= 6V \end{aligned}$$

5.

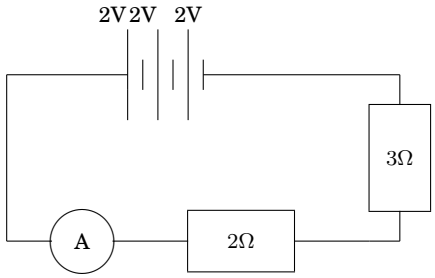


Fig. 2

Three cells of e.m.f. 2V and negligible internal resistance are connected to two resistors as shown in the circuit in fig. 2. The reading of the ammeter is

A. 0.40 A.

B. 0.83 A.

C. 1.20 A.

D. 7.20 A. **C**

$$I = \frac{3E}{R}$$

$$\begin{aligned} &= \frac{3 \times 2}{3+2} \\ &= \frac{6}{5} \\ &= 1.2 \end{aligned}$$

6. The resistance of a metal in the form of a wire increases with

   A. decrease in length **B**

   B. increase in temperature.

   C. decrease in temperature.

   D. increase in cross-sectional area.

7. The effective resistance when two resistors of 5Ω and 15Ω joined in series are placed in parallel with a 20Ω resistor is

   A. 0.1Ω

   B. 10Ω

   C. 20Ω

   D. 40Ω **B**

$$\begin{aligned} R &= \frac{(5+15) \times 20}{(5+15)+20} \\ R &= 10\Omega \end{aligned}$$

8. Which of the following only works with a direct current?

   A. Electric lamp.

   B. Transformer.

   C. Electroplating.

   D. Electric bell. **D**

9. In fig. 7, the ammeter A reads 4A and the voltmeter V reads 4V.

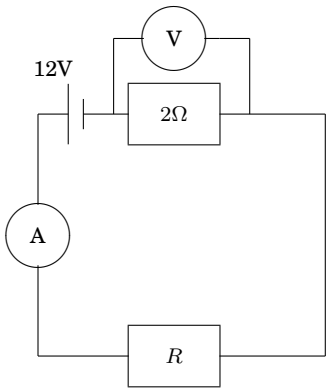


Fig. 7

Find the value of R.

A. 1Ω

B. 2Ω

C. 3Ω

D. 4Ω **B**

$$\begin{aligned} 12 &= 4 + IR \\ 12 &= 4 + 4R \\ 4R &= 12 - 4 \\ 4R &= 8 \\ R &= 2\Omega \end{aligned}$$

10. An electric appliance having 4 heating elements, each rated at 0.75KW, is used on a 240V mains. What is the power rating of the appliance?

    A. 80KW

    B. 60KW

    C. 3KW

    D. 3W **C**

$$\begin{aligned} P &= 0.75KW \times 4 \\ &= 3KW \end{aligned}$$

11.

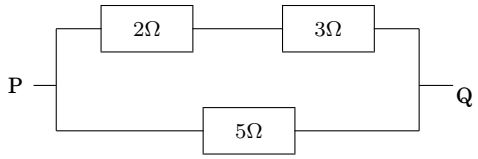


Fig. 10

Fig. 10 shows a network of resistors. The effective resistance between points P and Q

A. 0.97Ω.

B. 1.2Ω

C. 2.5Ω

D. 10Ω **C**

$$\begin{aligned} R &= \frac{R_1 \times (R_2 + R_3)}{R_1 + (R_2 + R_3)} \\ R &= \frac{5 \times (2+3)}{5 + (2+3)} \\ &= \frac{5 \times 5}{5+5} \\ &= \frac{25}{10} \\ &= 2.5. \end{aligned}$$

12. A car head lamp bulb is marketed 12V, 48W. this means that when a

A. voltage of 12V is applied, a current of $\frac{1}{4}$ A flows.

B. power of 48W is developed, the resistance is 4Ω.

C. voltage of 12V is applied, resistance is 4Ω.

D. voltage of 12V is applied, energy used in every second is 48J. **D**

$$\begin{aligned} P &= \frac{V^2}{R} \\ R &= \frac{12^2}{48} \\ &= 3\Omega \end{aligned}$$

13. An electricity board charges Shs. 10 per kilowatt-hour of electrical energy supplied. What is the total cost in Shs. of operating 4 light bulbs, each rated at 100W for 5 hours

A. Sh. 2.

B. Sh 20

C. Sh 4,000.

D. Sh 20,000. **B**

$$\begin{aligned} E &= pt \\ &= 4 \times 100W \times 5hrs \\ &= 2000Wh \\ E &= 2Kwh \\ \text{Cost} &= 2Kwh \times 10sh/Kwh \\ &= 20.sh \end{aligned}$$

14. When brass is to be copper-plated, the suitable electrolyte used is

A. distilled water.

B. sulphuric acid

C. lead (IV) oxide.

D. copper-sulphate. **D**

Copper platting is putting or depositing a thin layer of copper on a substance.

15.

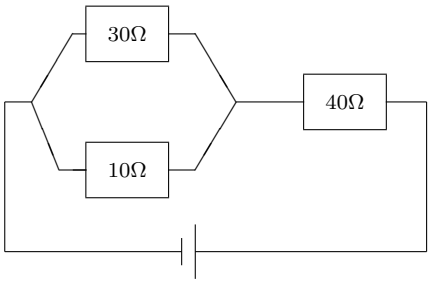


Fig. 7

The diagram in fig. 7 shows three resistors connected in a circuit. What is the effective resistance of the circuit?

A. 20.0Ω

B. 47.5Ω

C. 60.0Ω

D. 90.0Ω **B**

$$\begin{aligned} R &= R_3 + \frac{R_1 \times R_2}{R_1 + R_2} \\ R &= 40 + \frac{10 \times 30}{10 + 30} \\ &= 40 + \frac{300}{40} \\ &= 47.5 \end{aligned}$$

16. What is the most suitable fuse for an electric heater rated 2.5kW when connected to a voltage of 240V?

A. 5A

B. 10A

C. 13A

D. 30A. **B**

$$\begin{aligned} I &= \frac{P}{V} \\ &= \frac{2500}{240} \\ &= 10.4A \end{aligned}$$

17.

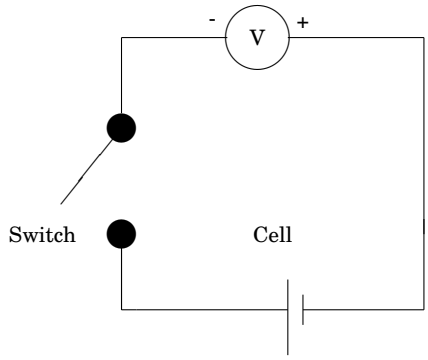


Fig. 9

When the circuit in fig. 9 is switched on, the voltmeter

A. shows no deflection

B. deflects in the wrong direction.

C. reads the e.m.f. of the cell.

D. reads the terminal potential difference across the cell **B**

Because the positive of the galvanometer should be connected to the positive of the cell.

18.

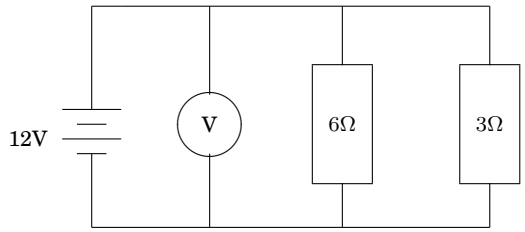


Fig. 5

A battery of e.m.f 12V is connected across two resistors of 6Ω and 3Ω as shown in fig. 5. Which one of the following statements is true about the circuit? The

A. p.d across 6Ω is half the p.d across 3Ω.

B. p.d across 6Ω is twice the p.d across 3Ω.

C. p.d across 6Ω is the same as the p.d across 3Ω.

D. reading of voltmeter V is greater than 12V. **C**

19. Two coils of wire of resistances 2Ω and 3Ω are connected in series to a 10V battery of negligible internal resistance. The current through the 2Ω resistor is

A. 0.5A.

B. 2A.

C. 5 A.

D. 50 A **B**

$$\begin{aligned} I &= \frac{E}{R} \\ &= \frac{10}{2+3} \\ &= 2A \end{aligned}$$

20. A bulb of resistance 1.5Ω is connected to a cell of e.m.f. 2.0V. Find the energy dissipated in 45s.

A. 60 J

B. 67.5 J.

C. 90 J.

D. 120 J **D**

$$\begin{aligned} E &= Pt \\ &= \left[\frac{V^2}{R}\right] t \\ &= \frac{2.0^2}{1.5} \times 45 \\ &= 120. \end{aligned}$$

21. Calculate the amount of current taken by an electric flat iron marked 250V, 1000W.

A. 0.25A.

B. 0.40A.

C. 250A.

D. 4.00A. **D**

From $$\begin{aligned} P &= IV \\ I &= \frac{P}{V} \\ &= \frac{1000}{250} \\ &= 4 \end{aligned}$$

22. .

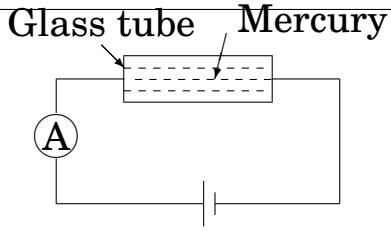


Fig. 1

When the diameter of the glass tube in the circuit in fig. 1 is doubled and again filled completely with mercury, the reading of ammeter A.

A. decreases.

B. Increases.

C. Remains the same.

D. Falls to zero **B**

because $I = \frac{V}{R}$ and V is constant and $R = \frac{\rho l}{A}$ then

$$\begin{aligned} I &= \frac{V}{\frac{\rho l}{A}} \\ &= \frac{VA}{\rho l} \end{aligned}$$

but $A = \frac{\pi d^2}{4}$ hence $I = \frac{\pi d^2}{4\rho l}$ then if d is doubled then I is multipled by 4 i.e. I increases. But filling it with more conducting material creates more conducting material which leads to increase incident.

23.

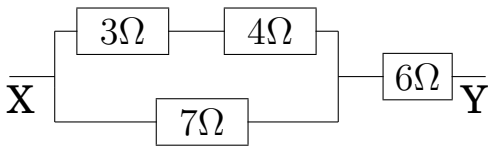


Fig. 3

The total resistance between X and Y in fig. 3 is

A. 20.0Ω

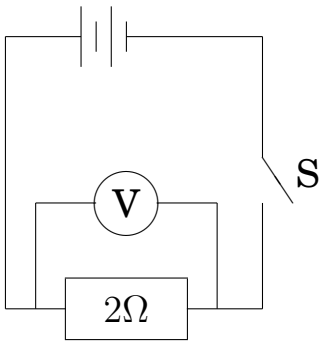
B. 9.50Ω

C. 6.30Ω

D. 4.20Ω **B**

$$\begin{aligned} R &= \text{parallel} + 6\Omega \\ R &= \frac{(3+4)\times 7}{(3+4)+7} + 6 \\ &= \frac{49}{14} + 6 \\ &= 3.5 + 6 \\ &= 9.5 \end{aligned}$$

24. Two cells each of e.m.f 1.5V and internal resistance 0.5Ω are connected in series with a resistor of 2Ω as in figure 4.



The reading of the voltmeter V when S is closed is

A. 1.0V.

B. 1.5 V.

C. 2.0 V

D. 3.0 V **C**

$$
\begin{aligned}
I &= \frac{V}{R} \\
I &= \frac{1.5 \times 2}{(0.5 \times 2 + 2)} = \frac{3}{1+2} \\
&= 1A \\
V &= IR = 1 \times 2 \\
&= 2.0V
\end{aligned}
$$

25. .

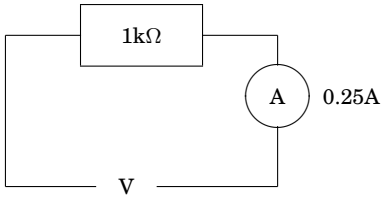


Fig. 3

The voltage supply in the circuit in fig. 3 is

A. 0.25V

B. 4.0V

C. 25V

D. 250V **D**

$$
\begin{aligned}
E &= Ir \\
&= 0.25 \times 1000 \\
&= 250
\end{aligned}
$$

26. To determine the value of a resistor R, a voltmeter, a rheostat and an ammeter must be connected in the gaps X, L and M as shown in fig. 4.

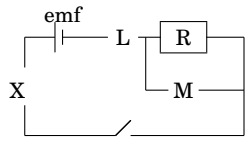


Fig. 4

Which one of the following arrangements gives the correct circuit?

	X	L	M
A.	Voltmeter	rheostat	ammeter
B.	ammeter	voltmeter	rheostat
C.	rheostat	voltmeter	ammeter
D.	ammeter	rheostat	voltmeter

The voltmeter must be in parallel with the load i.e. M is voltmeter the other devices can be interchanged and there is no net effect. **D**

Section B (Structured)

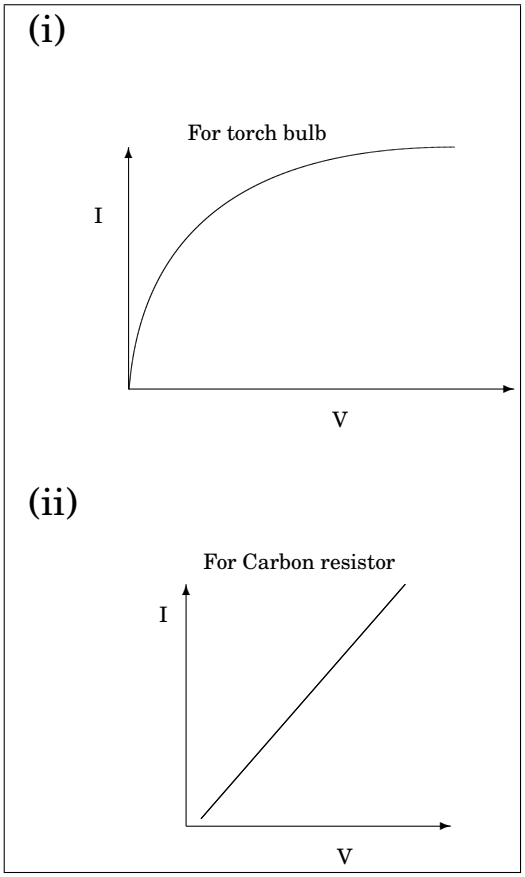
27. Explain why a current does not flow between the electrodes in dilute sulphuric acid until a certain value of p.d. is exceeded.

This is because some energy is used to dissociate or break the acid molecules into ions that can conduct the electric current.

28. Using the same exes, sketch a graph of current against p.d. for

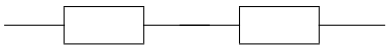
(i) a torch bulb

(ii) a carbon resistor

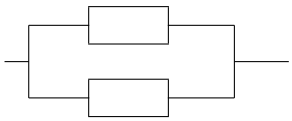


29. Draw diagrams to show two ways in which two resistors can be arranged in an electrical circuit.

Two resistors can be arranged either in parallel or in series as shown below;



series connection



Parallel connection

30. State what happens to the reading of the ammeter in the circuit in fig. 12 below, if one cell is removed.

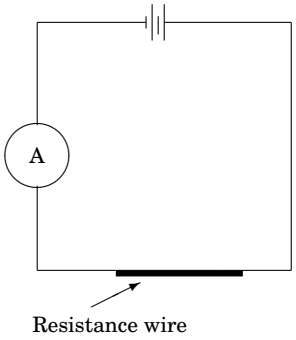


Fig.12

The ammeter reading decreases

31. State Ohm's law.

The current passing through a conductor is directly proportional to the potential difference across its ends provided all physical conditions remain constant.

32. .

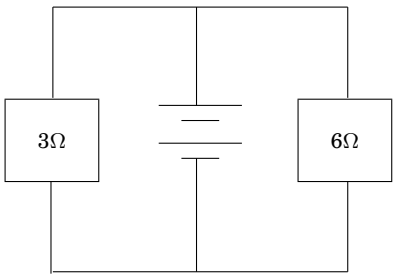


Fig. 14

Two resistors of resistances 3Ω and 6Ω are connected across a battery of $4V$ of negligible internal resistance as shown in fig. 14 above. Find the

(i) combined resistance.

(ii) current supplied by the battery.

(i) combined resistance.

$$\begin{aligned} R &= \frac{6 \times 3}{6+3} \\ &= \frac{18}{9} \\ &= 2\Omega \end{aligned}$$

(ii) current supplied by the battery.

$$\begin{aligned} I &= \frac{V}{R} \\ &= \frac{4}{2} \\ &= 2A \end{aligned}$$

33. A source of e.m.f. 20V and negligible internal resistance is connected to resistors of 2Ω, 2Ω, and 3Ω as shown in fig. 11.

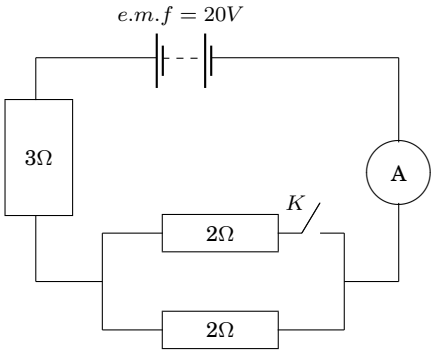


Fig.11

Find the ammeter reading when switch K is

(i) Open;

$I = \frac{V}{R} = \frac{20}{3+2} = 4A$

(ii) Closed;

$I = \frac{V}{R} = \frac{20}{3+\frac{2\times2}{2+2}} = \frac{20}{3+1} = 5A$

34. What is meant by short circuit as applied to electricity?

This is when two opposite electric terminal wires are joined or put into contact or it is when current by-passes a resistor.

35. An electric appliance is marked "240V 4Kw".

(i) What does this statement mean?

(ii) Calculate the current drawn by the appliance in normal use.

(i) *It means that when the appliance is connected to a 240V terminals it dissipates 4Kw i.e. 4000 watts of energy or 4000 joules of energy per second.*

(ii)

$$\begin{aligned} \text{Current} &= \frac{\text{power}}{\text{voltage}} \\ &= \frac{4000}{240} \\ &= 16.67A \end{aligned}$$

36. Define the volt.

A volt is the potential difference across a 1 Ω resistor when a current of 1A is passing through it.

37. .

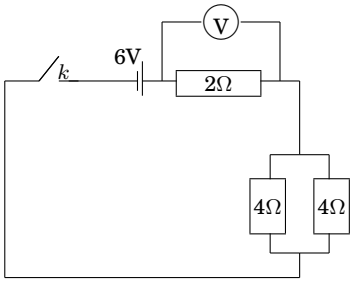


Fig.9

(i) What is the effective resistance in the circuit in Fig. 9? (The cell has negligible resistance).

(ii) What will be the reading of the voltmeter when the key, k is closed?

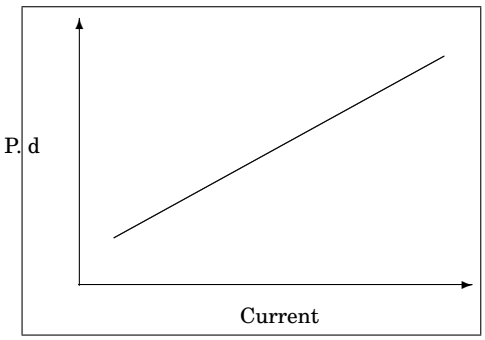
(i) effective resistance

$$\begin{aligned} R &= 2 + \frac{4 \times 4}{4 + 4} \\ &= 2 + \frac{16}{8} \\ &= 2 + 2 \\ &= 4\Omega \end{aligned}$$

(ii) voltmeter reading

$$\begin{aligned} I &= \frac{V}{R} \\ &= \frac{6}{4} \\ &= 1.5A \\ V &= IR \\ &= 2 \times 1.5 \\ &= 3V \end{aligned}$$

38. Sketch a p.d versus current graph for an Ohmic resistor.



39. State one example of a non-Ohmic conductor

Semi conductor diode or a thermistor

40. Find the voltage across a 3Ω resistor if a current of $4A$ passes through it.

from Ohm's law

$$\begin{aligned} V &= IR \\ &= 4 \times 3 \\ &= 12V \end{aligned}$$

41. Fig. 10 shows a charging circuit.

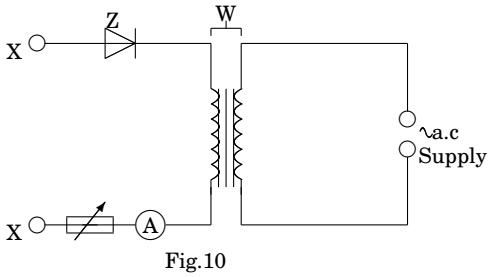


Fig.10

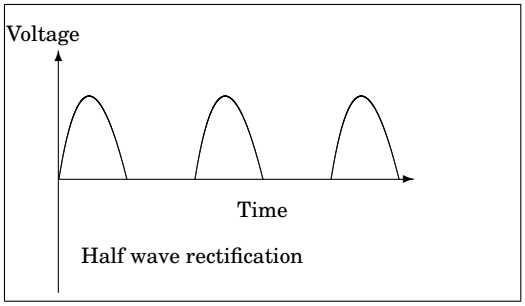
(a) Name and state the use of each of the parts labeled.

(i) w

(ii) z

W is a transformer; it steps up or steps down voltage or current
Z is a diode, it rectifies the alternating current to direct current by cutting off the negative parts of the cycle.

(b) Sketch the waveform that is obtained from terminals XX.



Paper II (Essay)

42. (a) Define the following terms:

(i) the volt,

(ii) **electrical resistance**

(b) List ways by which the life of an accumulator can be prolonged.

(c)

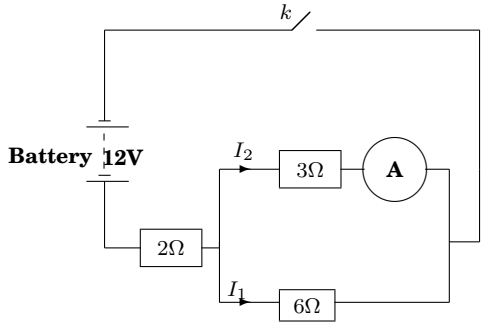


Fig. 3

A battery of e.m.f $12V$ and negligible internal resistance is connected to resistance 2Ω ,3Ω and 6Ω as shown in Fig. 3. Find the reading of the ammeter, A, when K is closed.

Solution

(a) (i) A volt is the potential difference between two points, if it requires 1joule of work to more a charge of xx coulomb from one point to the other.

(ii)electrical resistance is the opposition to the flow of electrical current through a given substance or material.

(b) To prolong life of an accumulator

- do not short circuit it i.e connect a wire across its terminals directly.
- Do not leave it in the discharge state for long.
- Do not overload it.

(c)

$$\begin{aligned} I &= \frac{E}{R} \\ R &= \frac{6+3}{6+3} + 2 \\ &= 2+2 \\ &= 4\Omega \end{aligned}$$

$$\begin{aligned} I &= \frac{E}{R} \\ &= \frac{12}{4} \\ I &= 3A \\ \text{but } I &= I_1 + I_2 \\ \text{Also } V_{3\Omega} &= V_{6\Omega} \\ 3 \times I_2 &= 6 + I_1 \\ I_2 &= 6I_1 \\ I_1 &= 2I_1 \end{aligned}$$

$$\begin{aligned} \Rightarrow I_1 &= I_1 \times I_2 \\ &= \frac{I_2}{2} + I_2 \\ &= \frac{I_2}{2} + \frac{2}{2}I_2 \\ I &= \frac{3}{2}I_2 \\ 3 &= \frac{3}{2}I_2 \\ \Rightarrow I_2 &= \frac{2 \times 3}{3} \\ I_2 &= 2A \end{aligned}$$

The reading of the ammeter A is $2A$

43. A bulb is rated 12.0V 36W when used on a 12.0 V supply.

(i) **How much current does it draw from the supply?**

(ii) **What is its resistance?**

Solution

for a bulb 12V 36w used on 12V supply.

(i) the current is draws when working normally is given by;

$$\begin{aligned} \text{from } P &= VI \\ I &= \frac{P}{V} \\ &= \frac{36W}{12V} \\ &= 3 \text{ Amperes} \end{aligned}$$

(ii) its resistance

$$\begin{aligned} \text{From } P &= I^2R \\ \Longrightarrow R &= \frac{P}{I^2} \\ &= \frac{36}{3^2} \\ &= \frac{36}{9} \\ &= 4\Omega \end{aligned}$$

Or

$$\begin{aligned} \text{Using } P &= \frac{V^2}{R} \\ \Longrightarrow R &= \frac{V^2}{P} \\ &= \frac{12^2}{36} \\ &= \frac{144}{36} \\ &= 4\Omega \end{aligned}$$

44. (a) **What is meant by the following:**

(i) **electromotive force,**

(ii) **internal resistance, of a cell?**

(b) **A cell is connected in series with an ammeter and a variable resistor. The potential difference, V, across the resistor varies with current I, supplied through the resistor as shown in the graph in Figure 4.1 on page 229 Use the graph to determine the**

(i) **e.m.f**

(ii) **internal resistance of the cell.**

Solution

(a) (i) Electromotive force is the total work done is moving a charge of one coulomb though out the electric circuit.

(ii) internal resistance of a cell is the opposition to the flow of electric current through a cell or battery.

(b) from the given graph

(i) $Emf = 2.0V$ i.e. it is the value of voltage when $I = 0A$ from the graph

(ii) Internal resistance , r

$$\begin{aligned} \text{From } E &= I(R+r) \\ &= IR + Ir \\ &= V + Ir \\ \Longrightarrow V &= E - Ir \\ &= -Ir + E \end{aligned}$$

Comparing with $y = mx + c$, the slope is $-r$

$$\begin{aligned} r &= -\text{slope} \\ &= -\frac{\Delta V}{\Delta I} \end{aligned}$$

Looking at the extreme points on the graph i.e. $(4.5, 0)$ and $(0, 2.0)$

$$\begin{aligned} r &= -\frac{\Delta V}{\Delta I} \\ &= -\frac{2.0-0}{0-4.5} \\ &= -\frac{2}{-4.5} \\ r &= 0.444\Omega \end{aligned}$$

Hence internal resistance is 0.444Ω

45. (a) Draw sketch graphs of p.d V against current , I, for the following;

(i) **a wire,**

(ii) **an electrolyte**

(iii) **a semi-conductor diode**.

(b) **Explain the differences between a voltmeter and an ammeter in terms of their:**

(i) **construction**

(ii) **use.**

(c) **State three physical properties that affect the resistance of a solid conductor.**

(d)

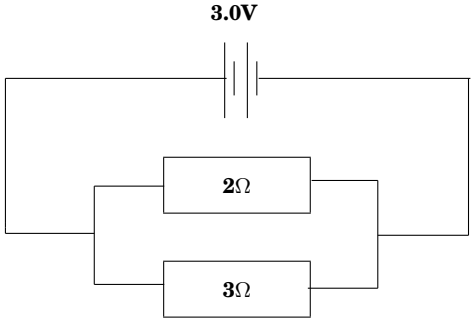


Fig. 4

Two cells each of e.m.f 1.5V and negligible internal resistance connected in series across two resistors of 2Ω and 3Ω as shown in fig. 4. Calculate the current.

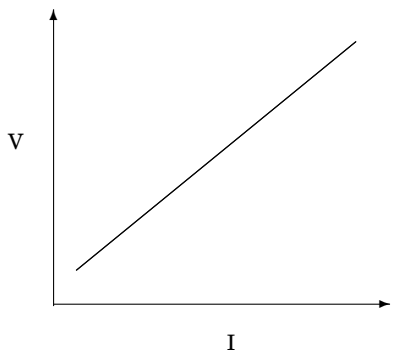
(i) **supplied by the cells,**

(ii) **that passes through the 3Ω resistor.**

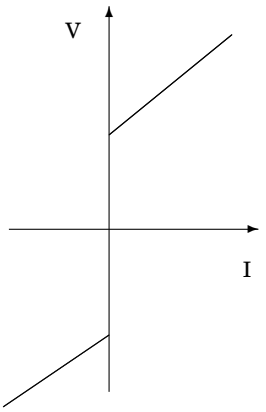
Solution

(a) Voltage current graph

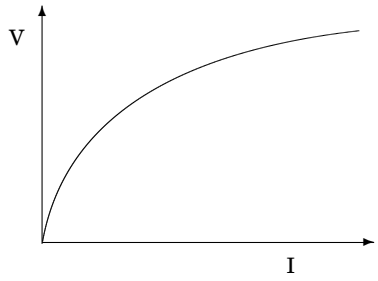
(i) for a wire



(ii) for an electrolyte



(iii) for a semi-conductor diode



(b) (i) in construction;

An ammeter has a low resistance resistor in parallel with the coil hence in general they have a low resistance.

A voltmeter has a high resistance resistor in series with the coil hence in general they have a high resistance.

(ii) in use;

A meters are connected in series with the device whose current they are measuring and voltmeters are connected in parallel with the device whose potential difference they are measuring.

(c) Resistance of a solid conductor is affected by;

- Cross-sectional area of the conductor
- Length of the conductor
- Temperature and
- Nature of the material of the conductor

(d) from question

$$Emf = 3.0V$$

Total resistance, R

$$\begin{aligned} R &= \frac{R_1 \times R_2}{R_1 + R_2} \\ &= \frac{2 \times 3}{2 + 3} \\ &= \frac{6}{5} \\ &= 1.2\Omega \end{aligned}$$

(i) Current supplied by the cell, I is

$$\begin{aligned} I &= \frac{E}{R} \\ &= \frac{3}{1.2} \\ &= 2.5 \text{ Amperes} \end{aligned}$$

(ii) Current through the 3Ω resistor.

Potential difference a cross the 3Ω resistor is $3.0V$

$$\begin{aligned} \text{Current} &= \frac{\text{P.d.}}{\text{Resistance}} \\ &= \frac{3.0}{3.0} \\ &= 1 \text{ Ampere} \end{aligned}$$

It is 1 ampere.

46. A cell of e.m.f E and internal resistance 1Ω is connected in series with a 2Ω resistor and a switch as shown in fig. 4. The voltmeter reads 1.5V when the switch is open.

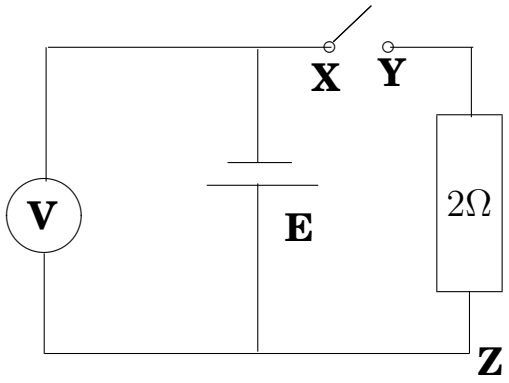


Fig. 4

(i) **What is meant by e.m.f of a cell?**

(ii) **Find the value of E**

(iii) **What will the voltmeter read when the switch is closed?**

(iv) **What will the voltmeter read if X is connected to Z. Give reasons for your answer.**

Solution

(i) Emf of a cell is the total work done in moving a charge of one coulomb throughout the circuit.

(ii) the value of emf is 1.5V

(iii) when the switch is closed total resistance, R is

$$\begin{aligned} R_{\text{total}} &= r + R \\ &= 1 + 2 \\ &= 3\Omega \\ \text{Current, } I &= \frac{V}{R} \\ &= \frac{E}{R_{total}} \\ &= \frac{1.5}{3} \\ &= 0.5A \end{aligned}$$

But always the voltmeter reads the potential difference across the external resistance i.e.

$$\begin{aligned} V &= IR \\ &= 0.5 \times 2 \\ &= 1Volt \end{aligned}$$

Hence the voltmeter reads 1 volt

(iv) When X - is connected to Z, the voltmeter reads 0 volts. This is because it is reading the potential difference across the wires which we assumed have zero resistance.

Since $V = IR$ and $R = 0V$ then V=0V that is why the voltmeter reads 0 volts.

47. (a) Describe a simple experiment to measure the internal resistance of a cell.

(b)

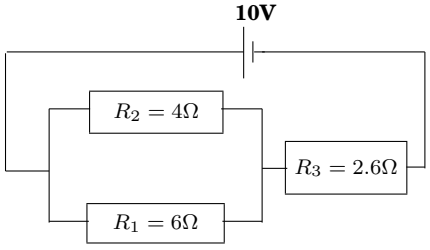


Fig. 5

A battery of e.m.f 10V and negligible internal resistance is connected to resistors R_1, R_2 and R_3 of resistances of 6Ω, 4Ω and 2.6Ω respectively as shown in fig. 5.

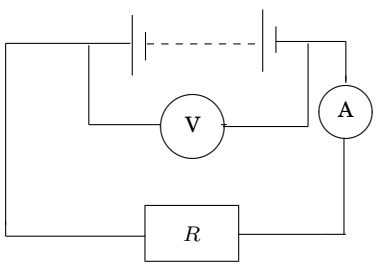
(i) **Calculate the effective resistance of the circuit.**

(ii) **Find the rate at which the electrical energy is convert to heat energy in R_3**

Solution

(a) An experiment to measure the internal resistance of a cell.

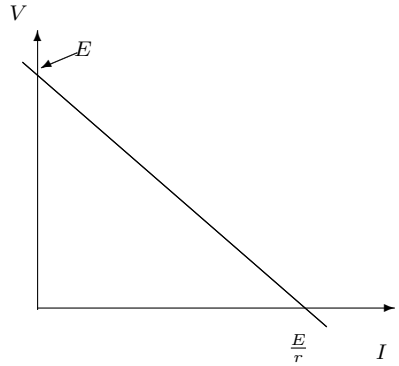
- **Apparatus**; a voltmeter, ammeter, connecting wires. Five or more known resistors (R's) and a battery of known *emf* are required.
- Connect them as shown below;



- Read and record the readings of the voltmeter (V) and the ammeter (I)
- Repeat the above procedure with difference resistors($R's$), measure and record the readings of the voltmeter (V) and Ammeter (I) in the table as shown below;

V(Volts)	I(Amperes)

- Plot a graph of V against I, you will obtain a graph of the form



- Calculate the slope, s, of the graph, it will be negative

$$s = \frac{\Delta V}{\Delta I}$$

- Internal resistance(r) of the wire, will be obtained as:

$$r = -s$$

(b) (i) effective resistance, R_f

$$\begin{aligned} R_f &= \frac{\text{parallel}}{\text{resistance}} + 2.6 \\ &= \frac{6 \times 4}{6+4} + 2.6 \\ &= 2.4 + 2.6 \\ &= 5\Omega \end{aligned}$$

(ii) Power dissipated in the resistor, R_3;

Total current, I

$$\begin{aligned} I &= \frac{\text{Emf}}{\text{effective resistance}} \\ &= \frac{10}{5} \\ &= 2A \end{aligned}$$

Power, P, dissipated in the resistor, R_3 is;

$$\begin{aligned} P &= I^2R \\ &= 2^2 \times 2.6 \\ &= 4 \times 2.6 \\ &= 10.4 \text{ Watts} \end{aligned}$$

hence heat is generated in the resistor R_3 at a rate of 10.4 watts.

48. (a) .

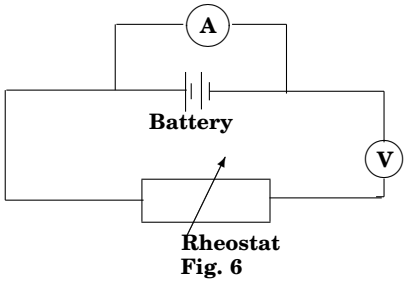


Fig. 6

An ammeter A and a voltmeter V are connected in a circuit as shown in fig. 6. What can you say about these connections?

(b)

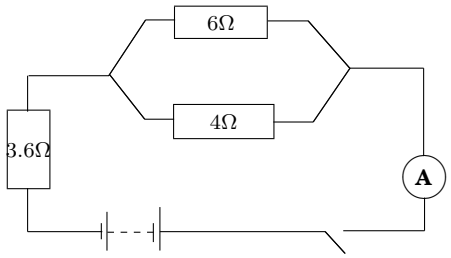


Fig. 7

Three resistors of 6Ω, 4Ω and 3.6Ω are connected to eight identical cells of negligible internal resistance connected in series as shown in fig. 7. If the ammeter reads 2A when the switch is closed, determine the:

(i) **current through the 4Ω resistor.**

(ii) **e.m.f of each cell.**

(c) **Abbot paid an electricity bill of sh. 180 after using two identical bulbs for 2 hours everyday for ten days at a cost of sh. 60 per unit.**

(i) **Determine the power consumption by each of the bulbs.**

(ii) **State the energy changes that occur in the bulb.**

Solution

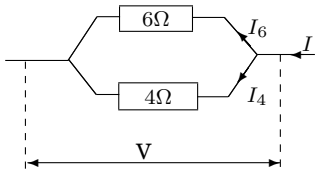
(a) The connections are faulty because;

- The ammeter is in parallel yet it should be in series hence it has to burnout or to blow.
- The voltmeter in connected in series yet it should be in parallel hence no or very little current flows in the circuit.

It can be corrected by exchanging the ammeter and the voltmeter.

(b)

Let the p.d. across the 6Ω and 4Ω be V.



$$I = I_4 + I_6$$

but p.d. across the 4Ω and across the 6Ω are the same since they are in parallel

$$\begin{aligned} V_{4\Omega} &= V_{6\Omega} \\ I_4 \times 4 &= I_6 \times 6 \\ 4I_4 &= 6I_6 \\ I_4 &= \frac{6}{4}I_6 = \frac{3}{2}I_6 \\ \text{but } I &= I_4 + I_6 \\ \text{and } I &= 2A \end{aligned}$$

hence

$$\begin{aligned} I &= I_4 + I_6 \\ 2 &= \frac{3}{2}I_6 + I_6 \\ 2 &= \left(\frac{3}{2} + 1\right) I_6 \end{aligned}$$

$$= \left(\frac{3}{2}+\frac{2}{2}\right)I_6$$

$$\begin{aligned} 2 &= \frac{5}{2}I_6 \\ \frac{2}{1} &= \frac{5I_6}{2} \\ \Rightarrow 5I_6 &= 4 \\ \frac{5I_6}{5} &= \frac{4}{5} \end{aligned}$$

$$\begin{aligned} I_6 &= \frac{4}{5} \\ I_6 &= 0.8 \\ I_4 &= \frac{3}{2}I_6 = \frac{3}{2}\times 0.8 \\ &= 1.2A \end{aligned}$$

hence currernt through the 4Ω resistor is 1.2A

(ii) emf

Total emf is equal to the p.d. across 3.6Ω + p.d. across 4Ω and 6Ω

$$\begin{aligned} E &= IR_{3.6} + I_6R_{6\Omega} \\ &= 2\times 3.6 + I_6\times 6 \\ &= 2\times 3.6 + 0.8\times 6 \\ &= 7.2 + 4.8 \\ E &= 12V \end{aligned}$$

OR

$$\begin{aligned} E &= V_{3.6\Omega} + V_{4\Omega} \\ E &= I\times R_{3.6} + I_4R_4 \\ &= 2\times 3.6 + 1.2\times 4 \\ &= 7.2 + 4.8 \\ &= 12V \end{aligned}$$

but this total emf is the sum of the emfs of each of the 8 cells.

If the emf of each cell is x, then

$$\begin{aligned} 8x &= 12V \\ \frac{8x}{8} &= \frac{12}{8} \\ x &= 1.5V \end{aligned}$$

hence the emf of each cell is 1.5V

(c) (i) Let the power consumption of each bulb be x watts.

Total energy used, E is

$$\begin{aligned} E &= \text{Power} \times \text{time} \\ &= x \times \text{No. of hours} \times 2bulbs \\ &= x\ \text{W} \times 10 \times 2\ \text{hrs} \times 2 \\ &= 40xWh \\ &= \frac{40x}{1000}\times 1000Wh \\ &= \frac{40x}{1000}KWh \\ &= 0.04xKWh \end{aligned}$$

A unit costs sh. 60

$0.04x$ unit cost sh. $0.04x\times 60$

$0.04x$ unit cost $sh.2.4x$

but the total cost or the bill

was sh. 180
hence

$$\begin{aligned} 180 &= 2.4x \\ \frac{2.4x}{2.4} &= \frac{180}{2.4} \\ x &= 75w \end{aligned}$$

hence the power consumption of each of the bulbs is 150Watts.

(ii) The energy changes that occur in the bulb are;
electricity energy $\rightarrow$ heat energy in the filament $\rightarrow$ light energy

49. (a) Sketch the current versus p.d variation for

(i) **metal wire.**

(ii) **semi-conductor diode**

(b)

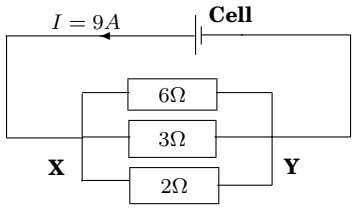


Fig. 4

Fig. 4 shows a cell of negligible internal resistance connected to a system of resistors. Calculate:

(i) **e.m.f of the cell**

(ii) **the current through the** 3Ω **resistor**

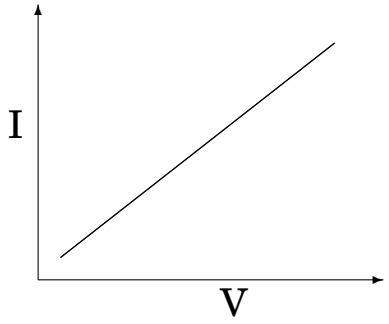
(iii) **power dissipation in the** 3Ω **resistor.**

(c) **Describe the energy changes which occur from the time an electric bulb is switched on.**

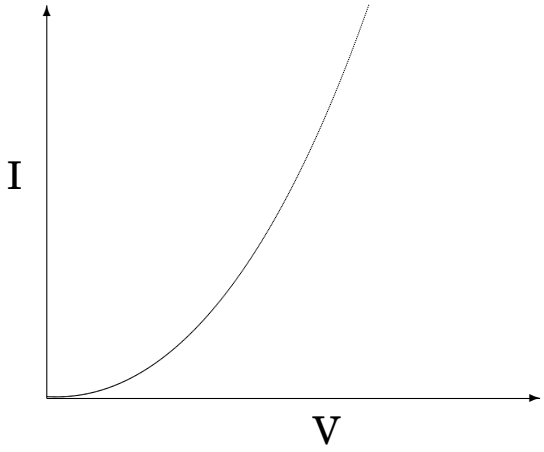
Solution

(a) Current versus potential difference variations.

(i) Metal wire



(ii) Semiconductor diode



(b) from the diagram

(i) let the total resistance of resistors in parallel be R

$$\begin{aligned} \frac{1}{R} &= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \\ &= \frac{1}{6} + \frac{1}{3} + \frac{1}{2} \end{aligned}$$

$$\begin{aligned} &= \frac{1+2+3}{6} \\ &= \frac{6}{6} \\ R &= 1\Omega \end{aligned}$$

Emf of the cell is equal to the p.d. across the 3 resistors

$$\begin{aligned} E &= IV \\ &= 9 \times 1 \\ &= 9V \end{aligned}$$

(ii) Current through the 3Ω resistor

The pd across 3Ω is equal to the p.d. across the whole parallel connection

$$\begin{aligned} I_{3\Omega}R_{3\Omega} &= 9V \\ I \times 3 &= 9 \\ 3I &= 9 \\ I &= \frac{9}{3} \\ I &= 3 \text{ Amperes} \end{aligned}$$

(iii) Power dissipation in the 3Ω

$$\begin{aligned} P &= \frac{V^2}{R} \\ &= \frac{9^2}{3} \\ &= 27 \text{ watts} \end{aligned}$$

OR

$$\begin{aligned} P &= I^2R \\ &= 3^2 \times 3 \\ &= 27 \text{ watts} \end{aligned}$$

OR

$$\begin{aligned} P &= VI \\ &= 9 \times 3 \\ &= 27 \text{ watts} \end{aligned}$$

(c) The electric energy is changed to heat energy in the filament which then is changed to light energy that comes from the bulb.

50. The graph in figure 4.2 on page 230 shows the variation of current through a tungsten filament with the p.d. across it.

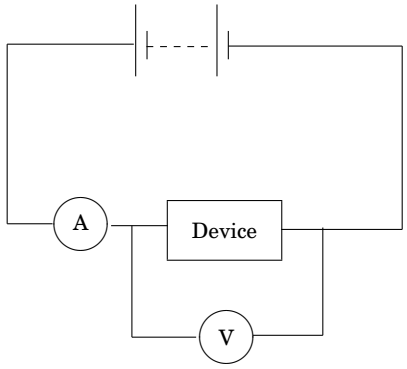
(i) **Draw a suitable circuit diagram to show how the results in the graph can be obtained.**

(ii) **State what happens to the resistance of the filament as the current increases.**

(iii) **Using the graph, determine the resistance of the filament when the current is 0.7A**

Solution

(i) .



Where the current is registered by the ammeter A and the voltage or potential difference is registered by the voltmeter V.

(ii) as the current increases the resistance of the filament also increases but tends to a constant value. This is observed when you measure the resistance at various points on the graph.

(iii) when current is 0.7A, we draw a tangent at that point on the curve where $I = 0.7A$ and then get the slope. at $I = 0.7A$

$$\begin{aligned} \text{slope} &= \left|\frac{\Delta I}{\Delta V}\right|_{\texttt{at } I=0.7A} \\ &= \frac{1.54 - 1.06}{10.8 - 4} \\ &= \frac{0.48}{6.8} \\ &= 0.0706AV^{-1} \end{aligned}$$

But Resistance, R

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

$$\begin{aligned} &= \frac{1}{\text{slope}} \\ &= \frac{1}{0.0706} \\ &= 14.167\Omega \end{aligned}$$

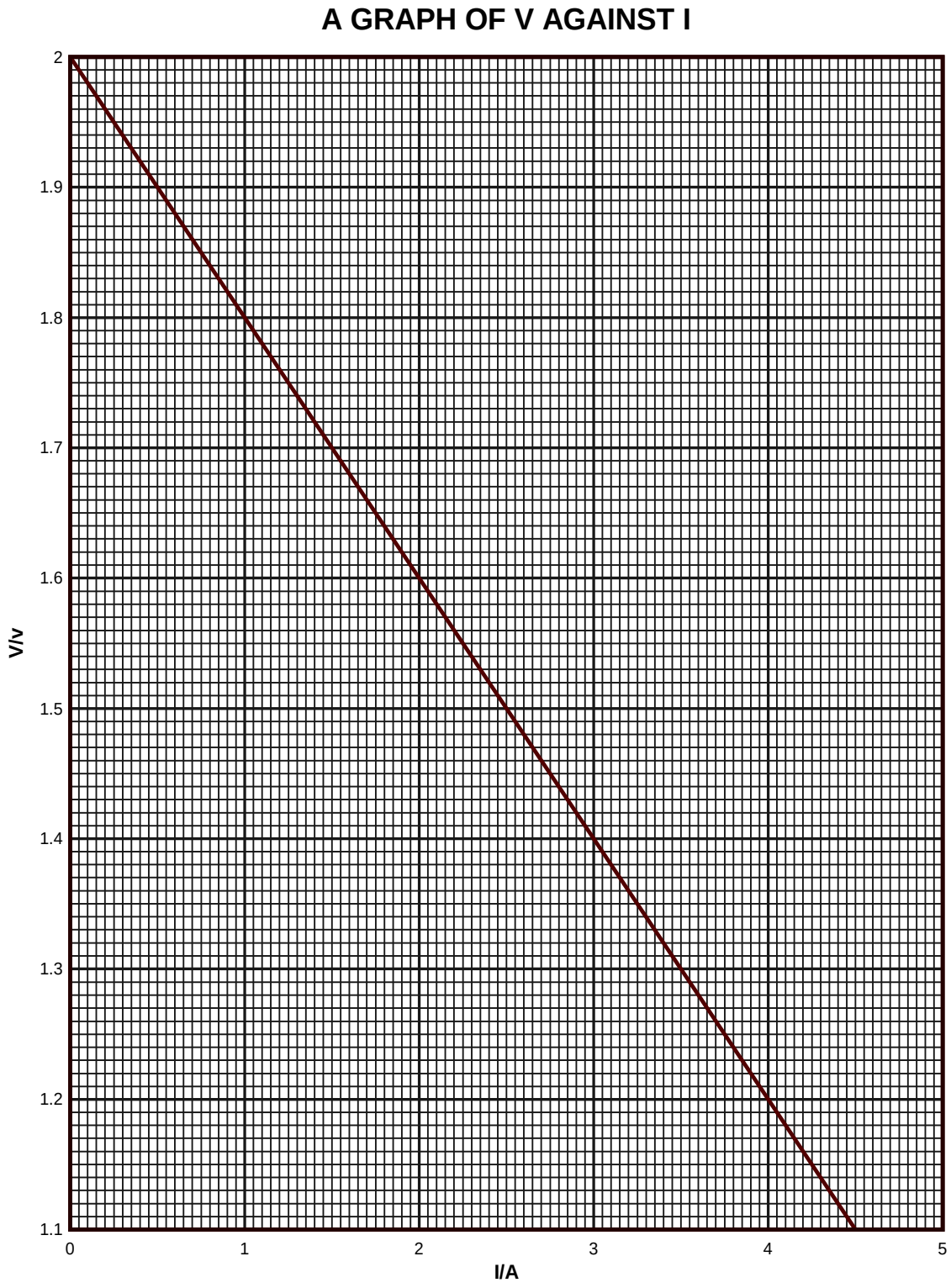


Figure 4.1: Graph of Voltage versus current

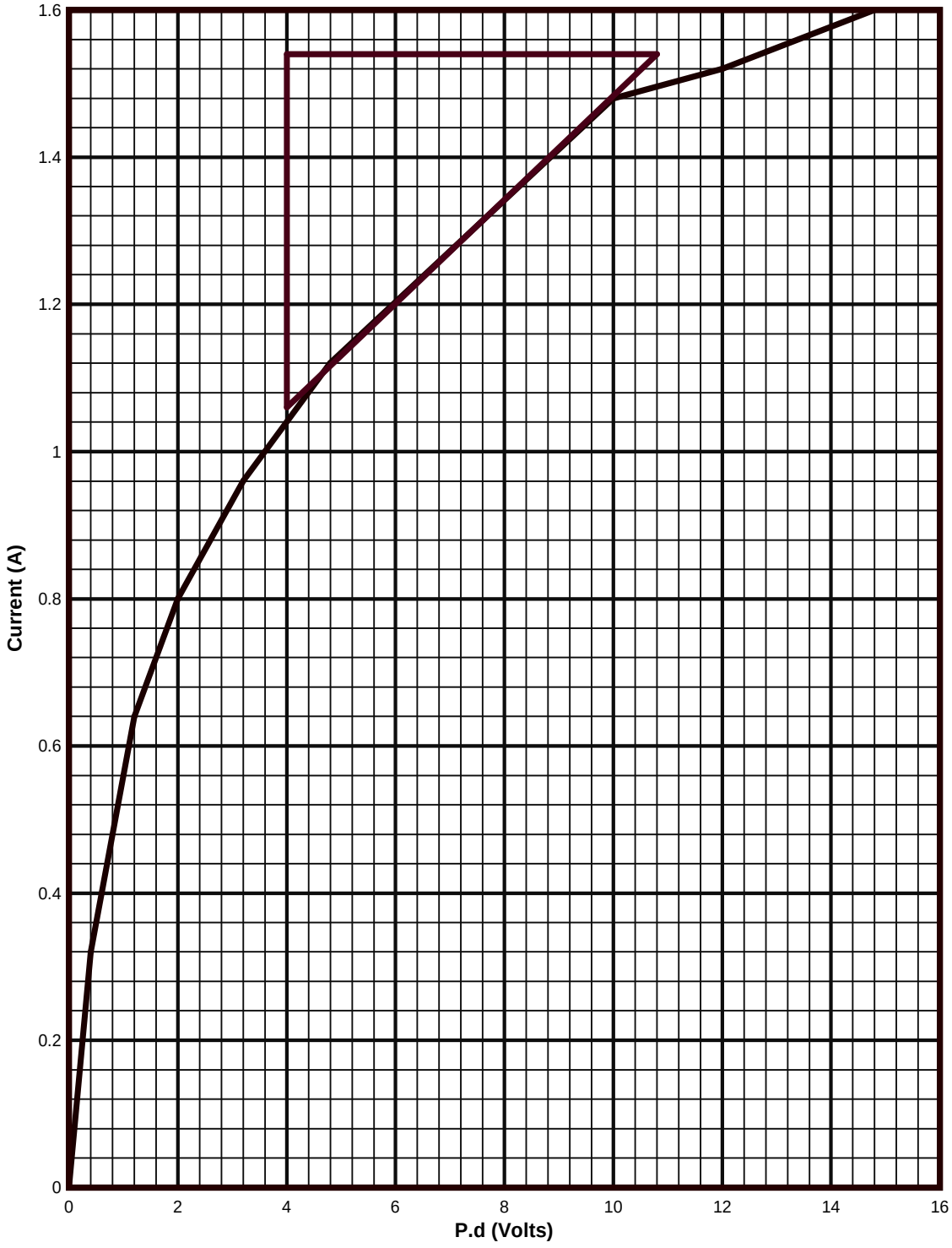


Figure 4.2: Graph of Current against Voltage

4.4 Magnetism

Section A (Objectives)

1. Four bars of metal P, Q, R, S are tested for magnetism Q attracts both P and R but not S. S does not attract P, Q or R. P and R sometimes attract one another and sometimes repel each other. Which of the following statement is correct about P, Q, R and S/

   A. P, Q, R are magnet., S is magnetic.

   B. P and Q are magnets. R and S magnetic.

   C. P and R are magnets. Q is magnetic, S is non magnetic.

   D. P and R are magnets. Q and S are non-magnetic. **C**

   It is only magnets that can repel each other, the only sure test for a magnet hence P and R are magnets. Hence **C**.

2. A magnet can be made to lose its strength by

   (i) Heating

   (ii) Throwing it violently

   (iii) Putting it in a solenoid carrying direct current

   A. (i) and (iii) only

   B. (ii) and (iii) only

   C. (i) and (ii) only

   D. (i), (ii) and (iii). **C**

3.

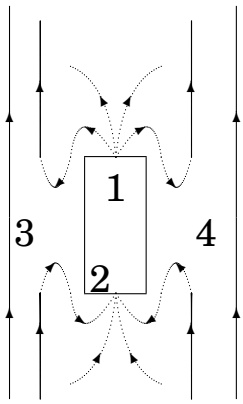


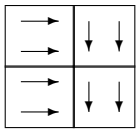
Fig.2

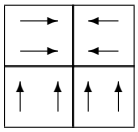
Fig. 2 shows the superposition of the earth's magnetic field and the field due to a magnet. Identify point marked 1,2,3 and 4.

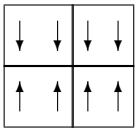
	1	2	3	4
A.	S pole	N pole	Neutral	Neutral
B.	N pole	S pole	Neutral	Neutral
C.	Neutral t	Neutral	N pole	S pole
D.	Neutral t	Neutral	S pole	N pole

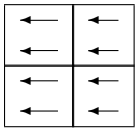
B

4. Which of the following shows a piece of material in a magnetized condition?

A. 

B. 

C. 

D. 

D

5.

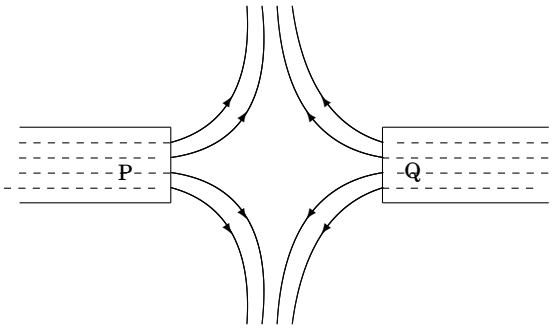


Fig. 9

In fig. 9 above name the polarities P and Q.

B

	P	Q
A.	N pole	S pole
B.	N pole	N pole
C.	S pole	S pole
D.	S pole	Un magnetized iron bar.

6. Which of the following statements is not true about magnets?

A. magnetic poles cannot be separated.

B. A paramagnetic material is a material from which a strong magnet can be made.

C. The neutral point in a magnetic field is a point where there is no force experienced.

D. heating a magnet can reduce its magnetism. **B**

Section B (Structured)

7. List two ways by which a magnet may lose its magnetic properties.

1. *by heating*
2. *by hammering it*
3. *by using a Solenoid carrying alternating current*

8. .

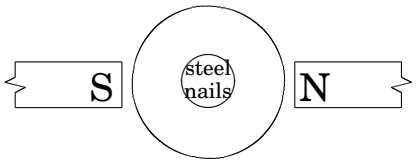


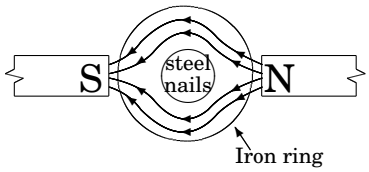
Fig. 7

Fig. 7 shows an iron between two opposite magnetic poles.

(i) Sketch the magnetic lines of force on the diagram.

(ii) Explain what happens to the steel nails.

(i)



(ii)*Nothing happens to them because they are in a space magnetically screened.*

9. What is a soft magnetic material?

This is a magnetic material that is easy to magnetize and demagnetize.

10. State two ways in which a bar magnet can be demagnetized.

1. *by heating it*
2. *by placing it i a solenoid carrying alternating current*

11. Explain why soft iron is preferred to steel in making electromagnets

because

(i) *it is easily magnetized strongly*

(ii) *it is easily demagnetized*

Paper II (Essay)

12. (a) (i) What is a magnetic field?

(ii) State the law of magnetism?

(b) (i) Explain with the aid of diagrams, how a steel bar can be magnetized by the single touch method.

(ii) Sketch the magnetic field pattern around two bar magnets whose north poles face each other.

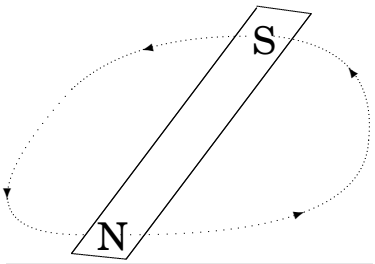
Solution

(a) (i) a magnetic field is the space where a magnetic material or magnet experiences a force.

(ii) the law of magnetism states that like poles of a magnet repel and unlike poles attract.

(b) (i) to magnetize a steel bar by single touch method.

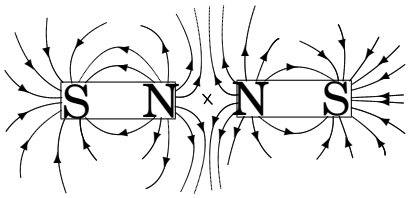
- Place the steel bar on a wooden table and hold it there firmly
- Bring a known magnet and stroke it on the steel bar for a few number of times as shown below



N Steel bar S

- The steel bar will be magnetized with the poles as shown above now the steel bar can attract other magnetic materials.

(ii)



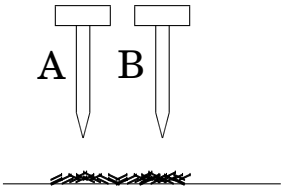
13. (i) Describe an experiment to distinguish between soft and hard magnetic materials.

(ii) State one instance in which each of these materials is used.

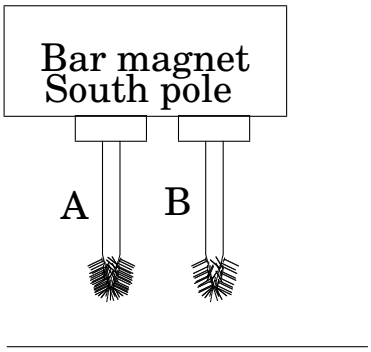
Solution

(i) An experiment to distinguish soft and hard magnetic materials

- Hold the two materials above iron nails as shown below;

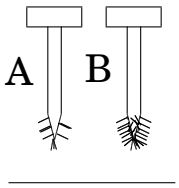


- Place a magnet on them, One will attract more nails than the other.



what attracts more nails is the material that is easily magnetised.

- Remove the magnet from them



The material that remains with more nails is the one that is not easily demagnetised. Hence A is the soft magnetic material because it is easily magnetised (it attracted more nails with the magnet on it). And easily demagnetised (because it retained nearly no nails when the magnet was taken off).

B is the hard magnetic material because it is not easily magnetised (it attracted fewer nails) and not easily demagnetised (retained more nails when the magnet was taken away).

(ii) Hard magnetic materials are used in making permanent magnets and soft magnetic materials are used in making temporary magnets like in the core of transformers and to make magnets used in the electric bell.

14. (a) Explain how a piece of iron can be magnetized by the single touch method. Illustrate your answer with a diagram.

(b) **How can you determine the polarity of a magnet?**

(c) **Explain why a magnet looses its magnetism when placed in a coil of wire carrying an alternating current.**

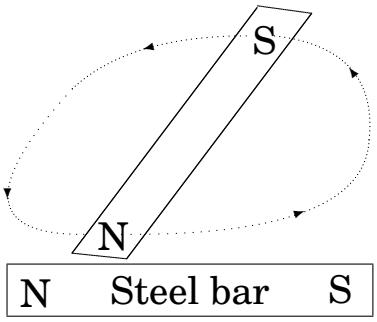
(d) **Describe the motion of a beam of electrons directed midway between the North and South poles of a permanent magnet.**

Solution

(a) To magnetize an iron bar by single touch method.

- Place the iron bar on a wooden table and hold it there firmly

- Bring a known magnet and stroke it on the iron bar for a few number of times as shown below



- The iron bar will be magnetized with the poles as shown above now the iron bar can attract other magnetic materials, i.e. it is magnetised.

(b)To determine the polarity of a bar magnet, just freely suspend it (in the earth's magnetic field). It will rest pointing in the north-south direction. The side which points in the Geographical north is the magnetic north pole of the magnet and that which points in the geographical south is the south pole of the magnet.

(c)A coil of wire carrying alternating current produces an alternating magnetic field that is a continuously changing magnetic field hence when a magnet is placed in the coil it gets magnetised and demagnetised in reverse directions continuously and as a result of this, it looses its magnetism i.e the magnetic domains are made to point in random directions.

(d) The electrons are negatively charged hence they are considered to be like an electric current moving in the opposite direction. Since an electric current in a wire between the magnets experiences a force then also these electrons will be deflected in a direction determined by Fleming's left hand rule

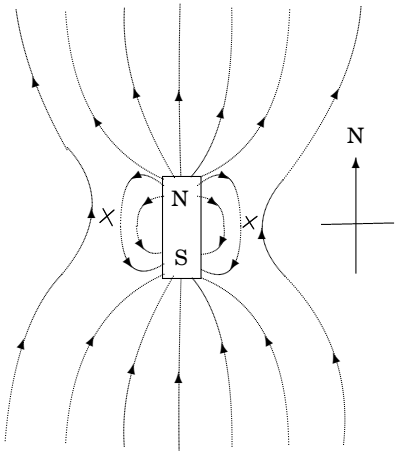
15. (a) Distinguish between angle of dip (inclination) and angle of declination.

(b) **Draw a diagram to show the magnetic field pattern around a bar magnet placed in the earth's field with the north pole of the magnet pointing to the earth's magnetic south.**

Solution

(a)Angle of a dip is the angle made by the earth's magnetic field to the horizontal while angle of declination is the angle between the earth's magnetic meridian and the geographical meridian.

(b)



(iv)The coil will come to rest with PQ at right angles to magnetic field.

A. (i), (ii) and (iii).

B. (i) and (iii) only

C. (ii) and (iv) only.

D. (iv) only. **B**

2. .

4.5 Magnetic effect of I

Section A (Objectives)

1.

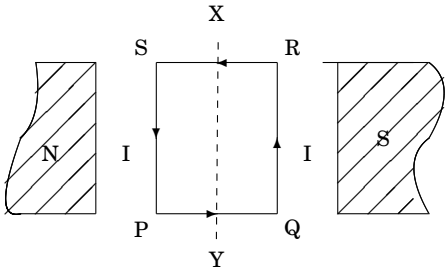


Fig. 6

The diagram in fig. 6 shows a current-carrying coil PQRS pivoted about XY between two magnets. Which of the statements are true about the coil?

(i)The sides PS and QR shall experience force.

(ii)As seen from X the coil will rotate anticlockwise.

(iii)The force on the coil can be increased by increasing the number of turns

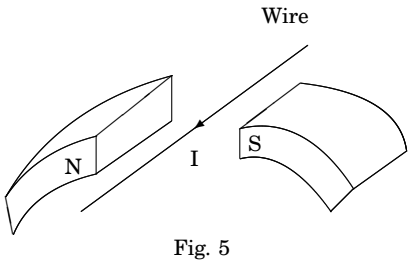


Fig. 5

When a current, 1, flows through a wire placed in between the poles of a U-magnet as shown in Fig. 5, the wire will move.

A. Upwards **A**

B. Downwards

C. Towards the south pole

D. Towards the north pole

3. A moving coil galvanometer can be used to

A. Measure a direct current.

B. Convert alternating current into direct current.

C. Covert direct current to alternating current.

D. Measure the peak value of an alternating current. **A**

4. What energy changes take place when a switch of the electrical bell is pressed?
   A. Chemical → electrical → kinetic → magnetic → sound
   B. Chemical → electrical → magnetic → kinetic → sound
   C. Chemical → electrical → sound
   D. Electrical → magnetic → sound **B**

5. Which of these factors affect the magnitude of force on a current carrying conductor in a magnetic field?
   (i) The direction of current.
   (ii) The amount of current.
   (iii) The direction of the magnetic field.
   (iv) The strength of the magnetic field.
   A. (i) and (ii)
   B. (ii) and (iii)
   C. (i) and (iii)
   D. (ii) and (iv) **D**

6. A magnetic material can be magnetized by
   (i) stroking with a permanent magnet
   (ii) using a direct current.
   (iii) by induction.
   A. (i) only.
   B. (i) and (ii) only.
   C. (ii) and (iii) only.
   D. (i), (ii) and (iii). **D**

7. The sensitivity of a moving coil galvanometer can be increased by using
   A. smaller coil.
   B. weaker magnet.
   C. weaker hairspring.
   D. fewer turns of wire on the coil. **C**

8. The strength of a magnetic field between the poles of an electromagnet remain the same if the
   (i) current in the electromagnet winding is doubled
   (ii) direction of the current in the electromagnet winding are reversed
   (iii) the number of turns are halved
   A. (i) only
   B. (ii) only
   C. (i) and (ii) only
   D. (ii) and (iii) only **B**

9 Which of the following factors affect the strength of an electromagnet?
   (i) Changing magnitude of the current.
   (ii) Changing direction of the current.
   (iii) Doubling number of turns.
   A. (ii) only.
   B. (i) and (ii) only.
   C. (i) and (iii) only.
   D. (ii) and (iii) only. **C**

10. Which of the following will increase the force on a current carrying wire?

(i) Using a large current.

(ii) Using a stronger magnetic field.

(iii) Using a shorter length of wire in the field.

(i) only.

(i) and (ii) only.

(i) and (ii) only.

(iii) and (iii) only. **B**

11. The diagram in fig. 6 shows a simple electric motor.

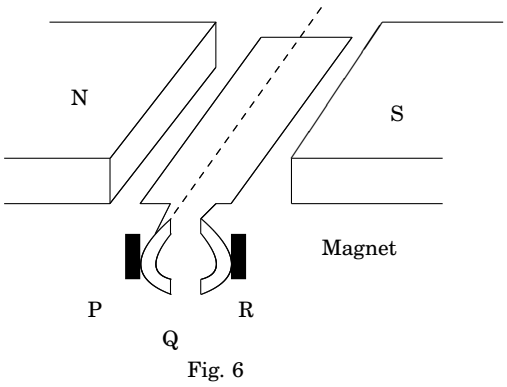


Fig. 6

The coil continues to turn in the same direction because the commutator Q and brushes P and R.

A. reverse current in the coil every half a revolution.

B. reverse current in the coil every quarter of a revolution.

C. reverse polarity of the field produced by the magnet.

D. carry the coil past its vertical position every half a revolution. **A**

12. A moving iron meter

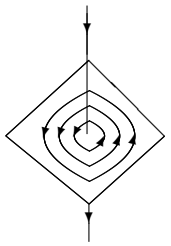
A. measures only direct current.

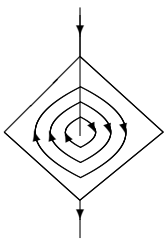
B. has a permanent magnet.

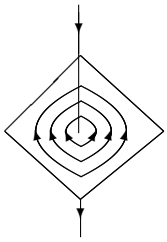
C. measures only alternating current.

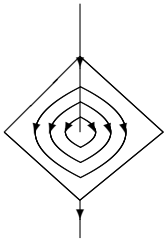
D. has the pointer attached to the soft iron. **D**

13. Which one of the following diagrams represents the correct magnetic field around a straight wire carrying a current?

A. 

B. 

C. 

D. 

B

14. Which of the following statements are correct?

(i) The particles of magnetic materials are tiny magnets.

(ii) The particles in unmagnetised iron arrange themselves in closed chains.

(iii)The particles in a magnetic are arranged in open

chains with N pole of one particle against the S pole of its neighbouring particle.

(iv)Groups of atoms form a magnetic domain.

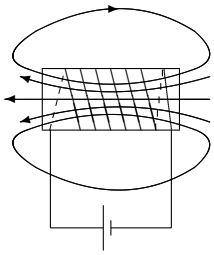
A. (i), (ii) and (iii) only.

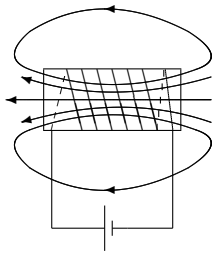
B. (i), (iii) and (iv) only.

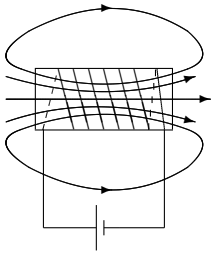
C. (ii) and (iv) only.

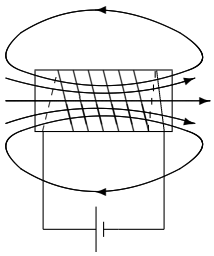
D. (iv) only **A**

15. Which one of the following diagrams shows a correct magnetic field due to a current flowing in a solenoid?

A. 

B. 

C. 

D.  **D**

In each of the questions 16 to 17 one or more of the answers given may be correct. Read each question carefully and then indicate the correct answer A, B, C or D according to the following:

A. if 1,2,3 only are correct.

B. If 1,3 only are correct.

C. If 2,4 only are correct.

D. If 4 only is correct.

16. Which of the following statements are true about magnets?

1. Magnets always have opposite polarities.
2. A magnet can be used as a compass.
3. Repulsion is the only sure test for a magnet.
4. Magnets attract all metals.

A

17. Which of the following statements is/are correct?

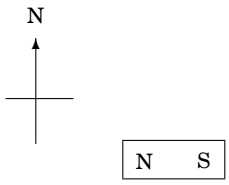
1. An electromagnet is a temporary magnet because it can be activated and deactivated.
2. The strength of the magnetic field increases as the current through a wire decreases.
3. The strength of an electromagnetic decreases with

the number of turns around the core.

4. The magnetic field lines form concentric circles about the conductor. **C**

Section B (Structured)

18. A bar magnet is placed in the earth's magnetic field with its north pole pointing to the geographical west as shown below.

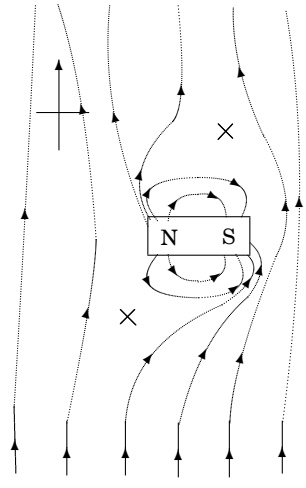


(a)

(i) On the diagram, draw the lines of the resultant magnetic field around the magnet.

(ii) Mark the neutral point X.

(i)



(ii) *The neutral points are shown in the diagram above as X*

19. The diagram in fig. 11 shows a straight wire connected to the terminals of a centre zero galvanometer.

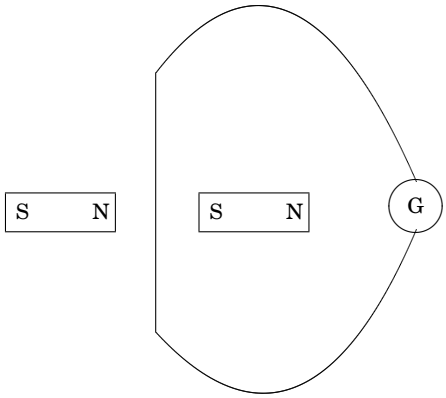


Fig.11

When the wire is moved vertically upwards out of the plane of the paper. The galvanometer deflects.

(i) In what direction does the galvanometer deflect?

(ii) Why does the galvanometer deflect?

(iii) State one way by which the deflection of the galvanometer can be reversed.

(i) *In either direction depending on the direction of movement of the wire in the magnetic field and how the galvanometer was connected.*

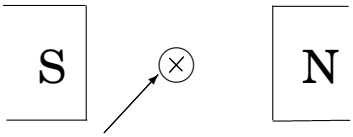
(ii) *Because an emf is induced in the circuit, this creates an induced current which the galvanometer deflects to show.*

(ii) *By moving the wire vertically down wards i.e. in a direction opposite the previous direction.*

21. State **two** ways by which the effect of what was observed in (20) (i) above can be increased.

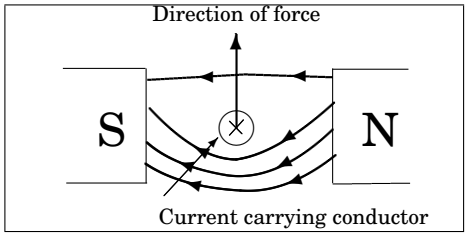
By winding more turns of coils on the soft iron material.

22. .



Current carrying conductor
Fig. 9

fig. 9 shows a straight conductor carrying current between the poles of a permanent magnet. Sketch on the diagram above the resultant magnetic field pattern.



20. .

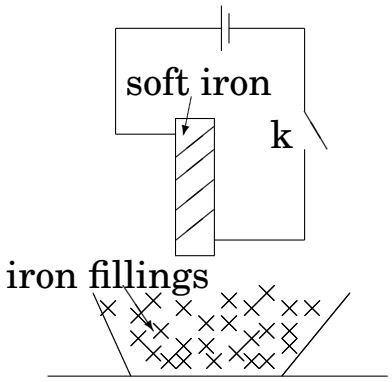


Fig. 11

A coil is wound on a soft iron rod as shown in Fig. 11. Describe what is observe when the key, K, is

(i) Closed.

The iron nails are attracted to the soft iron rod

(ii) Closed and then again opened

Some iron nails are attracted to soft iron on closing and some fall off on opening.

23. What is meant by;

(i) magnetic saturation?

(ii) neutral point in a magnetic field?

1. *magnetic saturation is when a magnet can not be magnetized any more or it is when all the magnetic domains of a magnet are fully aligned in the same direction.*
2. *A magnetic neutral point is a point in the magnetic field where a magnetic pole experiences no force.*

24. .

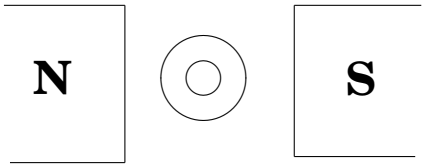
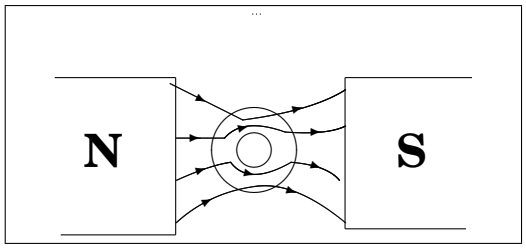


Fig. 11

An iron ring is placed between two poles of two permanent magnet as shown in fig. 11. Draw the magnetic field pattern set up between the two poles.



25. Why is an ammeter constructed such that it has a low internal resistance

so that it does not affect the current passing through the device, whose current the ammeter is measuring

26. A milliammeter has an internal resistance of 4Ω and a full scale deflection of 0.015A. Calculate the value of the resistor that must be connected to the milliameter so that a maximum current of 5A can be measured.

p.d across shunt, V_{shunt} is equal to p.d. across ammeter, V_{ammeter}

$$\begin{aligned} V_{\text{shunt}} &= V_{\text{ammeter}} \\ R \times (5 - 0.015) &= 4 \times 0.015 \\ R &= \frac{4 \times 0.015}{4.985} \\ &= 0.012\Omega \end{aligned}$$

27. A galvanometer has resistance of 5Ω and a range of $0 - 40mA$. Find the resistance of the resistor which must be connected in parallel with the galvanometer if a maximum current of $10A$ is to be measured.

By pass current

$$\begin{aligned} &= 10A - 40mA \\ &= 10A - 0.04A \\ &= 9.96A \end{aligned}$$

Common p.d

$$\begin{aligned} V &= 5 \times 0.04 \\ &= 0.2V \end{aligned}$$

required resistance

$$R = \frac{V}{I} = \frac{0.2}{9.96} = 0.02\Omega$$

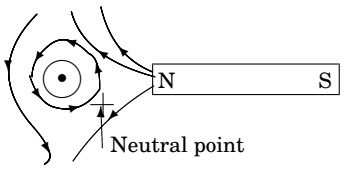
28. What is a neutral point in a magnetic field?

This is a point in a magnetic field where the net magnetic field strength in zero or a point where a magnetic north pole experiences no magnetism force.

29. .

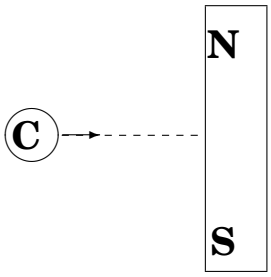
Fig.8

The diagram in Fig. 8 shows a straight conductor carrying current vertically upwards placed near a bar magnet. Sketch the magnetic field pattern around the wire and the magnet.



30. What is an **electromagnet**?

An electromagnet is a solemid with a soft magnetic material in its middle. When current passes through it, it behaves like a magnet.



31.

Describe what happens to the compass needle, C, as it is moved closer to the bar magnet along the dotted line shown in Fig. 2.

The pointer of the compass goes on deflecting towards the south pole.

Paper II (Essay)

32. (a) With the aid of a diagram explain, the use of keeper to store magnets.

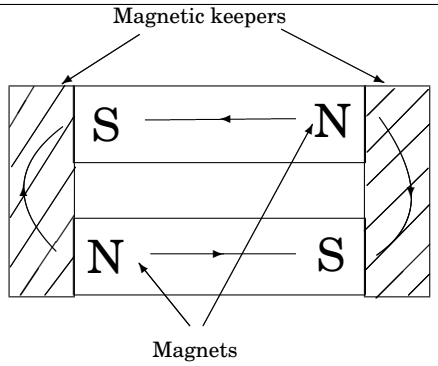
(b) (i) Describe using a labeled diagram how a telephone receiver works.

(ii) **State two ways by which the strength of an electromagnet can be increase**

Solution

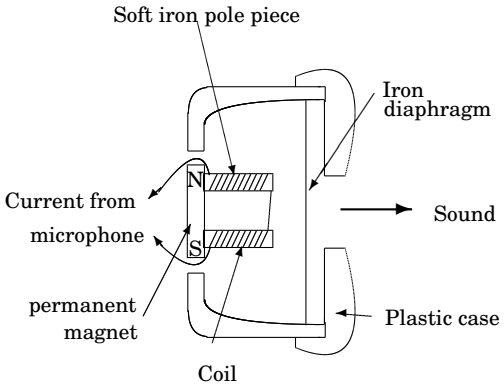
(a) Magnetic keepers create a closed loop of magnetic field lines which is required to keep the strength of the magnet intact because the magnetic domains are kept aligned in one direction or in a closed loop.

The magnetic keepers are used as shown below.



(b) (i) how a telephone receiver works;

This is the piece of the telephone handle that is placed near the ear. It converts electric energy to sound energy like a loud speaker or it converts speech current along the telephone line to sound waves in the air. Below is its circuit diagram;



When no current flows, the iron diaphragm is under tensional forces (i.e. it is not loose). When the varying current from the microphone (via the amplifier) passes through the coils that acts as an electromagnet wound around the permanent magnet, the tensional forces on the iron diaphragm also change. This is because the resultant magnetic force acting on the diaphragm changes and hence the diaphragm is pulled towards the poles and then released i.e. it is displaced by a distance proportional to the magnitude of the current and at a frequency equal to that of the changing current. As a result the diaphragm moves in and out of the permanent magnet's port setting the surrounding air into vibration producing sound waves that have the same frequency as that of the sound that entered the microphone at the other end.

(ii) The strength of an electromagnet can be increased by;

- Using a coil with more number of turns
- Using a soft iron magnetic material as its core material.

33. (a) Explain what happens when a magnet is

(i) **dipped in iron filings**

(ii) **freely suspended in air.**

(b)

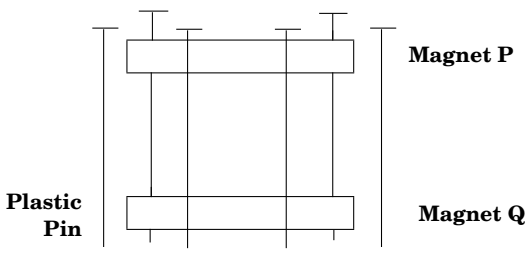


Fig. 3

A powerful magnet Q is placed on a soft board. Plastic pins are firmly stuck is the soft board around the magnet. An identical magnet P is held in the space surrounded by the pins above the magnet Q. When the magnet P is released it floats above the magnet Q as shown in fig. 3.

(i) **Explain why P floats above Q.**

(ii) **Why are plastic pins used instead of steel pins?**

(iii) **What would happen to magnet P if all the pins were removed at the same time?**

(c) **Explain in terms of the domain theory how a steel bar gets magnetized by stroking.**

Solution

(a) (i) when a magnet is dipped in iron filling it attracts them with most of them concentrated at two points which are the poles of the magnet.

(ii) when a magnet is freely suspended in air, it rests pointing in the north-south direction due to the earth's magnetic field.

(b) (i) P floats on Q because it has been arranged such that the like poles are close to each other and they have to repel so they are repelling keeping P floating above Q.

(ii) Plastic pins are used because plastic is not magnetic otherwise if steel pins were used they would get magnetized and affect the magnetic field due to the magnet

(iii) P would rotate and then land and rest on Q with unlike poles close to each other.

(c) When a magnet is stroked on a steel bar, the magnetic domains in it are forced to align in the direction of the magnetic field from the magnet, they do so and remain in that direction hence the steel bar gets magnetized.

34. (a) Draw the magnetic field pattern due to an electric current in:

(i) a circular coil

(ii) a solenoid.

(b) With the aid of a labeled diagram, describe briefly the action of an electric bell.

(c) What is meant by the following:

(i) magnetic meridian

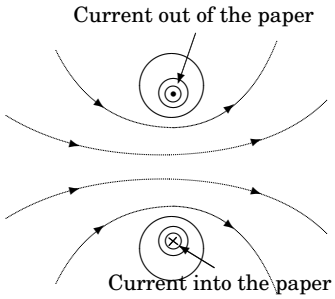
(ii) neutral point in a magnetic field?

(d) Describe briefly how a steel bar may be magnetized.

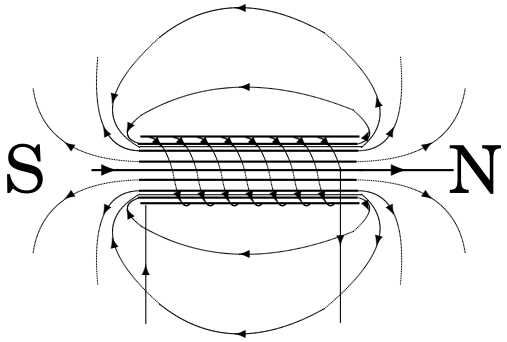
Solution

(a) Magnetic field pattern due to an electric current in

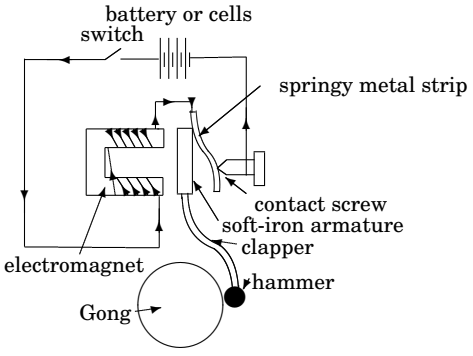
(i) a circular coil



(ii) a solenoid



(b) the circuit below is of an electric bell

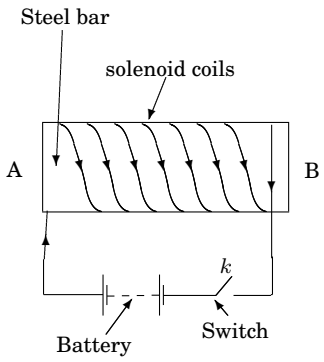


when the switch is closed the electric circuit becomes complete and current flows as indicated in the diagram the electromagnet becomes magnetized and attracts the soft iron armature. This breaks the circuit at the contact screw and current stops flowing, the electromagnet is demagnetized as the hammer hits the gong and sound is produced. The springy metal strip pulls the armature back touching the contact screw completing the circuit, repeating the cycle, the hammer hits the gong continuously at a frequency determined by the strength or tension in the springy metal.

(c) (i) Magnetic meridian is the plane containing the magnetic axis of a freely suspended magnet.

(ii) neutral point in a magnetic field is a point in the magnetic field where a magnetic material or a magnetic pole **does not** experiences a magnetic force.

(d) a steel bar can be magnetic by positioning it at the centre of a solenoid and connecting the terminals of the solenoid to a direct current source as shown below;



close the switch and then open it. On testing the steel bar it at-

tracted the small pieces of iron hence it has been magnetised.

35. (a) State any two factors which determine the magnitude of a force exerted on a current carrying conductor.

(b) With the aid of a well-labelled diagram, describe the structure and mode of action of a moving coil loud speaker.

(c) State the factors which determine the pitch and loudness of sound produced by a moving coil loudspeaker.

(d) A D.C motor has an armature resistance of 4Ω . If it draws a current of 10A when connected to a supply of 200V. Calculate the

(i) power wasted in the windings.

(ii) Efficiency of the motor.

Solution

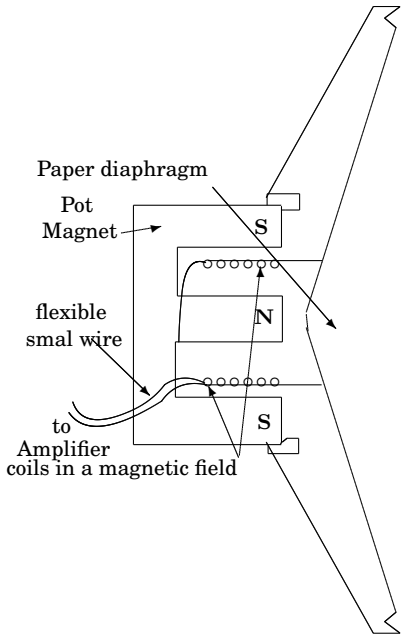
(a) factors are;

- The magnitude of current passing though it
- The strength of the magnetic field
- The length of the conductor in the magnetic field

(b) structure and mode of operation of a moving coil loudspeaker.

Construction A moving coil loud speaker is a device for converting electrical energy to sound energy. It is commonly used in radio receivers, record players, e.t.c. It works by the principle of a force exerted on a current carrying coil situated in a magnetic field.

Varying electric current which corresponds (in frequency) with the sound to be reproduced, is passed through a short cylindrical coil called **voice coil**. This coil is attached on a paper cone that is free to move in the radial magnetic field set up by a permanent pot-magnet.



This magnet produces a radial magnetic field that cuts through the turns of the coil at right angles, and consequently as the current passing through the coil varies, it will move to and fro in accor-

dance to Fleming's left hand rule. The coil is attached to a cone made of a special material paper which moves with the coil and sets the surrounding air in vibration producing the suitable sound, hence converting a suitably varying current to a suitable sound with a frequency numerically equal to that of the original sound.

(c) pitch is determined by the frequency of the alternating signal set to the loudspeaker and loudness is determined by the magnitude or amplitude of the current passing through the loudspeaker.

(d) For the d.c motor

$$\begin{aligned} R &= 4\Omega \\ I &= 10A \text{ when} V = 200V \end{aligned}$$

(i) Power wasted in the windings

$$\begin{aligned} P &= I^2R \\ &= 10^2 \times 4 \\ &= 400W \end{aligned}$$

(ii) Efficiency of the motor, is equal to the ratio $\frac{\text{Power given out by the motor}}{\text{Power supplied to the motor}}$

Supplied Emf, E is equal to the sum of back emf E_b and the P.d across the resistance coil , IR

$$E = E_b + IR$$

$$\begin{aligned} 200 &= E_b + 10 \times 4 \\ 200 &= E_b + 40 \\ E_b &= 160V \end{aligned}$$

power delivered by motor is

$$\begin{aligned} P_{out} &= IV \\ &= IE_b \\ &= 10 \times 160 \\ &= 1600W \end{aligned}$$

power supplies to motor is

$$\begin{aligned} P_{in} &= IE \\ &= 10 \times 200 \\ &= 2000W \end{aligned}$$

The efficiency, E, is

$$\begin{aligned} E &= \frac{P_{out}}{P_{in}} \times 100\% \\ &= \frac{1600W}{2000W} \times 100\% \\ &= 80\% \end{aligned}$$

36.

(a)

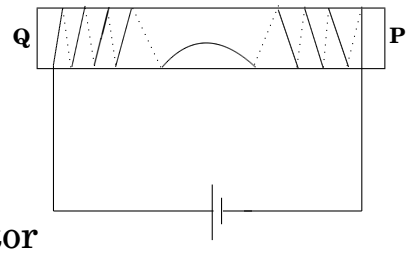


Fig. 3

Fig. 3 shows how a magnetic material can be magnetized by electrical method.

(i) **Indicate the direction of current in the coil.**

(ii) **Name the polarities P and Q.**

(b) **Describe how you can determine the polarity of a magnet.**

Solution

(a) (i) direction of current is

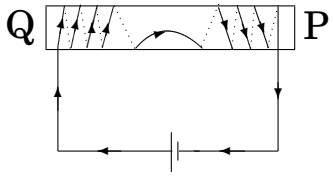


Fig. 3

(ii) Both P and Q are North poles

(b) How to determine the polarity of a magnet

- get the bar magnet
- freely suspend it on a thin thread in air
- it will point in the Geographical north – south direction
- the side that points in the north is the north pole and that which points in the south is the south pole.

3 hours if one unit of electricity costs Shs 70.

A. Shs 105

B. Shs 175

C. Shs 420

D. Shs 525. **D**

$$\begin{aligned} P &= 2kW + 500W \\ &= 2.5kW \\ E &= Pt = 2.5kw \times 3hr \\ &= 7.5kwh \\ \text{cost} &= 7.5kwh \times 70 \\ &= sh.525 \end{aligned}$$

2. An electric bulb has a resistance of 960Ω. Find the electrical power expended when connected across a 240 V supply.

A. $\frac{960}{240\times240}$

C. $\frac{960}{240}$

B. $\frac{240}{960}$

D. $\frac{240\times240}{960}$ **D**

$$\begin{aligned} P &= \frac{V^2}{R} \\ &= \frac{240 \times 240}{960} \end{aligned}$$

4.6 Electromagnetism

Section A (Objectives)

1. Two appliance are rated 240 V, 2kW and 240 V, 500 W. Find the cost of running these appliances for

3. The direction of induced current in a conductor moving in a magnetic field can be predicted by applying

A. Faraday's law

B. Maxwell's screw rule

C. Fleming's left hand rule

D. Fleming's right hand rule **D**

4. Power loss due to eddy currents in the core of a transformer can be minimized by

A. laminating the core.

B. using thick copper wires in the windings.

C. Using a soft iron core

D. winding the secondary coil on top of the primary coil. **A**

5. A current of 10A flows through an electric heater for 1 h. If 7.2 x 10^6 J of electrical energy is converted to heat. Find the p.d. across the heater.

A. 2.0×10^2V

B. 2.0×10^3V.

C. 1.2×10^4V.

D. 7.2×10^5V. **A**

$$\begin{aligned} E &= VIt \\ V &= \frac{E}{It} \\ &= \frac{7.2 \times 10^6}{10 \times 3600} \\ &= 200 = 2.0 \times 10^2 \end{aligned}$$

6. An electric lamp is marked 120W, 240 V. What does 120W mean?

A. total energy consumed by the lamp.

B. Rate at which energy is consumed.

C. Total current flowing through the lamp. **B**

D. Potential difference across the lamp.

7. Which of the following is true about both alternating current and direct current?

(i) cause heating.

(ii) can be stepped up or down with transformer.

(iii) can be used to charge a battery.

A. (i) only.

B. (i) and (ii).

C. (ii) and (iii).

D. (i), (ii), (iii). **A**

8. A transformer connected to 240V a.c mains is used to light a 12V 36w lamp. What current does the lamp draw?

A. 20.0 A

B. 6.7 A

C. 3.0 A

D. 0.33 A **C**

$$\begin{aligned} P &= IV \\ I &= \frac{P}{V} \end{aligned}$$

$$= \frac{36}{12}$$
$$= 3$$

9. A bulb is rated 40V, 60W. Find its resistance.

A. 0.25Ω

B. 410Ω

C. 120Ω

D. 960Ω **No Correct option**

$$P = \frac{V^2}{R}$$
$$R = \frac{V^2}{P}$$
$$= \frac{40^2}{60}$$
$$= \frac{1600}{60}$$
$$= 26.67\Omega$$

10. A current of 2A flows through a coil of resistance 3Ω for one minute. How much energy is converted into heat?

A. 6J.

B. 12J.

C. 360J.

D. 720J. **D**

$$E = I^2Rt$$
$$= 2^2 \times 3 \times 60$$
$$= 720$$

11. A 240V mains transformer has 1000 turns in the primary. The number of turns in the secondary if it is used to supply a "12V, 24W" lamp is

A. 2.0×10^4

B. 500.

C. 50.

D. 20 **C**

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$
$$N_2 = \frac{V_2}{V_1} \times N_1$$
$$= \frac{12}{240} \times 1000$$
$$= 50$$

12.

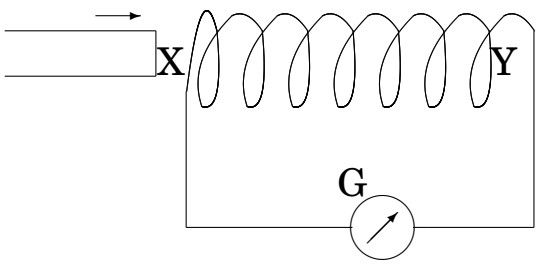


Fig. 1

Fig. 1 shows a coil connected to a centre zero galvanometer, G. The poles produced at the ends X and Y of the coil when the North pole of a magnet approaches it, is

A. X - North pole Y - South pole

B. X - South pole Y - North pole

C. X - North pole Y - North pole

D. X - South pole Y - South pole

A

13. The device which disconnects the mains when there is a sudden increase in voltage is

A. fuse

B. switch

C. earth wire

D. circuit breaker **D**

14. When transmitting electrical power over long distances, the voltage is stepped up in order to

A. transmit it.

B. reduce power loss.

C. Increase current for transmission.

D. Prevent electric shocks **B**

15. An electric heater is connected to a 200V supply. The heating element has a resistance of 10Ω. The cost of using the heater for 4 hours if each unit of energy costs Sh. 35 is

A. Sh. 5600.

B. Sh. 1400.

C. Sh. 560

D. Sh. 140. **C**

$$E = Pt$$

$$\begin{aligned} &= \frac{V^2}{R}t \\ &= \frac{200^2}{10} \times 4hrs \\ &= 16000wh \\ &= 16kwh \\ \text{Cost} &= 16 \times 35 \\ &= 560. \end{aligned}$$

16. The induced current in a generator

A. is a maximum when the coil is vertical.

B. is a minimum when the coil is horizontal.

C. changes direction when the coil is horizontal.

D. increases when the speed of rotation increases. **D**

17. How many kilowatt hours are used to run

(i) 8KW cooker for 1 hour

(ii) 3KW immersion heater for 40 min

(iii) 960W hair drier for 20 min?

A. 10.32kwh

B. 147.20kwh

C. 768.00kwh

D. 971.00kwh **A**

Total energy, E, in wh is

$$\begin{aligned} E &= 8k \cdot 1 + 3k \cdot \frac{40}{60} + 960 \cdot \frac{20}{60} \\ E &= (8k + 2k + 320)hr \end{aligned}$$

$$E = (8k + 2k + 0.32k)hr$$
$$E = 10.32ki.e10.32kwh$$

18. When a 240 V supply is connected across an electrical appliance, a current of 200 mA flows in the circuit. What is the electrical power supplied to the appliance?

A. 1.2W

B. 48.0W

C. 48000.0W

D. 120000.0W **B**

$$P = IV$$
$$= 200 \times 10^{-3} \times 240$$
$$= 48.$$

19. The arrangement in fig. 1 is used to produce an e.m.f. What causes the e.m.f.

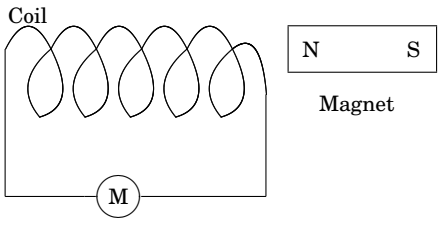


Fig. 1

A. The attraction between the coil and the magnet.

B. The magnetic field outside the coil.

C. The magnet placed close to the coil.

D. The variation of magnetic field lines linking the coil. **D**

20. In fig. 6, when switch K is closed, the two soft iron cores will

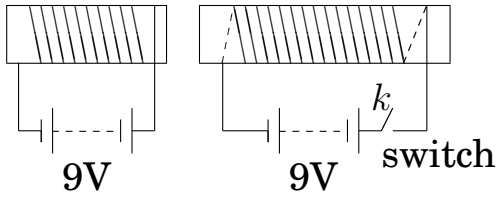


Fig. 6

A. Repel each other all the time.

B. Attract each other all the time.

C. Attract each other for just a brief moment.

D. Have no force of attraction or repulsion between them. **B**

21. For safety in a house, a fuse and a switch are connected to

	Fuse	Switch
A.	Live wire	Neutral wire
B.	Neutral wire	Earth wire
C.	Live wire	Live wire
D.	Earth wire	Neutral wire **A**

22. A rectifier is used to

A. step up an a.c voltage.

B. Amplify an a.c current.

C. Change an a.c voltage to a.d.c. voltage

D. Change a.d.c. voltage to an a.c. voltage. **C**

23. A transformer is used to step down an alternating voltage from 240V to 12V. calculate the number of turns on the secondary coil if the primary coil has 1200 turns.

A. 3.

B. 5

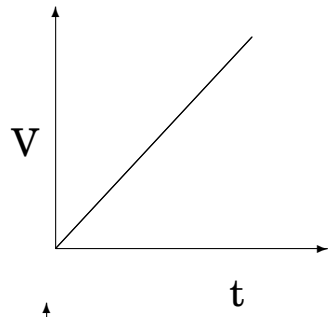
C. 60 **C**

D. 100.

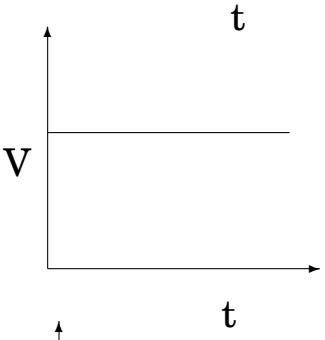
$$\begin{aligned}\frac{N_p}{V_p} &= \frac{N_s}{V_s}\\ N_s &= \frac{N_p V_s}{V_p}\\ &= \frac{1200 \times 12}{240}\\ &= 60\end{aligned}$$

24. Which of the following graphs represents the output voltage from a d.c. dynamo?

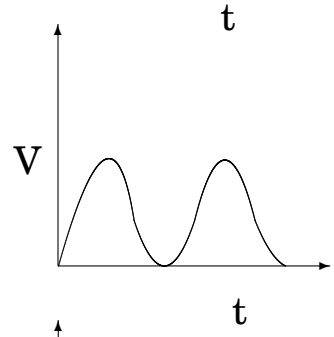
A.



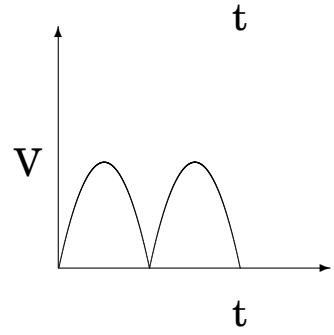
B.



C.



D.



D

25. Which of the following statements are true about electric wiring?

(i) The fuse is always connected into the live wire leading to a circuit.

(ii) The fuse is connected into the neutral wire leading to a circuit.

(iii) When a fault develops in the circuit, it is the neutral wire which has to be disconnected.

A. (i) only

B. (iii) only.

C. (i) and (ii) only.

D. (i), (ii) and (iii). **A**

26. An alternating current can be changed to direct current by a

A. transformer.

B. moving coil galvanometer.

C. dynamo.

D. diode. **D**

This process is called rectification, it can be done by either 1 diode, 2 diodes or 4 diodes

27.

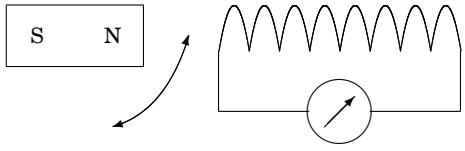


Fig. 8

A bar magnet is moved near a coil as shown in fig. 8. which of the following ways can be used to increase the size of the induced e.m.f. in the coil?

(i) Using a stronger magnet.

(ii) Moving the magnet at a higher speed.

(iii) Reducing the number of turns in the soil.

A. (i) and (ii) only.

B. (i) and (iii) only.

C. (ii) and (iii)

D. (i), (ii) and (iii). **A**

28. The transformer cores are laminated to

A. reduce eddy currents.

B. decrease the resistance of the coils.

C. determine the energy lost by the transformer.

D. distribute the voltage output equally within the transformer. **A**

The laminations increase resistance hence reducing the current in them, the eddy currents.

29. An electric heater which operates from 240V mains draws 15A for 40 minutes. Calculate the cost of electricity, given that electricity costs Sh. 9.00 per kilo watt hour.

A. Sh. 1.44

B. Sh. 21.60

C. Sh. 960

D. Sh. 1296 **B**

$$\begin{aligned} E &= Pt = VIt \\ &= 240 \times 15 \times \frac{40}{60} \times wh \\ &= 2400wh \\ &= 2.4Kwh \\ \text{Cost} &= 2.4 \times 9 \\ &= 21.6 \end{aligned}$$

30. A transformer cannot function normally with d.c. because a.d.c..

A. has extremely high heating effect.

B. reduces the efficiency of the transformer.

C. cannot produce a changing magnetic field. **C**

D. cannot provide high voltage required for power transmission.

31. .

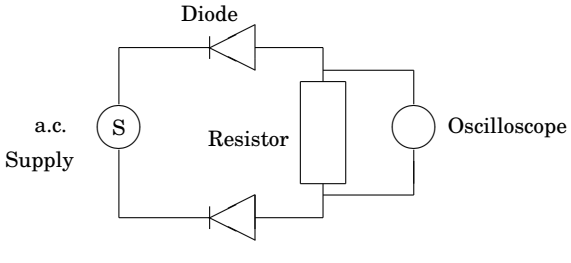


Fig. 1

In the circuit in fig. 1, what is observed on the oscilloscope when the time base is on?

A.  B. 

C.  D. 

A

32. A transformer has twice as many turns in the secondary coil as in the primary coil. The a.c. input to the primary is 4V.

Find the output.

A. 2V

B. 4V

C. 8V

D. 16V **C**

$$\begin{aligned} \frac{V_s}{V_p} &= \frac{N_s}{N_p} = 2 \\ Vs &= 2 \times Vp \\ &= 2 \times 4 \\ &= 8 \end{aligned}$$

33. Fig. 5 shows a transmission line from a power station to a consumer several kilometers a way.

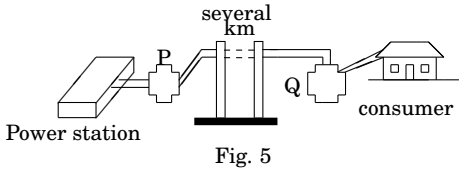


Fig. 5

Which one of the following is the correct type of transformers at P and Q?

A. Step-up step-up

B. Step-down step-down

C. Step-up step-down

D. Step-down step-up **C**

Section B (Structured)

34. .

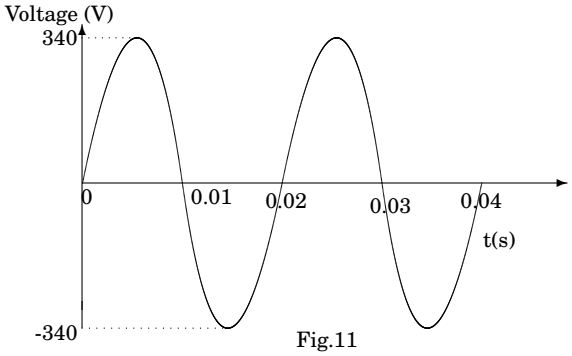


Fig.11

The graph in fig. 11 shows the variation of an a.c. with time. Find;

(i) the peak value.

(ii) the frequency

(i) $340V$

(ii) $T = 0.02s, f = \frac{1}{T} = \frac{1}{0.02} = 50Hz$

35.

(a) What is a transformer?

a transformer are two or more coils close to each other that work by mutual induction or a transformer are two coils such that when current in one changes, an emf is induced in the other.

36. A transformer whose efficiency is 80% has an output of 12W. calculate the input current if the input voltage is 240V.

$$\begin{aligned} 80\% \text{ of input} &= \text{output} \\ \frac{80}{100} \times I \times 240 &= 12 \\ I &= \frac{12 \times 100}{80 \times 240} \\ &= 0.0625 \end{aligned}$$

37. Explain briefly why bulbs in a building are connected in parallel.

- to ensure that the same voltage can be supplied to all bulbs
- to make sure that if one bulb blows or stops working, it does not affect the other bulbs (they remain lighting)

38. State any two factors which determine the magnitude of the e.m.f induced in a coil rotating in a magnetic field.

(i) *the speed of rotation*

(ii) *the magnitude of the magnetic field*

(iii) *length of the conductor in the magnetic field.*

39. State two differences between a.c. and d.c. generators.

In a.c generators, slip rings are used while in dc generators , split rings or commutators are used.

40. A $240V, 600W$ water heater is used to boil water for 5 minutes.

(a) By what means does heat spread through the water?

By convection and conduction

(b) Calculate

(i) the current that flows in the heater.

(ii) the electrical energy converted into heat.

(i) Current

$$\begin{aligned} \text{from } P &= IV \\ I &= \frac{P}{V} \\ &= \frac{600W}{240V} \\ &= 2.5A \end{aligned}$$

(ii) the electrical energy, E

$$\begin{aligned} E &= Pt \\ &= VIt \\ &= 240 \times 2.5 \times (5 \times 60) \\ &= 180000 \\ &= 180KJ \end{aligned}$$

41. State one advantage of a.c over d.c. in a mains supply.

a.c can be stepped up and down by the transformer unlike d.c

42. Explain briefly how a calculator which operates on a 6.0V d.c can draw power from a 240V mains supply.

By connecting a high resistance in series with the calculator so that the sum of the p.d across it and 6V is equal to 240V

43. State **three** advantages of an alternating current over a direct current in power transmission.

- It can be stepped up or down
- The ac generator is easy to construct compared with the dc generator that requires accumulator.
- It is not easy to use a low voltage device on an ac mains than on adc mains.

Paper II (Essay)

44. (a) A cable is connected to a centre-zero galvanometer, as shown in fig. 1.

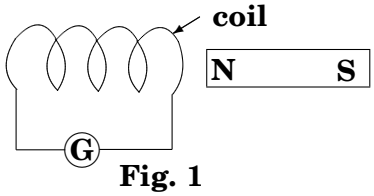


Fig. 1

(i) State what is observed when the N-pole of a bar magnet is moved towards the cable.

(ii) **State two ways in which the effect observed in (a) (i) can be increased.**

(b) (i) With the aid of a labeled diagram described how a simple a.c. general works.

(ii) Sketch the variation of the voltage from an a.c. generator and use it to define the terms peak value and period.

(c) **With the aid of a labelled diagram, describe how full wave rectification can be obtained using four diodes.**

Solution

(a) (i) the galvanometer deflects as the magnet experiences an opposing force

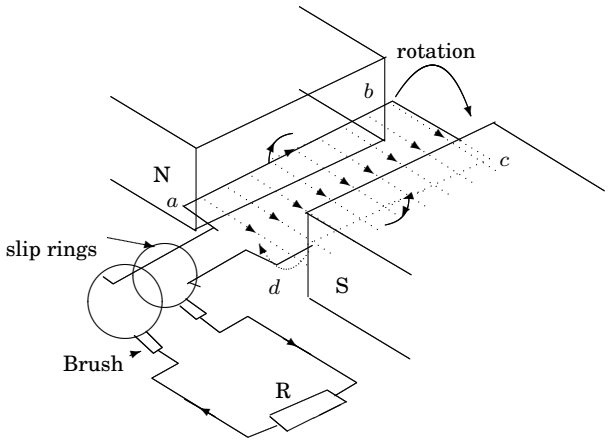
(ii) this effect (of deflection) can be increased by;

- Moving the magnet faster
- Increasing the number of turns in the coil and
- Using a stronger magnet.

(b) (i) How the simple ac generator works.

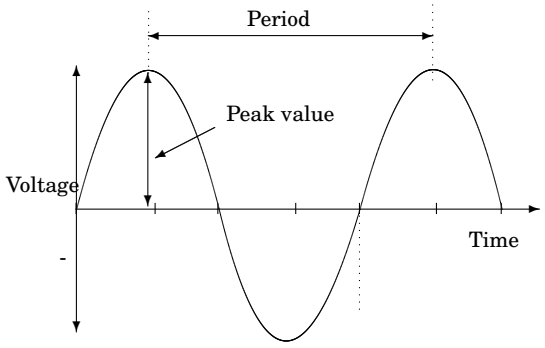
A simple ac generator consists of a rectangular coil of wire

which is rotated in the magnetic field provided by a permanent magnet as shown below:



When the coil is rotated, it cuts the magnetic field lines hence an emf is induced in the coil a cross ab and dc according to Faraday's law.
The direction of the induced current is determined by Fleming's right hand-rule hence it is from a, b, c, to d, if the coil is rotated in the direction shown

(ii) The Ac voltage is

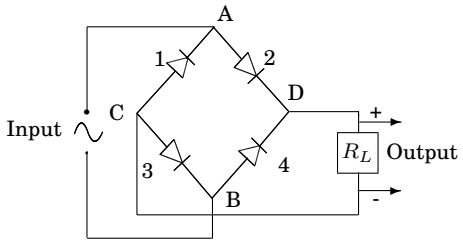


Peak value or **peak voltage** is the maximum voltage produced by the Ac generator.

Period is the shortest time through which the Ac voltage repeats itself.

(c) The circuit which uses four diodes to rectify Ac is called the bridge rectifier circuit.

It consist of four diodes connected as shown below;



When an Ac voltage is connected to the input the terminals above, the following happens;

- During the positive half cycle when point A is positive and B negative, diode 2 conducts and diode 1 is reverse biased. This makes point D positive.
- During the negative half cycle, When point A is negative, point B is positive. diode 4 conducts and diode 3 is reverse biased, this makes point D still positive hence point D is kept positive and point C negative and this is direct current or voltage.

The diagram below show the input Ac voltage and the rectified Dc voltage

45. (a) Describe briefly the structure and action of an a.c transformer

(b) (i) State any three causes of energy losses in a transformer

(ii) **How are these losses reduced in a practical transformer?**

(c) **Explain why it is an advantage to transmit electrical power at high voltage.**

(d) **Electric power is generated at 11kV. Transformers are used to raise the voltage to 440kV for transmission over large distances using cables. The output of the transformers is 19.8MW and they are 90% efficient. Find**

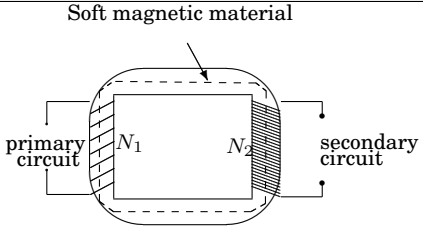
(i) **the input current to the transformers.**

(ii) **the output current of the cables.**

Solution

(a) structure and action of a transformer

a transformer is made up of two separate coils connected as shown below



when an alternating current is set into the primary terminals, they create a changing magnetic field which is linked to the secondary circuit by the soft magnetic material.

This changing magnetic field induces an emf in the secondary coil according to Faraday's law. This induced emf depends on;

- The number of turns is the secondary coil and
- The rate of change of the magnetic flux cutting or linking to the secondary coil

(b) (i) Causes of energy losses in a transformer are

- Some energy is used to heat the coils in the primary and secondary circuit.
- Some energy is used in the process of magnetization and demagnetization in the soft magnetic material.
- Not all the magnetic field produced by the primary coil is wholly linked to the secondary coil.
- Due to the changing magnetic field in the conducting magnetic core an emf

is induced in the magnetic core and this creates eddy currents that cause the heating effect in the magnetic core

(ii) The energy losses above are reduced by

- Using thick wires with low resistance to reduce Joule heating
- Using a soft magnetic material which is easy to magnetize and to demagnetize
- By winding the primary and secondary coils on the same magnetic core to ensure maximum flux linkage.
- by using laminated iron-core to reduce eddy currents

(c) At high voltage always current is low for the same power transmission. This is because from $P = IV$ =constant(same power transmitted) when V is large then I has to decrease or has to be low

therefore power is transmitted at high voltage to ensure or reduce heat loss due to joule heating since curent is low (Heat loss = I^2R.

(d) From the question

Unstepped voltage, V_p

$$\begin{aligned} V_p &= 11kV \\ &= 11 \times 10^3 V \end{aligned}$$

stepped up voltage, V_s

$$\begin{aligned} V_s &= 440kV \\ &= 440 \times 10^3 V \end{aligned}$$

Out put power, P_{out}

$$\begin{aligned} P_\circ &= 19.8MW \\ &= 19.8 \times 10^6 W \end{aligned}$$

Efficiency, $E = 90\%$

(i) Input current I_p of the transformer from

$$\begin{aligned} P_{out} &= 90\% \times P_{in} \\ \Longrightarrow P_{in} &= \frac{P_{out}}{90\%} \\ &= \frac{19.8MW}{0.9} \\ &= 22MW \end{aligned}$$

But $P_{in} = IV = I_pV_p$

$$\begin{aligned} I_pV_p &= 22MW \\ I_p &= \frac{22MW}{V_p} \\ &= \frac{22MW}{11kV} \\ &= \frac{22 \times 10^6 W}{11 \times 10^3 V} \\ &= 2000\text{Amperes} \end{aligned}$$

(ii) Output current to the cables

$$P_{out} = I_sV_s$$

$$\begin{aligned} I_s &= \frac{P_{out}}{V_s} \\ &= \frac{19.8MW}{440kV} \\ &= \frac{19.8 \times 10^6 W}{440 \times 10^3 V} \\ &= 45 \text{ Amperes} \end{aligned}$$

46. (a) Describe the structure and action of a fluorescent tube.

(b) **Give one advantage of a fluorescent tube over a filament lamp.**

(c) **Describe the function of:**

(i) **a fuse.**

(ii) **an earth wire.**

(d) **Describe briefly how power is transmitted from a power station to a home.**

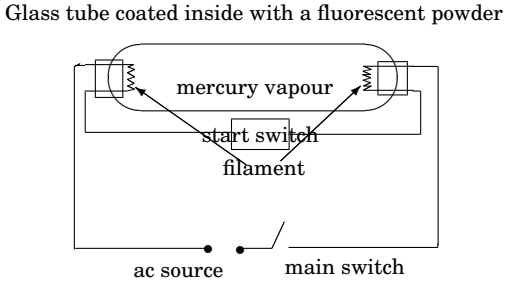
(e) **Find the cost of running two 60W lamps for 20 hours if the cost of each unit is sh.40.**

Solution

(a) Structure and action of a fluorescent tube

Structure

It is made up of two filaments at the two ends of a gas filled tube connected as shown below



Usually the fluorescent tube contains mercury vapour.

How it works

When the current is switched on by closing the switch, it passes though the starter and makes the two filaments hot. The starter breaks the circuit creating a back emf by self-induction by the coil inside it. The electric current now passes through the mercury vapour which produces ultra-violet radiations. This ultra-violet radiation strikes the fluorescent powder on the inside walls of the tube which absorbs the ultraviolet radiation and then produces the visible light radiation we see.

(b) A fluorescent tube changes more electric energy to light with an efficiency of about 50% compared to the filament bulb which has an efficiency of about 10%

(c) The function of;

(i) a fuse, is to break the electric circuit in which it is connected, when the electric current exceeds a certain value.

(ii) an earth wire is to transfer the excess charge that might have accumulated in a device to the earth so as to prevent an electric shock.

(d) How power is transmitted from the power station to the domestic consumer.

- power generated at the power station by electromagnetic induction in generators is stepped up by step-up transformers to high voltage (415V) for transmission over long distances.
- Near the consumer, in various regions or districts, it is stepped down to low voltages (240V) by step down transformers, This low voltage is less dangerous and can be used by the domestic electric devices. The stepping up is to ensure low power loss during transmission.

(e) One electric unit of energy is the kilowatt hour KWh

For one bulb

$$\begin{aligned} \text{Energy} &= \text{Power} \times \text{time} \\ &= 60W \times 20hrs \\ &= 1200Wh \\ &= \frac{1200}{1000}kWh \\ &= 1.2kWh \\ \text{But } 1Kwh &= Sh.40 \\ 1.2kWh &= 1.2 \times 40 \\ &= Sh.48 \end{aligned}$$

But this is for one bulb, for two bulbs the cost is $2 \times 48 = 96$ hence the required cost is Sh. 96.

47. (a) What is a transformer?

(b)

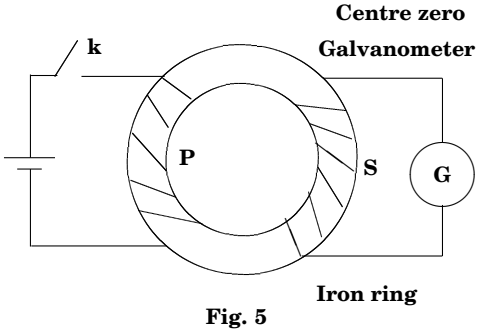


Fig. 5

The diagram in fig. 5 shows a model of a transformer in which the primary coil, P is connected to d.c and the secondary coil, S is connected to a galvanometer.

(i) **What is observed just as the switch k is closed?**

(ii) **What would be the effect of closing switch k very fast in (i) above?**

(iii) **What is observed when the switch k is left closed?**

(iv) **What is observed just as switch k is opened?**

(v) **What would be observed if the d.c source is replaced by an a.c source of low frequency?**

(c) **A transformer of efficiency 80% is connected to a 240V supply to operate a heater of resistance 240Ω. If the current flowing in the primary circuit is 5A**

(i) **Calculate the potential difference across the heate**

(ii) **if the transformer is cooled by oil of specific heat capacity 2100$Jkg^{-1}k^{-1}$**

and the temperature of the oil rises by 20° in 3 minutes. Find the mass of the oil in the transformer.

Solution

(a) A transformer is a device which consists of two separate coils wound on a soft magnetic material such that when current in one changes, according to Faraday's law, an *emf* is induced across the ends of the other coil.

(i) the galvanometer deflects and then goes to zero deflection slowly.

(ii) effect is a greater deflection in the galvanometer

(iii) the galvanometer deflection goes back to null or zero deflection.

(iv) The galvanometer deflects again but now in the opposite direction according to lenzi's law.

(v) The galvanometer pointer oscillates to and fro about the zero deflection point.

(c) from the question

$$\begin{aligned} \text{Efficiency} &= 80\% \\ V_{in} &= 240V \\ R_s &= 240\Omega \\ I_P &= 5A \end{aligned}$$

(i) power out put =80% of power input

$$\begin{aligned} \frac{V_S^2}{R} &= \frac{80}{100} I_P \times V_P \\ &= \frac{80}{100} \cdot 5 \cdot 240 \\ &= 960W \end{aligned}$$

$$V_S = \sqrt{\{960 \times R\}}$$

$$\begin{aligned} &= \sqrt{(960 \times 240)} \\ &= 480V \end{aligned}$$

(ii) The transformer is 80% efficient meaning 20% of the supplied energy is lost as heat in the transformer.

In terms of power; power loss in transformer is equal to 20% of the input power, this power heats the oil hence

$$\begin{aligned} \frac{mc\Delta T}{t} &= 20\% \text{ of } I_p V_P \\ &= \frac{20}{100} \cdot 5 \cdot 240 \\ &= 240 \\ m &= \frac{t}{c\,\Delta T} \times 240 \end{aligned}$$

$$\begin{aligned} &= \frac{3 \times 60\,\text{sec}}{2100 \times 20} \times 240 \\ &= 1.0286kg \end{aligned}$$

hence mass of oil in the transformer is 1.0286kg

Chapter 5

Modern Physics

Contents

5.1 Atomic structure

Section A (Objectives)

1. A nickel nuclide, $^{60}_{28}$Ni, contains

A. 28 protons and 28 neutrons.

B. 32 Electrons and 28 neutrons

C. 28 protons and 32 neutrons

D. 28 Electrons and 32 protons

C

$$\begin{aligned} \text{Protons} &= 28 \\ \text{neutrons} &= 60 - 28 \\ &= 32 \end{aligned}$$

2.

Element	Neutrons	Protons	Electrons
P	6	6	6
Q	8	6	6
R	2	2	2
S	2	3	3

The table above shows the structure of four atoms, P, Q, R and S. which ones are isotopes of the same element?

A. P and Q

B. Q and R

C. P and S

D. P and R **A**

3. An atom contains 3 electrons. 3 protons and 4 neutrons. Its nucleon number is

A. 3

B. 4

C. 6

D. 7 **D**

$$\begin{aligned} \text{nucleons} &= \text{protons} + \text{neutrons} \\ &= 3 + 4 \\ &= 7 \end{aligned}$$

4. A possible isotope of $^{7}_{3}$Li has

   A. 2 protons and 3 neutrons.

   B. 2 protons and 4 neutrons.

   C. 3 protons and 4 neutrons.

   D. 4 protons and 2 neutrons. **C**

5. The atomic number of an element is the number of

   A. Protons in its atom.

   B. Neutrons in its atom.

   C. Electrons and protons in its atom.

   D. Neutrons and protons in its atom.

   A

6. Isotopes are nuclides with the same number of

   A. protons but different number of electrons.

   B. protons but different number of neutrons.

   C. neutrons but different number of protons.

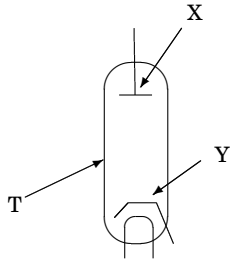
   D. electrons and the same number of neutrons **B**

Section B (Structured)

7. What is thermionic emission?

Is the emission of electrons from the metal surface when heated.

8. .



The diagram above shows a thermionic diode. Name the parts labeled.

(i) X

(ii) Y

(i) X - *Anode*

(ii) Y - *Cathode*

9. Describe briefly how electrons are made to move across the tube T.

By applying a high voltage across X and Y, with X positive and Y negative the electrons on the cathode are attracted to the anode.

10. One isotope of neon is denoted by $^{20}_{10}Ne$. How many neutrons does the isotope have?

20-10=10 Neutrons

11. What is meant by mass number?

Mass number is the number of nucleons in the nucleus of an atom.

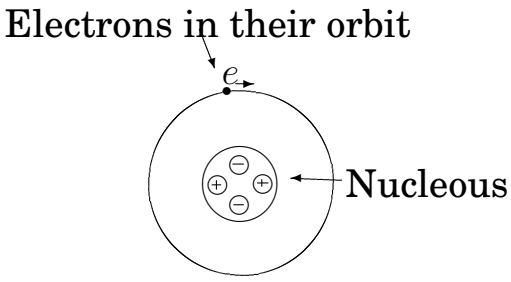
Paper II (Essay)

12. Describe a simple model of the atom

Solution

a simple model of an atom

An a tom is made up of a nucleus which contain protons and neutrons. This nucleus is surrounded by electrons moving around it.



The electrons are negatively charged.

The protons are positively charged and neutrons have no charge.

13. What is meant by the terms

(i) Isotopes,

(ii) atomic number?

Solution

(i) Isotopes are atoms of an element having the same atomic number but different mass numbers.

(ii) Atomic number is the number of protons in the nucleus of an a tom.

14. A zinc cathode was enclosed in an evacuated glass tube as shown in fig. 2.

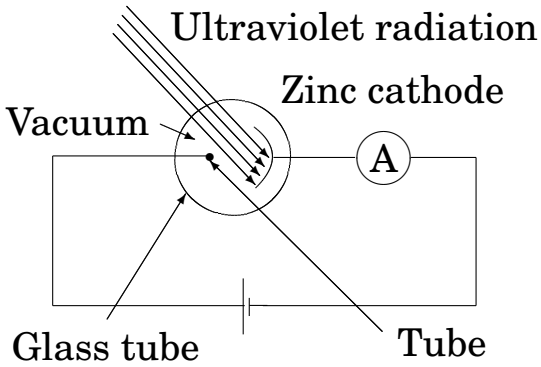


Fig. 2

When the cathode was irradiated with ultraviolet radiations, the ammeter gave a reading.

(i) Explain why the ammeter gave a reading.

(ii) A gas was gradually introduced into the glass tube. Explain what happened.

Solution

(i) this is because the electrons were emitted by photoelectric effect by the zinc cathode, when the ultra violet radiations fell on it. These electrons completed the circuit and current had to flow hence the ammeter gave a reading.

(ii) the ammeter reading decreases because not all the emitted electrons would reach the anode, since some would collide with the molecules of the introduced gas.

5.2 Cathode rays

Section A (Objectives)

1. How long does it take an alternating p.d. of peak 10V and frequency 50Hz to make one cycle?

A. 0.02 s.

B. 0.20s.

C. 5.00s.

D. 500.00s **A**

$$T = \frac{1}{f} = \frac{1}{50} = 0.02s$$

2.

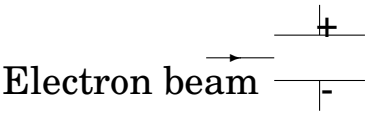


Fig. 7

Fig. 7 shows a beam of electrons incident mid way between two charged metal plates. Which of the following is correct? The beam

A. is deflected towards the positive plate.

B. Is deflected towards the negative plate.

C. Moves perpendicular to the plates.

D. Passes through the plates undeflected. **A**

3. Streams of electrons moving at high speed are called

A. X-rays.

B. Gamma rays.

C. Cathode rays.

D. Alpha particles. **C**

4. The process by which electrons are emitted from the surface of a metal by application of heat is known as

A. photoelectric emission.

B. electromagnetic emission.

C. thermionic emission.

D. hear emission. **C**

5. Which of the following parts of the cathode ray tube form the electron gun?

A. cathode, metal anode, heater, grid.

B. grid, metal anode, cathode, Y-plates.

C. cathode, grid, heater, X-plates.

D. cathode, metal anode, grid, heater, X-plates. **A**

6.

A. 

B. 

C. 

D. 

Which one of the sketches above represents the wave form observed in a C.R.O connected across an A.C. supply when the time-base of the C.R.O is on? **C**

7. The phenomenon by which electrons are released from a metal surface when radiation falls on it is known as

   A. radio activity.
   B. photoelectric effect.
   C. thermion emission.
   D. reflection. **B**

8. The brightness of the spot on a C.R.O. screen is controlled by

   A. X-plates.
   B. Anode
   C. grid.
   D. cathode. **B**

9. The brightness on the screen of a T.V set is determined by

   A. darkness in the room.
   B. the size of the screen.
   C. the number of electrons reaching the screen.
   D. the direction of the aerial. **C**

10. Which of the following are properties of cathode rays?

    (i) they are electrically neutral
    (ii) they travel in straight lines
    (iii) they are deflected by magnetic fields

    A. (i) and (ii) only
    B. (i) and (iii) only
    C. (ii) and (iii) only
    D. (i), (ii) and (iii) **C**

11. Which of the following are properties of Cathode rays?

    (i) They travel in straight lines
    (ii) They can penetrate a thick sheet of paper.
    (iii)They darken a photographic plate.
    (iv)They are deflected by a magnetic field.

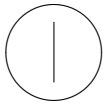
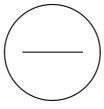
    A. (i), (iii) and (iv) only.
    B. (i), (ii) and (iv) only.
    C. (i), (ii) and (iii) only.
    D. (iv) only **A**

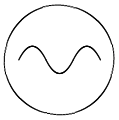
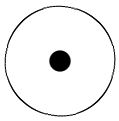
12. The cathode ray oscilloscope may be used to

    (i) measure energy.
    (ii) measure potential difference.
    (iii) display wave forms.

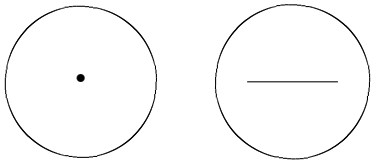
    A. (i) only.
    B. (i) and (ii) only.
    C. (ii) and (iii) only.
    D. (i), (ii) and (iii) **C**

13. Which of the following represents an appearance on the screen of a cathode ray oscilloscope when a d.c. voltage is connected across the X-plates with the time-base switched on?

    A. 
    B. 

C.  **B** D. 

14.



(a) (b)

Fig. 3

Fig. 3 (a) shows a spot on the screen of a cathode ray oscilloscope. The spot can be turned into a horizontal straight line as shown in fig. 3 (b) by

A. Switching off the time base.

B. Switching on the time base.

C. Making one of the plates positive

D. Connecting an a.c voltage to the y-plates. **B**

Section B (Structured)

15. .

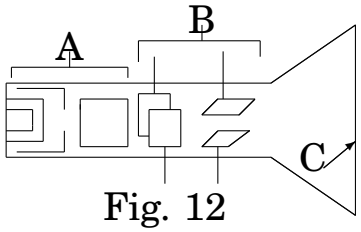


Fig. 12

Fig. 12 shows the main features of a cathode ray oscilloscope (C.R.O). Name the parts labelled A,B and C

A

Electron gun

B

Deflection system

C

Fluorescent screen

16. State the function of the part labelled B

To deflect the electron beam vertically or horizontally.

17. .

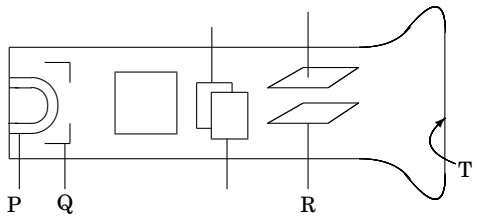


Fig.11

Fig. 11 shows the main parts of a cathode ray oscilloscope.

(i) Name the parts labeled P, Q, R and T.

P - Cathode

Q - Anode

R - Deflection plates

T - Fluorescent screen

(ii) State the functions of parts labeled Q and T

Q - to focus the electron beam on the screen as a small spot.

T - to show the point where the electron beam hits the screen by fluorescence i.e producing light at that spot.

Paper II (Essay)

18. Fig. 1 shows the main parts of a cathode ray oscilloscope. Identify the parts labeled U.V and X and briefly describe their functions.

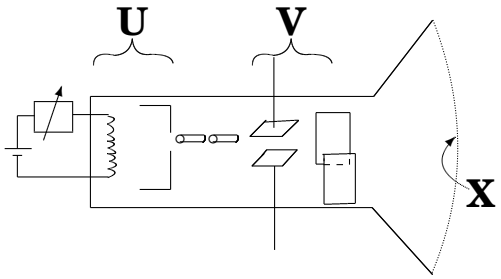


Fig. 1

Solution

- U - electron gun
- V - deflection plates or deflection system
- X - fluorescent screen

19. (a) (i) What is meant by cathode rays?

(ii) **With the aid of a labeled diagram, describe how cathode rays are produced by thermionic effect.**

(b) With reference to the cathode ray oscilloscope, describe

(i) the function of the time-base

(ii) **how the brightness is regulated.**

(c) **A cathode ray oscilloscope (C.R.O) with time-base switch on is connected across a power supply. The waveform shown in Fig. 3 is obtained.**

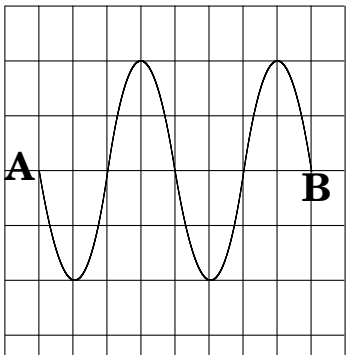


Fig. 3

Distance between each line is 1cm.

(i) **Identify the type of voltage generated by the powe supply.**

(ii) **Find the amplitude of the voltage generated if the voltage gain is** $5Vcm^{-}$

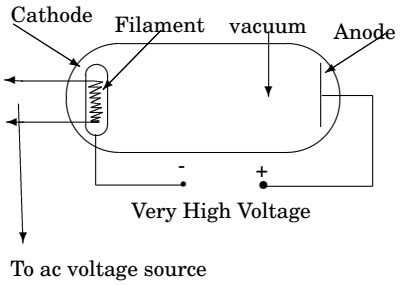
(iii) **Calculate the frequency of the power source if the time-base setting on the C.R.O is** 5.0×10^{-3}**s cm**$^{-1}$**.**

Solution

(a) (i) Cathode rays are high speed electrons

(ii) how cathode rays are produced by thermionic emission.

- Coat a metal filament with a certain metal oxide
- Place it in an evacuated tube with an anode terminal at the other end as shown below



- When the filament is heated by the low voltage Ac supply, it produces electrons by thermionic emission,
- When a high voltage dc supply is connected across the filament and the anode, the emitted electrons (electron cloud) are attracted to the anode at high speed and these high speed electrons are the cathode rays.

(b) About the cathode ray oscilloscope;

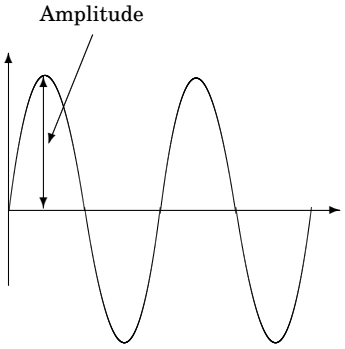
(i) the function of the time-base is to sweep the bright spot (electron beam) horizontally so as to display the wave pattern of the voltage signal applied to the y-plates.

(ii) the brightness is regulated by increasing or decreasing the anode voltage or filament current.

(c) (i) the type of voltage generated is an alternating voltage

(ii) the voltage gain is $5Vcm^{-1}$, it means that the bright spot on the screen of the C.R.O can be deflected vertically through 1cm by a voltage of 5V applied to the y plates.

for the wave below the amplitude is as shown.



From the given graph

$$\text{Amplitude} = 2cm$$

but 1cm is deflected by 5V

2cm are deflected by $5 \times 2V$

2cm are deflected by 10V

hence the amplitude of the voltage generated is 10V.

(iii) The time-base setting of 5.0×10^{-3}scm^{-1} means that it takes

5.0×10^{-3} seconds for the time base circuit to deflect the spot horizontally through a distance of 1cm.

For the given waveform the wave-length is 4cm and a wave-length is the distance moved by the wave in a period.

Since 1cm is deflected in 5.0×10^{-3} seconds

4cm are deflected in $4\times5.0\times10^{-3}$ seconds

4cm are deflected in 2.0×10^{-2} seconds

since 4cm is the wave length, then the period T of the wave is 2.0×10^{-2} second

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

$$\begin{aligned} f &= \frac{1}{T} \\ &= \frac{1}{2.0\times10^{-2}} \\ &= 50Hz \end{aligned}$$

hence the frequency of the voltage is 50Hz.

20. (a) What is meant by the following:

(i)**thermionic emission,**

(ii) **photo-electric effect**

(b) State the conditions necessary for photo electric effect to take place.

Solution

(a) (i) thermionic emission is the emission of electrons from a metal surface when it is heated

(ii) **Photoelectric effect** is the emission of electrons from a metal surface when it is irradiated with a **suitable** radiatio

i.e. a radiation with a frequency above the cut-off frequency of the metal surface.

(b) Photo-electric effect occurs if; The radiation has a frequency more than the cut-off frequency of the metal surface.

21. (a) .

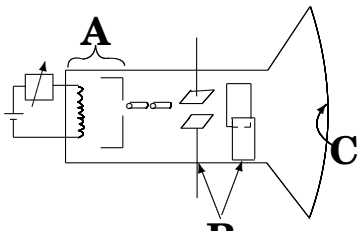


Fig. 5

The diagram in fig. 5 shows the main parts of a cathode ray oscilloscope (C.R.O)

(i) **Name the parts labeled A, B and C.**

(ii) **Why is the C.R.O evacuated?**

(b) (i) Describe briefly the principles of operation of C.R.O

(ii) **How is the bright spot formed on the screen?**

(c) **Use the diagrams to show**

what is observed on the screen of a C.R.O when

(i) **the C.R.O is switched on and no signal is applied to the Y-plates.**

(ii) **the time-base is switched on and no signal is applied to the Y-plates**

(iii) **an alternating signal is applied to the Y-plates while the time-base is switched off.**

(d) **Give two uses of the C.R.O.**

Solution

(a) the parts of the C.R.O.

(i)

A is electron gun

B are deflection plates

C is the fluorescent screen

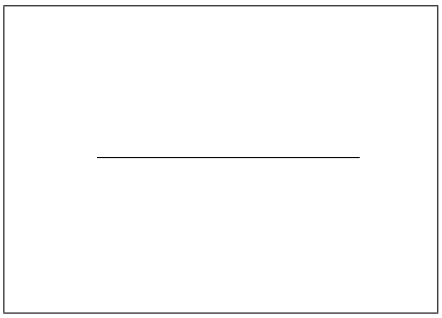
(ii)C.R.O. is evacuated to reduce the collisions the elections (cathode rays) would make with the air molecules.

(b) (i) Principle of operation of a C.R.O. is

- electrons are produced by thermionic emission by the hot filament and accelerated to a certain speed by the High voltage, the Extra High Tension (E.H.T).
- The moving electrons are deflected, by the electric fields between the deflection plates.
- When the elections hit the screen, the fluorescent material on it emits visible light which enables one to see the electron beam as a brigh spot.

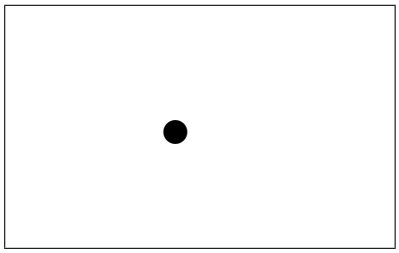
(ii) the bright spot is formed by the electrons which hit the fluorescent material that gives out the visible light seen as a bright spot, if the time base is off.

(c) (i) C.R.O on, no signal on the y-plates



we see a horizontal bright line

OR

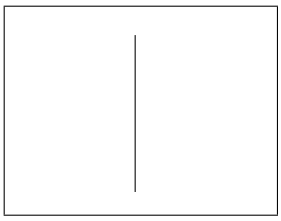


a bright spot

(ii) time base on, no signal on the y-plates, we see

a horizontal bright line

(iii) Ac on the y-plates and time base off



we see a vertical bright line

(d) uses of the C.R.O are;

- to measure frequency of signals
- to measure Ac and Dc voltages
- to measure very short intervals of time.

5.3 X-rays

Section A (Objectives)

1. Which of the following are properties of X-rays? they

   (i) carry no change.

   (ii) are longitudinal waves.

   (iii) are not deflected by the magnetic and electric fields.

   (iv)travel in straight lines.

   A. (i), (ii) and (iv) only.

   B. (i), (ii) and (iii) only.

   C. (ii), (iii) and (iv) only.

   D. (i), (iii) and (iv) only. **D**

2. X-rays are

   A. electrons of high velocity.

   B. particles of negative charge.

   C. neutrons of high velocity.

   D. electromagnetic waves. **D**

3. The difference between hard and soft X-rays is that

   A. hard x-rays travel faster than soft x-rays.

   B. hard x-rays penetrate more than soft x-rays.

   C. hard x-rays are less dangerous than soft x-rays.

   D. soft x-rays are produced at high potential differences. **B**

Section B (Structured)

4. State two differences between cathode rays and x-rays.

1. *Cathode rays are negatively charged yet x-rays are not charged.*
2. *Cathode rays can not be reflected but x-rays can be reflected.*

5. In the production of x-rays in an x-ray tube, why must the target be cooled?

To conduct away the heat generated by the cathode rays

Paper II (Essay)

6. .

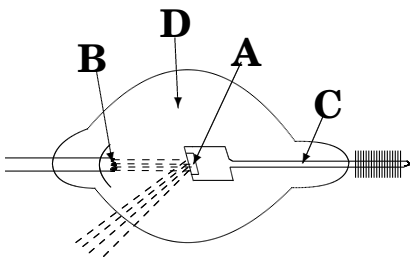


Fig. 2

(a) **Name the parts labeled A, B, C and D.**

(b) **List in order the energy changes which occur in the x-ray tube.**

(c) **Describe one industrial use of x-rays**

Solution

(a) For an x-ray tube, the parts labeled are

A = tungsten or hard metal target
B = hot filament
C = cooling copper fins or plate
D = vacuum

(b) energy changes in x-tray tube are as follows

electric energy in the power supply

↓

heat energy at hot cathode or filament

↓

kinetic energy of the accelerated electrons

↓

heat energy in the cooling copper fins and the wave energy in the x-rays

(c) x-rays are used to detect cracks in metals or engines like those of aeroplanes without opening them

7. .

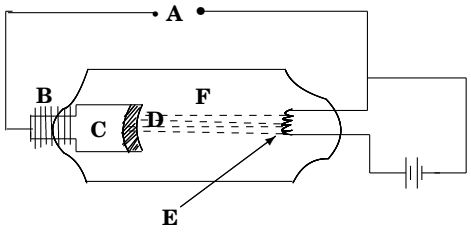


Fig. 3

The diagram in fig. 3 shows the essential parts of an x-ray tube.

(i) **Name the parts labeled A, B, C, D, E and F.**

(ii) **State the function of each part.**

(iii) **Describe how x-rays are produced.**

(iv) **What safety precautions must be taken in an x-ray laboratory?**

Solution

(i) the labeled parts are;

A - Extra High Tension (E.H.T) or high voltage, B - Cooling casing or cooling fins, C - Copper casing, D - Hard metal or tungsten target, E - Hot filament, F - Stream of electrons

(ii) Function of the labeled parts are;

A - The Extra High Tension is to accelerate the electrons to the tungsten target.

B - Cooling fins are to radiate the heat in the copper casing to the surrounding air.

C - Copper casing transfer heat from the tungsten target to the cooling fins since copper is a good conductor of heat.

D - Hard metal target to absorb the heat generated by the electrons, so it must be made from a metal with a high melting point like tungsten.

E - Hot filament, it produces electrons by thermionic emission.

F - A stream of electrons, these transfer their kinetic energy to the heat and x-rays at the tungsten target.

(ii) how x-rays are produced.

The filament connected to the low voltage source heats up the cathode which emits electrons by thermion emission. The emitted electrons are accelerated to a very high speed by the E.H.T and they hit the hard metal target. At the hard metal target 99% of the kinetic energy of the electrons is changed to heat energy that is conducted away from the hard metal target by the copper cooling fins to the surrounding air and the rest (i.e 1%) is changed to x-rays.

(b) Safety precautions taken in an x-ray laboratory are;

1 - you should never over expose your body to x-rays.

2 - always stand behind thick walls of concrete.

3 - always cover the x-ray tube walls with lead shields to prevent stray x-rays.

5.4 Radioactivity

Section A (Objectives)

1. Which of the following statements are true?

(i) protons and neutrons are found in the nucleus of an atom.

(ii) Electrons and beta particles are the same.

(iii) Protons and electrons occur in equal numbers in all neutral atoms.

(iv) Alpha particles and beta particles are both positively charged.

A. (i), (ii) and (iii).

B. (i) and (iii) only.

C. (ii) and (iv) only.

D. (iv) only. **A**

2. The activity of a radioactive element with a half life of 30 days is 2400 counts per second. Find the activity of the element after 120 days.

A. 75 counts per second

B. 150 counts per second

C. 300 counts per second

D. 600 count per second **B**

$$\begin{aligned} A &= A_\circ \left(\frac{1}{2}\right)^n \\ n &= \frac{120}{30} = 4 \\ A &= 2400 \left(\frac{1}{2}\right)^4 \\ A &= 150 \end{aligned}$$

3. A radioisotope of sodium atom decays by emission of a beta particle as shown in the equation below; ${}^{24}_{11}Na \Rightarrow {}^{A}_{Z}Y + {}^{0}_{-1}\beta$ Find the values of A and Z.

A. 24 10

B. 24 11

C. 24 12

D. 24 13 **C**

$$\begin{aligned} A + 0 &= 24 \\ A &= 24 \\ Z - 1 &= 11 \\ Z &= 12 \end{aligned}$$

4. The half life of a radioactive element is 2 minutes. What fraction of the initial mass is left after 8 minutes?

A. $\frac{1}{2}$

B. $\frac{1}{4}$

C. $\frac{1}{8}$

D. $\frac{1}{16}$ **D**

$\frac{8}{2} = 4$ half lives. From

$$\begin{aligned} M &= M_\circ \left(\frac{1}{2}\right)^n \\ \Rightarrow \frac{M}{M_\circ} &= \left[\frac{1}{2}\right]^4 \\ &= \frac{1}{16} \end{aligned}$$

5. The following equation represents part of a radioactive series.

${}^{234}_{90}Th \Rightarrow X +$ Radiation

Substance X and the radiation in the equation above are

A. ${}^{234}_{91}$Pa and gamma.

B. ${}^{230}_{90}$ Th and beta.

C. $^{234}_{90}$ Th and gamma.

D. $^{234}_{91}$ Pa and beta. **C**

6. Radium nucleus $^{226}_{88}$Ra decays to Random (Rn) by α - particle emission. What is the nuclear equation for this reaction?

A. $^{226}_{88}Ra \rightarrow {}^{3}_{2}He + {}^{223}Rn$

B. $^{226}_{88}Ra \rightarrow {}^{4}_{2}He + {}^{222}Rn$

C. $^{226}_{88}Ra \rightarrow {}^{4}_{2}He + {}^{222}Rn$

D. $^{226}_{88}Ra \rightarrow {}^{223}Rn + {}^{1}_{0}n$ **B**

7. State the radiations that may be emitted by a radioactive substance.

A. Alpha, gamma and x-rays.

B. Cathode, rays, x-rays and beta

C. Gamma, alpha and beta **C**

D. Cathode rays, x-rays and alpha.

8. The half-life of a radioactive substance is 10s. How long will it take for a mass of 16g of that substance to reduce to 2g?

A. 40s

B. 30s

C. 20s

D. 10s. **B**

$16 \rightarrow 8 \rightarrow 4 \rightarrow 2$

$$\begin{aligned} 3 \text{ halves} &= 3 \times t_{\frac{1}{2}} \\ &= 3 \times 10 \\ &= 30s. \end{aligned}$$

OR $2 = 16\left(\frac{1}{2}\right)^n, n = 3, t = 3 \times t_{\frac{1}{2}} = 30$

9. When uranium 235 is bombarded with a neutron, it splits according to the equation.

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{M}_{N}P + {}^{92}_{36}Kr + 3{}^{1}_{0}n$$

M and N on P represent,

	M	N	
A.	56	141	
B.	141	56	**A**
C.	199	36	
D.	107	128	

$$\begin{aligned} N &= 92 - 36 \\ &= 56 \\ M &= 235 + 1 - 92 - 3 \\ &= 141 \end{aligned}$$

10. Which of the following radiations is emitted from the nucleus of an atom?

A. Cathode rays.

B. Gamma rays.

C. Infra red rays

D. Ultra violet rays. **B**

11. The count rate from a radio active source is 138 counts per minute when the background rate is 10 counts per minute. If the half life of the source is 6 days, find the count rate after 18 days.

A. 16.0

B. 17.25

C. 26

D. 42 **A**

real or actual count rate is $138 - 10 = 128$ counts per minute 18 has 3 half lives of 6days hence $128 \overset{1st}{\rightarrow} 74 \overset{2nd}{\rightarrow} 32 \overset{3rd}{\rightarrow} 16$

12. In an atomic bomb, energy is produced by

A. fusion.

B. fission.

C. radioactivity.

D. thermionic emission. **B**

13. Which of the following are attracted towards the negative plate in an electric field?

A. Beta particles

B. Alpha particles.

C. Gamma rays.

D. Neutron. **B**

14. The equation below represents an activity in which thorium decays and emits an alpha particle. ${}^{228}_{90}Th \longrightarrow {}^{A}_{Z}X + \alpha$ Find value of Z.

A. 88.

B. 89

C. 91.

D. 92. **A**

${}^{228}_{90}Th \longrightarrow {}^{224}_{88}X + {}^{4}_{2}He$

$$\begin{aligned} Z &= 90 - 2 \\ &= 88 \end{aligned}$$

15. Element X emits radiation r and forms element Y as given in the equation.

${}^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + r$

While A and Z are mass and atomic numbers respectively, radiation r is

A. alpha particles

B. beta particles.

C. Gamma rays.

D. X-rays **B**

$r = {}^{0}_{-1}\beta$ beta particles have mass zero and charge -1.

16. Nuclear fission occurs when

A. uranium is heated to a very high temperature.

B. two deuterium (heavy hydrogen) atoms come together.

C. a hydrogen molecule splits into two atoms.

D. nuclei of uranium atoms split into lighter nuclides. **D**

17. Background radiation is due to

(i) cosmic rays from the sun.

(ii) microwaves.

(iii) radioactive fall out.

(iv) radiations from T.V. set

A. (i), (ii) and (iv) only.

B. (i), (ii) and (iii).

C. (i), (iii) and (iv) only.

D. (ii), (iii) and (iv) only. **C**

18. Two alpha particles are produced when an unknown particle x is used to bombard lithium, ${}^{7}_{3}Li$ as shown in the equation:

${}^{7}_{3}Li + x \Rightarrow {}^{4}_{2}He + {}^{4}_{2}He$

What is x?

A. A beta particle.

B. An alpha particle.

C. A neutron.

D. A proton. **D**

x = ${}^{1}_{1}x$ a proton, of hydrogen nuclei

19. A radioactive material decays to $\frac{1}{16}$ of its original quantity in 2 hours. What is its half life?

A. 15min.

B. 24min

C. 30min.

D. 40 min. **C**

$1 \xrightarrow{t_{\frac{1}{2}}} \frac{1}{2} \xrightarrow{t_{\frac{1}{2}}} \frac{1}{4} \xrightarrow{t_{\frac{1}{2}}} \frac{1}{8} \xrightarrow{t_{\frac{1}{2}}} \frac{1}{16}$ hence they are 4 half lives

$$\begin{aligned} t_{\frac{1}{2}} &= \frac{2 \times 60}{4}\text{mins} \\ &= 30min \end{aligned}$$

Section B (Structured)

20. Name any two radiations emitted by radioactive substances.

1. *alpha particles*
2. *Beta particles or Gamma rays*

21. ${}^{60}_{70}C_0$ is a radioactive isotope of cobalt which emits a beta particle and very high energy gamma rays to form an element X. Write a balanced equation for the nuclear reaction.

${}^{60}_{70}Co \Rightarrow {}^{60}_{71}X + {}^{0}_{-1}e + \gamma$

22. What is a radioactive nuclei?

This is an unstable nuclei that can emit either gamma, beta or alpha particles.

23. A radioactive element X decays by emitting an alpha particle and gamma rays. Write a balanced equation for the decay.

${}^{A}_{Z}X = {}^{A-4}_{Z-2}P + {}^{4}_{2}He + {}^{0}_{0}\gamma$

24. The symbol ${}^{235}_{92}U$ denotes a uranium nucleus. What is the meaning of

(i) 235?

(ii) 92?

(i) *235 is the number of nucleons in this uranium atom*

(ii) *92 is the number of protons in this uranium atom*

25. Write down a balanced nuclear equation showing the decay of ${}^{235}_{92}U$ to a nuclide X by emission of an alpha particle.

$$^{235}_{92}U \rightarrow {}^{4}_{2}He + {}^{231}_{90}X$$

26. A radioactive source emits radiation which are directed between two positively charged metal plates as shown in fig. 12.

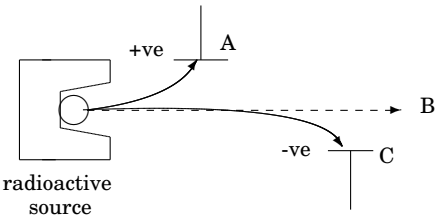


Fig. 12

Name the radiation labeled, A, B and C.

A. *Beta particles*
B. *Gamma rays*
C. *Alpha particles*

27. What can you deduce about the charges of the radiations above?

Beta particles *as negatively charged*
Gamma rays *have no charge*
Alpha particles *are positively charged*

28. What happens when the radioactive source is completely covered with an ordinary sheet of paper?

Nothing happen apart from stopping only alpha particles it they are emitted by the radioactive source.

29. Name the particles emitted by radioactive materials.

- alpha particles
- Beta particles

Note that Gamma rays are not particles.

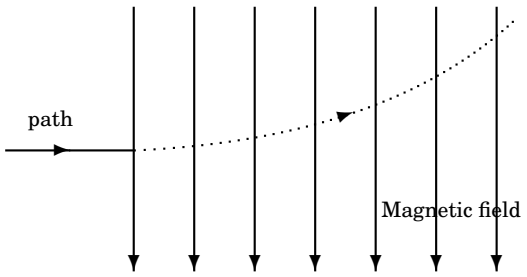


Fig. 9

30. The path of one of the particles in the above number through a magnetic field is as shown in fig. 9. Identify the particle giving reasons for your answers.

A beta particles because they are always the most deflected or alpha particles because they are always the least deflected

31. What is meant by radioactivity?

This is the spontaneous decay of an unstable nuclei.

32. A radioactive materials takes 50 hours for 93.75% of its mass to decay. Find its half-life.

The fraction left is

$$\begin{aligned} &= \frac{100 - 93.75}{100} \\ &= \frac{6.25}{100} \\ &= \frac{625}{10000} \\ &= \frac{1}{16} = \frac{1}{2^4} \\ &= \left(\frac{1}{2}\right)^4 \end{aligned}$$

hence there are 4 half life in $50hrs$

$$\begin{aligned} \text{half life} &= \frac{50}{4}\text{hrs} \\ &= 12\frac{1}{2} \\ &= 12.5\text{hours} \end{aligned}$$

33. (i) What is meant by nuclear fission?

(ii) Give one method of starting the process in (a) (i).

(i) *nuclear fission is the splitting of an unstable nuclei into two or more daughter nuclei.*

(ii) *one method of starting the process in (a) (i) is by putting two radioactive materials with mass above critical size close to each other or by putting it at a very very high temperature*

34. (i) Account for the energy released in nuclear fission.

(ii) State one use of nuclear energy.

(i) *It is the energy that holds the constituents of the nucleus (binding energy).*

(ii) *In the production of electricity in nuclear reactors or in the treatment of diseases like cancer in radiotherapy*

Paper II (Essay)

35. (a) State **one example where nuclear fusion occurs naturally**.

(b) **State one use of nuclear fission.**

(c) **The following nuclear reaction takes place when a neutron bombards a sulphur atom.**

$$^{34}_{16}S + ^{1}_{0}n \rightarrow ^{a}_{b}Y$$

(i)**Describe the composition of the nuclide, Y, formed.**

(ii)**The nuclide, Y, decays by emission of an $\alpha-$particle and a $\gamma-$ray. Find the changes in mass number and atomic number of the nuclide.**

(iii) **State two properties of $\alpha-$particles.**

(d)**The half life of the isotope cabolt-60 is five years. What fraction of the isotope remains after 15 years?**

(e) State:

(i) one medical use of radioisotopes.

(ii) **two ways of minimizing the hazardous effects of radiation from radioactive materials.**

Solution

(a) In Uranium - 235 isotope atoms

In nuclear bombs or produce electricity in nuclear reactors.

(b) (i) $^{34}_{16}S + ^{1}_{0}n \rightarrow ^{35}_{16}Y = ^{a}_{b}Y$ hence Y has 16 and 35 nucleous or $35 - 16 = 19$ neutrons,

(ii)

$$Y \rightarrow ^{4}_{2}He + \gamma + X$$

The mass number decreases by 4 and the atomic number decreases by 2

(iii)
- They are positively charged
- They have a range of about $4 - 5cm$in air.

(d) 15 years have $\frac{15}{5} = 3$half litres

$$i.eI \overset{5yrs}{\rightarrow} \frac{I}{2} \overset{I0yrs}{\rightarrow} \frac{I}{4} \overset{15yrs}{\rightarrow} \frac{I}{8}$$

hence $\frac{1}{8}^{th}$of the original sample remains after 15 years.

(e) (i) To treat iodine by $I - 131$

(ii)Do not smoke near them, Not to touch them with base hands.

36. (a) **state two differences between an alpha particle and a beta particle.**

(b) Give one example in each case where nuclear fusion and nucllear fission occurs.

(c) **The half-life of a radioactive substance is 24days. Calculate the mass of the substance which has decayed after 72 days if the original mass is 0.64g.**

Solution

(a) differences between alpha and beta particles

- Alpha particles are positively charged while beta particles are negatively charged
- Alpha particles are Helium nuclei while beta particles are high speed electrons

(b) nuclear fusion is what takes place in a nuclear reactor or nuclear bomb while nuclear fusion is what takes place in the interior of the sun and in other stars.

(c) From the question

$$\begin{aligned} t_{\frac{1}{2}} &= 24days \\ \text{Original mass, } m_\circ &= 0.64g \\ \text{Time of decay, } t &= 72 \text{ days} \end{aligned}$$

But in a time interval equal to half-life, the mass decays to half its initial value but how many half-lives are in 72 days?

$$\begin{aligned} \text{they are, } n &= \frac{72}{24} \\ &= 3 \text{ half-lives} \end{aligned}$$

$$M \xrightarrow{t_{\frac{1}{2}}} \frac{M_\circ}{2} \xrightarrow{t_{\frac{1}{2}}} \frac{M_\circ}{4} \xrightarrow{t_{\frac{1}{2}}} \frac{M_\circ}{8}$$

$$0.64g \xrightarrow{t_{\frac{1}{2}}} 0.32g \xrightarrow{t_{\frac{1}{2}}} 0.16g \xrightarrow{t_{\frac{1}{2}}} 0.08g$$

hence after 72 days, we would be left with 0.08 grams.

The mass that has decayed is given by;

$$\begin{aligned} \text{decayed mass} &= 0.64 - 0.08 \\ &= 0.56 \text{ grams} \end{aligned}$$

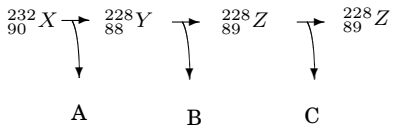
37. (a) Define half-life of a radioactive substance.

(b) **The mass of a radioactive substance decays to a $\frac{1}{16}^{th}$ of its original mass after 16 days.**

(i) **What is its half-life?**

(ii) **fraction of the original mass will have decayed after 20 days?**

(c)



(i) **Identify the particles or radiation A, B and C emitted in the decay process shown above.**

(ii) **State two differences between radiations A and B**

(iii) **Name two health hazards of radioactivity.**

(iv) **What is the difference between nuclear fusion and nuclear fusion.**

Solution

(a) half-life is the time it takes for the mass or count rate of a radioactive substance to decay to half of its original value.

(b) Mass delays to $\frac{1}{16}^{th}$ of original mass in 16 days.

(i) how many half-lives are required to remain with $\frac{1}{16}^{th}$ of the original mass?

$$\begin{aligned} M &= M_\circ \left(\frac{1}{2}\right)^n \\ \frac{M}{M_\circ} &= \frac{1}{16} = \frac{1}{2^4} = \frac{1}{2^n} \\ n &= 4 \end{aligned}$$

hence they are 4 half-lives in 16 days.

$$\begin{aligned} 4t_{\frac{1}{2}} &= 16 \\ t_{\frac{1}{2}} &= \frac{16}{4} \\ &= 4 \text{ days} \end{aligned}$$

Hence the half-life of the radioactive substance is 4 days.

(ii) What fraction will have decayed after 20 days.

In 20 days, there are $\frac{20}{4} = 5$ half-lives

$$\frac{M}{M_\circ} = \left(\frac{1}{2}\right) = \frac{1}{32}$$

hence in 20 days $\frac{1}{32}^{th}$ of the original mass will be available, therefore $1 - \frac{1}{32} = \frac{31}{32}$ has decayed therefore $\frac{31}{32}$ of the original mass will have delayed after 20 days.

(c) (i)

A is ${}^4_2A$ - Alpha particle

B is ${}^0_{-1}B$ - beta particle

C is ${}^0_0C$ - gamma ray

(ii) differences between radiations A and B

- A is positively charged while B is negatively charged
- A is very heavy compared to B

(iii) two health hazards of radioactivity

- They cause cancer
- They cause genetic mutation
- They cause deep seated burns

(iv) nuclear fusion involves the joining of two or more light nuclei to form one heavy nuclei while nuclear fission involves the splitting of one large nuclide to two or more light nuclide

38. (a) (i) What is meant by a radioisotope?

(ii) State one and one industrial application of radioisotopes.

(b) **Describe what happens when a beam of radiations consisting of α, β and γ rays is incident on a thin sheet of lead.**

Solution

(a) (i) a radioisotope is an isotope of a radioactive element which can emit either α particles, β particles or γ rays.

(ii) An example of a radioisotope is a Uranium -235. It is used in nuclear reactors to generate electricity.

(b)

- Alpha - particles will be stopped by this thin sheet of lead.
- Beta - particles will be stopped by this thin sheet of lead.

But

- Gamma rays will pass through this thin sheet of lead.

39. (a) What is an alpha particle?

(b) **A radioactive source decays by emission of all the three radiations.**

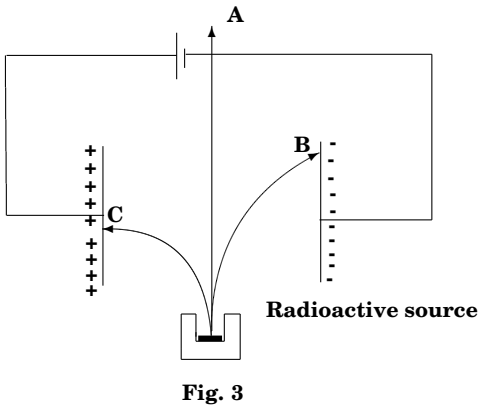


Fig. 3

The radiation enter normally into an electric field as shown in fig. 3. Which radiation are most likely to be detected at

(i) **position A,**

(ii) **position B,**

(iii) **position C?**

(c).

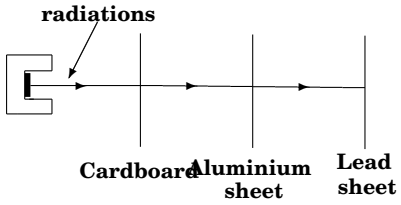


Fig. 4

A radioactive source which emits all the three radiations is placed infront of cardboard, aluminium and lead sheets as shown in fig. 4. Name the radiation likely to be between the;

(i) **cardboard and the aluminium sheet**

(ii) **aluminium and lead sheet**

(d) **Name any three precautions which must be undertaken by one working with ionizing radiation.**

(e) **Name one:**

(i) **industrial use,**

(ii) **biological use of radioactivity.**

(f) **A radioactive material of mass 8g has a half-life of 20 days. Find how much of it will decay after 60 days?**

Solution

(a) An alpha particle is a helium nuclei

(b) (i) Gamma rays - because they are not affected by electric fields

(ii) Alpha particles because they are the least deflected this is because they are heavy or because they are positively charged and are attracted to the negative plate.

(iii) Beta particles, they are deflected most since they are the very light compared to alpha particles or because they are negatively charged, they are deflected towards the positive plate.

(c) (i) Beta particles and gamma rays because they are not stopped by cardboard

(ii) Gamma rays because the beta particles were stopped by aluminum sheet.

(d)Precautions

- never touch them with bare hands.
- do not smoke near them
- keep them out of reach of children.

(e) (i) Industrial use; in determining amount of wear of an engine part or in locating cracks in metals and machines like aeroplane engines.

(ii) Biological use; in the treatment of cancer using Iodine - 131

(f) 60 days have 3 half-lives of 20 days i.e.

$$\begin{array}{l} 8kg \\ \downarrow \ 20\text{days} \\ 4\,kg \\ \downarrow \ 20\,\text{days} \\ 2g \\ \downarrow \ 20\,\text{days} \\ 1g \end{array}$$

i.e. after 60 days only 1g will be left. hence 7g have decayed.

40. (a) **A radioactive sample has a half-time of 3×10^3 years.**

(i) **What does the statement half-time of 3×10^3years mean?**

(ii) **How long does it take for three quarters of the sample to decay?**

(b) **Give two uses of radioactivity.**

Solution

(a) Half-life = 3×10^3 years

(i)half life of 3×10^3 years means that the mass or activity of the radioactive sample decreases to half its original value in a time internal equal to 3×10^3 years.

(ii)For $\frac{3}{4}$ i.e.three-quarters of the radioactive sample to decay, we must be left with $\frac{1}{4}$ of it and this requires two half lives i.e.

$m_\circ \longrightarrow \frac{m_\circ}{2} \longrightarrow \frac{m_\circ}{4}$

i.e.

$$\begin{aligned} t &= 2 \times \text{half - life} \\ &= 2 \times \left(3 \times 10^3\right) \text{ years} \\ &= 6 \times 10^3 \text{ years} \end{aligned}$$

(b)Uses of radioactivity

- In treatment of cancer
- In treating goiter using iodine -
- In generating electricity in nuclear reactors

41. (i) Name the particles emitted by radioactive materials.

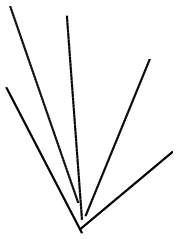
(ii) **Draw diagrams to show the paths of the particles named in (b) (i) in a cloud chamber.**

Solution

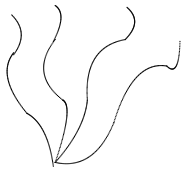
(i) radioactive materials emit;

- alpha particles
- beta particles and
- Gamma rays

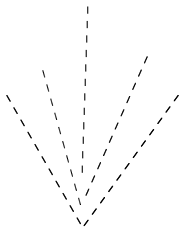
(ii)



alpha particles, form short thick tracks



beta particles, form faint thin tracks



gamma particles, form thin short tracks

42. (i) Name and state the nature of the emissions from radioactive nuclides.

(ii) **What effects does each of the emissions have on the parent nuclide?**

Solution

(b) (i) The emissions are 3;

- Alpha practicles; they are helium nuclei.
- Beta - particles; they are high speed electrons

- Gamma rays; they are high frequency electromagnetic waves.

(ii) effect of radioactive emissions on parent nuclide.

- Alpha particles - they lower its mass number by 4 and also lowers its atomic number by 2.
- Beta particles - these lead to no change to atomic mass but increase the atomic number by 1
- Gamma rays these have no effect on the parent nuclei a part from either making it more stable or unstable.