MARKING GUIDE ATTACHED

P510/2
PHYSICS
Paper 2
Nov. / Dec. 2015
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

Paper 2

2 hours 30 hours

INSTRUCTIONS TO CANDIDATES:

Answer **five** *questions, taking at least* **one** *from each of the sections,* **A**, **B**, **C** and **D**, *but* **not** *more than* **one** *question should be chosen from either* **A** *or* **B**.

Any additional question(s) answered will **not** *be marked.*

Mathematical tables and squared paper are provided.

Non-programmable scientific calculators may be used.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Speed of light in a vacuum, c	=	$3.0 \times 10^{8}\ ms^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19}\ C$
Electron mass	=	$9.11 \times 10^{-31}\ kg$
Planck's constant, h	=	$6.6 \times 10^{-34}\ Js$
Permeability of free space, μ_0	=	$4.0\pi \times 10^{-7}\ Hm^{-1}$
Permittivity of free space, ε_0	=	$8.85 \times 10^{-12}\ Fm^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	=	$9.0 \times 10^{9}\ F^{-1}m$
One electron volt (eV)	=	$1.6 \times 10^{-19}\ J$
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Resistivity of Nichrome wire at 25 ^0C	=	$1.2 \times 10^{-6}\ \Omega m$
Specific heat capacity of water	=	$4.2 \times 10^{3}\ Jkg^{-1}K^{-1}$

SECTION A

1. (a) Explain what is meant by **conjugate points**. *(02 marks)*

(b) A converging lens forms an image of height h_1 on a screen, of an object O of height h. When the lens is displaced towards the screen, an image of height h_2 is formed on the screen.

(i) Sketch a ray diagram to show the formation of the images on the screen. *(02 marks)*

(ii) Show that $h = \sqrt{h_1 h_2}$ *(04 marks)*

(c) Describe an experiment to determine the focal length of a diverging lens using a concave mirror of known focal length. *(05 marks)*

(d) The objective of an astronomical telescope in normal adjustment has a diameter of 150 mm and focal length of 3.0 m. The eye-piece has a focal length of 25.0 mm. Calculate the

(i) position of the eye-ring. *(03 marks)*

(ii) diameter of the eye-ring. *(03 marks)*

(e) Give **one** advantage of placing the eye at the eye ring. *(01 mark)*

2. (a) Show that for a ray of light passing through layers of transparent media separated by parallel boundaries,

$$n \sin i = a$$

where a is a constant and n is the refractive index of the medium containing angle i. *(04 marks)*

(b) (i) What is meant by **critical angle**? *(01 mark)*

(ii) Describe an experiment to determine the critical angle for a water – air boundary. *(05 marks)*

(c) Figure **1** shows an isosceles prism *ABC* of refractive index 1.51, dipped in a liquid with its refracting edge downwards. A ray of light incident on the prism at angle $i = 34.6^0$ emerges perpendicularly through the base.

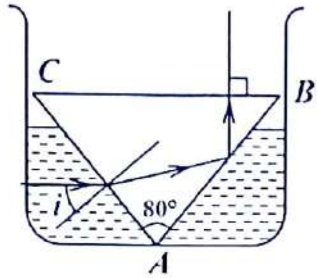

Fig. 1

Calculate the refractive index of the liquid. (*04 marks*)

(d) Explain how an optical cable transmits light. (*03 marks*)

(e) An optical pin held above a concave mirror containing water of refractive index 1.33, coincides with its image at a distance of 12 cm above the mirror. When the water is replaced by a little quantity of a certain liquid, the point of coincidence of the object and the image becomes 13.3 cm. Calculate the refractive index of the liquid. (*03 marks*)

SECTION B

3. (a) Distinguish between **progressive** and **stationary** waves. (*03 marks*)

(b) (i) What are **overtones**? (*01 mark*)

(ii) Explain why a musical note played on one instrument sounds different from the same note played on another instrument. (*03 marks*)

(c) A stretched string of length, L, is fixed at both ends and then set to vibrate in its allowed modes. Derive an expression for frequency of the second overtone in terms of the fundamental frequency. (*04 marks*)

(d) A wire of length 0.60 m and mass 9×10^{-4} kg is under tension of 135 N. The wire is plucked such that it vibrates in its third harmonic. Calculate the frequency of the third harmonic. (*05 marks*)

(e) Describe the variation of pressure with displacement of air in a closed pipe vibrating with fundamental frequency. (*04 marks*)

Turn Over

4. (a) What is meant by the following as applied to waves?

(i) **Phase difference.** *(01 mark)*

(ii) **Optical path difference.** *(01 mark)*

(b) (i) Explain how interference fringes are formed in an air wedge. *(04 marks)*

(ii) Two glass slides are separated by a thin wire to form an air wedge. When the wedge is illuminated normally by light of wavelength 5.6×10^{-7} m, a total of 20 fringes occupying a distance of 15 mm are obtained. Calculate the angle of the wedge. *(03 marks)*

(c) In a Young's double slit experiment, 21 bright fringes occupying a distance of 3.6 mm were visible on the screen. The distance of the screen from the double slit was 29 cm and the wavelength of the light used was 5.5×10^{-7} m. Calculate the separation of the slits. *(03 marks)*

(d) (i) Describe how plane polarised light can be produced by double refraction. *(02 marks)*

(ii) Describe **one** practical use of polarised light. *(05 marks)*

SECTION C

5. (a) What is meant by the following as applied to the earth's magnetic field?

(i) **Magnetic meridian.** *(01 mark)*

(ii) **Angle of dip.** *(01 mark)*

(b) (i) Define the **ampere**. *(01 mark)*

(ii) Three conductors **P**, **Q** and **R** carrying currents 3 A, 6 A and 8 A respectively are arranged as shown in figure **2**.

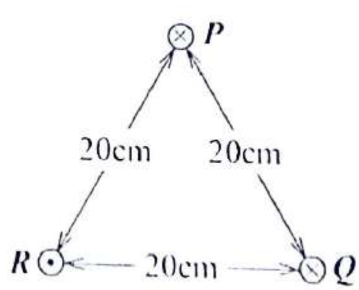

Fig. 2

Calculate the force experienced by conductor ***P***. *(06 marks)*

(c) (i) Define **magnetic flux** and **magnetic flux density**. *(02 marks)*

(ii) A charge particle of mass 1.4×10^{-27} kg and charge 1.6×10^{-19} C, enters a region of uniform magnetic field of flux density 0.2 T at a point ***P*** and emerges at a point ***Q*** as shown in figure **3**.

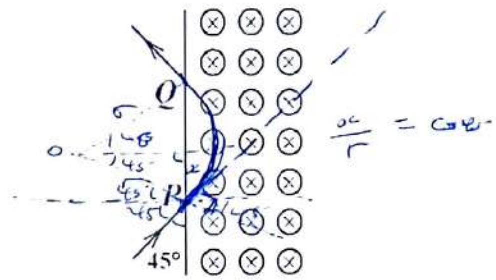

Fig. 3

If the speed of the particle is 10^7 ms^{-1}, calculate the distance ***PQ***. *(04 marks)*

(d) Describe an experiment to measure the magnetic flux density between the pole pieces of a strong magnet. *(05 marks)*

6. (a) (i) State the **laws of electromagnetic induction**. *(02 marks)*

(ii) Describe with the aid of labelled diagram, an experiment to verify Faraday's law of electromagnetic induction. *(05 marks)*

(b) Explain

(i) why when a plate of copper is pushed into a strong magnetic field between the poles of a powerful electromagnet, considerable resistance to the motion is felt, but no such effect is felt with a sheet of glass. *(04 marks)*

(ii) how damping is achieved in a moving coil galvanometer. *(03 marks)*

(c) An aeroplane of wing– span 30 m flies horizontally at a speed of 1000 kmh^{-1}.
What is the p.d across the tips of its wings, if the horizontal component of the earth's field is 1.46×10^{-4} T ?
(*Angle of dip at the place is* 70^0) *(03 marks)*

(d) A coil of 500 turns and area 80 cm^2 is rotated at 1200 revolutions per minute about an axis perpendicular to its plane and magnetic field of flux density 0.25 T.
Calculate the maximum e.m.f induced in the coil. *(03 marks)*

Turn Over

7. (a) (i) Define **root mean square (rms)** current of an a.c. *(01 mark)*

(ii) Derive an expression for capacitive reactance. *(04 marks)*

(iii) Sketch on the same axes, the graphs showing variation of applied p.d and current when an inductor is connected to an a.c supply. *(02 marks)*

(b) (i) A capacitor of capacitance, C, and an ammeter are connected in series across an alternating voltage, V, of frequency f. Explain why current apparently flows through the capacitor. *(03 marks)*

(ii) A sinusoidal p.d of rms value of 20 V and frequency 50 Hz is applied across a 100 μF capacitor. Calculate the capacitive reactance of the circuit. *(02 marks)*

(c) Describe the mode of operation of a transformer. *(04 marks)*

(d) A transformer connected to a.c. supply of peak voltage 240 V is to supply a peak voltage of 9.0 V to a mini – lighting system of resistance 5 Ω. Calculate the

(i) rms current supplied to the lighting system. *(02 marks)*

(ii) average power delivered to the lighting system. *(02 marks)*

SECTION D

8. (a) (i) Define **temperature coefficient** of resistance. *(01 mark)*

(ii) Explain the origin of the heating effect of electric current in a metal conductor. *(03 marks)*

(iii) Describe with the aid of an I–V sketch the variation of current with p.d across a semiconductor diode. *(02 marks)*

(b) A cell, a bulb, a switch and a thermistor with negative temperature coefficient of resistance are connected as shown in figure **4(i)**.

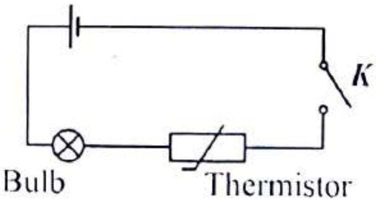

Fig. 4 (*i*)

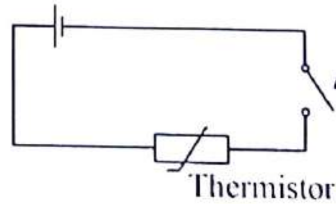

Fig. 4 (*ii*)

(i) Explain what would happen when in figure **4(i)** switch ***K*** is closed. *(04 marks)*

(ii) If the bulb in figure **4(i)** is removed and circuit connected as shown in figure **4(ii)**, explain what would happen when switch ***K*** is closed. *(03 marks)*

(c) State the **law of conservation of current at a junction**. *(01 mark)*

(d) Two cells *A*, of e.m.f 6 V and internal resistance 2 Ω and ***B*** of e.m.f 3 V and internal resistance 1 Ω respectively are connected across a uniform resistance wire ***CD*** of resistance 8 Ω as shown in figure **5**.

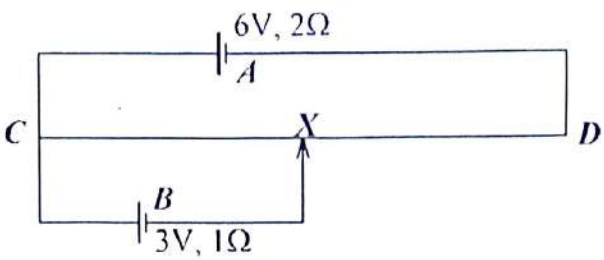

Fig. 5

If *X* is exactly in the middle of the wire ***CD***, calculate the;

(i) power dissipated in *CX*. *(04 marks)*

(ii) p.d across the terminals of cell *A*. *(02 marks)*

9. (a) (i) Define **capacitance** of a capacitor. *(01 mark)*

(ii) Describe briefly an experiment to show the effect of placing a sheet of glass or mica between the plates of a capacitor on capacitance. *(05 marks)*

(b) Describe how the unknown capacitance of a capacitor can be determined using a ballistic galvanometer. *(04 marks)*

(c) Explain briefly how a charged capacitor can be fully discharged. *(02 marks)*

(d) A 3 μF capacitor is connected in series with a 6 μF capacitor. The combination is then connected in parallel with a 1 μF capacitor to 12 V battery as shown in figure **6**.

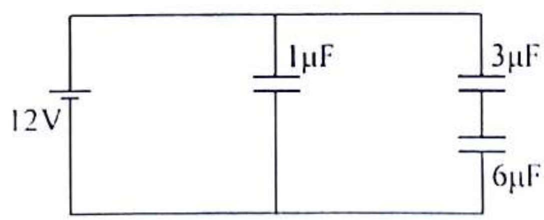

Fig. 6

Calculate the

(i) charge stored by each capacitor. *(05 marks)*

(ii) energy stored in the 6 μF capacitor when fully charged. *(03 marks)*

10. (a) (i) Define **electric potential**. *(01 mark)*

(ii) Derive an expression for the electric potential at a point of a distance r, from a fixed charge. *(04 marks)*

(b) With reference to a charged pear-shaped conductor,

(i) describe an experiment to show the distribution of charge on it. *(03 marks)*

(ii) show that the surface of the conductor is an equipotential surface. *(03 marks)*

(c) Explain how a lightning conductor protects a house from lightning. *(04 marks)*

(d) Three charges Q_1, Q_2 and Q_3 of magnitude $2\ \mu C$, $-3\ \mu C$ and $5\ \mu C$ respectively are situated at corners of an equilateral triangle of sides 15 cm as shown in figure 7.

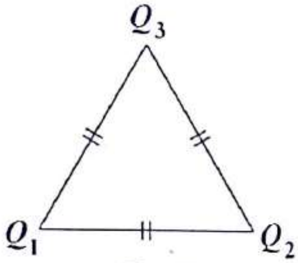

Fig. 7

Calculate the net force on Q_3. *(05 marks)*

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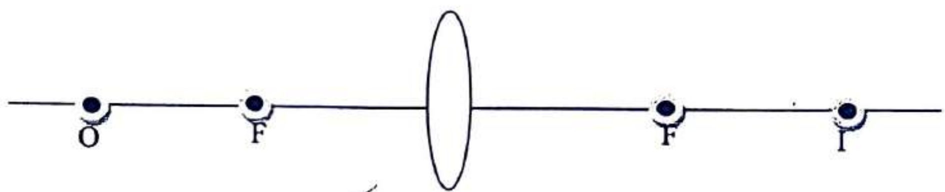
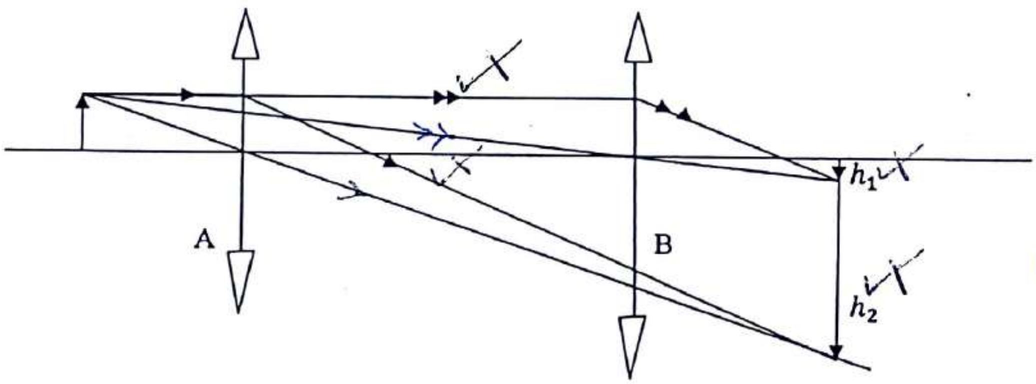
1. (a)



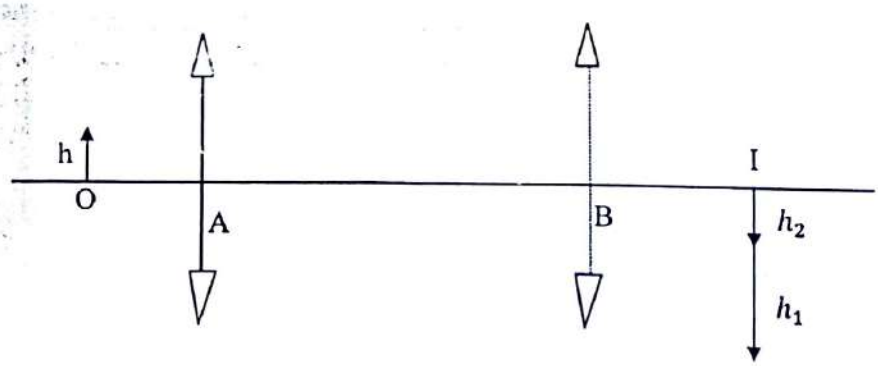
An object at a point O in front of a converging lens has its image formed at a point I. since light rays are reversible, an object placed at I will give rise to an image at O. the points O, I are interchangeable and are called conjugate points. (2)

(b) (i)



(2)

(ii) O and I are conjugate points with respect to the lens.



Case 1

$$m_1 = \frac{h_1}{h} = \frac{AI}{OA}$$

CASE II

$m_2 = \frac{h_2}{h} = \frac{BI}{OB}$ but OB=AI and OA=BI

$m_1 m_2 = \frac{h_1}{h} \times \frac{h_2}{h} = \frac{h_1 h_2}{h^2}$ but $m_1 m_{2=1}$

$1 = \frac{h_1 h_2}{h^2}$ $\therefore h = \sqrt{h_1 h_2}$

4

OR

OB=AI and OA=BI

When the lens is in position A,
linear magnification

$m_A = \frac{AI}{OA}$ hence $\frac{h_1}{h} = \frac{AI}{OA}$ .... (i)

In position B

$m_B = \frac{BI}{OB}$ hence $\frac{h_2}{h} = \frac{BI}{OB}$ .... (ii)

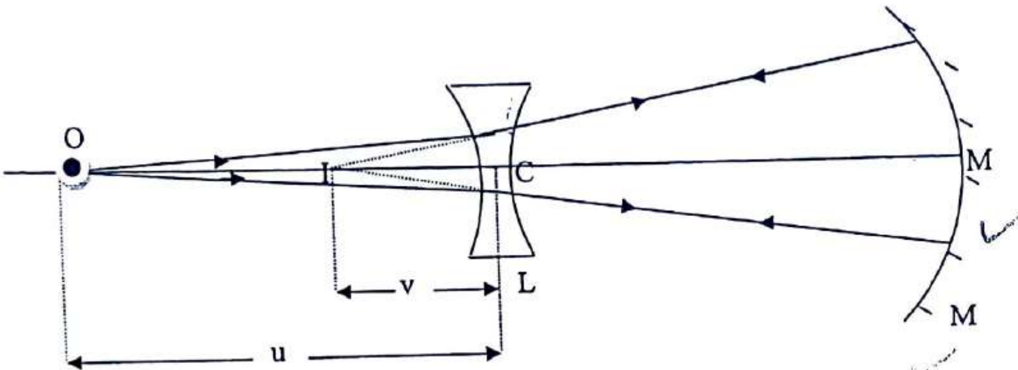
But AI=OB

Hence $\frac{h}{h_1} = \frac{h_2}{h}$

4

Hence $h = \sqrt{h_1 h_2}$

(c) An illuminated object O is placed infront of a diverging lens L arranged coaxially with a concave mirror , M of known focal length f_1



The position of an object O is adjusted until it coincides with its image . the distances OC and CM are measured and recorded. The image distance V=IM-CM= -(r-CM). but r=2f. the object distance u= OC. The focal length of the diverging lens L is obtained from $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$

5

(d) (i) for the eye ring , u=f_o+f_e=3000+25=3025mm

f=f_e=25mm

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{3025}+\frac{1}{v}=\frac{1}{25}$$

V=25.2mm

3

(ii) angular magnification m=$\frac{diameter\ of\ the\ objective}{diameter\ of\ the\ eye\ ring}$

M=$\frac{150}{D_e}$ also, $m=\frac{f_o}{f_e}=\frac{3000}{25}=120$

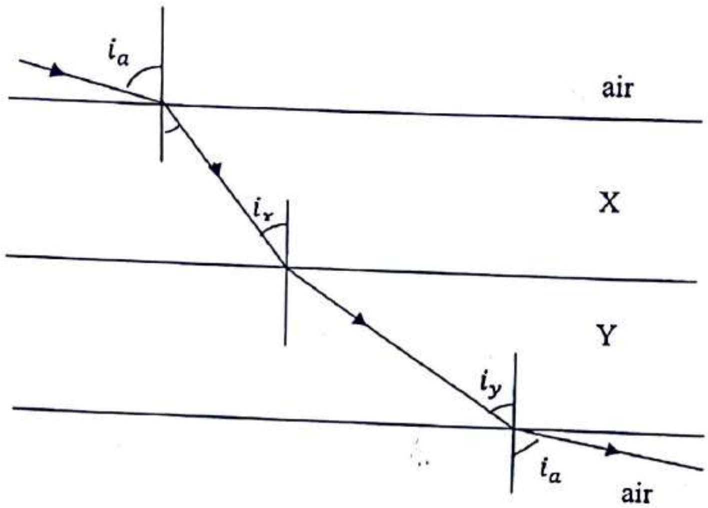
Hence , 120=$\frac{150}{D_e}$

Therefore, diameter of the eye ring =1.25mm

(e) when the eye is placed at the eye ring, all the rays passing through the objective will enter it and the image viewed is brightest.

1

2. (a)



Consider a ray of light incident on a plane boundary of air and X. the ray moves through X, Y, and then into air again.

${}_an_x = \frac{\sin i_a}{\sin i_x}$ hence $\sin i_a = {}_an_x \sin i_x$

${}_an_y = \frac{\sin i_a}{\sin i_y}$ hence $\sin i_a = {}_an_y \sin i_y$

but $n_a = 1,$

${}_an_x = n_x$, ${}_an_y = n_y$

4

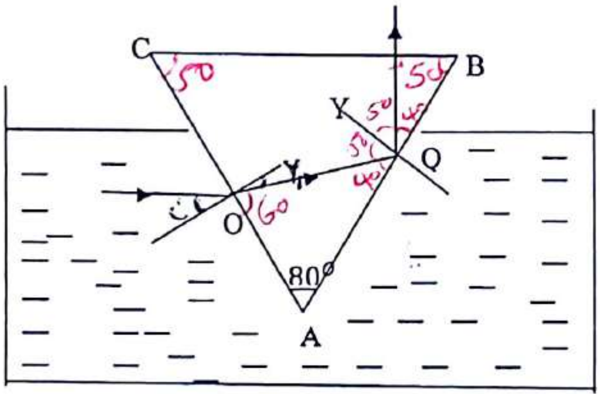
$$n_a \sin i_a = n_x \sin i_x = n_y \sin i_y$$
$$\therefore n \sin i = a$$

(b) (i) critical angle is the angle of incidence in a dense medium for which the angle of refraction in the less dense medium is 90°

1

(ii) two glass slides are cemented together to form an air cell. The air cell is dipped into water in a parallel vessel. A narrow beam of light is directed onto the air cell and is viewed from the opposite side. The air cell is then turned in one direction until light just disappears. This position is noted. The air cell is is then turned in opposite direction until light just disappears again. This position is noted. The angle between the two positions is measured, Θ. Now the critical angle $C = \frac{\theta}{2}$ (5)

(c)



$\angle CBA = \frac{180-80}{2} = 50°$

$\angle YQO = 50°$ hence

$\angle OQA = 40°$
$\angle AOQ = 60°$
$\angle Y_1 = 30°$

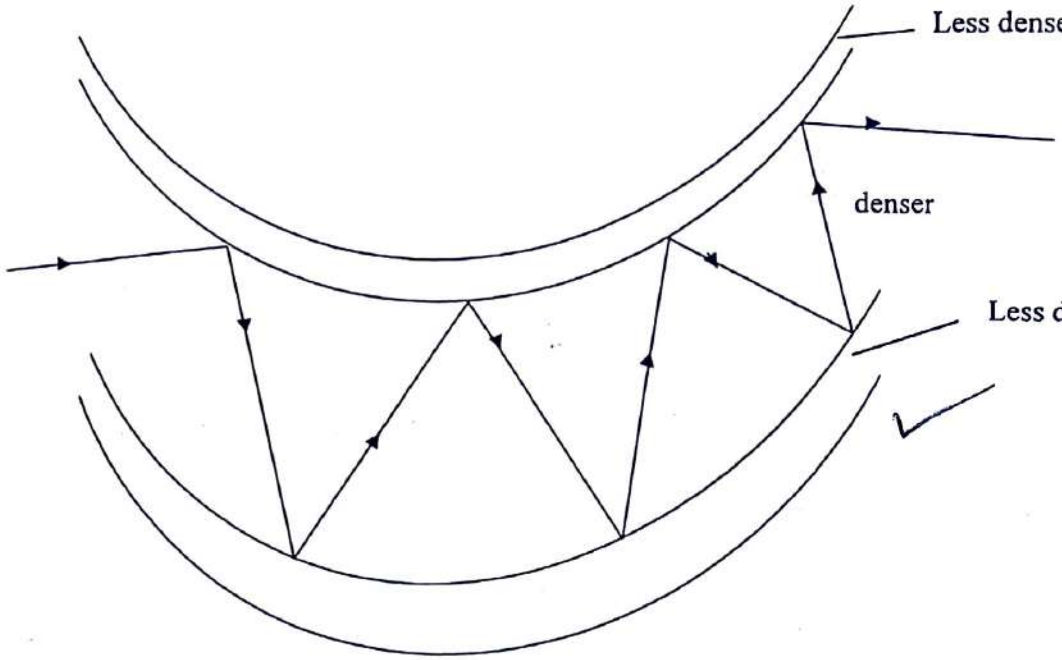
Now, nsini=constant

$n_L \sin 34.6^o = 1.51 \sin 30^o$

$\therefore n_L = 1.36$

4

(d)



An optical cable is made of a transparent material coated with another of less optical density. Light entering the pipe strikes the boundary of the media at an angle of incidence greater than the critical angle . total internal reflection thus takes place . this takes place repeatedly in the pipe until the light beam emerges from the pipe.

3

(e) let r be the radius of curvature of the mirror

Then $n_{w} = \frac{r}{h_w}$ and $n_L = \frac{r}{h_L}$

$$\frac{n_L}{n_w} = \frac{h_w}{h_L}$$

$$\frac{n_L}{1.33} = \frac{12}{13.3}$$

Hence, $n_L = \frac{12x1.33}{13.3} = 1.2$

(2)

3. (a)

Progressive waves	Stationary waves
Energy is conveyed from one point to another along the wave	Energy is not conveyed but confined in particular section of the wave
All particles in the transmitting medium oscillate with the same amplitude	Amplitude of particles in the medium vary with position along the wave
Only particles an integral multiple of a wavelength apart are in phase	All particles between two successive nodes are in phase
They do not have nodes and antinodes	They have nodes and antinodes

(3)

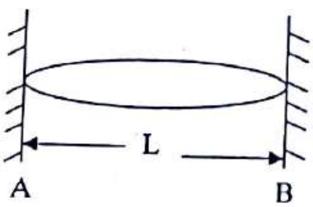
(b) (i) overtones are notes of higher frequency produced by an instrument than the fundamental or main note.

(1)

(ii) when an instrument is played, all the allowed vibrations take place producing different frequencies. The quality of the musical note is determined by the number and strength (or intensity) of the overtones. When the note played on an instrument has fewer overtones, it sounds different from the same note played on a different instrument with more overtones.

(3)

(c)



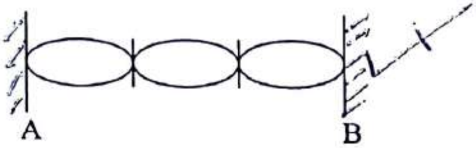
When the string is vibrating with fundamental frequency, the number of waves between A and B is $\frac{1}{2}\lambda$

$L = \frac{1}{2}\lambda$ hence, λ=2L

Let the velocity of the wave be V. then the frequency of the fundamental

$f_o = \frac{v}{\lambda} = \frac{v}{2L}$

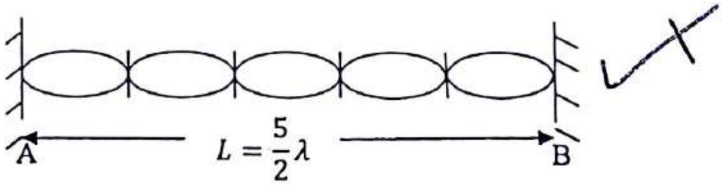
When vibrating with 2nd overtone, the number of waves made by the length of the string between A and B is $\frac{3}{2}\lambda$



$$\therefore L = \frac{3}{2}\lambda \Rightarrow \lambda = \frac{2}{3}L$$

The frequency of the wave $f_2 = \frac{v}{\lambda} = \frac{v}{\frac{2L}{3}} \Rightarrow f_2 = \frac{3v}{2L} = 3\left(\frac{v}{2L}\right)$. hence,
$f_2 = 3f_o$ (4)

Alternatively,



$$\Rightarrow \lambda = \frac{2L}{5} \quad f = \frac{v}{\lambda} = \frac{5v}{2L} \quad but\ f_o = \frac{v}{2L} \therefore f = 5f_o$$ (4)

(d) $\mu = \frac{m}{L} = \frac{9x10^{-4}}{0.6} = 1.5x10^{-3}kgm^{-1}$ $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{135}{1.5X10^{-3}}} = 300ms^{-1}$

The frequency of the third harmonic

$$f_2 = 3f_o = \frac{3v}{2L} = \frac{3X300}{2X0.60} = 750Hz$$ (4)

OR

$$\mu = \frac{m}{L} = \frac{9x10^{-4}}{0.6} = 1.5x10^{-3}kgm^{-1} \quad f_o = \frac{1}{2L}\sqrt{\frac{T}{\mu}} = \frac{300}{2x0.60}$$

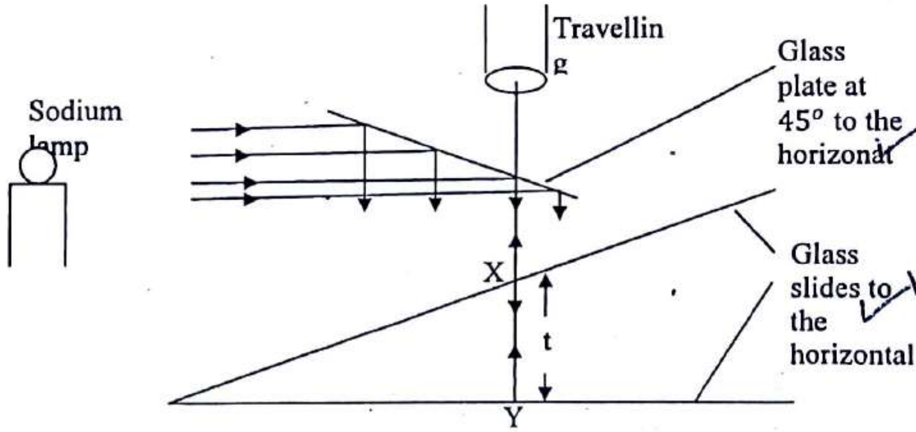
(4)

$$f^1 = 3f_o = 3x\frac{300}{2x0.60} = 750Hz$$

(e) ~~(e)~~ At the mouth, the air is free to move and therefore, the displacement of air molecules is large and the pressure is low. At the closed end , the molecules are less free and the displacement is minimal (or zero) and the pressure is high. (4)

4. (a) (i) it is the difference in phase angles of two waves at a given time. (1)
   (ii) it is the difference in length of paths taken taken by two wave trains from coherent sources to the point of meeting.
   or: It is the difference in length of paths taken by two light waves from the source to the point of meeting.

(b)



Light from the lamp is reflected by the inclined glass plate so that it is incident on the wedge normally. On reaching X some of the light energy is reflected at the bottom part of the top glass slide while part is transmitted to Y and and is reflected at the top surface of the bottom slide. The two waves interfere. The wave reflected at X suffers no phase change while that from Y reflected at a boundary with a dense medium suffers a phase change of π due to reflection. This is equivalent to an additional path length of $\frac{\lambda}{2}$. When the two waves meet, darkness is observed where the path difference is 2t=mλ, m=0,1,2, and t is the air gap due to cancellation. Brightness is observed where the path difference is

$$2t = \left(m + \frac{1}{2}\right)\lambda \text{ , } m = 0,1,2 \textit{ due to reinforcement.}$$ 5

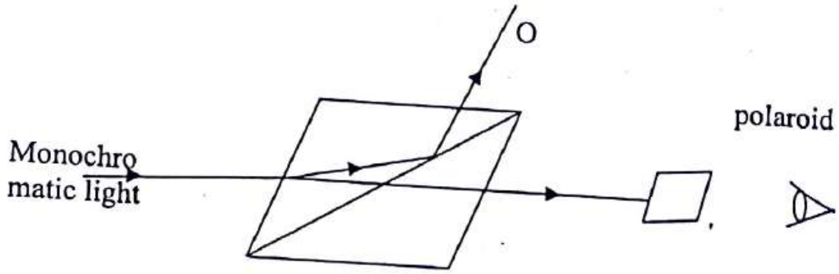
(ii) $\tan \varphi = \frac{\lambda}{2y}$,

$$= \frac{5.6x10^{-7}}{0.75x10^{-3}} = 5 \qquad y = \frac{15}{20}x10^{-3} = 0.75x10^{-3}$$

$$\therefore \varphi = 0.043^{o} \text{ or } 3.733x10^{-4} rad$$ 3

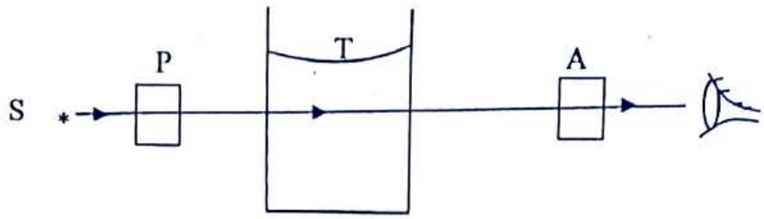
(c) $a = \frac{\lambda D}{x}$ where $x = \frac{3.6x10^{-3}}{21} = \frac{5.5x10^{-7}x0.29x21}{3.6x10^{-3}} = 3.35x10^{-3}m$ 3

(d)



A narrow beam of monochromatic light is made incident on the nicol prism and viewed from the opposite side as shown above. The angle of incidence is gradually increased (or changed) and at each angle the Polaroid is rotated about an axis through its plane. At one point the light gets cut off from the observer. At this point the emergent light is plane polarized. 2

(ii) polarized light is used in measurement of concentration of sugar in a solution. (1)



S= source of monochromatic light
P and A are nicol prisms
T= glass vessel.

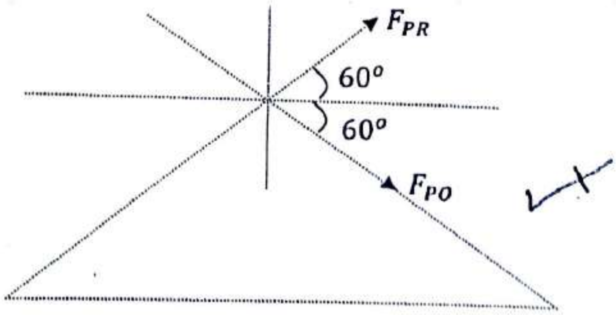
The apparatus are arranged as above. First without solution, the prism A called the analyser is rotated until the emergent light from T is completely extinguished. This orientation is noted. T is then filled with sugar solution. On looking through A ,light can now be seen. A is then rotated again until light is again extinguished. This point is noted. The angle Θ between the positions is measured. the angle of rotation Θ depends on the concentration , so the concentration can be calculated. (4)

5. (a) (i) magnetic meridian is the vertical plane through the magnetic north and south poles of a freely suspended magnet. (1)

(ii) angle of dip is the angle between the resultant earth's magnetic field and the horizontal. (1)

(b) (i) the ampere is that current flowing in two parallel infinitely long conductors of negligible cross-section area one metre apart in a vacuum when the force between them is $2x10^{-7}$ N m^{-1} (1)

(ii)



I_2 The force per metre (F) on a wire carrying a current placed in the magnetic field of another wire carrying a current I_1 is: $F = \frac{\mu_0 I_1 I_2}{2\pi a}$ $\quad F_{PR} = \frac{4\pi X10^{-7}X3X8}{2\pi X0.2} = 2.4X10^{-5}\,Nm^{-1}$

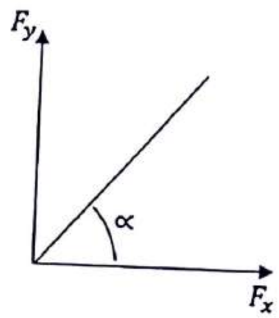
$$F_{PQ} = \frac{4\pi X6X3}{2\pi X0.2} = 1.8X10^{-5}Nm^{-1}$$

$$\rightarrow F_X = F_{PR}cos60^o + F_{PQ}cos60^o = (2.4x10^{-5} + 1.8x10^{-5})cos60^o = 2.1x10^{-5}Nm^{-1}$$

$$\uparrow F_y = F_{PR}sin60^o - F_{PQ}sin60^o = (2.4 - 1.8)x10^{-5}sin60^o = 0.6x0.866x10^{-5} = 0.5196x10^{-5}\cancel{N10^{-5}Nm^{-1}}\ Nm^{-1}$$

$$F = \left(\sqrt{2.1^2 + 0.52^2}\right)X10^{-5} \quad F = 2.16X10^{-5}Nm^{-1}$$

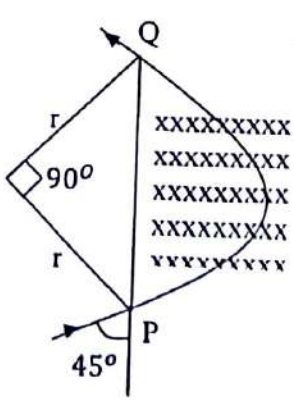
6



$\tan \propto = \frac{F_y}{F_x} = \frac{0.52}{2.1} =$

(c) (i) magnetic flux is the product of the magnetic flux density and the projection of the area normal to the magnetic field.
Magnetic flux density is the force acting on a conductor of length 1m carrying current of 1A placed perpendicular to the magnetic field. 2

(ii)



The conductor describes a circle of radius r

$Bev = \frac{mv^2}{r}$ $r = \frac{mv}{Be}$ $r = \frac{1.4x10^{-27}x10^7}{0.2x1.6x10^{-19}} = 0.4375cm$

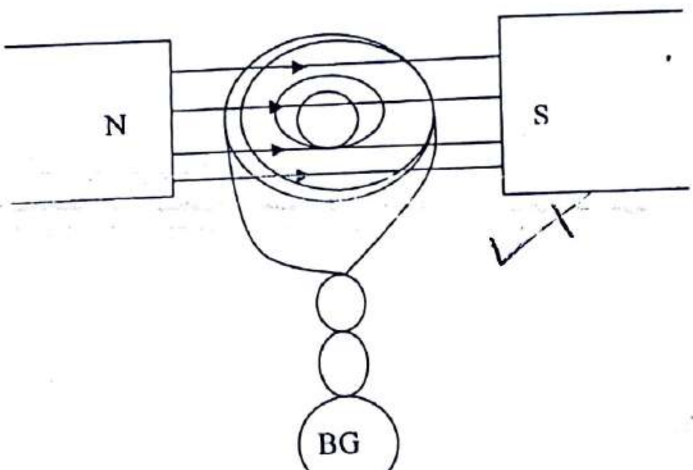
$PQ = \sqrt{r^2 + r^2} = \sqrt{0.4375^2 + 0.4375^2} = 0.62m$

4

OR

$$r = \frac{mv\cos 45^o}{Bq} = \frac{1.4x10^{-27}x10^7\cos 45^o}{0.2x1.6x10^{-19}} = \frac{0.4375}{\sqrt{2}} \quad PQ = 2r$$
$$= 2x\frac{0.4375}{\sqrt{2}} = 0.62m$$

(d)



A search coil of known geometry is connected to a ballistic galvanometer. The coil is then placed with its plane normal to the magnetic field whose B is required. The coil is then pulled completely out of the field and the deflection Θ_1 of the BG is noted.
A capacitor of known capacitance C is is charged to a p.d V and is then discharged through the BG and the deflection Θ_2 is noted.
B is then calculated from

$$B = \frac{\theta_1}{\theta_2} \cdot \frac{RCV}{NA}$$

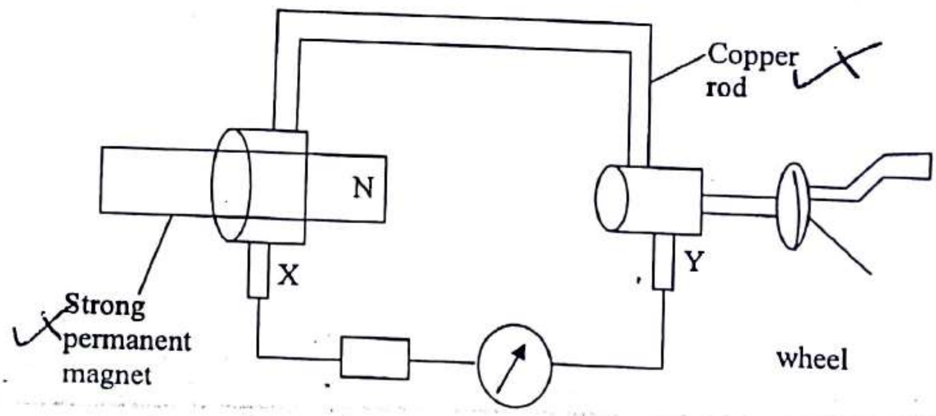
5

R=Resistance of the coil N is the number of turns of the coil and is its cross-sectional area.

6. (a) (i) the induced emf acts in a such a way as to oppose the change causing it. The magnitude of the induced emf in a conductor is directly proportional to the rate of change of magnetic flux linking it.

2

(ii)



X and Y are brush contacts .
A copper rod which can rotate round the north pole of a permanent magnet is connected as shown above. The wheel is turned steadly until deflection of of the galvanometer is constant. The time t for N revolutions is measured
and the no. of revolutions per second is determined from $n = \frac{N}{t}$.
The deflection Θ of the galvanometer is also noted. The experiment is repeated for different speeds of rotation of the wheel and the corresp[onding values of Θ and n are recorded. A graph of Θ against n

is plotted . a straight line graph is obtained implying $\theta \propto n$. Since $\theta \propto emf\ induced\ and$
$n \propto\ speed\ of\ rotation\ of\ the\ rod, then\ emf$
$induced\ \propto\ rate\ of\ change\ of\ magnetic\ flux\ linkage.$ 5

(b) (i) when the plate moves, it cuts the magnetic field and eddy currents are induced in it. the magnetic field due to the current interacts with the applied field opposing the motion. Glass is an insulator and no current is induced in it hence no resistance to its motion. 4

(ii) damping in a moving coil galvanometer is due to eddy currents. This is archieved by winding the coil on a metal former. When the coil swings, the field of the magnet induces eddy currents in the former which creates a field that produces a retarding force on the former so the coil comes to rest sooner than it would.

(c) $\varepsilon = B_v LV.$ $B_V = B_H \tan 70^o.$ $\varepsilon = B_H \tan 70^O\ LV$

$= 1.46X10^{-4}X \tan 70^O\ X30X\frac{1000X1000}{3600} = 3.34volts.$ 3

(d) $emf = BAN\omega = BAN2\pi f = 0.25x80x10^{-4}x500x2\pi x\frac{1200}{60} = 126V$ 3

Alternatively
$emf = 0$

7. (a) (i) root mean square current is the steady current which converts electrical energy to other forms of energies in a given resistor at the same rate as the alternating current. 1

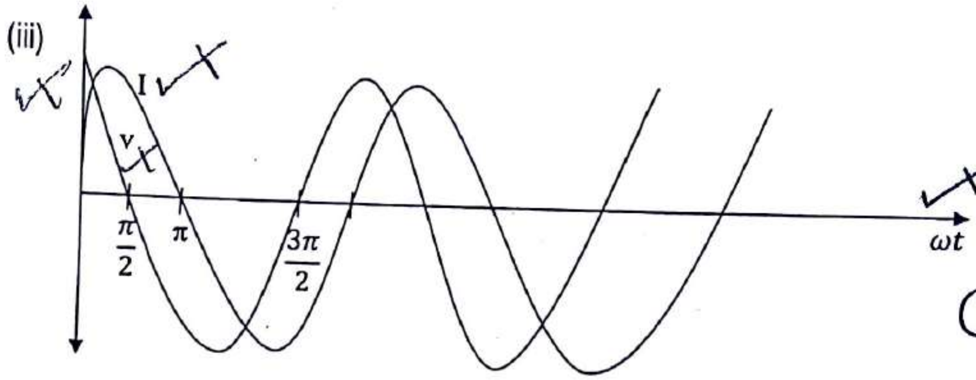
(ii)

$applied\ voltage\ v = v_o sin\omega t, Q = CV = CV_O sin\omega t\ .I = \frac{dQ}{dt}$
$= \frac{d}{dt}[CV_O sin\omega t], I = CV_O \cos \omega t$

$$\Rightarrow I_O = CV_O\omega \ , \ X_C = \frac{V_O}{I_O} = \frac{1}{C\omega} \ \ OR \ X_C = \frac{1}{2\pi f c}$$

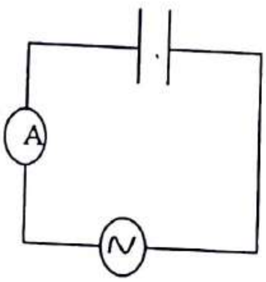
4

(iii)



2

(b) (i)



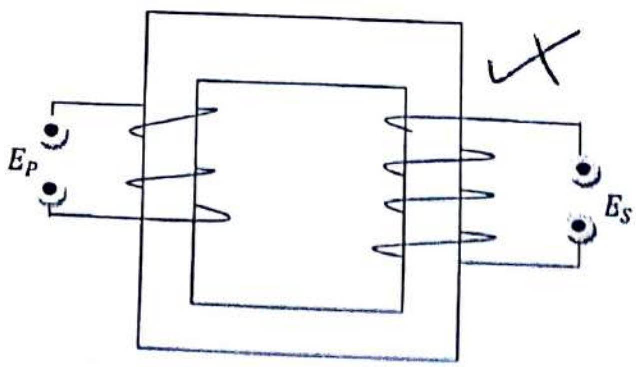
When a circuit is completed the ammeter deflects indicating that current is flowing in the circuit. In the first quarter, capacitor charges to maximum and in the second quarter it discharges. In the third quarter it charges again but with charge on the plate interchanged, and in the fourth quarter it discharges. This is repeated at the frequency of the a.c . the charging and discharging current flows flows throughout in the circuit though no charge passes across the capacitor.

3

(ii) $X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi x 100 x 10^{-6} x 50} = 31.8\Omega$

2

(c)



When a changing current I_P flows in the primary coil , it produces a large alternating magnetic flux in the primary coil. This changing magnetic flux links the secondary coil through the soft iron core. The changing flux in the secondary induces emf in the coil through the load.

$$\frac{E_S}{E_P}\frac{N_S}{N_P}$$

The magnitude of the induced emf depends on the number of turns in the secondary. If $N_S > N_P$, the induced emf is greater than the applied p.d and if $N_S < N_P$, the induced emf is less than the applied p.d.. (4)

(d) (i) $V_{rms} = \frac{V_O}{\sqrt{2}}$, $I_{rms} = \frac{V_{rms}}{R} = \frac{V_O}{\sqrt{2}R} = \frac{9.0}{5\sqrt{2}} = 1.27A$ (2)

(ii)

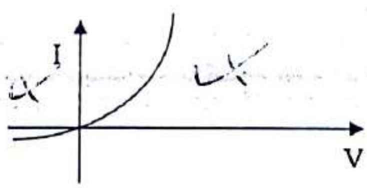
$$P = (I^2)R = I_{rms}^2 R = (1.27)^2 x5 = 8.1W$$ (2)

8. (a) (i) temperature coefficient of resistance is the fractional change in resistance at 0^oC for every degree Celsius rise in temperature. (1)

(ii) during electric current flow, electrons that move through the metal conductor collide with the positive ions of the lattice.

On collision , the kinetic energy which an electron gained as a result of being accelerated by the field is transferred to the ions with which it has collided . this increases the vibrational energy of the lattice ions and so increases the temperature of the metal. (3)

(iii)



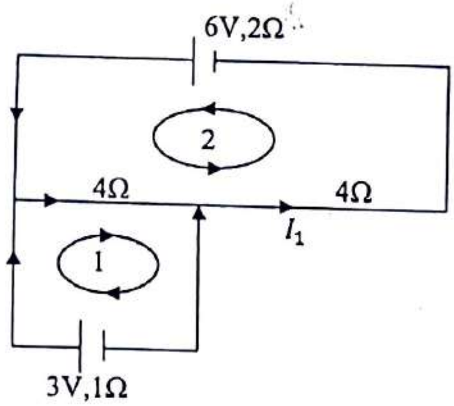
When the diode is forward biased , the current increases rapidly as the p.d is increased. When reverse biased, little or no current flows.

(b) (i) at room temperature the resistance of the thermistor is high, current flowing is thus small and the bulb lights dimly. As current flows , the thermistor heats up (or temperature increases , the resistance decreases , leading to an increase in current and hence increase in brightness of the bulb. (4)

(ii) on closing K , the cell is soon destroyed by over heating . the resistance offered by the thermistor soon reduces due to effect of heating because of current passing through it. an increasing large current flows through it and the cell, dissipated heat in the cell due to its internal resistance leading to its damage. (3)

(c) the law of conservation of current at a junction states that the algebraic sum of currents at a junction is zero. (1)

(d) (i)



$$I_3 = I_1 + I_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

$$consider\ loop\ 1, \qquad 3 = I_2 + 4I_3 \ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

$$consider\ loop\ 2, \qquad 6 = 2I_1 + 4I_3 + 4I_1$$

$$\Rightarrow 6 = 6I_1 + 4I_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

$$from\ (ii) and\ (i), 3 = I_2 + 4(I_1 + I_2)\ \ , 3 \qquad = 5I_2 + 4I_1 \dots\dots\dots\dots\dots (iv)$$

$$from\ (iii) and\ (i), 6 = 6I_1 + 4(I_1 + I_2)\ \ \Rightarrow 3 = 5I_1 + 2I_2 \dots\dots\dots\dots\dots\dots (v)$$

$$(v)x5 - (iv)x2 \ \ \Rightarrow 15 = 25I_1 + 10I_2$$

$$-6 = 10I_2 + 8I_1. \ \ \therefore 9 = 17I_1 \ \ . \Rightarrow I_1 = \frac{9}{17} = 0.53A$$

$$now, 6 = 6x\frac{9}{17} + 4I_3 \ \ \therefore I_3 = \frac{12}{17} = 0.71A$$

4

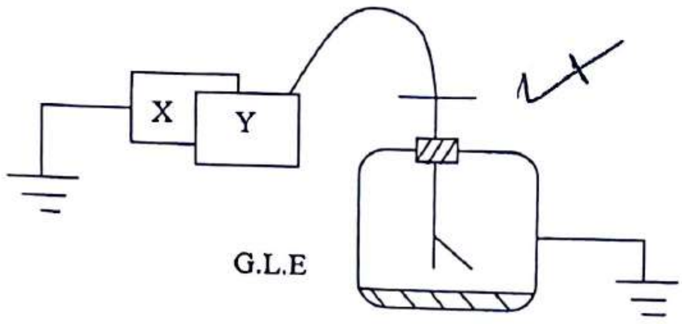
$$power = I^2R = \left(\frac{12}{17}\right)^2 x4 = 1.99W$$

2

(ii) $Terminal\ p.d = 6 - 2I_1 = 6 - 2x\frac{9}{17} = 4.9V$

9. (a) (i) capacitance of a capacitor is the ratio of the magnitude of charge on either plates of the capacitor to the potential difference across the plates. (1)

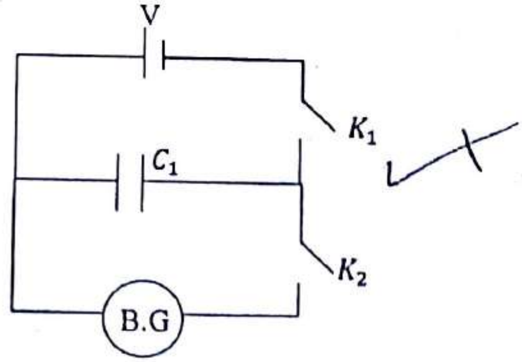
(ii)



Two metal plates X and Y are set close to each other, but not touching as shown above.

Plate Y is given a charge by means of an electrophorus and the divergence of the leaf of the electroscope noted. A sheet of glass or mica is placed between ~~X and~~ Y. the divergence of the electroscope is observed to decrease ~~implying~~ that the new p.d between ~~the~~ plates has decreased. This means that capacitance has increased since $C = \frac{Q}{V}$ and Q is constant. (5)

(b)

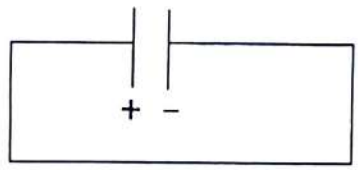


... input switch. K1 is closed and K2 opened. The capacitor of capacitance C1 is charged by the battery of emf V. K1 is opened and K2 is closed ...

The circuit is connected as shown with a capacitor of known capacitance C_1. Switch K_1 is closed and K_2 ~~is closed~~ to discharge the capacitor through the B.G. The first deflection is of the B.G., θ_1 is noted. The capacitor is then replaced by the capacitor of unknown capacitance C_2 and the experiment is repeated the deflection θ_2 is noted. Hence $\frac{C_1}{C_2} = \frac{\theta_1}{\theta_2} \Rightarrow C_2 = C_1 \frac{\theta_2}{\theta_1}$

4

(c)



The wire is connected from the positive plate to the negative plate. Electrons flow from the negative plate to the positive plate neutralizing positive charge. The electrons flow until all the charge has been neutralized and there is no charge on either plates and the capacitor is then fully discharged.

2

(d) (i) $charge\ stored\ on\ 1\mu F\ capacitor, Q_1 = CV = 1x10^{-6}x12 = 12x10^{-6}C$

$$Total\ capacitance\ in\ series\ C = \frac{6x3}{6+3} = 2\mu F$$

$\therefore$ $the\ total\ charge\ stored\ in\ the\ combination\ Q_2 = CV = 2 \times 10^{-6} \times 12 = 2.4x10^{-5}C$

$the\ charge\ on\ each\ of\ the\ 6\mu F\ and\ 3\mu F\ capacitors\ is\ 2.4x10^{-5}C.$

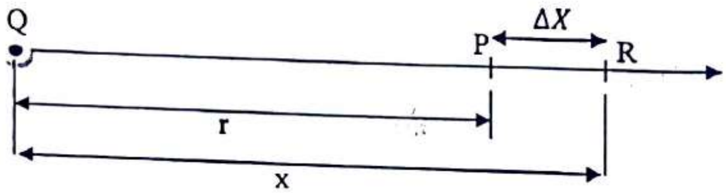
5

(ii)

$$E = \frac{Q^2}{2C},\ E = \left(\frac{24X10^{-6}}{2X6X10^{-6}}\right) = 4.8x10^{-5}J$$ 3

10. (a) (i) electric potential is the work done in bringing 1C of positive charge from infinity to a point against an electric field. 1

(ii)



$the\ force\ experienced\ by\ the\ charge\ of + 1C\ placed\ at\ R, F = \frac{KxQx1}{x^2}$

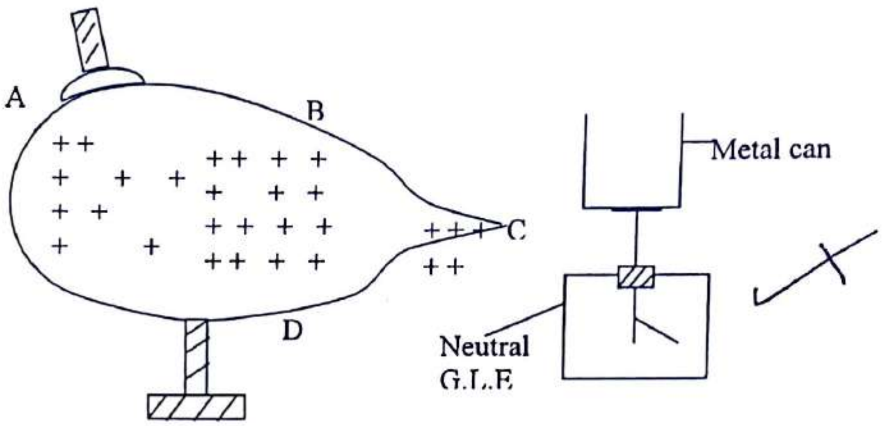
$the\ work\ done\ to\ move\ the\ charge\ of + 1C\ a\ distance\ \Delta x, towards\ the\ fixed\ charge$

$$\Delta W = F.-\Delta X = -\frac{KQ}{X^2}\Delta X$$

$the\ toatal\ work\ done\ to\ bring\ the\ charge\ to\ a\ point\ a\ distance\ r, from\ the\ fixed\ charg$

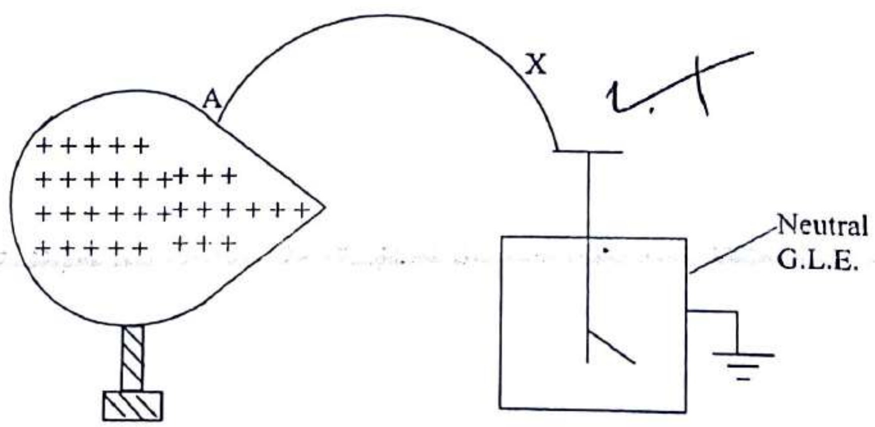
$$W = \int_{\infty}^{r} -\frac{KQ}{X^2}dX = KQ\left[\frac{1}{X}\right]_{\infty}^{r} = \frac{KQ}{r}$$ 4

(b)



The proof plane is placed on the body at A and transferred into the can without touching it. the divergence Θ of the leaf is noted. The proof plane is removed and discharged. The procedures above are repeated for different points say B, C, D on the body. It is found that the divergence is greatest when the proof plane is at C, the sharp point. Since
$\theta \propto Q$, *there is high concentration of charge at the sharp point.*

(ii)



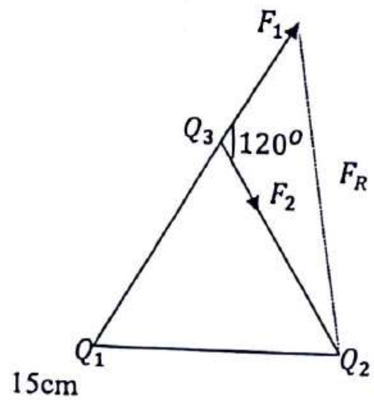
A conducting wire X is connected to a point A and brass cap. The deflection θ is noted. End A is moved over the surface of the conductor while noting the lection. deflection of the leaf. It is observed that there is no change in deflection. So the potential is constant implying that the surface is equipotential.

3

(c) when a negatively charged cloud passes over a building, it induces positive charges on the spikes of the conductor and repels electrons to the copper plate when they are dissipated to the earth.
High concentration of charge at the spikes builds high electric field intensity around the spikes that ionizes air molecules around the spikes. Electrons are attracted to the spikes and neutraulised while positive ions are repelled towards the cloud that neutralizes its effect , hence the house is protected from lightening.

4

(d)

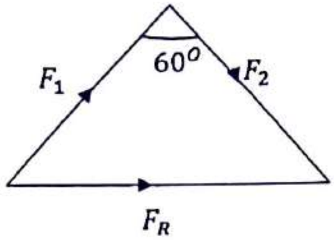


1

$$F_1 = K\frac{Q_1Q_2}{X^2} = \frac{9x10^9x2x10^{-6}x5x10^{-6}}{(0.15)^2} = 4.0N.$$

$$F_2 = \frac{9x10^9x3x10^{-6}x5x10^{-6}}{(0.15)^2} = 6.0N$$

$$F_R = \sqrt{F_1^2 + F_2^2 - 2F_1F_2\cos 60^o} = \sqrt{4^2 + 6^2 - 2x4x6\cos 60^o} = \sqrt{28} = 5.29N.$$

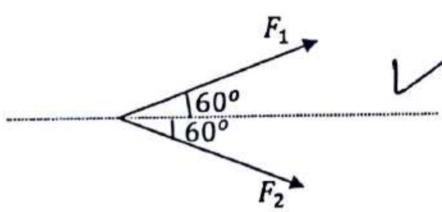


5

$$\alpha = \sin^{-1}\left(\frac{6\sin 60^O}{5.29}\right) = 79.1^O$$

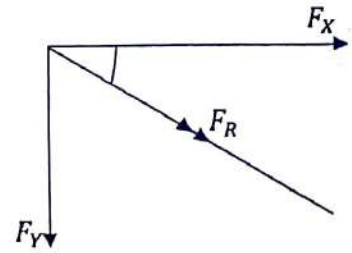
$$alternatively, F_1 = K\frac{Q_1Q_2}{X^2} = \frac{9x10^9x2x10^{-6}x5x10^{-6}}{(0.15)^2} = 4.0N$$

$$F_2 = \frac{9x10^9x3x10^{-6}x5x10^{-6}}{(0.15)^2} = 6.0N$$



$$\rightarrow F_{X=}F_1\cos 60^O + F_2\cos 60^O = (4+6)\cos 60^O = 5N$$

$$\uparrow\ F_Y = (F_1 + F_2)\sin 60^O = -2x0.866 = -1.732N$$



$$F_R = \sqrt{5^2 + 1.732^2 = \sqrt{28}} = 5.29N$$

$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right) = \tan^{-1}\left(\frac{1.732}{5}\right) = 19.1^o$$

END END

Activity	Time frame	Input/Cost	expected output	Per Mountain evaluation	Cost	Comment	~~To responsible~~
1. Schemes							
2. lessons							

to be used for lessons 7

BUT S.4, light x 310 students

6. ONCDC syllabus

COHRB2016 2015

10. Pry workshops