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.

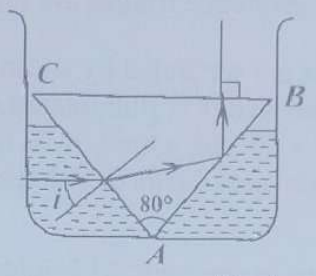

Fig. 1

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*)

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**.

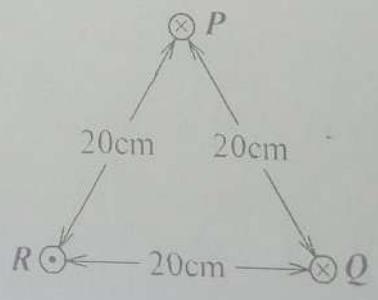

Fig. 2

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.

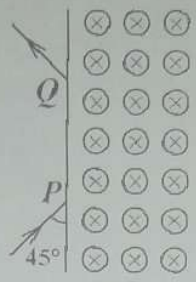

Fig. 3

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)*

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)**.

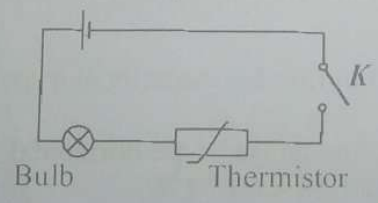

Fig. 4 (*i*)

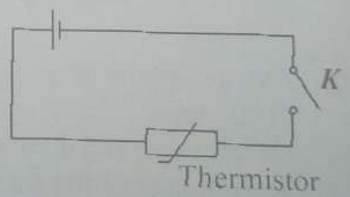

Fig. 4 (*ii*)

(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**.

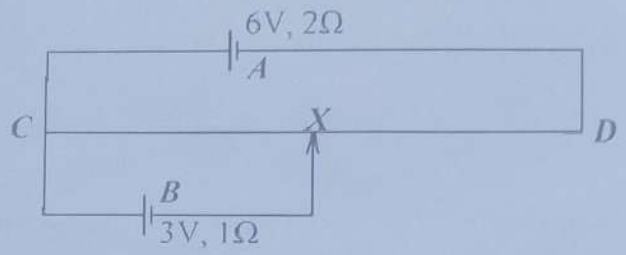

Fig. 5

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**.

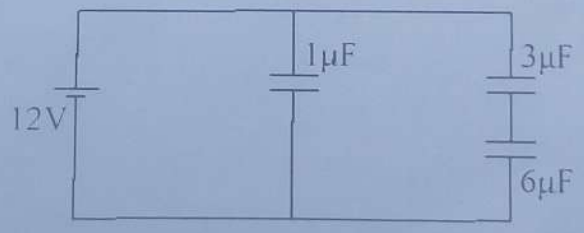

Fig. 6

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 μC, −3 μC and 5 μC respectively are situated at corners of an equilateral triangle of sides 15 cm as shown in figure 7.

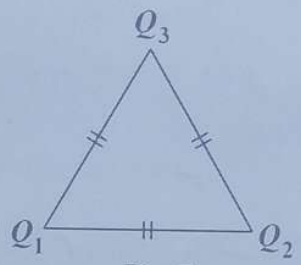

Fig. 7

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

END

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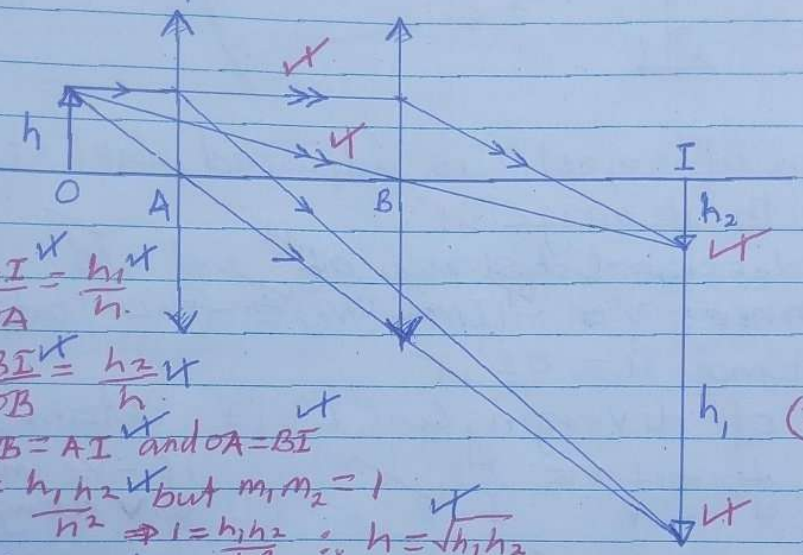
1a) Conjugate points are any two points on the principal axis of a lens such that if an object is placed at one of the points, its image is formed at the other point. (2)

- Accept mirror/lens converging

(b)

(i)



- Deny Imk if rays are missing.

OR

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

$m_2 = \frac{BI}{OB} = \frac{h_2}{h}$

but $OB = AI$ and $OA = BI$

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

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

(ii) O and I are conjugate points with respect to the lens. $OB = AI$ and $OA = BI$. When lens is in position A, by linear magnification,

$$M_A = \frac{AI}{OA} = \frac{h_1}{h} \quad \text{— (i)}$$

In position B, $M_B = \frac{BI}{OB} = \frac{h_2}{h}$ — (ii)

But $AI = OB \Rightarrow \frac{h}{h_1} = \frac{h_2}{h}$

Thus $h^2 = h_1 h_2 \therefore h = \sqrt{h_1 h_2}$ (4)

(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 as shown below.

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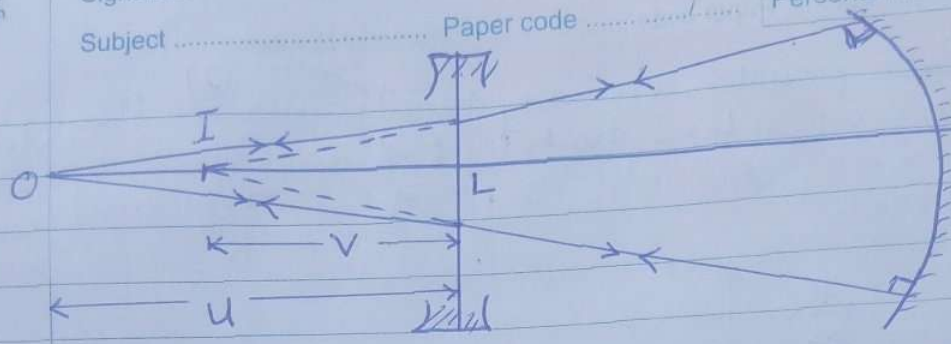


- Position of O, L and M

- The position of object O is adjusted until it coincides with its image ✓
- Measure and record distances OL and LM. ✓ (5)
- Image distance $v = -(IM - LM) \equiv -(r - LM)$ but $r = 2f_1$ ✓
- Object distance $u = OL$ ✓
- Focal length of diverging lens L is obtained from $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ ✓

if -ve misses on v deny ½ mark

(b)(i) For eyering. ✓

$u = f_o + f_e = 3000 + 25 = 3025\text{mm}$

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

$\frac{1}{3025} + \frac{1}{v} = \frac{1}{25}$ ✓ (3)

$v = 25.2\text{mm}$ ✓

(ii) Angular magnification

$M = \frac{\text{Diameter of objective}}{\text{Diameter of eyering}}$ ✓

$M = \frac{150}{\Delta_e}$ ✓

But $M = \frac{f_o}{f_e} = \frac{3000}{25} = 120$ ✓ (3)

$\Rightarrow 120 = \frac{150}{\Delta_e}$ ✓, $\Delta_e = 1.25\text{mm}$ ✓

(c) When the eye is placed at the eyering, all rays passing through the objective will enter it and the image viewed is brightest. ✓ (1)

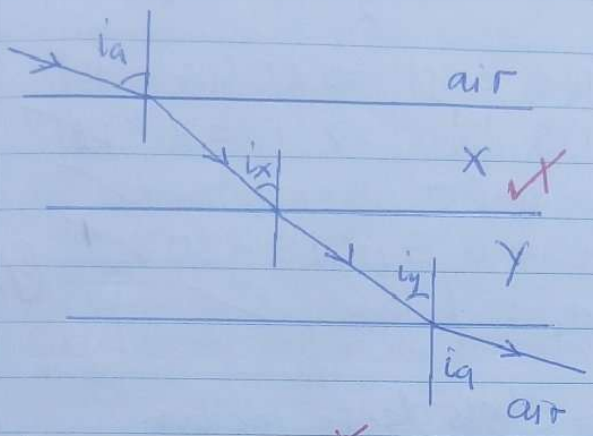
or

- The brightest image is observed
- Widest field of view

} accept any

Question 2

2a



consider a ray of light incident on a plane boundary of air and x. The ray moves through x, Y then into air again

$_aN_x = \frac{\sin i_a}{\sin i_x}$, $\sin i_a = {}_aN_x \sin i_x$

Also $_aN_y = \frac{\sin i_a}{\sin i_y}$, $\sin i_a = {}_aN_y \sin i_y$

but $n_a = 1$, $_aN_x = n_x$ and $_aN_y = n_y$. (4)

so, $n_a \sin i_a = n_x \sin i_x = n_y \sin i_y$.

$\therefore$ $n \sin i$ = a constant

b(i) Critical angle of incidence is the angle in a denser 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 sided transparent vessel

- A narrow beam of monochromatic light is directed onto the air cell and is viewed from the opposite side
- The air cell is turned in one direction until light just disappears. Note this position.
- The air cell is then turned in the opposite direction until light just disappears again. Note this position
- The angle between the two cell positions is measured as θ. (5)
- Critical angle c is obtain from:

$$c = \frac{\theta}{2}$$

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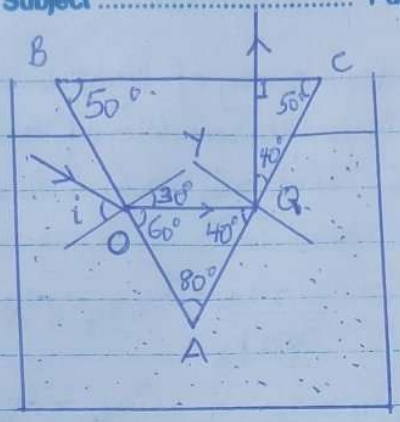
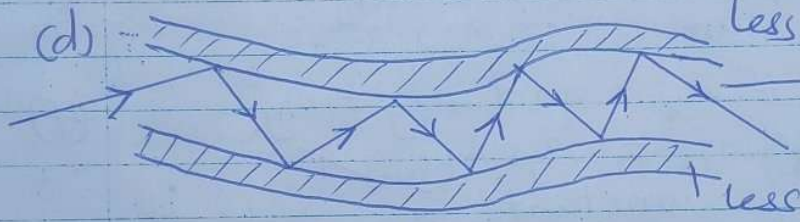
c) 

$\angle CBA = \frac{180-80}{2} = 50°$ ✓

$\angle YQO = 50°$, $\Rightarrow \angle OQA = 40°$ ✓
$\angle AOQ = 60°$, $\Rightarrow r_1 = 30°$ ✓
now, $n \sin i$ = a constant ✓
$n_L \sin 34.6 = 1.51 \sin 30$ ✓
$n_L = 1.36$. ✓ (4)

(d) 

An optical cable is made of a transparent material coated with another material 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 repeatedly in the pipe until the beam of light emerges from the pipe. (3)

(e) Let r be radius of curvature.
$\therefore n_w = \frac{r}{h_w}$ and $n_L = \frac{r}{h_L}$.

$\frac{n_L}{n_w} = \frac{h_w}{h_L} \Rightarrow \frac{n_L}{1.33} = \frac{12}{13.3}$ ✓

$n_L = 1.2$ ✓ (3)

Question 3.

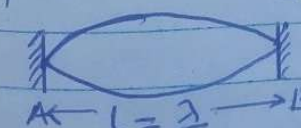
(a)(i)

Progressive waves	Stationary waves
- Energy is transfered from one point to another along the wave. ✓	- Energy is not transfered but confined in a particular section of a wave.
- All particles in the transmitting medium oscillate with the same amplitude. ✓	- Amplitude of particles in the medium vary with position along the wave.
- Distance between two successive crests or troughs is equal to λ ✓	- Distance between two successive nodes or antinodes is equal to $\lambda/2$
- Don't have nodes and antinodes. ✓	- Have nodes and antinodes.

(3) any three

(ii) Overtones are notes of higher frequencies than a fundamental note produced by an instrument. ✓ (1)

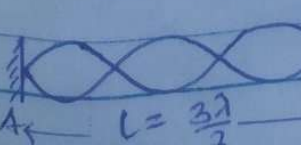
(iii) Different instruments produce different number of overtones ✓. The number of over tones produced affect the quality of the ✓ note played. Hence the quality of notes produced by different instruments are different. ✓ (3)

(b) 

When string vibrates at fundamental, $L = \frac{\lambda}{2}$, $\lambda = 2L$

Fundamental frequency; $f_0 = \frac{v}{\lambda} = \frac{v}{2L}$

When vibrating with 2nd over tone, $L = \frac{3\lambda}{2}$



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

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But $f_2 = \frac{v}{\lambda} = \frac{3v}{2l}$ ✓✓

But $\frac{v}{2l} = f_0$.

$f_2 = 3f_0$. ✓

(4)

(d) $\mu = \frac{m}{l} = \frac{9\times10^{-4}}{0.6} = 1.5\times10^{-3}\ kgm^{-1}$ ✓

$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{135}{1.5\times10^{-3}}} = 300\ ms^{-1}$ ✓

(5)

Freq. of 3rd harmonic $f_3 = 3f_0 = \frac{3v}{2l} = \frac{3\times300}{2\times0.60} = 750\ Hz$

(e) At the mouth, air is free to move and therefore the displacement of air molecules is large and 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)

Question 4

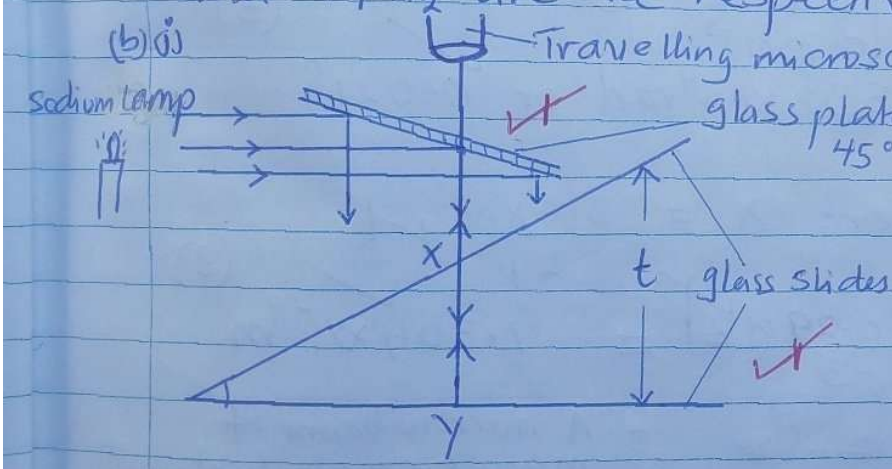
4a(i) Path difference is the difference in phase angles of two waves at a given time ✓ (1)

(ii) Optical path difference is the difference in length of paths taken by two light waves from the source to the point of meeting ✓ (1)

OR:

Optical path difference is $n_1x_1 - n_2x_2$ where n_1, n_2 are refractive indices of the two media and x_1, x_2 are the respective geometrical paths.

(b)(i)



- 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 is reflected at the top surface 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 denser medium suffers a phase change of π ✓ due to reflection. This is equivalent to an additional path length of $\frac{\lambda}{2}$.

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- When the two waves meet darkness is observed where the path difference is $2t = m\lambda$, $m = 0, 1, 2$ and t is the air gap due to cancellation. Brightness is observed where the path difference is $2t = (m + \frac{1}{2})\lambda$, $m = 0, 1, 2$ due to reinforcement. (5)

(ii) $\tan\phi = \frac{\lambda}{2y}$, $y = \frac{15}{20} \times 10^{-3} = 0.75 \times 10^{-3}$

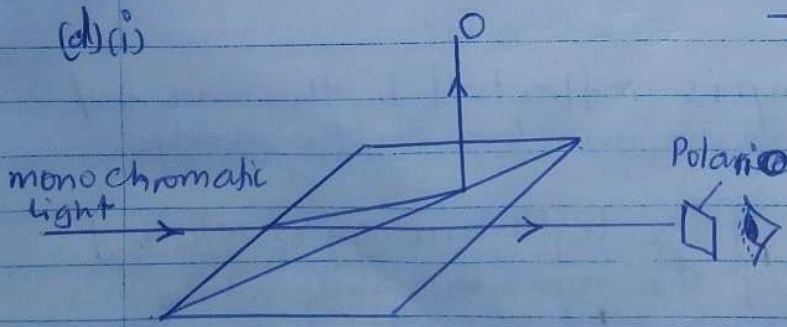
$$\phi = \tan^{-1}\left(\frac{5.6 \times 10^{-7}}{0.75 \times 10^{-3} \times 2}\right)$$

$$= 3.7333 \times 10^{-4} \text{ rad. or } 0.021^{\circ}$$ (3)

(c) $a = \frac{\lambda D}{x}$ where $x = \frac{3.6 \times 10^{-3}}{21}$

$$a = \frac{5.5 \times 10^{-7} \times 0.29 \times 21}{3.6 \times 10^{-3}} = 9.304 \times 10^{-4} \text{ m}.$$ (3)

(d)(i)



- 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 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 polarised. (2)

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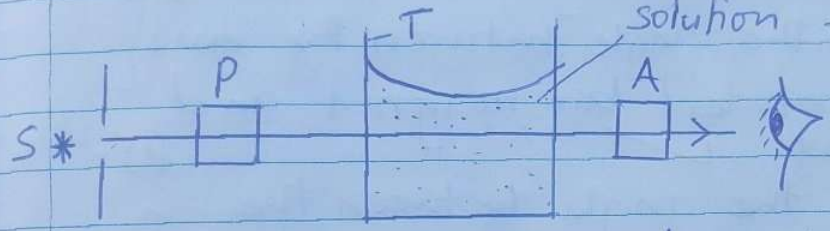
(i) Polarised light is used in measurement of concentration of sugar in a solution. ✓



any two @ ½ ✓✓

S - Source of monochromatic light

P and A - nicol prisms ✓✓

T - glass vessel

Apparatus is arranged as shown above. First without the solution, prism A (analyser) is ✓ rotated until emergent light from A is completely extinguished. The 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 ✓ extinguished. Note this point. Measure the angle θ between the two positions. ✓ The angle of rotation θ depends on the concentration, so the concentration can ✓ be calculated. (5)

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Question 5

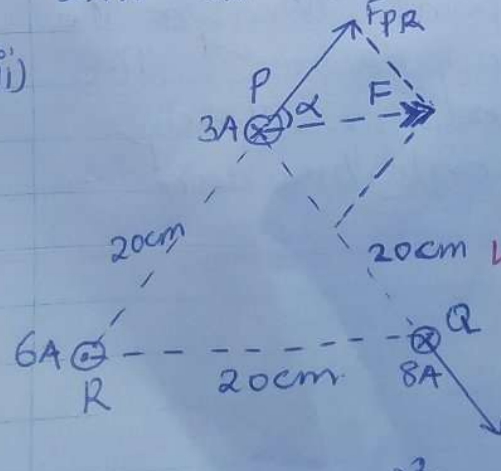
5a(i) Magnetic meridian is the vertical plane through the magnetic north and south poles of the earth's magnet. (01)

(ii) Angle of dip is the angle between the axis of a freely suspended bar magnet and the horizontal. (1)

- Angle of dip is the angle between the resultant of earth's magnetic field and the horizontal.

b(i) The ampere is a steady current which when flowing in two parallel infinitely long conductors of negligible cross-sectional area placed 1m apart in a vacuum produces a force of 2×10^{-7} Nm^{-1} between them. (1)

(ii)



$$F = \frac{\mu_0 I_1 I_2}{2\pi r}$$

$$F_{PR} = \frac{4\pi\times10^{-7}\times3\times8}{2\pi\times0.2} = 2.4\times10^{-5}\,N$$

$$F_{PQ} = \frac{4\pi\times10^{-7}\times6\times3}{2\pi\times0.2} = 1.8\times10^{-5}\,N$$

$$F^2 = F_1^2 + F_2^2 - 2F_1F_2\cos\theta$$

$$F^2 = (2.4\times10^{-5})^2 + (1.8\times10^{-5})^2 - 2\times2.4\times10^{-5}\times1.8\times10^{-5}\cos60^\circ$$

$$F = 2.16\times10^{-5}\,Nm^{-1}$$

Also $\frac{\sin\alpha}{1.8\times10^{-6}} = \frac{\sin60}{2.16\times10^{-5}} \Rightarrow \alpha = 46.2^\circ$ (6)

(α is angle between F and F_{PR}).

OR.

$F_x = F_{PR}\cos 60° + F_{PQ}\cos 60° = (2.4+1.8)\times10^{-5}\cos 60$

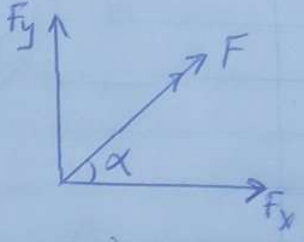
$= 2.1\times10^{-5}\ Nm^{-1}$ ✓

$F_y = F_{PR}\sin 60° - F_{PQ}\sin 60° = (2.4-1.8)\times10^{-5}\sin 60$

$= 0.5196\times10^{-5}\ Nm^{-1}$ ✓

$F = \left(\sqrt{(2.1)^2+(0.5196)^2}\right)\times10^{-5}$ ✓

$= 2.16\times10^{-5}\ Nm^{-1}$ ✓



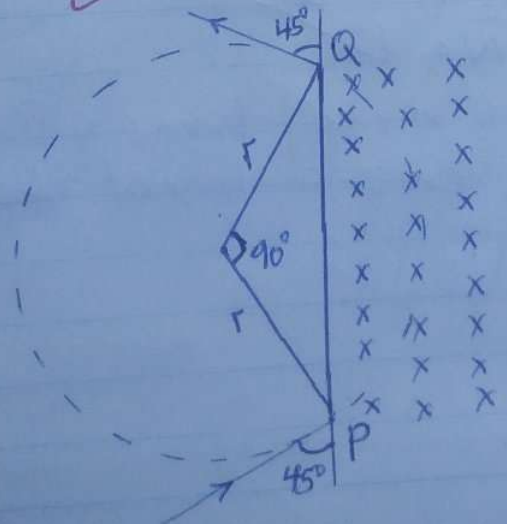
$\alpha = \tan^{-1}\left(\frac{F_y}{F_x}\right) = \tan^{-1}\left(\frac{0.5196}{2.1}\right)$

$\alpha = 13.9°$ ✓

c(i) Magnetic flux is the product of the magnetic flux density and the projection of the area normal to the magnetic field. ✓

(ii) Magnetic flux density is the force acting on a conductor of length 1m carrying a current of 1A placed perpendicular to the magnetic field. ✓ (2)

(i)



The charged particle describes a circular path

So, $BqV = \frac{mV^2}{r}$ ✓

$r = \frac{mV}{Bq}$

$= \frac{1.4\times10^{-27}\times10^{7}}{0.2\times1.6\times10^{-19}}$ ✓

$= 0.4375\ m$

(12)

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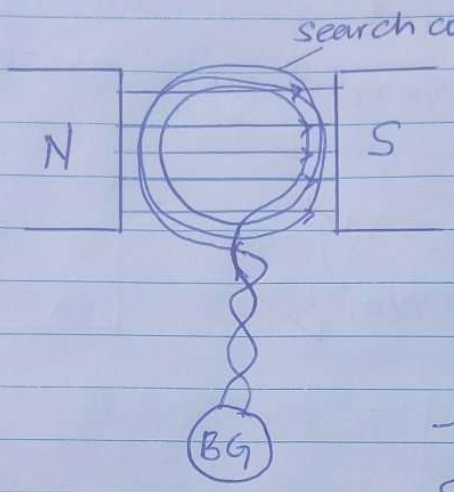
$PQ = \sqrt{r^2 + r^2} = \sqrt{2 \times 0.4375^2} = 0.6187\,m.$ (4)

(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 B.G is noted.

$\frac{NAB}{R} = K\theta_1$ — (i) R – resistance of coil

- A capacitor of known capacitance C is charged to p.d V and is then discharged through the B.G and the first deflection θ_2 noted.

$CV = K\theta_2$ — (ii)

B is then calculated from. (5)

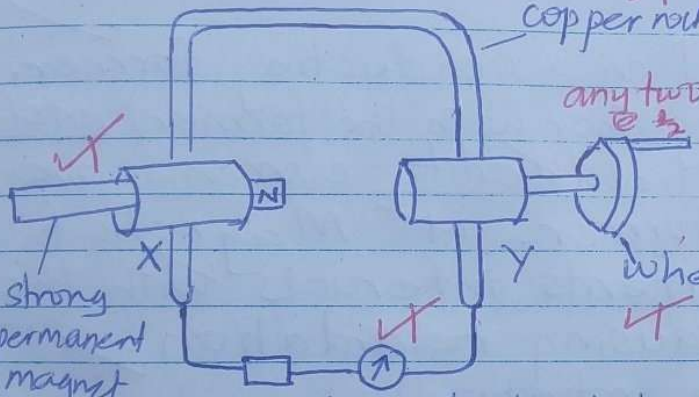
$$B = \frac{\theta_1}{\theta_2} \frac{RCV}{NA}$$

where N is no of turns of the coil
A is cross-sectional area of coil.

Question 6.

6(a)(i) - Induced emf acts in such a direction as to oppose the change causing it ✓
- The magnitude of induced emf in a conductor is directly proportional to the rate of change of magnetic flux linking it. ✓ (2)

(ii)



- A copper rod which can be rotated round the North pole of a permanent magnet is connected as shown above
- The wheel is turned steadily until the deflection of the galvanometer is constant
- The time t for N revolutions is measured and the number of revolutions per second is determined from $n = \frac{N}{t}$.
- Note the deflection θ of the galvanometer. (5)
- Repeat the experiment for different speeds of rotation of the wheel and the corresponding values of θ and n are recorded.
- A graph of θ against n is plotted. A straight line 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.

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b(i) When the plate moves, it cuts the magnetic field and eddy currents are induced in it The magnetic field due to the currents 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) The coil is wound on a conducting former. When the coil (together with the former) rotate in the magnetic field, eddy currents are induced in the former. Magnetic field due to eddy currents interacts with the applied field causing retardation. (or opposing the rotation) (3)

(c) $E = B_V L V$ But $B_V = B_H \tan 70°$.

$E = B_H \tan 70° \cdot LV = 1.46 \times 10^{-4} \tan 70 \times 30 \times \frac{1000}{3600} \times 1000$ (3)

$= 3.34 V$

(d) $E.m.f = BANw$

$= BAN 2\pi f$

$= 0.2 \times 80 \times 10^{-4} \times 500 \times 2\pi \times \frac{1200}{60}$ (3)

$= 126 V$.

Accept $E = BANw$
$= 0$.

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Question 7

(a)(i) R.M.S 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)

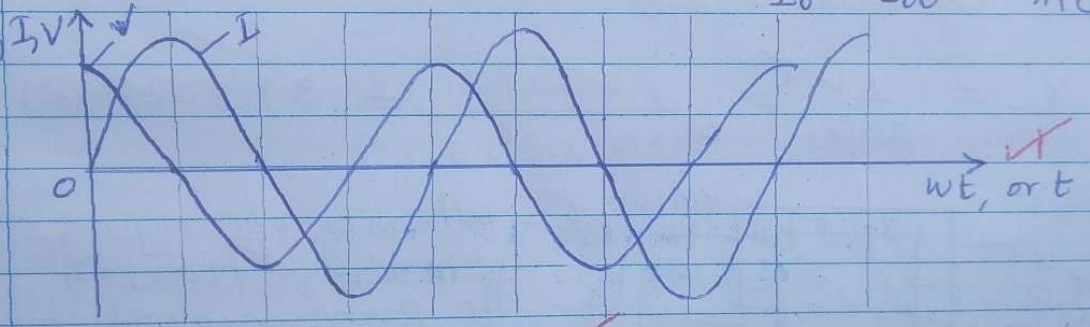
(ii) Applied voltage $V = V_0 \sin \omega t$ ✓

$Q = CV$ ✓ $= CV_0 \sin \omega t$.

$I = \frac{dQ}{dt}$ ✓ $= \frac{d}{dt}(CV_0 \sin \omega t) = C V_0 \omega \cos \omega t$ ✓ (4)

$\Rightarrow I_0 = CV_0\omega$ ✓ so, $X_c = \frac{V_0}{I_0}$ ✓ $= \frac{1}{C\omega}$ or $\frac{1}{2\pi fC}$ ✓

(iii)



✓ - any correct graph

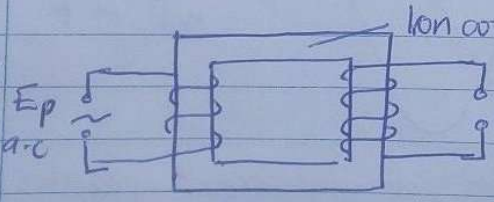
✓ - correct phase relation for second graph.

(b)(i) When the circuit is closed, the capacitor charges and discharges ✓ continuously in opposite direction alternately. ✓ Charge (current) therefore flows in the circuit continuously ✓ and the capacitor appears to conduct current. ✓ (3)

OR When the circuit is completed, the ammeter deflects indicating the current flowing in the circuit. In the first quarter, capacitor charges to maximum. In the second quarter, it discharges. In the third quarter it charges again 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 throughout the circuit though no charge passes across the capacitor. (3)

(ii) $X_c = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 100 \times 10^{-6} \times 50} = 31.852$ (2)

(c)



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

$$\frac{E_s}{E_p} = \frac{N_s}{N_p}$$

- The magnitude of induced emf depends on the number of turns in the

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secondary ✓t

If $N_s > N_p$ then induced Emf is greater than applied p.d. ✓t

If $N_s < N_p$, the induced emf is less than the applied p.d. ✓t

(4)

d(i) $V_{rms} = \frac{V_0}{\sqrt{2}}$ ✓t

$I_{r.m.s} = \frac{V_{r.m.s}}{R} = \frac{V_0}{R\sqrt{2}} = \frac{9}{5\sqrt{2}} \approx 1.27\,A$ ✓t ✓t (2)

(ii) $P = I^2R = I_{r.m.s}^2 R$ ✓t

$= (1.27)^2 \times 5$ ✓t

$= 8.1\,W$ ✓ (2)

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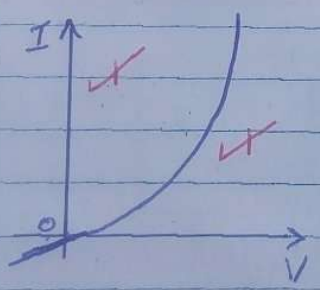
Question 8

8a(i) Temperature coefficient of resistance is the fractional change in resistance at 0°C for every degree Celsius rise in temperature. ✓ (1)

(ii) - During electric current flow, electrons that move through the metal conductor collide with positive ions of the lattice. ✓
On collision, the K.E which an electron gained as a result of being accelerated by the field is transfered to the ions (atoms) with which it has collided. ✓
- This increases the vibrational energy of the lattice ions and so increases the temperature of the metal. ✓

(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. ✓ (2)

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

~~or As I flows, ✓ temps increases, the resistance ✓ reduces and more current flows. So the brightness increases ✓~~ (4)

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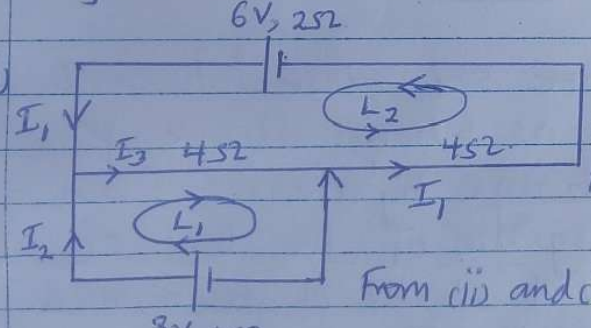
(ii) On closing k the cell is soon destroyed by over heating. The resistance offered by the thermistor soon reduces due to effect of heating because of current passing through it. An increasing large current flows through it and the cell, dissipated heat in the cell due to internal resistance leading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

or The current in the circuit reduces by a large amount. Current flowing is thus large. This causes heating of connecting wire (and or battery) and may destroy them. (3)

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

(d)(i)



$I_3 = I_1 + I_2$ — (i)

For loop L_1: $3 = I_2 + 4I_3$ — (ii)

For loop L_2: $6 = 6I_1 + 4I_3$ — (iii)

From (ii) and (i) $3 = I_2 + 4(I_1 + I_2)$

$\Rightarrow 3 = 5I_2 + 4I_1$ — (iv)

From (iii) and (i) $6 = 6I_1 + 4(I_1 + I_2)$

$\Rightarrow 6 = 10I_1 + 4I_2$ — (v)

solving (iv) and (v) $I_1 = \frac{9}{17} = 0.53\,A$

$I_3 = \frac{12}{17} = 0.71\,A$ (4)

Thus Power $= I^2R$

$= \left(\frac{12}{17}\right)^2 \times 4 = 1.99\,W$

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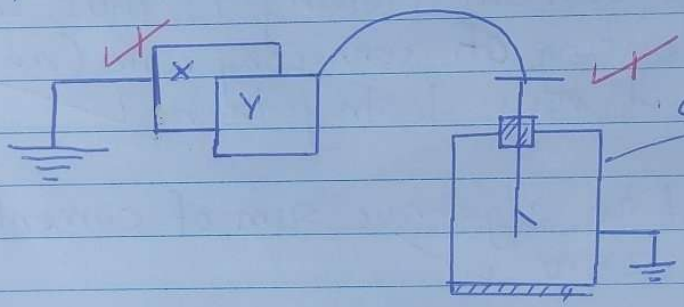
(ii) Terminal p.d = $6 - 2I_2$
$= 6 - 2 \times \frac{9}{17}$
$= 4.9\,V$ (2)

Question 9.

9a(i) Capacitance of a capacitor is the ratio magnitude of charge on either plates of the capacitor to the p.d across the plates. (1)

(ii)



Two plates X and Y are set closed to each other but not touching as shown above. Plate Y is given a charge by means of an electrophorous and 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. (5)
(the p.d btn the plates has decreased) Implying This means that capacitance has increased since $C = \frac{Q}{V}$ and Q is constant to be

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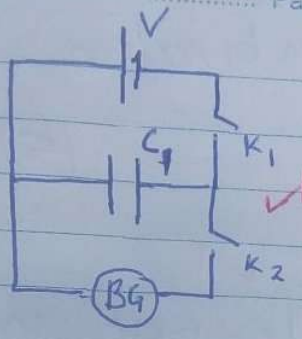
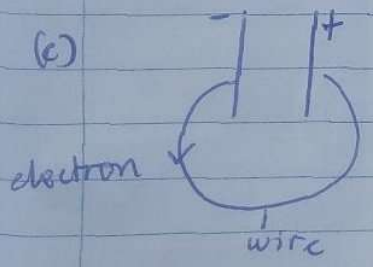
(b)



- The circuit is connected as shown with a capacitor of known capacitance C_1 ✓
- Close K_1 and open K_2. C_1 charges by a battery of emf V. K_1 is open and K_2 is closed to discharge C_1 through the B.G.
- The first deflection of the B.G, θ_1 is noted.
- The capacitor is now replaced by another capacitor of unknown capacitance C_2 and the experiment is repeated and deflection θ_2 is noted.

Hence $\frac{C_1}{C_2} = \frac{\theta_2}{\theta_1} \Rightarrow C_2 = \frac{C_1\theta_2}{\theta_1}$ (4)

(c)



- The wire is connected from the positive plate to the negative plate
- Electrons flow from the negative plate to the positive plate neutralising the positive charges until all the charge has been neutralised and there is no charge on the either plates. The capacitor is then fully discharged. (2)

(d) Charge stored on 1μF: $Q_1 = CV$
$= 1\times10^{-6}\times12$
$= 12\times10^{-6}$ C

Total capacitance in series, $C = \frac{6\times3}{6+3} = 2\mu F$

(22)

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∴ The charge stored in combination.

$Q_2 = CV$ ✓

$= 2\times10^{-6}\times12$ ✓

$= 2.4\times10^{-5}\,C$ ✓ (5)

The charge on each of the 6μF and 3μF capacitor is $2.4\times10^{-5}\,C$ ✓

(ii) $E = \frac{Q^2}{CV}$ ✓

$= \frac{(24\times10^{-6})^2}{2\times6\times10^{-6}}$ ✓ (3)

$= 4.8\times10^{-5}\,J$ ✓

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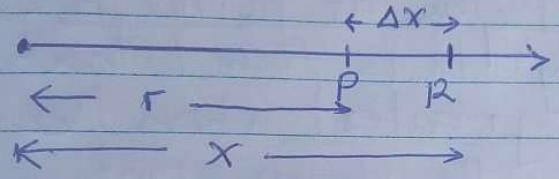
Question 10.

10a(i) Electric potential is the work done in moving +1 C charge from infinity to a point against an electric field. ✓ (1)

(iii)



- Force experienced by the +1C at R

$$F = k\frac{Q \times 1}{x^2}$$ ✓

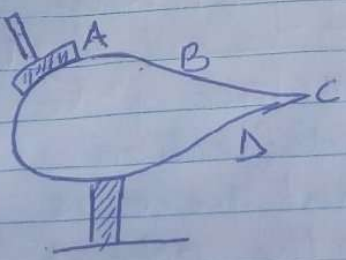
- Work done to move the charge of +1C a distance Δx towards the fixed charge $+Q$.

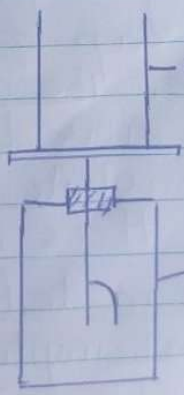
$$\Delta W = F \times -\Delta x = -\frac{kQ}{x^2}\Delta x$$ ✓✓

Total work done to bring the charge to a point a distance r from the fixed charge $+Q$ (4)

$$W = \int_{\infty}^{r} -\frac{kQ}{x^2}dx = kQ\left[\frac{1}{x}\right]_{\infty}^{r} = \frac{kQ}{r}$$ ✓✓✓

b(i)





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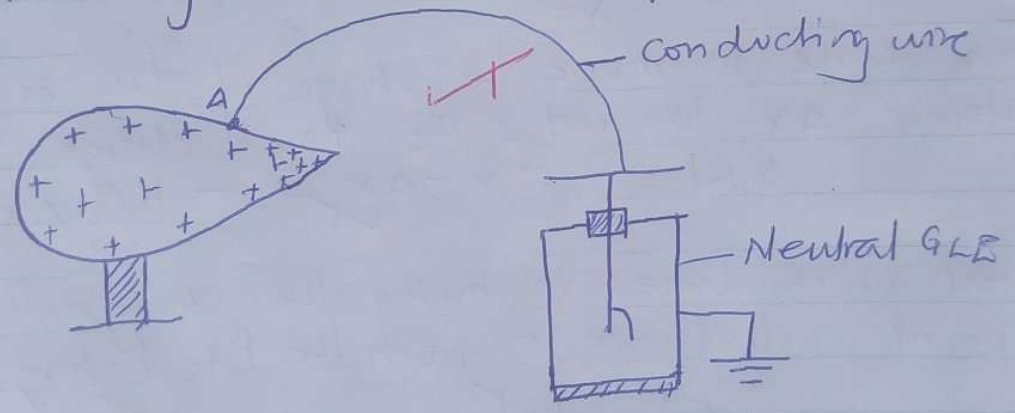
The proof plane is placed on the body at A and transferred into a can without touching it. The divergence θ of the leaf is noted. The procedure is repeated by placing the proof plane at points B, C, and D on the body. It is found that the divergence is greatest when the proof plane is at C, the sharp point. Since θ ∝ Q there is high concentration of charge at the sharp point. (3)

(ii)



A conducting wire is connected to a point A on a charged pear shaped conductor and the brass cap of a neutral gold leaf electroscope. The deflection θ is noted. End A is moved over the surface of the conductor while noting the deflection of the leaf. It is observed that there is no change in deflection. So the potential is constant implying that the surface is an equipotential. (3)

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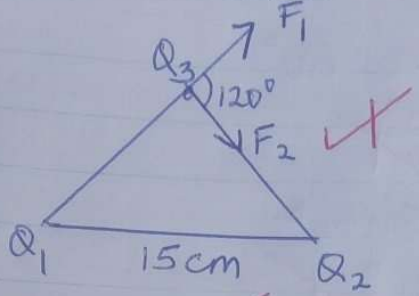
d)



$F_1 = \frac{KQ_1Q_2}{x^2}$ ✓ $\frac{9\times10^9 \times 2\times10^{-6}\times5\times10^{-6}}{(0.15)^2} = 4N$ ✓✓

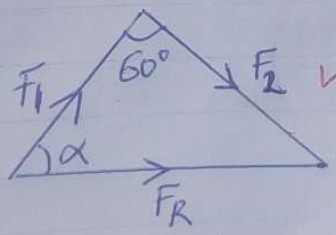
$F_2 = \frac{9\times10^9\times3\times10^{-6}\times5\times10^{-6}}{(0.15)^2} = 6N$ ✓✓

$F_R = \sqrt{F_1^2 + F_2^2 - 2F_1F_2\cos60°}$ ✓✓ (5)

$= \sqrt{4^2+6^2-2\times4\times6\cos60°}$ ✓

$= 5.29N$ ✓

3)



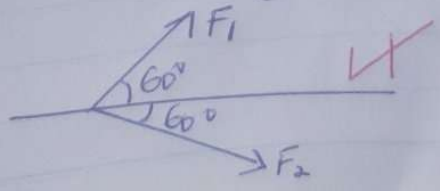
✓✓ $\alpha = \sin^{-1}\left(\frac{6\sin60}{5.29}\right)$

$= 79.2°$ ✓✓

Alternatively:

$F_1 = \frac{KQ_1Q_2}{x^2}$ ✓✓ $= \frac{9\times10^9\times2\times10^{-6}\times5\times10^{-6}}{(0.15)^2} = 4N$ ✓✓

$F_2 = \frac{9\times10^9\times3\times10^{-6}\times5\times10^{-6}}{(0.15)^2} = 6N$ ✓✓



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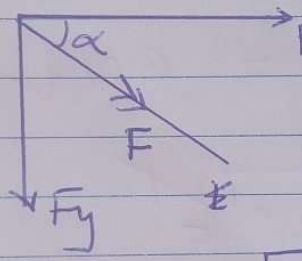
$F_x = F_1 \cos 60^\circ + F_2 \cos 60^\circ$
$= (4+6)\cos 60^\circ$
$= 5N.$ ✓

$F_y = F_1 \sin 60 - F_2 \sin 60^\circ.$
$= (4-6)\sin 60^\circ.$ ✓
$= -1.732\,N.$



$F = \sqrt{F_x^2 + F_y^2}$ (5)
$= \sqrt{5^2 + (-1.732)^2}$
$= 5.29\,N.$ ✓

$\alpha = \tan^{-1}\left(\frac{1.732}{5}\right)$
$= 19.1^\circ.$ ✓

—END—