



UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

Paper 2

2 hours 30 minutes

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 section A or B.

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

Mathematical tables and squared paper will be 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	=	$3.0 \times 10^8 \text{ ms}^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19} \text{ C}$
Electron mass	=	$9.11 \times 10^{-31} \text{ kg}$
Plank's constant, h	=	$6.6 \times 10^{-34} \text{ Js}$
Permeability of free space, μ_0	=	$4.0\pi \times 10^{-7} \text{ Hm}^{-1}$
Permittivity of free space, ϵ_0	=	$8.85 \times 10^{-12} \text{ Fm}^{-1}$
The constant $\frac{1}{4\pi\epsilon_0}$	=	$9.0 \times 10^9 \text{ F}^{-1} \text{ m}$
One electron volt (eV)	=	$1.6 \times 10^{-19} \text{ J}$
Avogadro's number, N_A	=	$6.02 \times 10^{23} \text{ mol}^{-1}$
Resistivity of Nichrome wire at 25°C	=	$1.2 \times 10^{-6} \Omega\text{m}$
Specific heat capacity of water	=	$4.2 \times 10^3 \text{ J kg}^{-1}\text{K}^{-1}$

SECTION A

- ✓ 1. (a) (i) State the laws of reflection of light. (02 marks)
- (ii) A ray of light is incident on a plane mirror. The mirror is then turned through an angle α keeping the direction of the incident ray constant. If the reflected ray turned through an angle β , find the relationship between α and β . (04 marks)
- (b) Describe how a sextant is used to determine the angle of elevation of a star. (05 marks)
- (c) Describe an experiment to determine the refractive index of a small quantity of a liquid using a concave mirror. (05 marks)
- (d) A plane mirror is placed 10 cm in front of a convex mirror so that it covers about half of the convex mirror surface. A pin placed 20 cm in front of the plane mirror gives an image which coincides with that of the pin in the convex mirror. Find the focal length of the convex mirror. (04 marks)
2. (a) Define angular magnification of an optical instrument. (01 mark)
- (b) (i) Describe with the aid of a ray diagram, the operation of a telescope made up of a converging lens and a diverging lens when used in normal adjustment. (05 marks)
- (ii) State two limitations of this type of telescope. (01 mark)
- (c) The diagram in Figure 1 shows a path followed by a ray of monochromatic light through a right angled prism of refractive index 1.52. The light emerges in air at an angle of 47.6° .

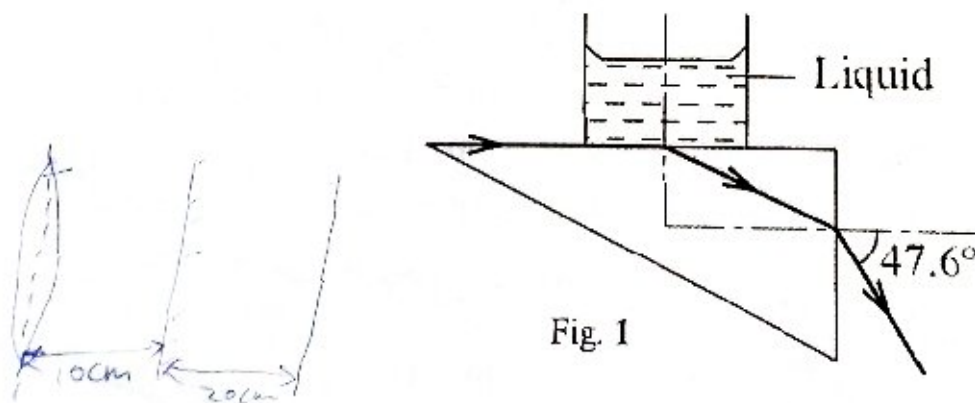


Fig. 1

Find the refractive index of the liquid.

(06 marks)

- (d) Explain the following as applied to lenses.
- (i) Chromatic aberration. (02 marks)
 - (ii) Spherical aberration. (02 marks)
- (e) Explain how chromatic aberration and spherical aberration are minimized in a reflecting telescope. (03 marks)

SECTION B

- ✓ 3. (a) What is meant by the following as applied to wave motion?
- (i) **Wave length.** (01 mark)
 - (ii) **Wave front.** (01 mark)
- (b) (i) Define resonance. (01 mark)
- (ii) Describe how velocity of sound in air can be determined using a resonance tube. (05 marks)
- (c) (i) Explain how stationary waves are formed. (03 marks)
- (ii) A tuning fork of 760 Hz is sounded near the open end of a closed pipe of length 40 cm. If air in the tube resonates with the tuning fork, determine the mode of vibration and the end correction. (Velocity of sound in air is 330 ms^{-1}) (05 marks)
- (d) (i) Explain reverberation as applied to sound waves. (02 marks)
- (ii) Explain how reverberation may be minimised in a large hall. (02 marks)
4. (a) (i) State two conditions necessary for interference patterns to be formed. (02 marks)
- (ii) With the aid of a diagram, describe how interference can be produced by division of wave front. (04 marks)
- (b) In Young's double slit experiment, the slits are 0.5 mm apart and interference is observed on the screen placed at a distance of 100 cm from the slits. It is found that the 9th bright fringe is at a distance of 8.84 cm from the second dark fringe from the centre of the fringe pattern. Find the wave length of light used. (05 marks)

- (c) Explain what is observed on the interference fringes in Young's double slit experiment when the monochromatic source of light is replaced by a source of white light. (05 marks)
- (d) Describe how interference fringes are formed in a wedge-shaped film of air. (04 marks)

SECTION C

5. (a) State the laws of electromagnetic induction. (02 marks)
- (b) Describe a method of measuring the magnetic flux density in the region between the poles of a magnet. (06 marks)
- (c) Two straight parallel wires A and B carrying steady currents I_A and I_B respectively are placed close to each other as shown in Figure 2.

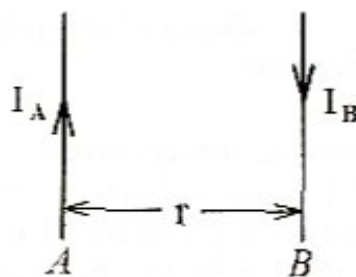


Fig. 2

- (i) Sketch the resultant magnetic field pattern. (02 marks)
- (ii) Explain what happens when the currents I_A and I_B are steady currents. (04 marks)
- (iii) Find the force per unit length of the wires when $I_A = 8.0$ A, $I_B = 11.0$ A and $r = 3.0$ cm. (04 marks)
- (d) Explain how eddy currents are produced. (02 marks)
6. (a) (i) Write an expression for the force exerted on a straight wire of length, l metres carrying a current of I amperes, placed at right angles to a uniform magnetic field of flux density B teslas. (01 mark)
- (ii) Explain the origin of the force in (a) (i). (04 marks)
- (b) A rectangular coil of N turns each of length l , and breadth, b , is inclined at an angle θ to a uniform magnetic field of flux density B . Derive an expression for the torque of the coil when a current I is passed through it. (05 marks)

- (c) A single rectangular loop of wire with dimensions 35 cm by 75 cm is arranged such that part of it is inside a region of uniform magnetic field of flux density 0.45 T and part of it is outside the field. The total resistance of the loop is 0.23Ω . Calculate the force required to pull the loop from the field at a constant velocity of 3.4 ms^{-1} perpendicular to the field. (05 marks)
- (d) (i) Define the term **magnetic flux**. (01 mark)
 (ii) An electron revolves in a circular orbit of radius $2.0 \times 10^{-10} \text{ m}$ at a frequency of 6.8×10^{15} revolutions per second. Calculate the magnetic flux density at the centre of the orbit. (04 marks)
7. (a) (i) What is meant by a **sinusoidal alternating current**? (01 mark)
 (ii) Define **peak value**, **root mean square (r.m.s) value** and **frequency** of an alternating sinusoidal current. (03 marks)
- (b) A sinusoidal voltage of r.m.s value 13.2 V is connected across a $50 \mu\text{F}$ capacitor.
 (i) Find the peak value of the charge on the capacitor. (02 marks)
 (ii) Sketch using the same axes the graphs of charge Q on the capacitor and current I in the circuit against time. (02 marks)
 (iii) If the frequency of the alternating current is 49.6 Hz, calculate the r.m.s value of the current through the capacitor. (03 marks)
- (c) Explain why a capacitor in a circuit blocks the flow of direct currents but allows the flow of alternating current. (04 marks)
- (d) Describe the structure and mode of operation of the repulsion type moving iron meter. (05 marks)

SECTION D

- ✓ 8. (a) (i) Define the following: **electric field intensity** and **electric potential** at a point. (02 marks)
 (ii) Show that the electric field intensity at a point is equal to the negative potential gradient at that point. (04 marks)
- (b) (i) Explain with the aid of a diagram, how an insulated metal sphere can be charged by induction using a negatively charged rod. (03 marks)
 (ii) Describe how a gold leaf electroscope can be used to detect the presence of charge on a body. (02 marks)

- (c) (i) Write down the equation for the electrostatic force between two isolated point charges in a vacuum. (01 mark)
- (ii) Sketch the electric field lines between two negatively charged spheres carrying unequal charges and use the sketch to explain a neutral point. (02 marks)
- (d) A charged polystyrene sphere of mass 2 g is suspended by a fine nylon thread between two plates 5 cm apart as shown in Figure 3.

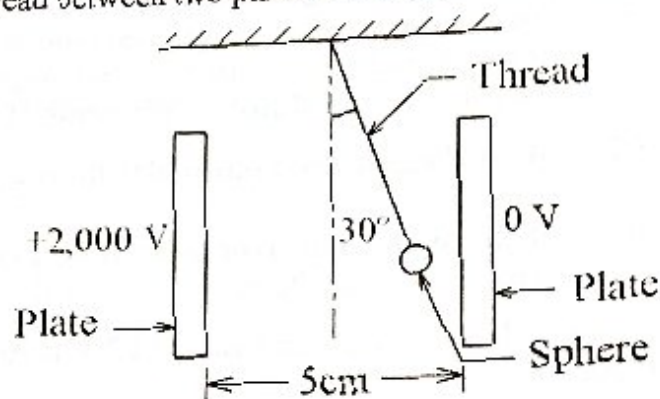


Fig. 3

When a p.d of 2000 V is applied across the plates, the thread attached to the sphere deflects through an angle of 30° . Calculate the charge on the sphere. (06 marks)

9. (a) Describe an experiment to verify Ohm's law. (04 marks)
- (b) Derive an expression for the combined resistance of three resistors in parallel. (04 marks)
- (c) (i) Explain the principle of operation of a slide wire potentiometer. (04 marks)
- (ii) Two cells A and B connected in series give a balance length of 80.0 cm along a potentiometer wire. When cell B is reversed, the balance length falls to 15.0 cm. If the e.m.f of cell A is 1.5 V, calculate the e.m.f of cell B. (04 marks)
- (d) A battery of e.m.f. 20.0 V and internal resistance 4.0Ω is connected to a resistor of resistance 10.0Ω . Calculate the;
- (i) power generated. (02 marks)
- (ii) efficiency of the circuit. (02 marks)

10. (a) (i) Define **capacitance** and **dielectric constant**. (02 marks)
(ii) State the factors which affect the capacitance of a capacitor. (02 marks)

- (b) A capacitor of capacitance C_1 is charged by a battery of e.m.f, V_0 . The charging battery is then removed and the capacitor is connected to an uncharged capacitor of capacitance C_2 . Show that the loss of energy, E after connection is given by

$$E = \frac{1}{2} \left[\frac{C_1 C_2}{C_1 + C_2} \right] V_0^2 \quad (05 \text{ marks})$$

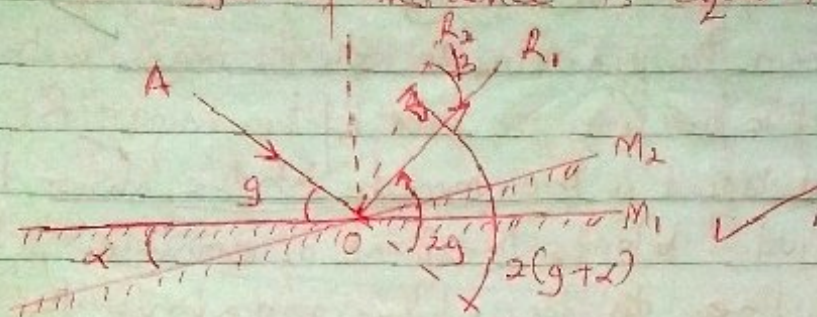
- (c) Describe an experiment to measure the capacitance of a capacitor using a ballistic galvanometer. (05 marks)
- (d) A capacitor, X of $5.0 \mu\text{F}$ and another, Y of $8.0 \mu\text{F}$ are connected in series with a 20 V supply.

Calculate the;

- (i) charge on X . (04 marks)
(ii) potential drop across X . (02 marks)

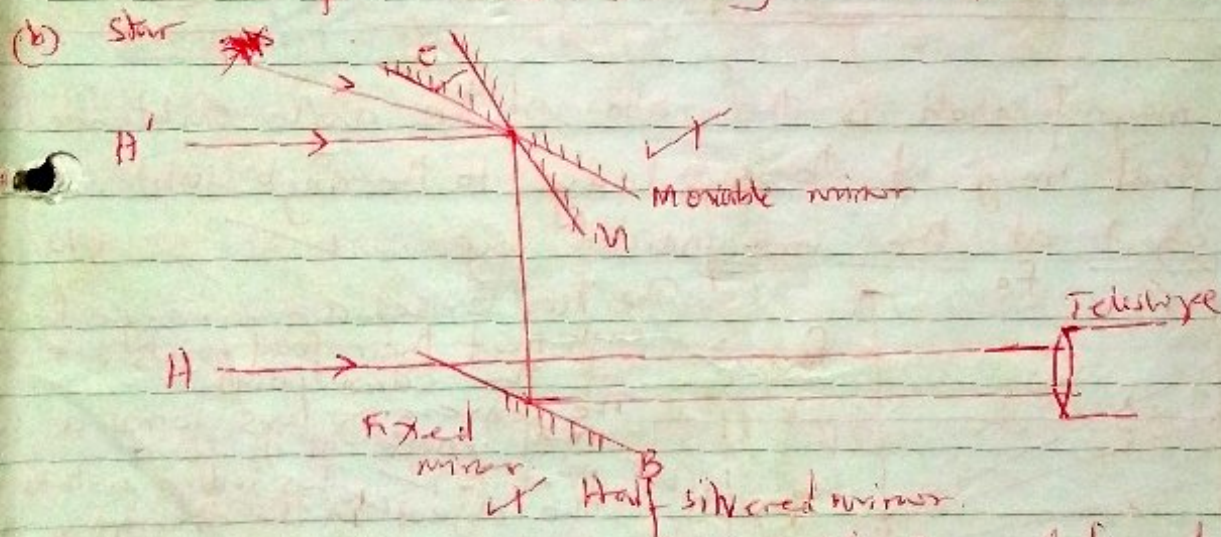
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- (a) (i) - The incident ray, the reflected ray and the normal at the point of incidence all lie in the same plane ✓ (1)
 - The angle of incidence is equal to the angle of reflection ✓ (1)



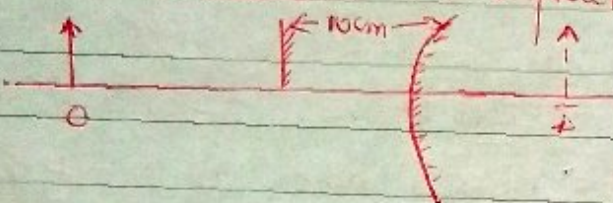
A constant ray of light OA is incident onto a plane mirror in position M_1 and it is reflected along OR. The glancing angle = g , deviation $d = 2g$. When the mirror is turned through angle α , the new glancing angle = $(g + \alpha)$ and the new deviation = $2(g + \alpha)$ ✓

The angle β through which the ray rotates is
 $\beta = 2(g + \alpha) - 2g \Leftrightarrow \beta = 2\alpha$ ✓ (4)

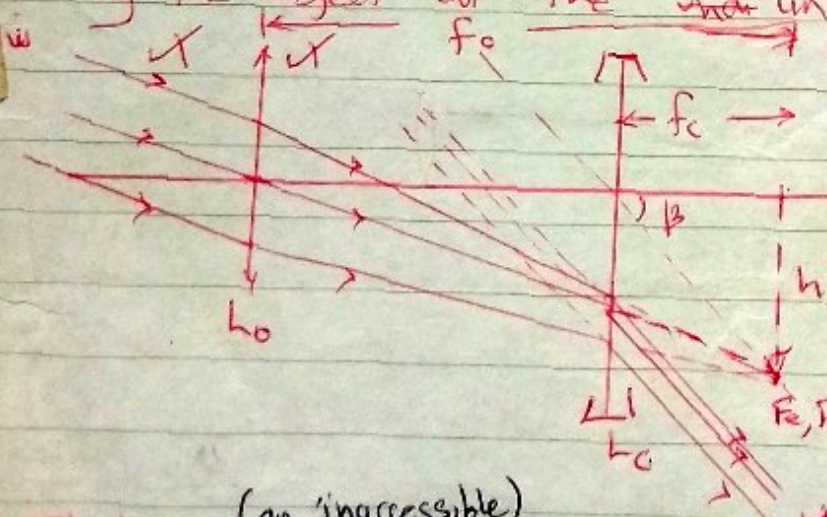


- The set up is as above, B is half silvered fixed mirror while M can rotate. First mirror M is rotated until the image of horizon H' is seen to coincide with horizon H. ✓ ~~the position of the mirror or pointer on the scale is noted~~
 M is now rotated until the image of the star is seen to coincide with horizon H. ✓ The image of rotation θ is measured, the angle of ~~deviation~~ elevation is 2θ ✓ (5)

(c) The concave mirror is placed on a table with its reflecting surface upward. An optical pin is clamped horizontally on a stand above the mirror with one end on the principal axis of the mirror. The pin is adjusted vertically while viewing from above. A point is located when the pin coincide with its image without parallax. The distance of the pin from the pole of the mirror R is measured. The test liquid is then poured into the mirror to a depth d . The pin is adjusted to locate the point of coincide of the pin and its image. The distance of the pin above the liquid h is measured. The refractive index of the liquid $n_L = \frac{R-d}{h}$ or $\frac{R}{h}$.

(d)  The object distance $u = 30\text{cm}$
The image distance $v = -(40-30) = -10\text{cm}$
using $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{30} - \frac{1}{10}$
 $\Rightarrow f = -15\text{cm}$ (20) (4)

(a) Angular magnification is the ratio of the angle subtended by the final image at the aided eye to the angle subtended by the object at the unaided eye. (1)

 The two lenses are arranged such that their focal points are at the same point. The converging lens forms a real image at its focal point F_o . This image acts as the object for the diverging lens. The final image formed by the diverging lens is erect and at infinity. (5)

(an inaccessible)

- It has a virtual eyering. (1)
- It has a small field of view. (1)
- It produces unclear image or less bright image. (1)



(3)

(c) $n_L \sin 90^\circ = n_g \sin \alpha$ ✓

$n_L = n_g \sin \alpha$

$n_g \sin \beta = \sin 47.6^\circ$ ✓

$n_g \sin (90 - \alpha) = \sin 47.6$

$\cos \alpha = \frac{\sin 47.6}{1.52} \approx 0.4858$

$\alpha = 60.9^\circ$ ✓

$\therefore n_L = n_g \sin 60.9^\circ = 1.52 \times 0.8137 = 1.33$ ✓

OR

$n_L = \sqrt{n_g^2 - \sin^2 47.6^\circ}$ ✓

$= \sqrt{1.52^2 - \sin^2 47.6^\circ}$ ✓

$= \sqrt{1.52^2 - 0.5453}$

$= \sqrt{2.3104 - 0.5453}$

$= \sqrt{1.7651}$

$= 1.33$ ✓ (06)

(d) (i) Chromatic aberration is the colouring of the image produced by a lens. A ^(down rays) parallel beam of ^{white} light incident on a convex lens is dispersed and each colour is brought to its own focus. This is because the different colours have different refractive indices. ✓

(ii) Spherical aberration is the distortion of the image by a lens of wide aperture in a wide beam of white light. Marginal rays and paraxial rays are brought to different focus. The image formed is thus distorted. ✓ (2)

(e) The objective is a concave mirror so there is no dispersion. There fore no chromatic aberration. If the concave mirror is parabolic, parallel rays incident on it are brought to a single focus $\Rightarrow$ no spherical aberration. ✓ (3)

3 a) Wave length is the distance between two successive particles in phase. ✓ (1)

(ii) Wave front is a section through an advancing wave on which all particles are in phase. ✓ (1)

b) Resonance is a condition obtained when the forcing frequency of an oscillation is equal to the natural frequency of the oscillating (or vibrating) object. ✓ (1)

(i) A glass tube which can be drained from the bottom is filled with water. A sounding tuning fork of frequency, f , is brought to the mouth of the tube. The water is then slowly drained until a loud sound is heard. The tap is closed and the length L_1 of the air column is measured. The tuning fork is again sounded at the mouth of the tube and the water drained further until a loud sound is heard. The tap is closed and the length L_2 of the air column is measured. The velocity of sound in air is $v = 2f(L_2 - L_1)$ (5)

(ii) Stationary waves are formed when two waves of equal frequency and amplitude travelling at the same speed in opposite directions are superposed resulting into formation of nodes and antinodes. (6)

(iii) Assuming negligible end correction.

Resonance frequency f is given by

$$f = \frac{nv}{4L} \quad n = \frac{4fL}{v} = \frac{4 \times 0.4 \times 760}{330}$$

$$= 3.68$$

but $n = 1, 3, 5, 7, 9, \dots$

$\therefore n = 5$, implying resonance occurs in the 2nd overtone or 5th harmonic.

From eqn (i) above taking end correction.

$$L + c = \frac{nv}{4f} \Rightarrow c = \frac{nv}{4f} - L$$

OR

For 1st resonance $L + c = \frac{v}{4f} = \frac{330}{4 \times 760}$

$$\Rightarrow c = 0.108 - 0.4 = -0.29m$$

For 2nd resonance $L + c = \frac{3v}{4f} = \frac{3 \times 330}{4 \times 760}$

$$\Rightarrow c = 0.326 - 0.4 = -0.07m$$

For 3rd resonance $L + c = \frac{5v}{4f} = \frac{5 \times 330}{4 \times 760}$

$$\Rightarrow c = 0.548 - 0.4 = 0.1428m$$

The end correction is positive

Hence $c = 0.1428m$ and it occurs in the 2nd overtone or 5th harmonic.

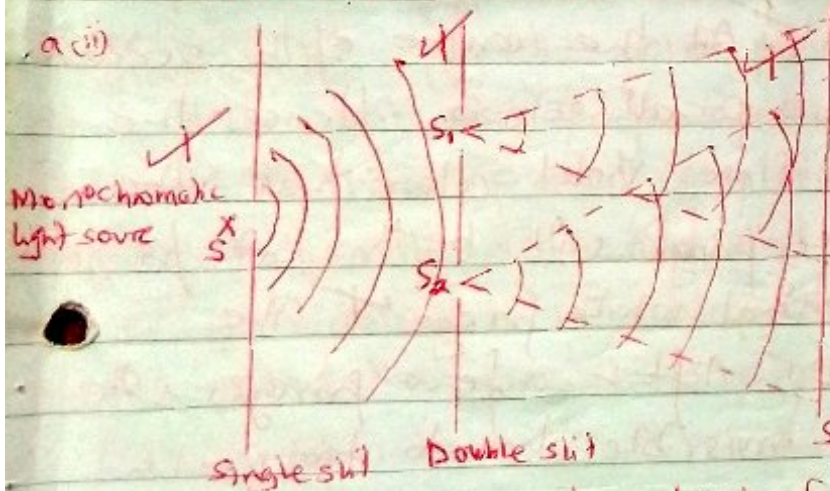
$$= \frac{5 \times 330}{4 \times 760} - 0.4$$

$$= 0.5438 - 0.4$$

$$= 0.1428m. \quad (5)$$

- (i) When sound is reflected from a hard surface close to the observer, the echo follows the incident sound so closely that the observer cannot distinguish between the two. The observer gets an impression of a prolonged original sound. This effect is called reverberation. (2)
- (ii) The walls of the hall are lined with soft materials or the chairs so that there is no reflection of sound (or all incident sound is absorbed). (2)

- 4 (i) - The two sources must be coherent i.e. ~~they~~ (or waves have constant phase relationship or they must have same frequency & wavelength) ✓
- The sources must be close to each other ✓
 - Waves should be travelling in the same medium.
 - The sources should be narrow ✓ any two. (2)



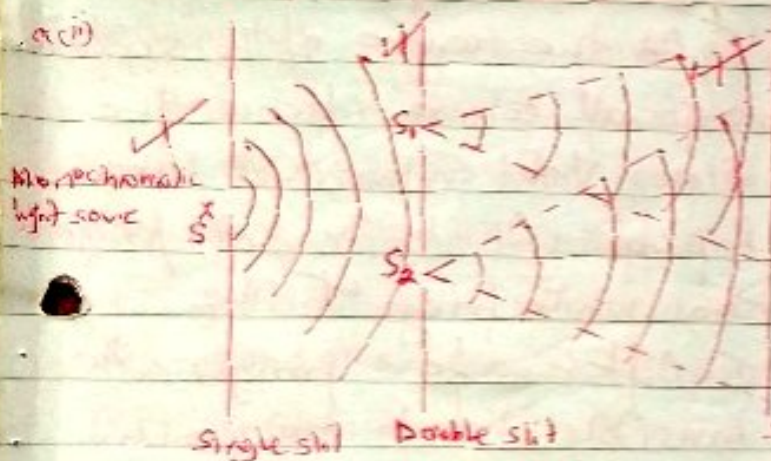
S , S_1 , and S_2 are narrow slits which are parallel to each other. S diffracts light that falls on it and so illuminates both S_1 and S_2 . Diffraction also takes place at S_1 and S_2 .

Screen and interference occurs in the region where the light from S_1 overlaps that from S_2 . Since S is narrow, the light which emerges from S_1 and S_2 comes from the same wave front as that which emerges from S . Thus S_1 and S_2 are coherent.

- (b) The distance of the n^{th} bright fringe from central fringe, $y = \frac{n\lambda D}{a}$ ✓
- For the q^{th} bright fringe $y = \frac{q\lambda D}{a}$ ✓ (ii)
- The distance of the n^{th} dark fringe from the central fringe $y' = (n - \frac{1}{2}) \frac{\lambda D}{a}$ ✓

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- (a) The distance of the n^{th} bright fringe from central fringe $y = \frac{n\lambda D}{a}$ ✓
 For the q^{th} bright fringe $y = \frac{q\lambda D}{a}$ ✓ (1)
- The distance of the n^{th} dark fringe from the central fringe $y' = \left(n - \frac{1}{2}\right) \frac{\lambda D}{a}$ ✓

For the 2nd dark fringe from the central fringe
 $y'_2 = (2 - \frac{1}{2}) \frac{\lambda D}{a} = \frac{3 \lambda D}{2a}$ (ii)

from (i) and (ii) $y_9 - y'_2 = \frac{9 \lambda D}{a} - \frac{3 \lambda D}{2a} = \frac{15 \lambda D}{2a}$

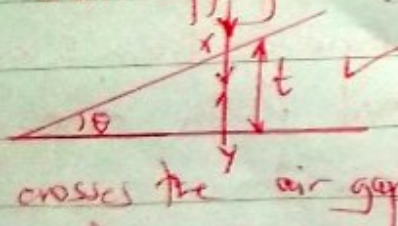
$$y_9 - y'_2 = 8.84 \times 10^{-2} \text{ m}$$

$$\Rightarrow \frac{15 \lambda D}{2a} = 8.84 \times 10^{-2} \text{ m}$$

$$\therefore \lambda = \frac{8.84 \times 10^{-2} \times 2 \times 0.5 \times 10^{-3}}{15 \times 1}$$

$$= 5.9 \times 10^{-6} \text{ m} \quad (5)$$

(c) A central white fringe with coloured edges is observed. White light consists of different component colours. The interference pattern is due to different component colours of white light overlap. At the centre of the screen, the path difference is zero for all colours. Hence the central fringe is white. Since violet colour has the lowest wavelength, a violet fringe will be the first fringe on either side of the central white fringe. The furthest fringe is red. After a few fringes, the fringe pattern becomes invisible due to too much overlapping.

(d)  Some light which is incident on X from above is reflected at X and some light crosses the air gap to Y, and is reflected at Y. X and Y act as two coherent sources. There is a geometrical path difference of 2t between waves from X and Y. The waves reflected at Y undergo phase change of π radians. There is darkness when 2t is equal to the whole number.

of the wave length and brightness when it is equal to an odd number of half wave length. When viewed from directly above alternating bright and dark bands which are equally spaced are observed. ✓

(4)

5(a) Faraday's law: The magnitude of the emf induced in a circuit is directly proportional to the rate of change of magnetic flux linked with the circuit. ✓

(b)

Lenz's law: The direction of the induced emf is such that it tends to oppose the flux change causing it. ✓

(b)



A search coil of known cross section area A and number of turns N is connected in series with a ballistic galvanometer.

Search coil

G - ballistic galvanometer

The search coil is then placed between the pole pieces of the magnets such that the plane of the coil is perpendicular to the magnetic field. The coil is then pulled completely out of the field by moving it smartly downward and the first throw θ produced in the galvanometer is observed. The charge Q which passes round the circuit is proportional to θ . i.e. $Q \propto \theta$

$Q = c\theta$ where c is a constant

Change of flux linkage = NBA

Quantity of charge through galvanometer = $\frac{NBA}{R}$

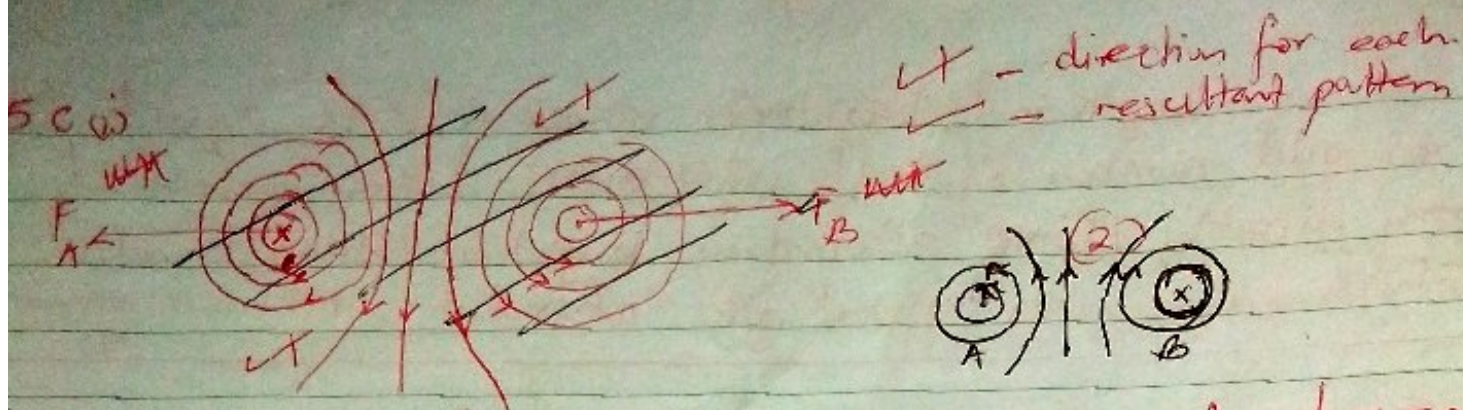
where R = Resistance of (G)

$$\Rightarrow c\theta = \frac{NBA}{R} \Rightarrow B = \frac{c\theta R}{AN}$$

The constant c is found by discharging a capacitor through the galvanometer. Knowing c , R , N , θ and A the flux density B can be obtained. ✓

(5)

⑧



When two current carrying conductors are placed near each other, the conductors repel each other. If the currents I_A and I_B are steady, the resultant magnetic field is constant. The force acting per metre length $\frac{F}{L} = \frac{\mu_0 I_A I_B}{2\pi r}$. Therefore the force is constant. (4)

The flux density which A produces at B is given by $B = \frac{\mu_0 I_A}{2\pi r} = \frac{4\pi \times 10^{-7} \times 8}{2\pi \times 0.03} = 5.3 \times 10^{-5} \text{ T}$

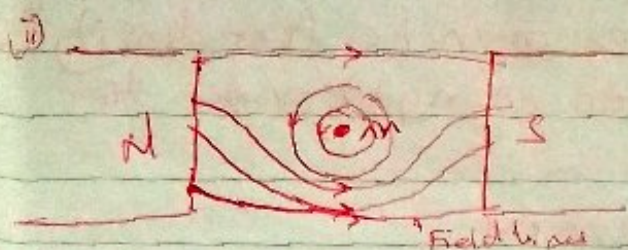
Force which A exerts on B is given by $F = B I_B L \Rightarrow \frac{F}{L} = B I_B = 5.3 \times 10^{-5} \times 11 = 5.83 \times 10^{-4} \text{ Nm}^{-1}$ (4)

OR $\frac{F}{L} = \frac{\mu_0 I_A I_B}{2\pi r} = \frac{4\pi \times 10^{-7} \times 8 \times 11}{2\pi \times 0.03}$

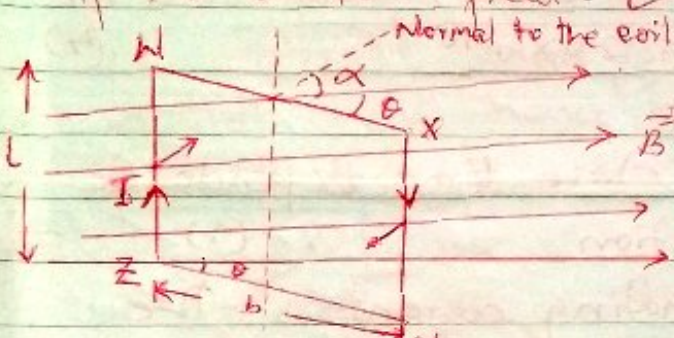
$= 5.83 \times 10^{-4} \text{ Nm}^{-1}$

If a conductor cuts through a magnetic field, the magnetic flux linking it changes, hence causes small currents to flow in loops in the conductor. These induced currents are called eddy currents. (2)

(a) $F = BIL$ ✓



When current flows through the wire, magnetic field due to the current interacts with the applied magnetic field to form a resultant field pattern. The resultant field pattern has more closely packed field lines on one side of the wire (or stronger field) compared to the other. Magnetic force acts in such a way as to move the wire from the region of stronger field to the region of the weaker field. (4)



By Fleming's left hand rule
 force on WX = $BINb \sin \theta$ (upwards)
 force on YZ = $BNIb \sin \theta$ (downwards)
 force on WZ = $BNI L$ (inwards)
 force on XY = $BNI L$ (outwards)

Forces on WX and YZ cancel since they are equal and opposite. Forces on XY and WZ constitute a couple of moment of torque given by $\tau = (BINL) b \sin \theta = BINA \cos \theta$

(c) Induced Emf in the loop on pulling it out of the field. $E = BLV$ ✓

$$\epsilon = 0.45 \times 7.5 \times 10^{-2} \times 3.4 = 1.1475$$

$$= 0.45 \times 35 \times 10^{-2} \times 3.4 = 0.5355$$

$$\text{or } F = \frac{B^2 L^2 v}{R} = \frac{0.45^2 \times 0.75^2 \times 3.4}{0.23} = 1.684 \text{ N}$$

The current I that flows in the loop, $I = \frac{E}{R} = \frac{0.5355}{0.23}$

$$\text{or } I = \frac{1.1475}{0.23} = 4.989 \text{ A}$$

$$= 2.328 \text{ A}$$

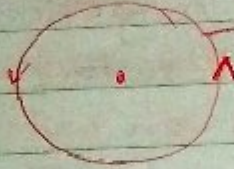
Mechanical power expended = Electrical energy developed

$$\tau = \frac{1.1475 \times 4.989}{3.4} = 1.684 \text{ N}$$

$$FV = IE \quad \checkmark$$

$$F = \frac{IE}{v} = \frac{0.5355 \times 2.328}{3.4} = 0.367 \text{ N} \quad (5)$$

def Magnetic flux is the product of magnetic flux density and the projection of the area at right angles to the magnetic field. ✓

(ii)  orbit of the electron
The circulation of the electron constitutes a current $I = \frac{e}{t} = ef$ ✓

$$B_0 = \frac{\mu_0 I}{2R} = \frac{\mu_0 ef}{2R}$$

$$= \frac{4\pi \times 10^{-7} \times 1.6 \times 10^{-19} \times 6.8 \times 10^{15}}{2 \times 2.0 \times 10^{-10}} = 3.4 \text{ T} \quad (4)$$

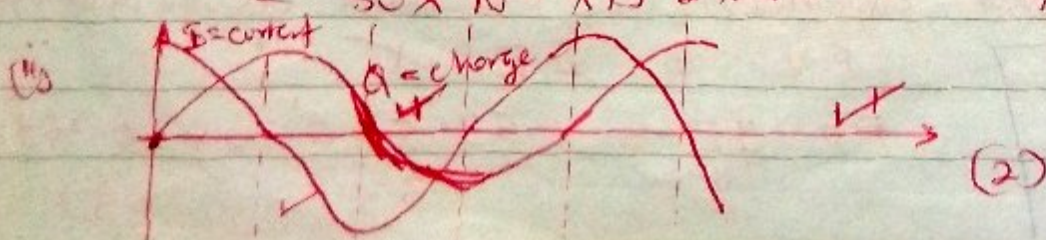
7(a) (i) Is the periodic current whose time dependence is given by a sine function. (1)

(ii) - Peak value of an alternating current is the maximum value of current. ✓

- Root mean square value of the alternating current is the value of steady current that dissipates heat in a resistor at the same rate as the alternating current. ✓

- Frequency of an alternating current is the number of complete cycles which the current goes through in one second. ✓ (03)

b(i) $Q_0 = CV_0$ But $V_0 = V_{rms} \times \sqrt{2}$ ✓
 $= CV_{rms} \sqrt{2}$ ✓
 $= 50 \times 10^{-6} \times 13.2 \times \sqrt{2} = 9.33 \times 10^{-4} \text{ C}$ (2)



(11)

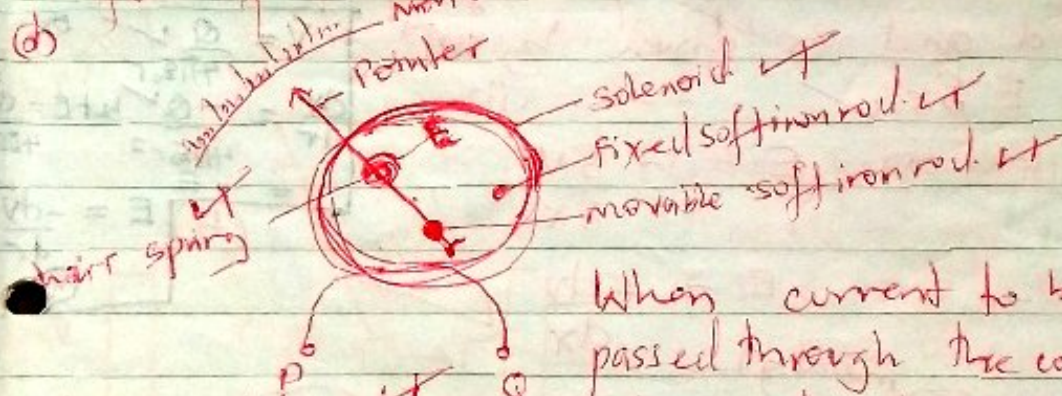
$$(iii) \frac{V_{rms}}{I_{rms}} = \frac{1}{2\pi fC} = X_c$$

$$\Rightarrow I_{rms} = V_{rms} \times 2\pi fC$$

$$= 2 \times 3.14 \times 49.6 \times 50 \times 10^{-6} \times 13.2$$

$$= 0.206 A$$

(c) When the capacitor is connected to a d.c. source the capacitor charges and when it is fully charged, current flow stops. When it is connected to an a.c. source, it charges when the voltage is increasing and discharges when the voltage is decreasing. Since increase and decrease in voltage is continuous, there is continuous flow of current in the circuit hence the capacitor appears to allow flow of a.c. (4)

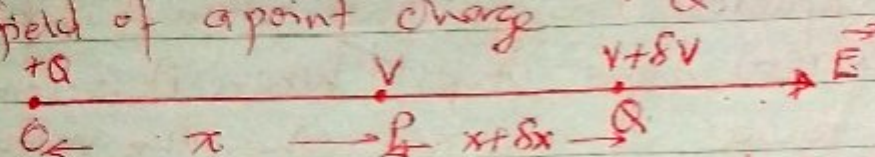


When current to be measured is passed through the coil (solenoid) via terminals P and Q. Whatever the direction of current, the rods are magnetised in the same sense and so they repel one another causing the pointer to move over the scale until it is stopped by the restoring couple due to the hair spring. Now the force of repulsion between the rods is proportional to the square of current. Hence the deflection of the pointer is proportional to $\langle I^2 \rangle$. (5)

(2) Electric field intensity ^{at a point} is the force experienced by a unit positive charge placed ^{at that point} in the electric field.

Electric potential at a point is the work done to move 1C of positive charge from infinity to that point against electrostatic repulsion. (2)

(iii) Consider two point charges P and Q in the field of a point charge +Q.



If the potential at P is V and that at Q is $V + \delta V$, potential difference between P and Q = V_{PQ}

$$\therefore V_{PQ} = V_P - V_Q = V - (V + \delta V) = -\delta V \quad \text{--- (i)}$$

Work done to move 1C of charge from P to Q = P.d and is given by

$$V_{PQ} = E \delta x \quad \text{--- (ii)}$$

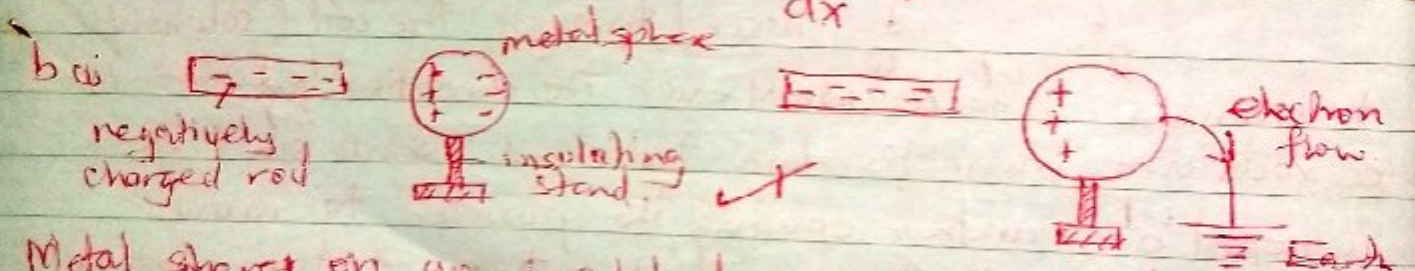
From (i) and (ii) $\Rightarrow E = -\frac{\delta V}{\delta x}$

As $\delta x \rightarrow 0$, $E = -\frac{dV}{dx}$

$$V = \frac{Q}{4\pi\epsilon_0 r} \quad \text{OR}$$

$$\frac{dV}{dr} = -\frac{Q}{4\pi\epsilon_0 r^2} \quad \text{but } E = \frac{Q}{4\pi\epsilon_0 r^2}$$

$$\Rightarrow E = -\frac{dV}{dr} \quad \text{--- (4)}$$



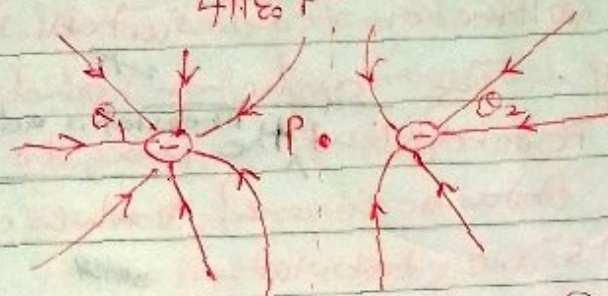
Metal sphere on an insulated support is placed near the charged body. Free electrons in the metal sphere are repelled to the far end of the sphere. The sphere is earthed while the charged body is still in position, free electrons move from the sphere to the earth. The charged body is removed while the charged body is still in place, the charges distribute themselves all over the sphere. Hence the metal sphere is said to be positively charged. (3)

(13)

bio A body to be tested is brought near the cap of uncharged electroscope. If the leaf diverges then the body is charged and if the leaf remains uncharged unaffected then the body is not charged. (2)

ccio $F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$ ✓

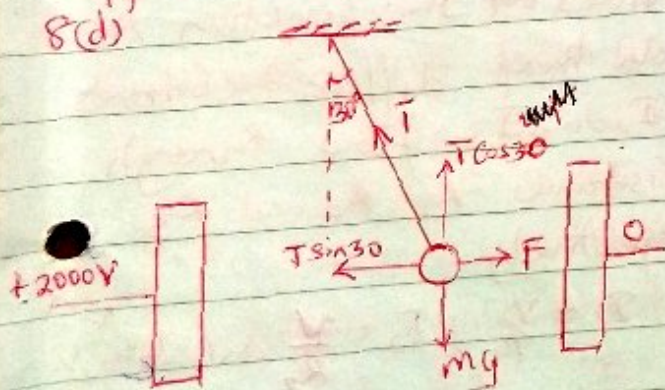
(ii)



field pattern — $\frac{1}{2}$
position of P near — $\frac{1}{2}$
the less magnitude charge

The resultant electric field intensity at P is zero and this point is the neutral point. ✓ (2)
At P the electric field due to Q_1 is equal and opposite to that due to Q_2 hence resultant field is zero.

8(d)



Resolving force vertically

$$T \cos 30 = mg$$

$$T = \frac{2 \times 10^{-3} \times 9.81}{\cos 30}$$

$$T = 2.27 \times 10^{-2} \text{ N}$$

Resolving forces horizontally

$$F = T \sin 30$$

$$F = 2.27 \times 10^{-2} \times \sin 30$$

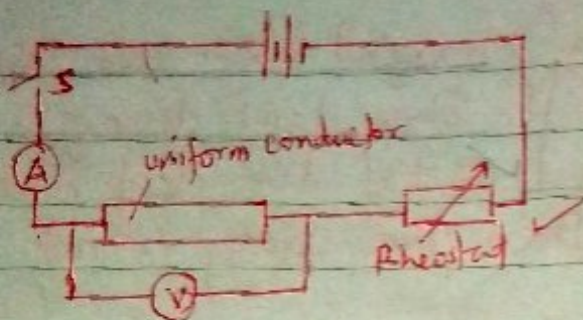
$$= 1.13 \times 10^{-2} \text{ N}$$

$$\begin{aligned} T \cos 30 &= mg \quad \text{--- (i)} \\ T \sin 30 &= F \quad \text{--- (ii)} \\ \Rightarrow F &= mg \tan 30 \\ \text{but } F &= EQ \text{ and } E = \frac{V}{d} \\ &= \frac{VQ}{d} \\ \tan 30 &= \frac{VQ}{mgd} \\ Q &= \frac{mgd \tan 30}{V} \quad \text{--- (6)} \end{aligned}$$

Electric field intensity $E = \frac{V}{d}$ ✓
but $F = EQ$ where $Q = \text{charge}$ ✓

$$\Rightarrow Q = \frac{F}{E} = \frac{Fd}{V} = \frac{1.13 \times 10^{-2} \times 5 \times 10^{-2}}{2000} = 0.2825 \times 10^{-6} \text{ C}$$

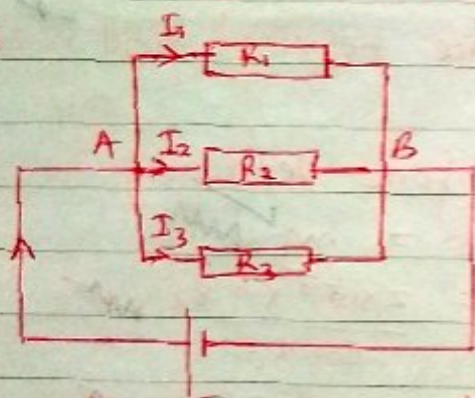
9(a)



S - switch
V - Voltmeter
A - Ammeter

The switch is closed. The rheostat is adjusted ~~so~~ so that the ammeter and voltmeter read suitable values of I and V respectively. The ammeter and voltmeter readings are recorded. The procedure above is repeated to obtain several values of I and V . The results are tabulated. A graph of I against V is plotted. If a straight line through the origin is obtained, Ohm's law is verified.

(b)



The I due to the source divides at the junction A such that different currents I_1 , I_2 and I_3 flow through resistances R_1 , R_2 and R_3 respectively.

$$I = I_1 + I_2 + I_3 \quad \text{where} \quad I_1 = \frac{V}{R_1}, \quad I_2 = \frac{V}{R_2} \quad \text{and} \quad I_3 = \frac{V}{R_3}$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

R = equivalent resistance.

(15)

c) The driver cell is connected across the slide wire maintains a steady ^{current through} p.d across the slide wire. ✓
 The resistance per unit length of the slide wire is constant ✓
 The p.d per unit length of the slide wire is therefore constant ✓ Knowing the p.d per unit length of the slide wire any p.d can be determined by balancing it against a known length of wire. If the p.d. per unit length is k and the balance length is l then the required p.d $V = kl$ mm (04)

$$(ii) (E_A + E_B) = kl_1 \quad \checkmark \quad (1)$$

$$1.5 + E_B = 80k \quad \checkmark$$

$$1.5 - E_B = kl_2 \quad \checkmark$$

$$1.5 - E_B = 15k \quad \checkmark \quad (2)$$

Adding (1) and (2)

$$\Rightarrow 3 = 95k$$

$$\therefore k = \frac{3}{95} \quad \checkmark$$

Subtracting (2) from (1)

$$2E_B = 65k \quad \checkmark$$

$$E_B = \frac{65 \times 3}{2 \times 95} = 1V \quad \checkmark$$

d) Power generated = IE

$$\text{But } I = \frac{E}{R+r} \quad \checkmark$$

$$\Rightarrow P = \frac{E^2}{R+r} = \frac{20^2}{(10.0+4.0)} = 28.57W \quad \checkmark \quad (2)$$

$$(iii) \text{ Efficiency} = \frac{I^2 R}{IE}$$

$$= \frac{R}{R+r} \quad \checkmark$$

$$= \frac{10}{14} = 0.714 \text{ or } 71.4\% \quad \checkmark \quad (2)$$

10(a) - The capacitance of a capacitor is the ratio of the magnitude of charge on either plates of the capacitor to the potential difference between the plates. ✓

- Dielectric constant of the material is the ratio of the capacitance of a capacitor when the space between its plates is filled with a ^{dielectric} material to the capacitance of the same capacitor when the space between its plates is a vacuum. (2) ✓

(ii) - Separation of the plates ✓

- Area of overlap of the plates ✓ (2)

or Permittivity of the medium between the plate (Nature of the medium between the plate).

(b) Total charge before connection $Q_0 = C_1 V_0$ ✓

Total charge after connection $Q = (C_1 + C_2) V$ ✓

but $Q_0 = Q$

$$E = \frac{1}{2} C V^2$$

$$\Rightarrow C_1 V_0 = (C_1 + C_2) V$$

$$V = \frac{C_1 V_0}{C_1 + C_2}$$

Total energy before connection $E_0 = \frac{1}{2} C_1 V_0^2$ ✓

Total energy after connection, $E = \frac{1}{2} (C_1 + C_2) V^2$
 $= \frac{1}{2} (C_1 + C_2) \left(\frac{C_1 V_0}{C_1 + C_2} \right)^2$ ✓

Energy loss = $E_0 - E$ ✓

$$= \frac{1}{2} C_1 V_0^2 - \frac{1}{2} (C_1 + C_2) \left[\frac{C_1 V_0}{C_1 + C_2} \right]^2$$

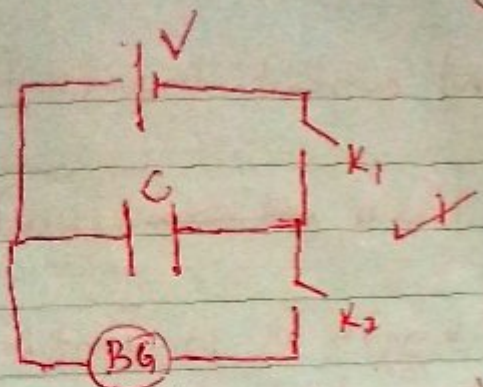
$$= \frac{1}{2} C_1 V_0^2 - \frac{1}{2} \frac{C_1^2 V_0^2}{C_1 + C_2}$$

$$= \frac{1}{2} C_1 V_0^2 \left[1 - \frac{C_1}{C_1 + C_2} \right]$$

$$= \frac{1}{2} \left(\frac{C_1 C_2}{C_1 + C_2} \right) V_0^2$$

(17)

(e)

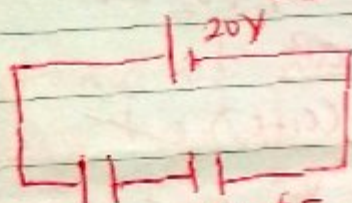


The test capacitor is connected in the circuit as shown. Switch K_1 is closed and after some time it is opened and K_2 is immediately closed and the first deflection θ_1 of the ballistic galvanometer is noted.

The test capacitor is then replaced with a standard capacitor of capacitance C_s and the procedure is repeated. The first deflection θ_s of the ballistic galvanometer is noted. The capacitance of the test capacitor is obtained from

$$C = \frac{C_s \theta_1}{\theta_s} \quad \checkmark$$

(d) as



For capacitors in series, overall capacitance, C , is

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \quad \checkmark \quad \frac{1}{5 \times 10^{-6}} + \frac{1}{8 \times 10^{-6}} \quad \checkmark$$

$$C = 3.08 \times 10^{-6} \text{ F} \quad \checkmark$$

$$Q = CV \quad \checkmark$$

$$= 3.08 \times 10^{-6} \times 20 \quad \checkmark$$

$$= 6.16 \times 10^{-5} \text{ C} \quad \checkmark$$

(4)

$$d(i) \quad V = \frac{Q}{C} \quad \checkmark$$

$$\text{Pd across } X = \frac{6.16 \times 10^{-5}}{5.0 \times 10^{-6}} \quad \checkmark$$

$$= 12.3 \text{ V} \quad \checkmark$$

(2)

(18)

- 9(b) - The driver cell maintains constant current through the slide wire. ✓
- The slide wire is uniform i.e. has a ~~uniform~~ constant resistance per unit length. ✓
 - Therefore the p.d. per unit length is constant. ✓
 - Hence any test p.d. can be balanced across an appropriate length of the slide wire. ✓

10(b) Energy stored in a capacitor $E = \frac{1}{2} CV^2$ ✓

Energy stored in the capacitor initially $E_1 = \frac{1}{2} C_1 V_0^2$ ✓

charge stored $Q = C_1 V_0$ ✓

Capacitance of the combined network = $C_1 + C_2$ ✓

Energy stored in the network $E_2 = \frac{Q^2}{2(C_1 + C_2)}$ ✓

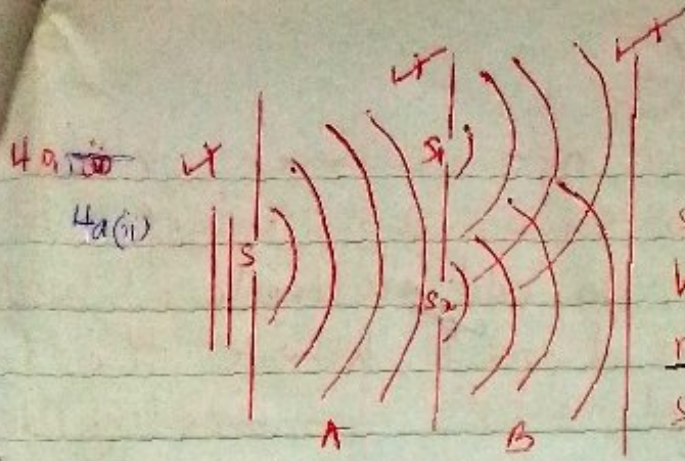
$$= \frac{C_1^2 V_0^2}{2(C_1 + C_2)} \quad \checkmark$$

$$E_1 - E_2 = \frac{1}{2} C_1 V_0^2 - \frac{C_1^2 V_0^2}{2(C_1 + C_2)} \quad \checkmark \quad (5)$$

$$= \frac{C_1 V_0^2}{2} \left(1 - \frac{C_1}{C_1 + C_2} \right) \quad \checkmark$$

$$= \frac{C_1 C_2 V_0^2}{2(C_1 + C_2)} \quad \checkmark$$

(19)



S is a narrow slit and S_1 and S_2 are narrow slits. Waves from source S diffract into region A and travel towards S_1 and S_2 and diffract again into region B. S_1 and S_2 are

equal distance from S hence the wave energy diffracting through S_1 and that through S_2 at any time come from the same wavefront; hence they are coherent. (4)

The waves superpose ~~from~~ permanent alternate regions of maximum and minimum intensities (or interference patterns)

4 (b) Distance of n^{th} bright fringe from the centre of the fringe system. $Y_n = \frac{n \lambda D}{a}$ ✓

Distance of 9^{th} fringe $Y_9 = \frac{9 \lambda D}{a}$ ✓

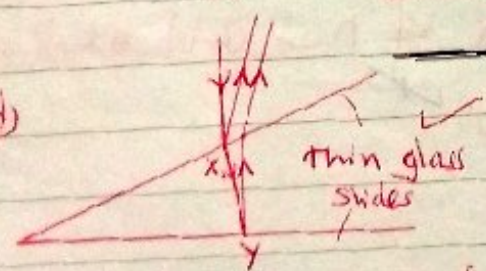
Distance of the 2^{nd} fringe $Y'_2 = \frac{1\frac{1}{2} \lambda D}{a}$ ✓ (5)

∴ Separation of the fringes above

$$Y = \frac{(9 - 1\frac{1}{2}) \lambda D}{a} = \frac{7\frac{1}{2} \lambda D}{a} = 8.84 \times 10^{-2} \text{ ✓}$$

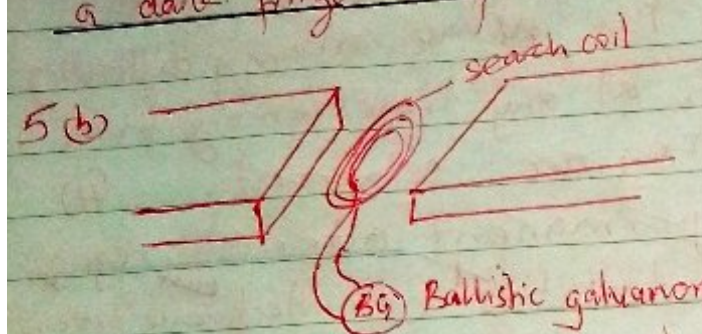
$$\lambda = \frac{8.84 \times 10^{-2} \times 0.5 \times 10^{-3}}{7\frac{1}{2} \times 1} = 5.89 \times 10^{-6} \text{ m. ✓}$$

4 (d)



Monochromatic light is made incident almost normally on the upper glass slide. It is partly reflected at the lower surface of X and partly transmitted in the air film and reflected at the upper surface of Y

The light reflected at X and Y are coherent. When they overlap above the upper slide, they interfere. Where the path difference is an odd multiple of half a wave length, a bright fringe is formed. Where the path difference is an integral multiple of a wave length, a dark fringe is formed. ✓ (4)

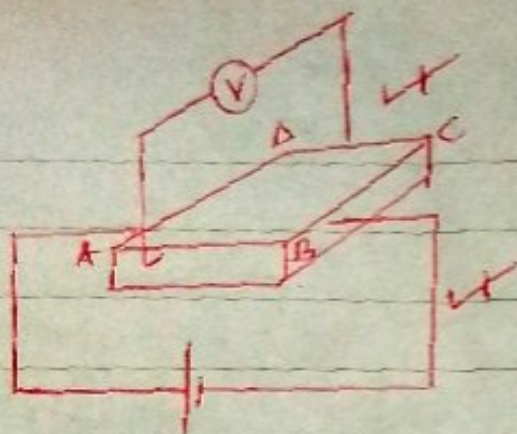


A search coil is connected in series with a ballistic galvanometer (B.G.). A search coil is placed between poles pieces of the magnet with its plane perpendicular to the magnetic field. ✓ After the B.G. pointer has settled, the coil is completely withdrawn from the field and the first deflection θ of the B.G. pointer is noted. ✓ A capacitor of known capacitance C is charged to a p.d. V and then discharged through the B.G. ✓ and the first deflection θ' is noted. ✓ The magnetic flux density B is now calculated from

$$B = \frac{CVR\theta}{NA\theta'} \quad \checkmark \quad (6)$$

where A and N are area of the coil and no. of turns of the coil respectively. ✓

3b

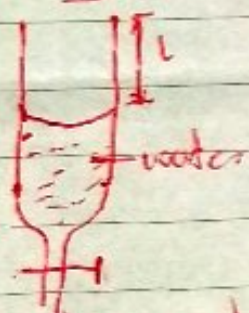


(2)

A semiconductor slice is connected across a source of d.c. voltage and a voltmeter connected across the slice as shown.

The slice is now placed in the test magnetic to the field such that the face ABCD is perpendicular to the field. The voltmeter reading V is noted. The slice is now placed into a magnetic field, whose flux density B_0 is known. The voltmeter reading V_0 is noted. The test flux density is now calculated from $B = \frac{B_0 V}{V_0}$.

3b (1)



A glass tube which can be drained from the bottom is filled with water. A sounding tuning fork of frequency f is brought to the mouth of the tube. The water is then slowly drained

until a loud sound is heard. The tap is closed and the length l of the air column is measured. The experiment is repeated with other tuning forks and the values l and f recorded including values of $\frac{1}{f}$. A graph of l against $\frac{1}{f}$ is drawn, and the slope, s , determined. The velocity, v of sound is now calculated from: $v = 4s$.

(5)