P510/2
PHYSICS
Paper 2
July/August. 2024

2 ½ hours

UGANDA MUSLIM TEACHERS' ASSOCIATION (UMTA)

JOINT MOCK EXAMINATIONS 2024

UGANDA ADVANCED CERTIFICATE OF EDUCATION

PHYSICS

Paper 2

(Theory)

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Answer **five** *questions, including at least* **one,** 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 sections **A** or **B.**
Any additional question(s) answered will **not** *be marked.*
Silent, Non-programmable scientific calculators may be used.
Mathematical tables and squared paper will be provided.
Assumed where necessary:

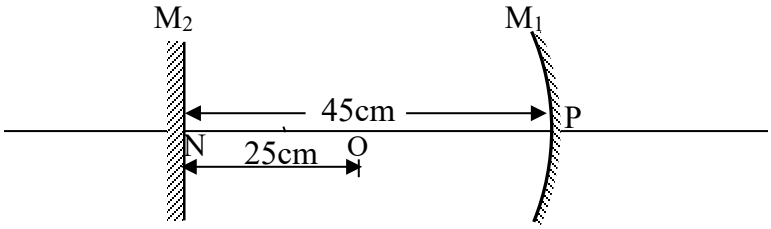
Acceleration due gravity, g	=	$9.81 ms^{-2}$
Speed of light in vacuum, C	=	$3.0 \times 10^{8}\ ms^{-1}$
Speed of sound in air	=	$340\ ms^{-1}$
Charge on an electron, e	=	$1.6 \times 10^{-19}\ C$
Electron mass	=	$9.1 \times 10^{-31}\ kg$
The constant $\frac{1}{4\pi\varepsilon_0}$	=	$9.0 \times 10^{9}\ F^{-1}m$
Permeability of free space, μ_o	=	$4\pi \times 10^{-7}\ Hm^{-1}$
Permittivity of free space, ε_o	=	$8.85x10^{-12}\ Fm^{-1}$

SECTION A:

1. (a) (i) Define **focal length** and **centre of curvature** as applied to concave mirrors. *(02 marks)*

(ii) Show that the radius of curvature, r, of a concave mirror is given by the expression: $r = 2f$, where f is the focal length of the mirror. *(03 marks)*

(b) A plane mirror, M_2 is placed 30 cm in front and perpendicular to the principal axis of a concave mirror, M_1, whose centre is at P, as shown below.



An object O placed 25 cm from M_2 produces an image in the hole drilled at pole P. If the light rays are reflected first from M_1 and then from M_2,

(i) Draw rays showing the formation of the image. *(02 marks)*

(ii) Find the focal length of M_1. *(04 marks)*

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

(ii) Describe an experiment in which the refractive index of a liquid can be determined using an air cell. *(05 marks)*

(d) Light from a luminous point source on lower face of a rectangular glass block strikes the upper surface and is total internally reflected to form a circle of radius $4.0cm$ on lower surface. If the refractive index of the glass block is 1.64, find the thickness of the glass block. *(03 marks)*

2. (a) (i) Define **focal length** as applied in a concave lens. *(01 mark)*

(ii) Describe an experiment to determine the focal length of a concave lens using a concave mirror. *(04 marks)*

(b) What is meant by the terms **Magnifying power** and **far point** as used in Optics? *(02 marks)*

(c) A concave lens of focal length 15cm is arranged coaxially with a convex lens of focal length 20cm. When an object is placed 60cm in front of the concave lens, on the side remote from the convex lens, a virtual image is formed 10cm from the convex lens. Find the separation of the lenses. *(04 marks)*

(d) (i) Derive an expression for the magnifying power of a Galilean telescope in normal adjustment. *(04 marks)*

(ii) Explain the limitation of the telescope in (d)(i) above. *(02 marks)*

(e) A far sighted man can read clearly without glasses at distance not less than 75cm. Find his new near point when he puts on glasses of power 2.5D. *(03marks)*

SECTION B:

3. (a) Explain **damped** oscillations. *(02 marks)*

(b) (i) What is meant by **phase difference**, and **harmonics** as applied to wave motion. *(02 marks)*

(ii) Sketch a graph to show the variation of pressure along a longitudinal wave and explain the shape of the graph. *(03 marks)*

(c) Figure 2 shows a source S emitting sound of frequency 210Hz mounted over the open end of the tube when is fitted with a movable piston.

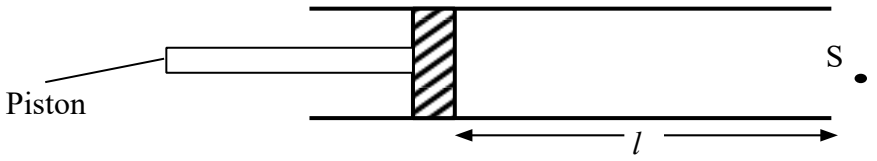


Figure 2

It is found that when the piston is moved slowly along the tube, the sound intensely reaches the first maximum when the length l between the piston and open end is 41cm and second maximum intensely occurs when l is 121cm.

(i) Explain the observation. *(02 marks)*

(ii) Calculate the speed of sound in air. *(02 marks)*

(d) A wire of fixed length and mass 6.5g is fixed at two points and carries an alternating current of frequency 50Hz. The wire is stretched between the poles of a strong horse shoe magnet such that the wire is set into oscillation, with two antinodes. If the tension in the wire is $1.25\times 10^2\ N$, find the length of the length of the wire. *(04 marks)*

(e) (i) Define **beat frequency.** *(01 mark)*

(ii) Describe how an audio oscillator is used to determine the frequency of a tuning fork. *(04 marks)*

4. (a) (i) State **Huygen's principle**. *(01 mark)*

(i) Use Huygen's principle to show that the angle of incident is equal to the angle of reflection of light. *(05 marks)*

(b) (i) Define the term **diffraction** as applied to a light wave. *(01 marks)*

(ii) Describe an experiment in which the wave length of light can be determined using a diffraction grating and a spectrometer. *(06 marks)*

(c) (i) What is meant by **interference of light wave**s? *(01 marks)*

(ii) Explain why a series of bright and dark lines are observed in an air wedge when irradiated normally with a monochromatic light. *(03 marks)*

(d) Two plane glass plates which are in contact at one edge are separated by a piece of metal foil 12.5cm from that edge. Interference fringes parallel to the line of contact are observed in reflected light of wavelength 5.46×10^{-7}m and are found to be 1.50mm apart. Find the thickness of the foil. *(04 marks)*

SECTION C:

5. (a) (i) Define **magnetic flux density** and **magnetic moment.** *(02 marks)*

(ii) Explain why diamagnetism is almost independent of temperature. *(03 marks)*

(b) (i) Describe the structure and mode of operation of a moving coil galvanometer. *(05 marks)*

(ii) A galvanometer whose sensitivity is 3.5 divisions per mA gives a full scale deflection of 30 divisions when connected in series with a battery of emf 5.0V and of negligible internal resistance and a resistor of 490Ω. Calculate the resistance of the galvanometer. *(03 marks)*

(iii) Explain **two** ways of improving the current sensitivity of a moving coil galvanometer. *(02 marks)*

(c) The coil of a dc motor is mounted in a radial magnetic field of flux density 0.49T. The coil has 10 turns, each of area $50cm^2$ and a total resistance of 3.5Ω. Calculate the;

(i) maximum angular velocity the motor attains when working on a 240V mains and drawing a current of 0.85A. *(03 marks)*

(ii) efficiency of the motor. *(02 marks)*

6. (a) Define a **root mean square value** (*r.m.s*) and **amplitude** of an alternating current. *(02 marks)*

(b) (i) Describe how a repulsive – iron ammeter is able to measure alternating current. *(05 marks)*

(ii) Give **one** advantage of the moving iron meter over the moving coil meter. *(01 mark)*

(c) What is meant by **reactance** of an ac circuit? *(01 mark)*

(d) A 240V supply with frequency of 1kHz connected in series with a 4.6μF capacitor and an inductor of negligible resistance causes current of 3.0A to flow through them. Calculate the;

(i) Reactance of the inductor. *(02 marks)*

(ii) Inductance of the inductor. *(02 marks)*

(e) (i) Explain why a metal swinging with its plane perpendicular to a uniform magnetic field heats up after some time. *(03 marks)*

(ii) Describe one application of the phenomenon in e(i) above. *(03 marks)*

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

(ii) Figure 2 shows a copper ring suspended by a thread in a vertical plane. One end of a bar magnet is brought horizontally towards the ring.

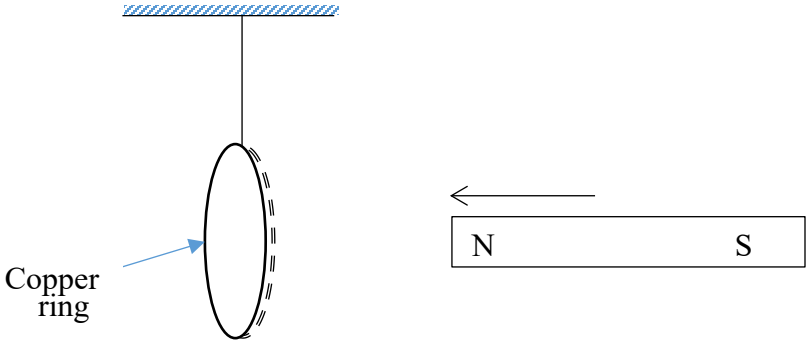


Figure 2

Explain what will be observed. *(03 marks)*

(b) Show that the magnitude of induced e.m.f across the ends of a rod of length l perpendicular to magnetic field of flux density B, moving with velocity, u in a direction inclined at an angle to the magnetic field is given by $E = Blusin\theta$. *(04 marks)*

(c) At a certain place on the earth, when a metal rod of length 15m facing east-west is moved northwards at a speed of 200m/s, an emf of 1.2mV develops between the ends. When the rod is moved at the same speed vertically upwards, an e.m.f of 6mV develops between its tips. Determine the;

(i) angle of dip. *(03 marks)*

(ii) magnetic flux density of the earth at the place. *(02 marks)*

(d) (i) Describe the direct method of determining resistance. *(05 marks)*

(ii) Explain why the method in d(i) is called direct method. *(01 mark)*

SECTION D:

8. (a) (i) What is meant by the term **electric field intensity**? *(01 mark)*

(ii) Derive the relationship between electric field intensity and electric potential. *(03 marks)*

(b) (i) State C**oulomb's law?** *(01 mark)*

(ii) Explain why electrostatic induction leads to attraction of a neutral conductor. *(02 marks)*

(c) Two identical spheres A and B carry charges Q_1 and Q_2 respectively. When the spheres are 50cm apart in a vacuum, they attract each other with a force of $1.08x10^{-1}$N. The spheres are connected temporarily using a conducting wire. The spheres now repel each other with a force of $3.2x10^{-2}$N.

(i) Find the initial charges on A and B if $Q_1 > Q_2$. *(05 marks)*

(ii) Sketch the graph which shows the variation of potential between the charges initially relative to the earth. *(02 marks)*

(d) With aid of diagrams, explain how an electrophorus provides unlimited supply of charge. *(04 marks)*

9. (a) (i) Define the terms **capacitance** and a **dielectric** as applied to a capacitor. *(02 marks)*

(ii) Describe how a gold leaf electroscope can be used to compare the magnitude of charges on two dielectrics. *(04 marks)*

(b) In a reed switch experiment, an air spaced capacitor is charged and then discharged through a micro ammeter which reads a steady current, I_1. When a dielectric having the same thickness as the air gap is inserted between the plates of the capacitor so that one third of the volume of the gap is filled with the dielectric, the micro ammeter reads a steady current, I_2. Show that the relative permittivity, ε_r of the dielectric is given by the relation;

$$\varepsilon_r = \frac{3I_2}{I_1} - 2 \qquad \textit{(04 marks)}$$

(c) A capacitor is charged by a 100V d.c source. When fully charged, it is found to carry charge of $24.0nC$. The capacitor is th[illegible]nected across an

uncharged capacitor of capacitance $6.0nF$. Determine the;

(i) Capacitance of the first capacitor. *(02 marks)*

(ii) energy stored in network after the capacitors were joined. *(04 marks)*

(d) (i) Sketch a graph of charging current against time for a capacitor. *(02 mark)*

(ii) Explain the graph in d(i) above. *(02 marks)*

10. (a) (i) Define the terms **e.m.f.** and **internal resistance** of a cell. *(02 marks)*

(ii) A battery of e.m.f. E and internal resistance, r, is connected across a variable resistor of resistance, R. Derive an expression for the maximum power delivered by the battery to the resistor. *(04 marks)*

(b) Describe an experiment determine the internal resistance of a cell accurately using a potentiometer. *(05 marks)*

(c) In figure 3 is a circuit diagram, an accumulator, D, of e.m.f. 4.0V and internal resistance, 2.0Ω is connected across a uniform wire AB of length 100 cm and resistance 8.0Ω. X is a cell of e.m.f. 2.0V connected across a resistor R of 5.0Ω.

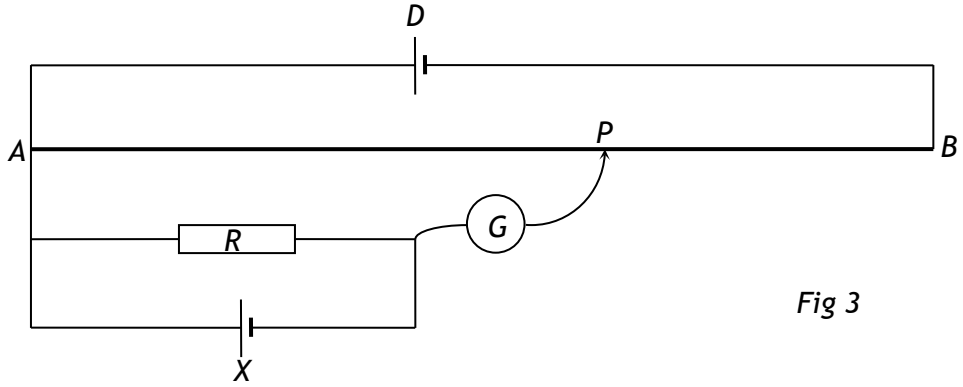


Fig 3

The galvanometer G shows no deflection when the sliding contact P is 45.0cm from A. Calculate:

(i) the current through resistor R. *(04 marks)*

(ii) the internal resistance of cell X. *(02 marks)*

(d) Compare the suitability of using a voltmeter and then a slide wire potentiometer to measure the p.d. *(03 marks)*

END

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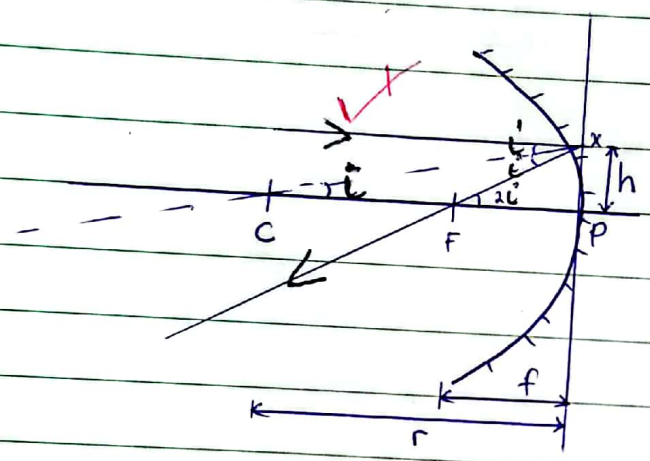
1 a(i) - Focal length is the distance from principal focus to the pole of the mirror
- Centre of curvature is the centre of the sphere of which the mirror forms part.

02

a(ii)



X is very close to P

∴ i and 2i are very small angles in radians

$i \times \tan i = h/r$ — ①

$2i \times \tan 2i = h/f$ — ②

① ÷ ②

$$\frac{i}{2i} = \frac{h}{r} \Big/ \frac{h}{f}$$

$$\frac{i}{2i} = \frac{h}{r} \times \frac{f}{h}$$

$$1/2 = f/r$$

$$r = 2f$$

03

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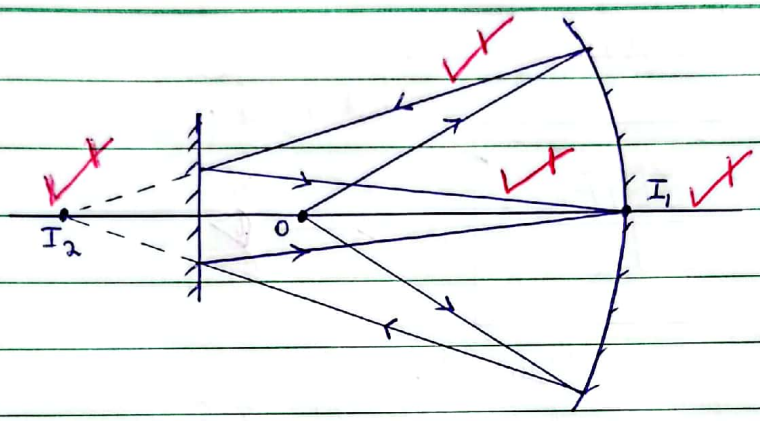
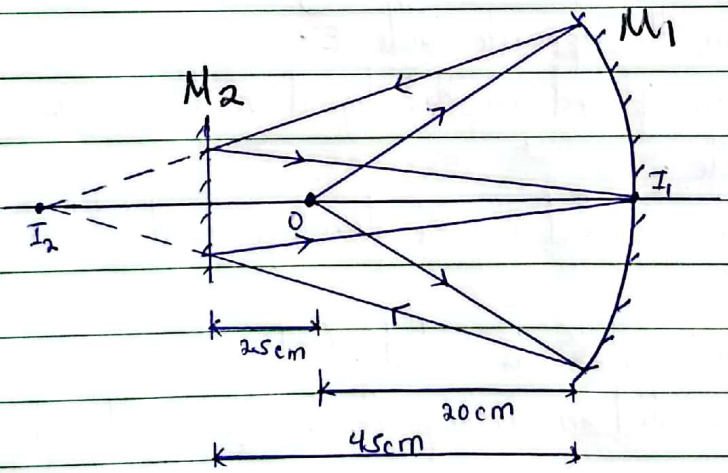
b(i)



02

b(ii)



In M_1

$u = 20cm$, $v = 90cm$

$u = 45 - 25 = 20cm$

$v = 45 + 45 = 90cm$

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

$\frac{1}{f} = \frac{1}{20} + \frac{1}{90}$

$f = 16.4cm$

04

c(i) Critical angle is the angle of incidence for which the angle of refraction is 90°.

01

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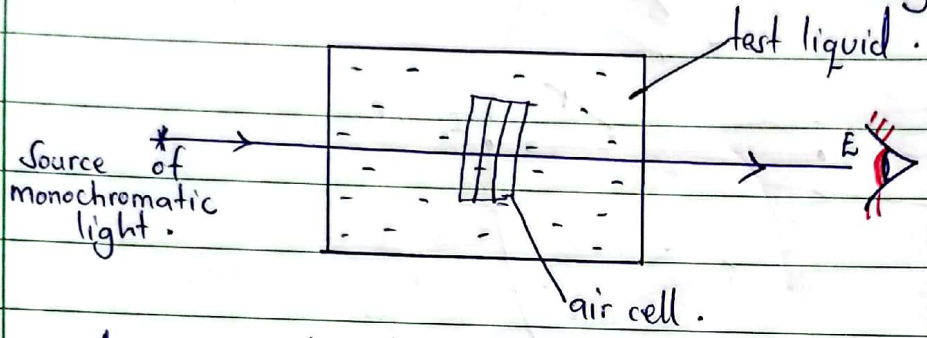
c(ii) An experiment to determine refractive index using an air cell method.

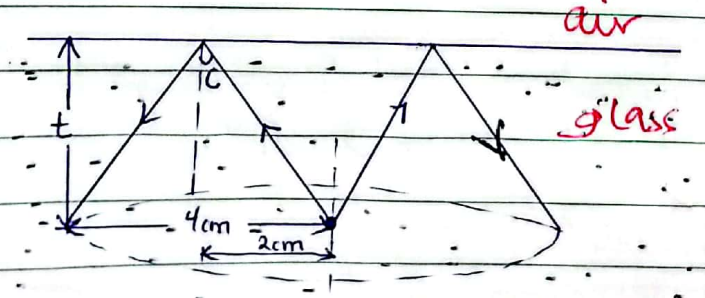


- A specimen liquid is poured into a parallel sided glass vessel.
- The vessel is then illuminated normally using monochromatic light and the light is viewed from the opposite side E.
- The aircell is then placed in the liquid so that it is illuminated normally on one side.
- The air cell is then rotated in one direction until light is just cut off again.
- The angle θ_1 of rotation is noted.
- The air cell is rotated in an opposite direction until light is just cut off again.
- The angle θ_2 of rotation is noted.
- The critical angle $c = \frac{\theta_1 + \theta_2}{2}$

05

- The refractive index of the liquid is calculated from $n_L = \frac{1}{\sin C}$

1(d)



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$\tan c = \frac{2}{t}$ ✓

$n_g \sin C = n_a \sin 90$ ✓

$C = \sin^{-1}\left(\frac{1}{1.64}\right)$

$C = 37.6°$ ✓

$t = \frac{2}{\tan 37.6°}$

$t = 2.6\,cm$ ✓

The glass block is 2.6cm thick.

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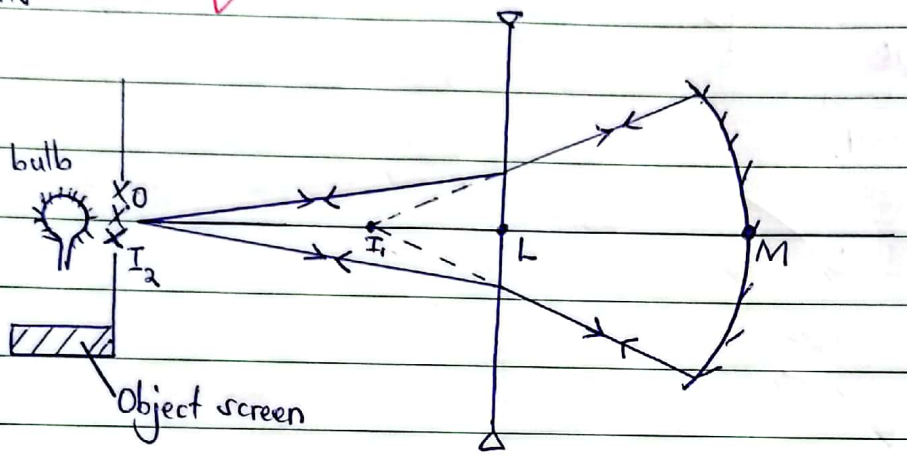
2a(i) Focal length is the distance from pricipal focus to optical centre of the lens. ✓ 01

a(ii)



- Without lens L an illuminated object O is placed infront of a concave mirror M ✓
- The position of the mirror is adjusted until a sharp image of the wire guaze is formed on the object screen. ✓
- The distance, r of the object screen from the mirror is measured. ✓
- L is placed between the screen and the mirror and its position is adjusted until the image of the wire guaze is formed on the object screen again. ✓ 04
- Distance OL and LM are measured. ✓✓
- In concave lens, L, $u = OL$ and $v = -(r - LM)$ ✓
- The focal length of the lens is then calculated from $1/f = 1/v + 1/u$ ✓

(b) - Magnifying power is the ratio of angle subtended by the final image at the aided eye to the angle subtended by the object at the naked eye. ✓ 02

- Far point is the furthest point an object can be seen clear details.

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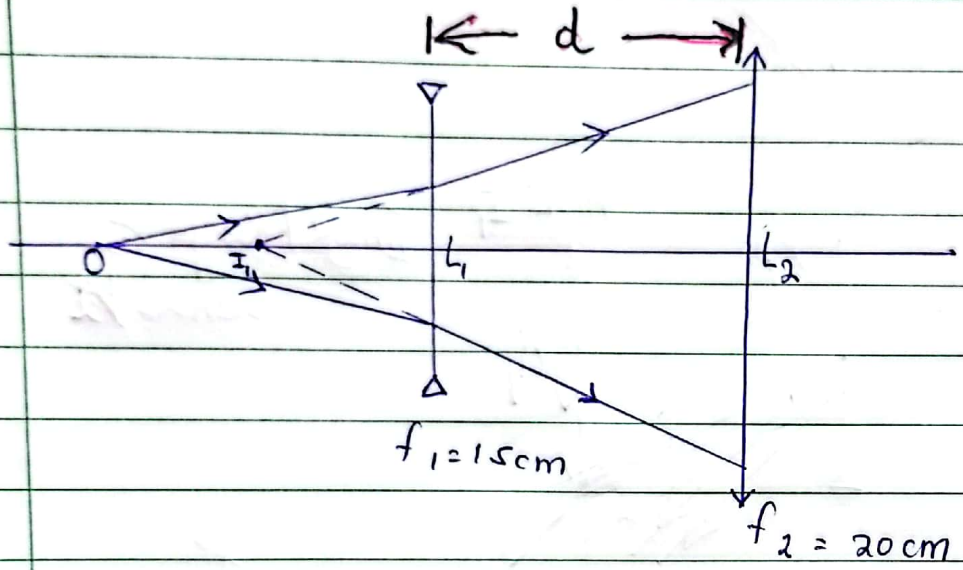
c



In L_1

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

$\frac{1}{-15} = \frac{1}{60} + \frac{1}{v_1}$

$v_1 = -12cm$ ✓

In L_2, $u = (d+12)$ ✓

$\frac{1}{20} = \frac{1}{d+12} + \frac{1}{-10}$ ✓

04

$\frac{3}{20} = \frac{1}{12+d}$

$36 + 3d = 20$

$3d = -16$

$d = -5.33cm$ ✓

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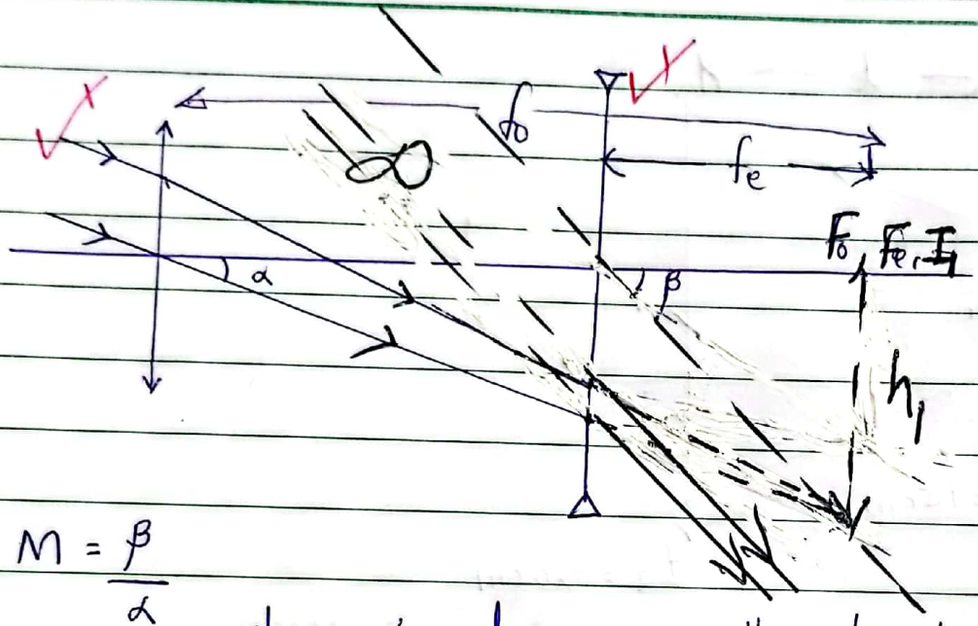

Image & Rays ½
Lenses ½

$M = \frac{\beta}{\alpha}$ where α and β are small angles in radians

$\alpha \approx \tan \alpha = \frac{h_1}{f}$

$\beta \approx \tan \beta = \frac{h_1}{f_e}$

04

$\therefore M = \frac{h_1}{f_e} \times \frac{f_o}{f_1} = \frac{f_o}{f_e}$

Has virtual eyering which limits field of view. Hence forms less bright image -

02

$1/f = 1/u + 1/v$

$f = 1/P = 1/2.5$

$f = 0.4\,m$

$1/40 = \frac{1}{-75} + \frac{1}{v}$

$v = 26.1\,cm$

03

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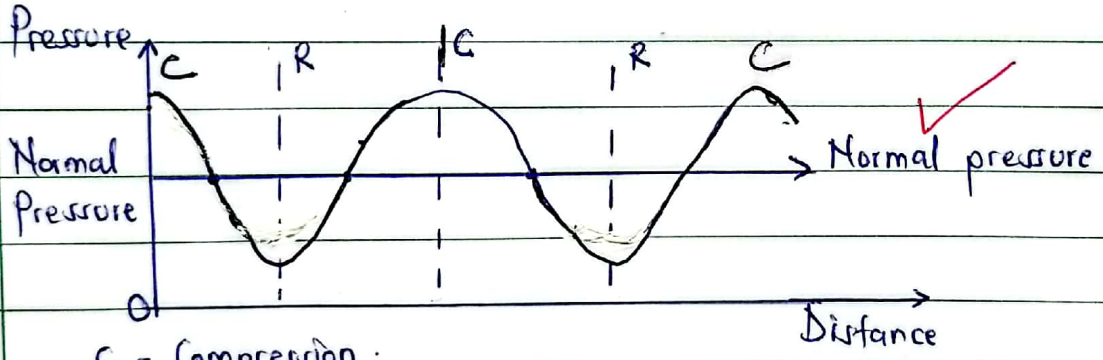
3 (a) Damped oscillations are oscillations where energy of the system and amplitude reduces with time due to dissipative forces. 02

b (i) Phase difference is the difference between angular displacements of vibrating wave particles from their mean positions.

Harmonics are notes produced by particular instrument where frequency is an integral multiples of fundamental frequency. 02

b (ii)



C - Compression.

R - Rarefactions.

At the compression there is high particle density thus pressure is greater than normal. At the rarefactions, there is low particle density and pressure is less than normal. 03

b (i) - The incident waves on a piston and the reflected waves interfere.
- Where they meet in phase constructive interfence occurs and sound of maximum intensity is detected.
- The first maxima is the fundamental note while the second maxima corresponds to the first overtone. 02

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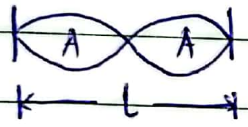
c (ii) $\frac{3\lambda}{4} = 121 + e$

$\rightarrow \frac{\lambda}{2} = 80 \rightarrow \lambda = 160\text{cm}$.

$V = f\lambda = \frac{210 \times 160}{100}\ ms^{-1}$

$= 336 ms^{-1}$

(d) 

$M = 6.5 \times 10^{-3}\ kg$.

$f = 50Hz$

$T = 1.25 \times 10^{2} N$

$l = \lambda$

$f = \frac{V}{\lambda} = \frac{1}{l}\sqrt{\frac{T}{M}} = \frac{1}{l}\sqrt{\frac{Tl}{m}}$

$f^2 = \frac{T}{ml}$, $l = \frac{T}{mf^2} = \frac{1.25 \times 10^2}{6.5 \times 10^{-3}(50)^2}$

$l = 7.692 m$

04

e(i) Beat frequency is the number of intense sounds heard per second.

01

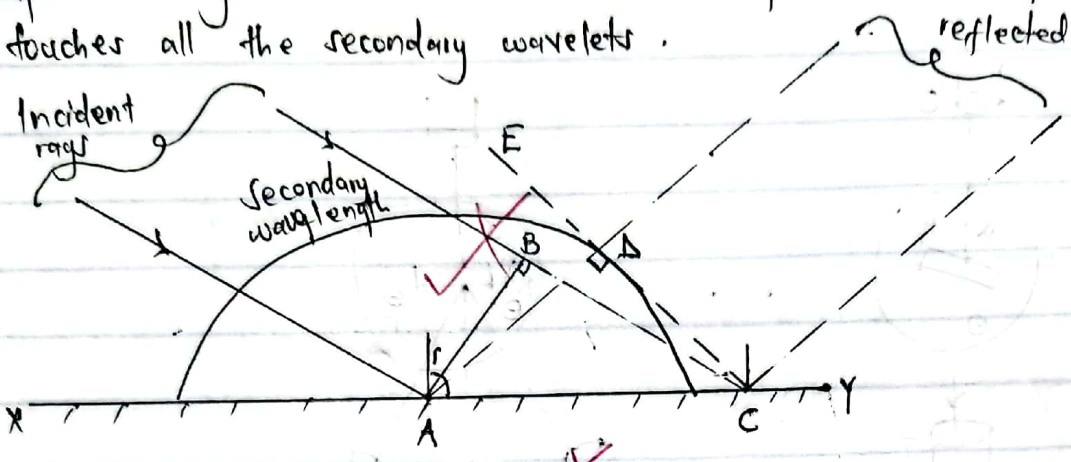
(ii) - A microphone is connected to a signal generator / oscillator.
- A tunning fork mounted on a hollow box is sounded and placed near the microphone.
- The frequency of signal generator is varied until no beats are heard.
- The frequency of generator is noted and [illegible] frequency of fork.

04

20

No. 4.

a (i) Every point on a wave front becomes a secondary source of secondary wavelets and the new wave front is the surface which touches all the secondary wavelets. 01



AB - Incident wave front

CE - refleded wavefront

If one side of the plane wavefront reaches A in the time that light from the other side of the wavefront B proceeds to C, a secondary wavelet of radius BC will be generated by A.

For reflection, the secondary wavelet must be emitted into region above XY and is shown as a semi-circle.

The tangent CE from C to this wavelet is the reflected wavefront

At time t the wavelet that had emerged from A had travelled a distance AD = BC, AD = CE. 05

In triangle ABC and ADC, AC is common

BC = AD (construction)

$\angle ABC = \angle ADC$ (right angles)

The two triangles are therefore congrient and thus $BCA = \Delta AC$

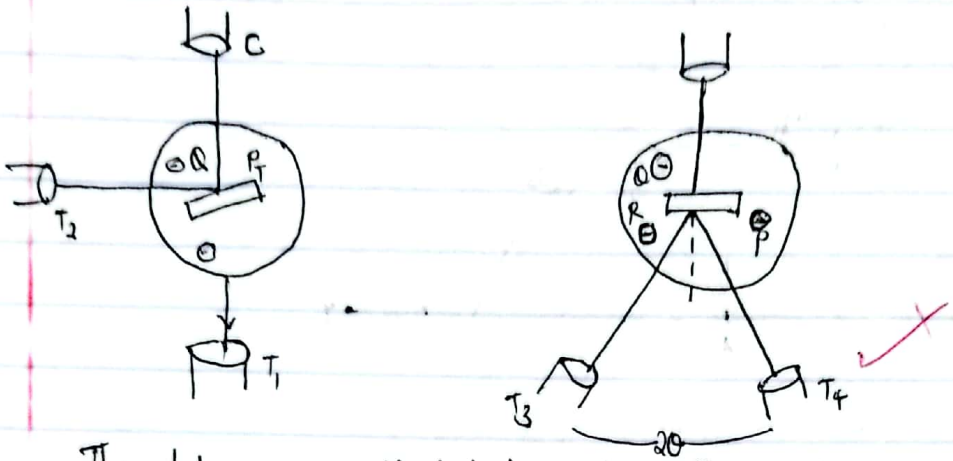
$BCA = \Delta AC$

$(90-i) = (90-r)$

$i = r$

Angle of incidence = Angle of reflection.

b (i) Spreading of waves when they pass through small aperture / narrow opening.

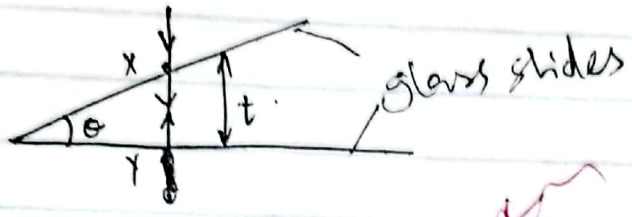


- The telescope is adjusted to produce parallel ligh
- The collimeter C is adjusted to produce parallel light, the
- The table is leveled so that plane of p is parallel to the axis ~~of rotatio~~ rotation of the telescope.
- The telescope is first placed in position T_1 directly opposite the illuminated slit of the collimator and rotated exactly through 90° to position T_2.
- The table is now turned until the slit is seen in T_2 by reflection at P and one of the screws Q, R turned until the slit image is in the middle of the field of view.
- The plane of P is now parallel to the axis of rotation of the telescope.
- The table is now turned through 45° so that the plane of the gr grating is exactly perpendicular to the light from C.
- The telescope is turned to position T_3 to receive the first diffraction image.
- ~~If the telescope is turned to position T_3 to receive the first diffraction~~ 06
- If the lines of the grating are not parallel to the axis of rotation of the telescope, the image will not be in the middle of the field of view.
- The third screw is then adjusted until the image is central
- The readings of the first diffraction images are obtained on both sides of the normal.
- The angular difference is 2θ and the wavelength is then calculated from $\lambda = d \sin \frac{\theta_1}{2}$

Where, and d is the spacing of the sli tained from number of lines per cm on the grating.

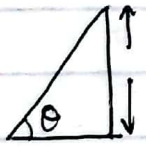
is the superposition of two coherent waves resulting into alternate bright and dark fringes. 01

(ii)



- Consider a monochromatic light incident at point x.
- It is partly reflected at X while some light crosses the air gap to Y and reflected at Y.
- X and Y act as two coherent sources.
- There is a geometrical path difference of 2T between the waves from X and Y.
- The waves reflected at Y undergo phase change of π radians. 03
There is darkness when 2T is equal to the whole number of the wavelength an brightness when 2T is equal to an odd number of half wavelength. When viewed from directly above alternating bright and dark bands which are equally spaced are observed.

d)



$\lambda = 5.46 \times 10^{-7} m$

$t = ?$

$y = 1.50mm$

$X = 12.5cm$

$$y = \frac{\lambda}{2\theta} \quad \text{or} \quad y = \frac{\lambda x}{2t}$$

$$1.50 \times 10^{-3} = \frac{5.46 \times 10^{-7} \times 12.5 \times 10^{-2}}{2t}$$ 04

$$t = \frac{6.825 \times 10^{-8}}{2 \times 1.50 \times 10^{-3}}$$

$$t = 2.275 \times 10^{-5} m.$$

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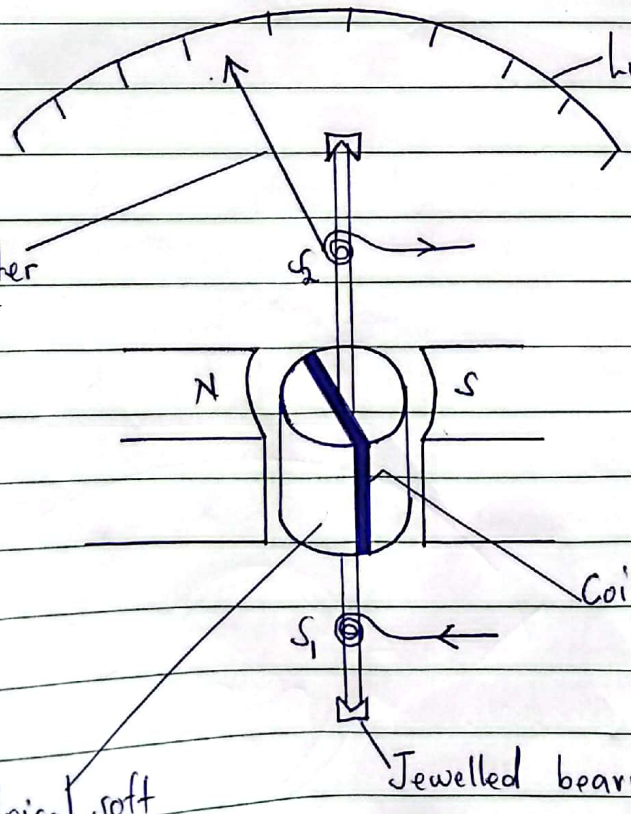
a(i) Magnetic flux density is the force acting on a conductor of length 1m carrying current 1A perpendicular to the magnetic field. ✓

Magnetic moment is the product of current, number of turns and area of the coil. ✓ 02

a(ii) - Effect of increasing temperature is to destroy the ✓ alignment of dipoles
- Since a diamagnetic material has no net magnetic moment, the alignment is already destroyed even at normal state temperature. ✓
- So increasing temperature will have negligible effect on their magnetic behavior. ✓ 03

b(i) Mode of operation of a moving coil galvanometer



N, S - Poles of a permanent magnet ✓
S_1, S_2 - Hair springs. ✓

Coil ✓

2mks on diagram

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- Current to be measured is passed through the coil via the hair springs.
- The coil experiences a magnetic torque, $\tau = BINA$ in a radial field.
- The coil then rotates making the pointer deflect over the scale until it is stopped by a restoring torque $\tau' = k\theta$ due to hair springs.
- At this point, $BINA = k\theta$ where k is tortional constant of spring

$$\therefore I = \left(\frac{k}{NBA}\right)\theta$$

But k/NBA = Constant

$I \propto \theta$.

05

b(ii) 3.5 div $= 1$ mA

1 div $= \frac{1}{3.5}$ mA

$\Rightarrow I_{fsd} = \frac{1}{3.5} \times 30$

$I_{fsd} = 8.57$ mA

$8.57 \times 10^{-3}(r_g + 490) = 5$

$r_g = 93.4\,\Omega$

b(iii) Current sensitivity: $S_I = \frac{\theta}{I} = \frac{NBA}{k}$

Current sensitivity is increased by using finner hair springs since $S_I \propto 1/k$

- Also by increasing number of turns since $S_I \propto N$
- By increasing the area of coil since $S_I \propto A$
- By increasing the strength of magnetic field

02

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(c)(i) $E_b = \omega NBA$

But $E_b = V - IR$

$= 240 - 0.85 \times 3.5$

$E_b = 237.025\,V$

$237.025 = \omega \times 10 \times 0.49 \times 50 \times 10^{-4}$

$\omega = 9.67 \times 10^{3}\,rad\,s^{-1}$

03

C(ii) $\eta = \frac{E_b}{V} \times 100\%$

$= \frac{237.025}{240} \times 100\%$

$\eta = 98.8\%$

02

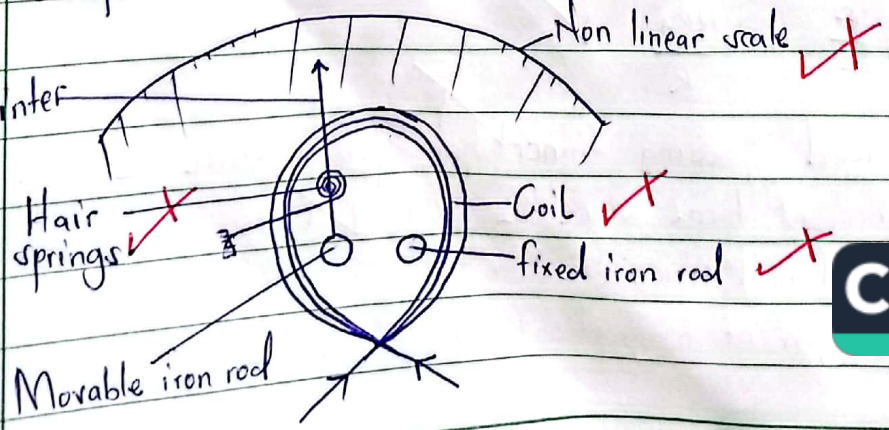
20

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

- Amplitude is the maximum value of alternating current.

02

b(i) Repulsive iron ammeter



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- Current to be measured is passed through the coil.
- Whatever the direction of current, the iron rods get magnetised in the same sence repelling each other.
- This causes the pointer attached to the movable rod to deflect over the scale until it is stopped by the restoring couple due to the hair springs.
- The deflection of the pointer is proportional to the repulsive force and therefore proportional to the average of square current.

02

b(ii) - Moving iron meter measures both ac and dc
- Cheap to construct

01

(c) Reactance is the non-resistive opposition to the flow of alternating current through a capacitor.

(d)(i) $Z = \sqrt{(X_L - X_C)^2}$

$X_C = \frac{1}{2\pi fC}$

$= \frac{1}{2\pi \times 1\times10^{3} \times 4.6\times10^{-6}}$

$X_C = 34.59\Omega$

$Z = \frac{V}{I} = \frac{240}{3{\cdot}0} = 80\Omega$

$Z = X_L - X_C$

$X_L = 80 + 34.59$

$X_L = 114.59\Omega$

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d(ii) $X_L = 2\pi fL$ ✓

$L = \frac{X_L}{2\pi f}$

$L = \frac{114.59}{2\pi \times 1 \times 10^3}$ ✓

$L = 0.018H$ ✓ 02

e(i) - When a metal swings with its plane perpendicular to a uniform magnetic field, it cuts the magnetic flux. ✓

- Eddy currents are induced in the metal. ✓
- These cause heating by I^2R mechanism. ✓
- Hence temperature of the metal riser ✓ 03

e(ii) - Heating in induction furnace. ✓

- A metal to be melted is placed in a crucible container around which is wound a thick copper coil. ✓
- This produces a rapidly changing magnetic flux in the metal piece ✓
- Eddy currents are induced in the metal pieces making them melt. ✓ 03

20

7a(i) - Faraday's law states that the magnitude of induced emf in a conductor is directly proportional to the rate of change of magnetic flux linking it. ✓

- Lenz's law states that induced emf acts in such a direction to oppose the change in the flux causing it. ✓ 02

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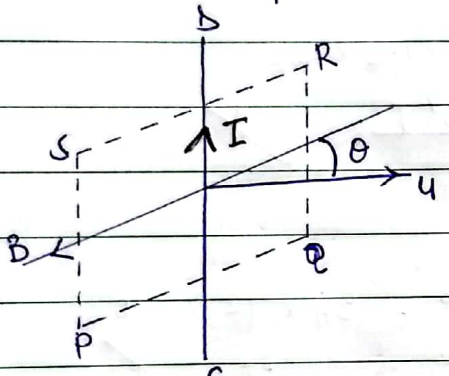
a(i) Ring moves away from magnet. This is because when N-pole is moved near the ring, the magnetic flux linking the ring changes and an emf is induced in it. Current flows in anti clockwise direction to oppose the motion of the coil.

This results into repulsion hence ring moves away.

(b)



- Component of u perpendicular to B is $u\sin\theta$
- Area normal to B swept out by L per second is given by

$$\frac{dA}{dt} = Lu\sin\theta$$

- Induced emf, $E = -\frac{d\phi}{dt} = -\frac{B\,dA}{dt} = -BLu\sin\theta$

$$\therefore |E| = BLu\sin\theta$$

04

c(i) $E = BLu\sin\theta$

$1.2\times10^{-3} = B\times15\times200\sin\theta$ —①

$6\times10^{-3} = B\times15\times200\cos\theta$ —②

Where θ is angle of dip

B is resultant of earths magnetic field.

from ① and ②

$\theta = \tan^{-1}\left(\frac{12}{6}\right)$

$\theta = 11.3^\circ$

03

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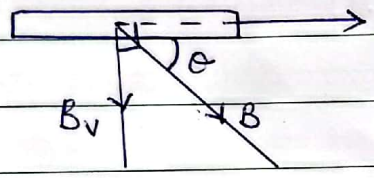
(ii) $B = \frac{1.2}{15 \times 200 \times \sin 11.3}$ ✓

$B = 2.04 \times 10^{-6} T$ ✓

02

OR

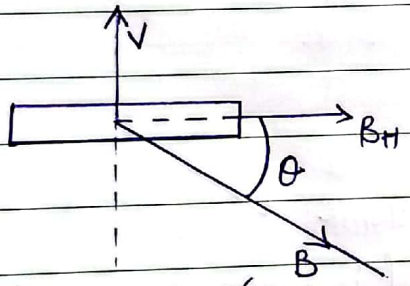
(c)(i)



$E = B_V l v$ ✓

$1.2 \times 10^{-3} = B_V \times 1.5 \times 200$

$B_V = 4 \times 10^{-7} T$ ✓



$6 \times 10^{-3} = B_H \times 15 \times 200$

$B_H = 2 \times 10^{-6} T$ ✓

Angle of dip, $\theta = \tan^{-1}\left(\frac{B_V}{B_H}\right) = \tan^{-1}\left(\frac{4 \times 10^{-7}}{2 \times 10^{-6}}\right)$ ✓

$\theta = 11.3^\circ$ ✓

(c)(ii) $B = \sqrt{B_H^2 + B_V^2}$ ✓

$= \sqrt{(4 \times 10^{-7})^2 + (2 \times 10^{-6})^2}$ ✓

$B = 2.04 \times 10^{-6} T$ ✓

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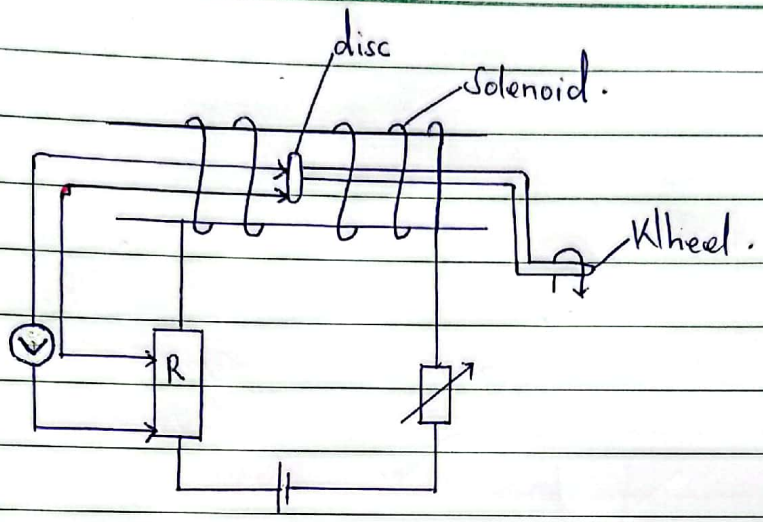
da)



- A metal disc of known radius r, is placed at the centre of a solenoid carrying current with its axis coincident with that of the solenoid. ✓
- The disc is rotated with its plane perpendicular to the axis of the solenoid in such a direction that the voltmeter reading reduces. ✓
- The speed is increased gradually until the voltmeter reads zero. ✓
- This speed is kept constant and the number of revolutions N in time, t is noted. ✓✓
- The frequency of rotation, f is determined from $f = N/t$ ✓✓ 05
- The unknown resistance $R = \mu_0 n \pi r^2 f$ - ✓

dai) Only non electrical quantities ✓ ie length and time are measured to determine resistance which is electrical quantity 01

20

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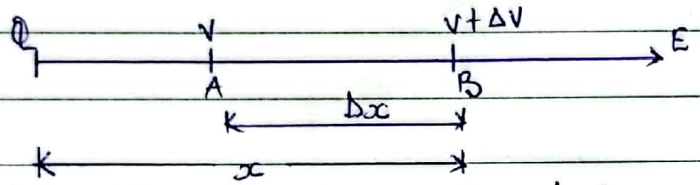
8 a(i) Electric field intensity is the force exerted on a positive charge of 1C placed at a point in an electric field. ✓ 01

a(ii) Relation between electric field intensity and electric potential



Potential difference between A and B

$V_{AB} = V_A - V_B$

$= V - (V + \Delta V)$ ✓

$= -\Delta V$ ✓

Workdone to move +1C from B to A, $W = E\Delta x$ ✓

$\therefore E\Delta x = -\Delta V$ ✓

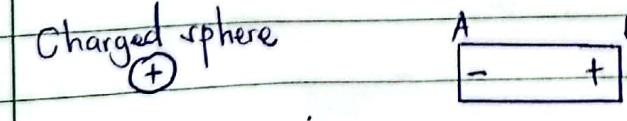
$E = \frac{-\Delta V}{\Delta x}$

As $\Delta x \to 0$, ✓

$E = \frac{-dV}{dx}$ ✓ 03

b(i) Coulomb's law states that the force between two point charges is directly proportional to the product of their magnitude and inversely proportional to the square of their distance apart. ✓

b(ii)



- When a charged sphere is brought near a neutral conductor, it induces opposite charges at A and repels similar charges to its own at B ✓

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- Since opposite charge is closer to the sphere, attraction force is greater than repulsive force. Hence attraction takes place. 03

8(c)(i) $F = \frac{KQ_1Q_2}{r^2}$

Before

$1.08 \times 10^{-1} = \frac{9\times10^9 Q_1 Q_2}{(0.5)^2}$ —(1)

$Q_1 Q_2 = 3\times10^{-12}$ —(i)

After

$3.2 \times 10^{-2} = \frac{9\times10^9 Q^2}{(0.5)^2}$ —(2), But $Q = Q_1 - Q_2$

$\frac{9\times10^9 (Q_1 - Q_2)^2}{(0.5)^2} = 3.2\times10^{-2}$

$(Q_1 - Q_2)^2 = 8.89 \times 10^{-13}$

$Q_1 - Q_2 = 9.43 \times 10^{-7}$

$Q_1 = Q_2 + 9.43\times10^{-7}$ —(ii)

(ii) into (i)

$Q_2 (Q_2 + 9.43\times10^{-7}) = 3\times10^{-12}$

$Q_2^2 + 9.43\times10^{-7} Q_2 - 3\times10^{-12} = 0$ 05

$Q_2 = 1.324\times10^{-6}$

$Q_2 = -2.27\times10^{-6}$

Q_1 when $Q_2 = 1.324\times10^{-6}$

$Q_1 = 9.43\times10^{-7} + 1.324\times10^{-6}$

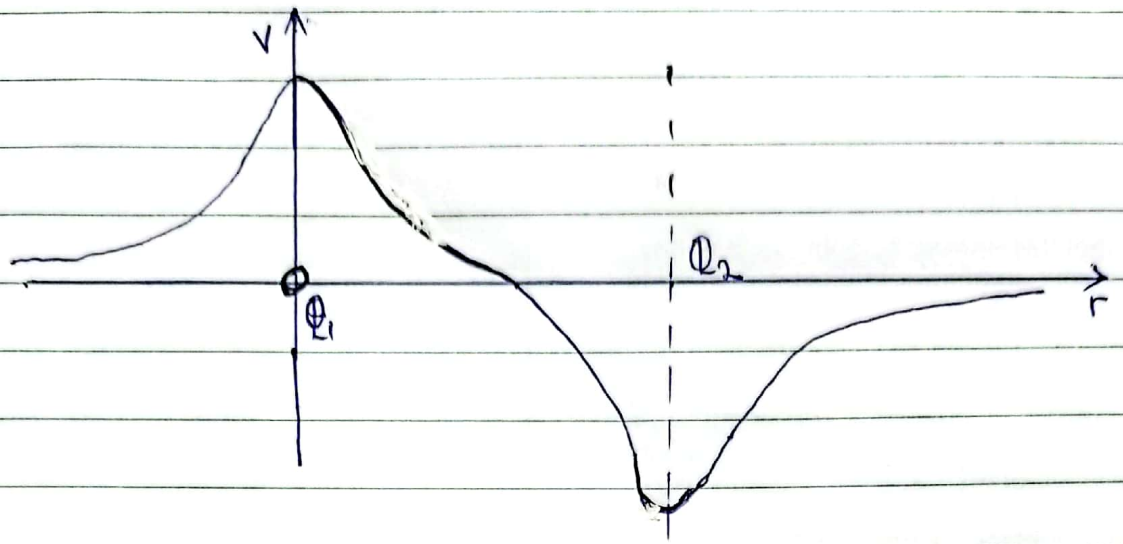
$Q_1 = 2.27\times10^{-6}$

Q_1 when $Q_2 = -2.27\times10^{-6}$

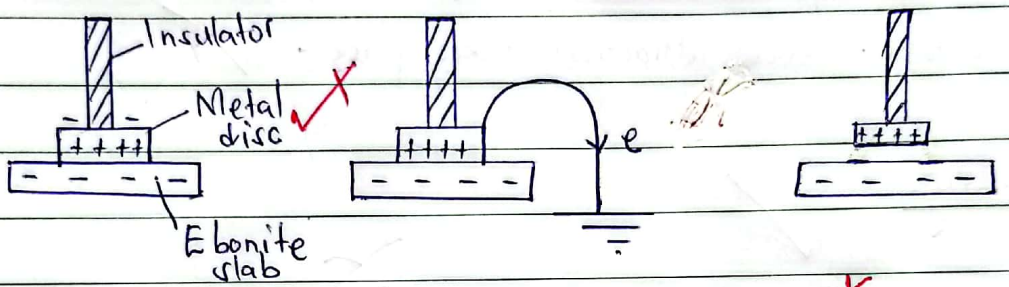
$Q_1 = 9.43\times10^{-7} - 2.27\times10^{-6}$

$Q_1 = -1.324\times10^{-6}$ ∴ $Q_1 = 2.27\times10^{-6}$C and $Q_2 = -1.324\times10^{-6}$C

8 c (ii) Variation of potential between the charges initially relative to the earth



8 (d)



- Ebonite slab is charged negatively by friction.
- Metal disc is placed on the slab
- Positive charge is induced on the lower side of the disc while negative one repelled to the upper surface of the disc.
- The disc is earthed and electrons flow to the earth.
- The disc remains with a net positive charge
- The disc is separated from the slab and used to charge other bodies.
- The process is repeated several times without ebonite losing all its charge.

04

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

A dielectric is an insulator that can withstand high electric field intensity before it conducts. ✓

OR

A dielectric is an insulator between the plates of a capacitor.

02

a(ii)
- A metal can is placed on the cap of a neutral gold leaf electroscope. ✓
- One of the dielectrics is lowered into the can without touching its walls. ✓
- Divergence θ_1 of leaf is noted. ✓
- The first dielectric is replaced with a second dielectric. ✓
- The divergence θ_2 of the leaf is noted. ✓
- The charges of the two dielectrics are compared from $\frac{Q_1}{Q_2} = \frac{\theta_1}{\theta_2}$ ✓ where Q_1 and Q_2 are the magnitudes of charges on the first and second dielectric respectively.

04

(b) $C_0 = \frac{\varepsilon_0 A}{d}$ ✓

$C_1 = \frac{\varepsilon_0 \varepsilon_r A}{3d} + \frac{2\varepsilon_0 A}{3d} = \frac{1}{3} C_0 (2 + \varepsilon_r)$ ✓

But $Q \propto I$ and $Q = CV$ ✓

$\Rightarrow \frac{C_0 V}{C_1 V} = \frac{I_1}{I_2}$ ✓

$\frac{1}{\frac{1}{3}(2+\varepsilon_r)} = \frac{I_1}{I_2}$ ✓

$\frac{3I_2}{I_1} - 2 = \varepsilon_r$

$\therefore \boxed{\varepsilon_r = \frac{3I_2}{I_1} - 2}$ ✓

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(i) $V = 100V$ $Q = 24.0nC$ $C = 6.0nF$

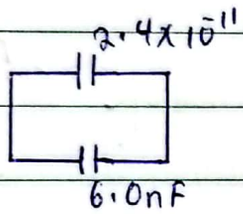
$Q = CV$ ✓

$C = Q/V$ ✓

$C = \frac{24 \times 10^{-9}}{1000}$ ✓

$C = 2.4 \times 10^{-11} F$ ✓ 02

(ii)



$C_t = (2.4 \times 10^{-11} + 6.0 \times 10^{-9}) F$ ✓

$C_t = 6.024 \times 10^{-9} F$

Charge initial = Charge final

$Q_i = Q_f$

$24 \times 10^{-9} = 6.024 \times 10^{-9} V$

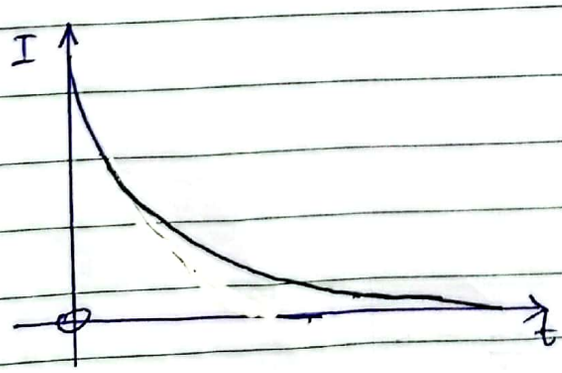
$V = 3.984V$ ✓

$E = \frac{1}{2} CV^2$ ✓

$= \frac{1}{2} \times 6.024 \times 10^{-9} \times (3.984)^2$ ✓

$E = 4.781 \times 10^{-8} J$ ✓ 04

d(i)



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d(ii) - When capacitor is empty, opposition to flow of current is zero hence current is maximum.

- As capacitor charges, opposition to flow of current increases hence current reduces.

- When capacitor is fully, opposition to flow of current is maximum, current becomes zero. 02

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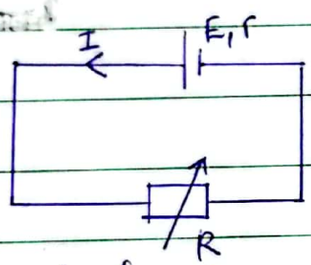
Emf is the potential difference across terminals of a battery in an open circuit. ✓

Internal resistance is the opposition to the flow of current due to its chemical composition. ✓

02



from circuit formula;

$$E = I(R+r) \Rightarrow I = \frac{E}{R+r}$$ ✓

Power dissipated in R, $P = I^2R$ ✓

$$P = \frac{E^2}{(R+r)^2} \cdot R$$ ✓

At maximum power; $\frac{dP}{dR} = 0$

$$\frac{dP}{dR} = \frac{(R+r)^2 E^2 - E^2 R \cdot 2(R+r)}{(R+r)^4} = 0$$ ✓

04

$$(R+r) - 2R = 0$$

$$R = r$$ ✓

$$\Rightarrow P_{max} = \frac{E^2}{4r}$$ ✓

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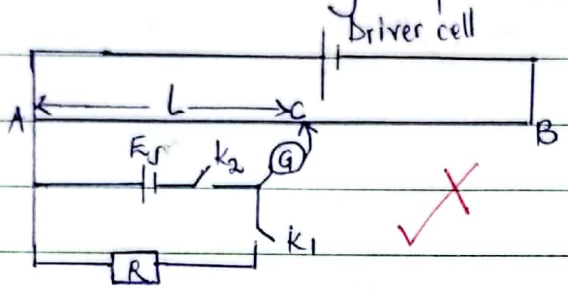
(b) Experiment to determine the internal resistance of a cell accurately using a potentiometer



- A standard cell E_s and a standard resistor R are connected as shown above.
- With k_1 open, k_2 closed, the jockey is tapped along the slide wire until the galvanometer shows no deflection
- The balance length l_s is noted
- At this point, $E_s = kl_s$ — ①
- k_2 opened and k_1 closed
- The jockey is tapped along the slide wire until the galvanometer shows no deflection
- The new balance length l is noted
- The internal resistance is calculated from $r = R\left(\frac{l_s}{l} - 1\right)$ 05

(c)(i) $I_R = kL$

$I \cdot 5 = \frac{4}{8+2} \cdot \frac{8}{100} \cdot 45$ 04

$I = 0.288\ A$

(ii) $E = I(R+r)$

$2 = 0.288\,(5+r)$

$\frac{2}{0.288} - 5 = r$ $\quad r = 1.9445\ \Omega$ 02

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(c) - The voltmeter draws current from the p.d it measures. Therefore its reading is less accurate ✓✓

- The potentiometer doesn't draw current from the p.d it measures Therefore gives more accurate p.d ✓✓

03

20