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Subject: PHYSICS

Paper code: P510/2

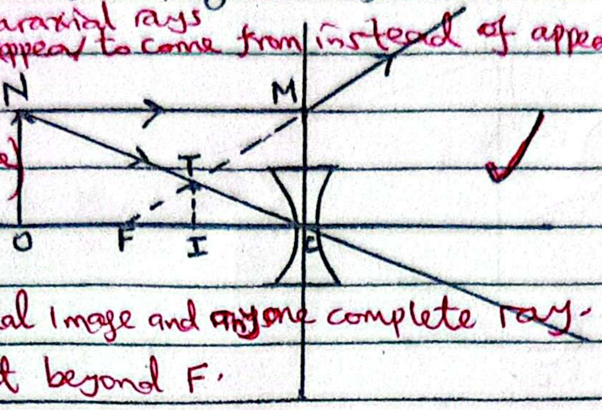
Level: ☐ PLE ☐ UCE ☑ UACE

Year: 2025

1.(a) Principal focus of a diverging lens is a point on the principal axis where rays close and parallel to the principal axis appear to diverge from, after refraction through the lens. ✓ (1)

*Accept paraxial rays
*Accept appear to come from instead of appear to...

(b)



(object must be beyond F)

*Accept the symbol of a lens.
*deny point object.
*Accept use of free hand.

✓ — Virtual Image and any one complete ray.
✓ — Object beyond F.

Method 1

ΔNOC and ΔTIC are similar

hence $\frac{NO}{TI} = \frac{OC}{IC}$ ✓ ——— (i)

ΔFIT and ΔFMC are similar

hence $\frac{MC}{TI} = \frac{FC}{FI}$ ✓ ——— (ii)

but NO = MC

$\therefore \frac{OC}{IC} = \frac{FC}{FI}$ ✓ ——— (iii)

$OC = u \quad FC = -f \quad IC = -v$
$FI = FC - IC = -f - (-v) = v - f$ } ✓ for sign convention

from eqn (iii) $\frac{u}{-v} = \frac{-f}{v-f}$ ✓

$u(v-f) = vf$

hence $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ ✓ (6)

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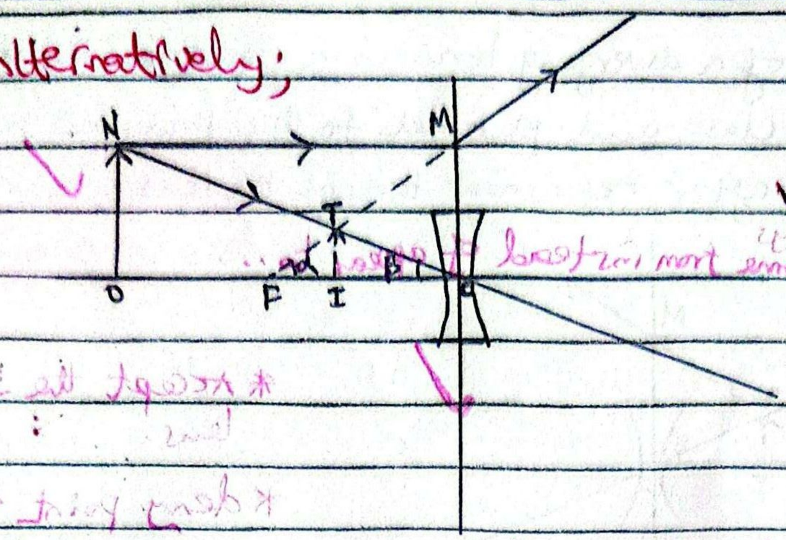
Alternatively;

(1)



* Accept appear to come from instead of appear.

* Accept the symbols of lines

* dany point object

x — Virtual image and arrows complete rays

x — object beyond F

$$\tan\alpha = \frac{MC}{FC} = \frac{TI}{FI}$$

$$\therefore \frac{MC}{TI} = \frac{FC}{FI}$$

$$\tan\beta = \frac{ON}{OC} = \frac{IT}{IC}$$

$$\frac{ON}{IT} = \frac{OC}{IC}$$

But $ON = MC$

$$\frac{OC}{IC} = \frac{FC}{FI}$$

$OC = u$ $IC = -v$
$FI = v - f$

$$\frac{u}{-v} = \frac{-f}{v-f}$$

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

(6)

(2)

NB; A candidate who uses a point object loses all the marks.

③

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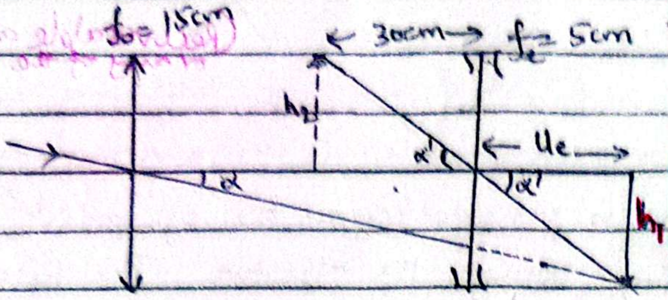
C(i)



$\frac{1}{f_e} = \frac{1}{u_e} + \frac{1}{v_e}$ ✓

$\frac{1}{5} = \frac{1}{u_e} - \frac{1}{30}$ ✓

$\frac{1}{u_e} = \frac{1}{30} - \frac{1}{5} = \frac{1-6}{30} = \frac{-5}{30}$

$u_e = -6\ cm$ ✓

$M = \frac{\alpha'}{\alpha} = \frac{h}{u_e} \times \frac{f_o}{h} = \frac{f_o}{u_e}$ ✓

$M = \frac{15}{6} = 2.5$ ✓

④

$M = \frac{\alpha'}{\alpha}$

OR $M = \left(\frac{h_2}{v_e}\right) \times \left(\frac{f_o}{h_1}\right)$

$= \left(\frac{h_2}{h_1}\right) \times \left(\frac{f_o}{v_e}\right)$

$= \left(\frac{v_e}{f_e} - 1\right) \times \left(\frac{f_o}{v_e}\right)$ ✓ ④

$= \left(\frac{-30}{-5} - 1\right) \times \left(\frac{15}{30}\right)$ ✓

$= 2.5$ ✓

C(ii) Separation $= f_o - u_e = 15 - 6 = 9cm$ ✓ ②

A candidate who uses this;

OR $M = \left(\frac{D}{f_e} - 1\right)\left(\frac{f_o}{D}\right) \times$

$= \left(\frac{-30}{-5} - 1\right)\left(\frac{15}{30}\right)$ ✓✓ Recognized.

OR

$M = \left(\frac{V_e}{f_e} - 1\right)\left(\frac{f_o}{V_e}\right)$ ✓

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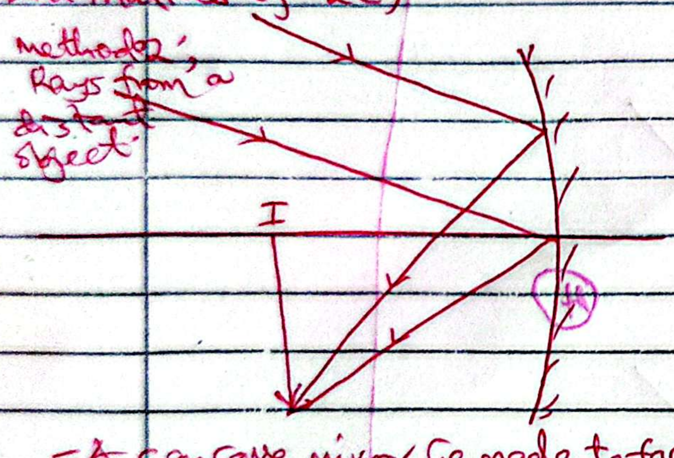
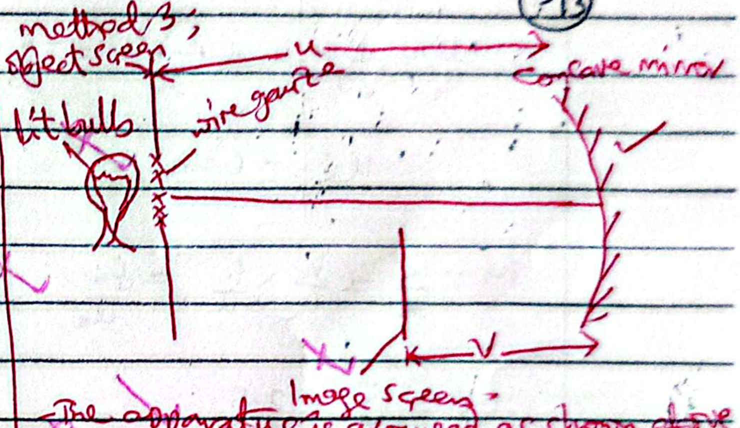
(d) The eyepiece is a concave lens. ✓ (Recoverable at point of not accessible or any of the 3 statements.)
The eyering is formed between the objective and the eyepiece and therefore not accessible. ie its a virtual eyering.
When the eye is placed beyond the eye piece, ✓ it does not collect all light passing through the objective. The field of view is therefore reduced. ✓ or The image formed is less bright. (4/4)

(e) The ability of the eye to focus near and far objects. ✓✓
This is done by the eye changing the shape and focal length of the eye lens. ✓ (3/3)

Alternatives of 2C)





- A concave mirror is made to face a distant object and a screen is placed in front of the mirror.
- The position of the mirror is adjusted until a sharp image of a distant object is formed on it.
- The distance b/n the screen and the mirror is measured.
- F is the focal length of the mirror. ✓ (½) (05)

- The apparatus is arranged as shown above.
- The illuminated object is placed at a distance U from the mirror. The position of the image screen is adjusted until a sharp image of the wire gauze is formed on it. The distance, V is measured. The focal length, f of the mirror is calculated from $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$.
OR same method but graphical method.

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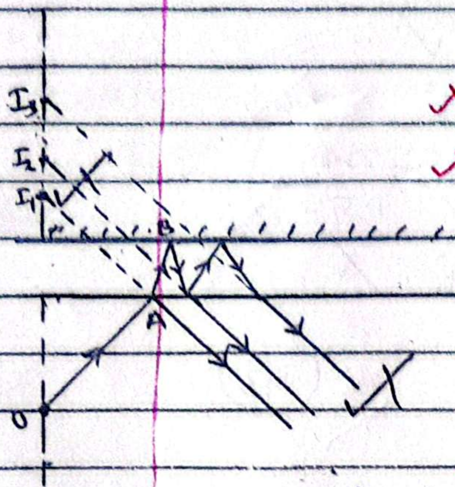
2(a)(i) The incident ray, the normal and the reflected ray at the point of incidence all lie in (on) the same plane. ✓
The angle of incidence is equal to the angle of reflection. ✓ (2/2)

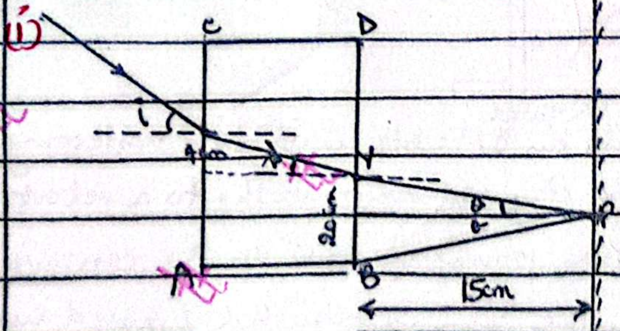
(ii)



✗ – for the Images.
✗ – for the reflected rays.

Light from O incident at A is partially reflected and partially (transmitted) refracted. The reflected light forms a faint image I_1. The refracted light is reflected at B. On reaching C, it undergoes partial reflection and refraction. The refracted light forms a bright image I_2. More partial reflections and refractions take place forming images in the same way. OR leading to formation of multiple images or other images. (3/3)

(b) (i)



$\tan\theta = \frac{10}{15}$ ✓

$\theta = 33.69°$ ✓ (3/3)

$i = \theta$ (law of refraction of light)

$i = 33.69°$ ✓

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(ii)

$\tan r = \frac{4}{AB}$ ✓

$AB = \frac{4}{\tan r}$

From $n \sin i = $ constant ✓

$1.52 \sin r = \sin 33.69°$

$r = \sin^{-1}\left(\frac{\sin 33.69°}{1.52}\right)$

$r = 21.4°$ ✓

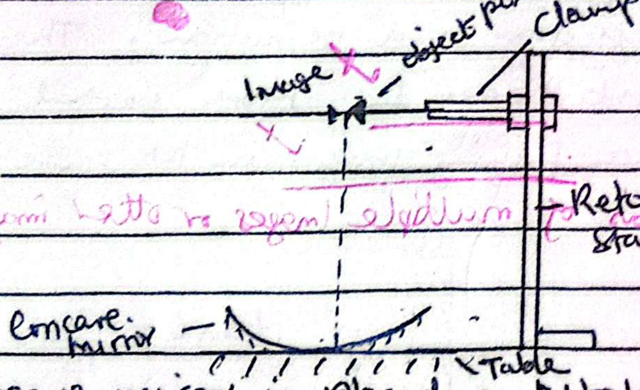
Recoverable if used in part (i)

$AB = \frac{4}{\tan 21.4}$ ✓

$AB = 10.21$ cm ✓

(3/3)

(c) Method I ✓



A concave mirror is placed on a table with its reflecting face upward. An optical pin is clamped horizontally to a retort stand such that its tip lies along the principal axis of the concave mirror. While looking from above, the pin is adjusted (moved up and down) until a point is reached when it coincides with its image, I. The distance r from the mirror to the pin is measured ✓

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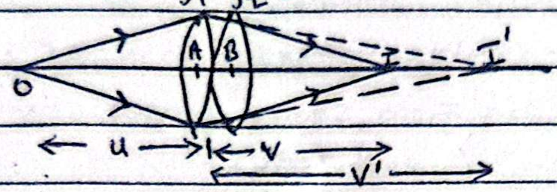
and recorded. The focal length, f of the mirror is calculated

$f = \frac{r}{2}$. ✓ (5/5)

*If distance r is not defined in the literature and on the diagram, then deny half mark

(ii)



✓ half mark if there are no arrows to show direction of light

Consider two thin lenses A and B of focal lengths f_1 and f_2 respectively, which are in contact.

Image I_1 is due to action of lens A only.

from $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ ✓ (Recoverable).

for lens A

$\frac{1}{f_1} = \frac{1}{u} + \frac{1}{v'}$ ✓ —— (i)

for lens B

$\frac{1}{f_2} = \frac{1}{-v'} + \frac{1}{v}$ —— (ii)

from (i) and (ii)

$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{u} + \frac{1}{v'} - \frac{1}{v'} + \frac{1}{v} = \frac{1}{u} + \frac{1}{v}$ ✓ ✓

but $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ ✓ (4/4)

There fore $\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f}$ ✓

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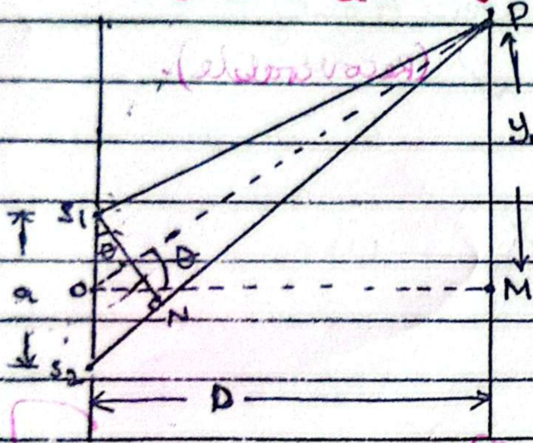
3(a)

(i) Interference of waves is the superposition of waves from coherent sources leading to alternate regions of maximum and minimum intensity. ✓ (01)

(ii) Conditions for observable interference of light
- Coherent sources must be from same light source ✓
- Sources must be close to each other ✓ (02) (1st two)
- Sources must be very narrow ✓
- Screen must be far from the sources.
- Same amplitude.
- Coherent sources ie same f and same λ or meet with constant phase R/ship.

(b)
(i)



Consider light from coherent sources S_1 and S_2 overlaping at point P. If P is position of n^{th} bright fringe,

$S_2P - S_1P = n\lambda$, ✓ $n = 1, 2, 3 \cdots$ ——— (1)

Suppose S_1N is normal to S_2P, $NP \simeq S_1P$ since $\overline{S_1S_2}$ is small.

$\overline{S_2N} = a\sin\theta = S_2P - S_1P = n\lambda$ ✓

$\therefore \sin\theta = \frac{n\lambda}{a}$ ——— (2)

$\tan\theta = \frac{y_n}{D}$ ✓ ——— (3)

For small angles, $\tan\theta \simeq \sin\theta$ ✓

3 c (ii) Alternative; considerable diffraction takes place when the obstacles or openings are of size comparable to wavelength of wave. The width of the openings in the house is in the same range of wavelength of sound. Sound is diffracted a lot through the openings. Wavelength of light is much smaller and diffraction is negligible. (9)

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$\frac{y_n}{D} = \frac{n\lambda}{a}$ ✓ $y_n = \frac{n\lambda D}{a}$ ——— (4)

For $(n+1)^{th}$ Bright fringe, $y_{n+1} = \frac{(n+1)\lambda D}{a}$ ✓

Fringe width: $\Delta y = y_{n+1} - y_n$

$\Delta y = \frac{\lambda D}{a}$ ✓ (05)

(ii)

Wide sources (slits) act like many slits ✓ close to each other, each pair produces its ✓ own fringe system. The fringe systems overlap ✓ forming a uniform illumination ✓ (interference pattern disappears) (03)

(c) (i)

Diffraction is the spreading of waves beyond their geometrical (geometric shadows) boundaries leading to interference ✓ OR (01)
spreading of waves around an obstacle

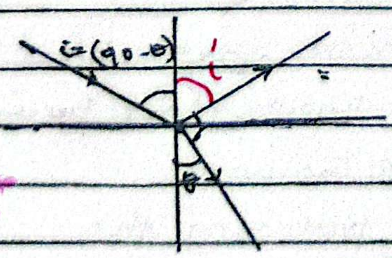
(ii)

Walls of the house are opaque ✓ thus light does not pass through ✓ Sound waves travel ✓ through the opaque walls by vibrations, thus the observer recieves sound but not light. (03)

d (i) Plane polarized light is produced by:-

- Selective absorption ✓ - Double refraction ✓ (02) (1st two)
- Reflection ✓ - Scattering. ✓

(ii)



$i = (90° - 35.2°) = 54.8°$ ✓

$n = \tan i$ ✓

$n = \tan 54.8°$ ✓

$n = 1.42$ ✓ (03)

4a) i) Accept same forced frequency being equal to forcing freq.

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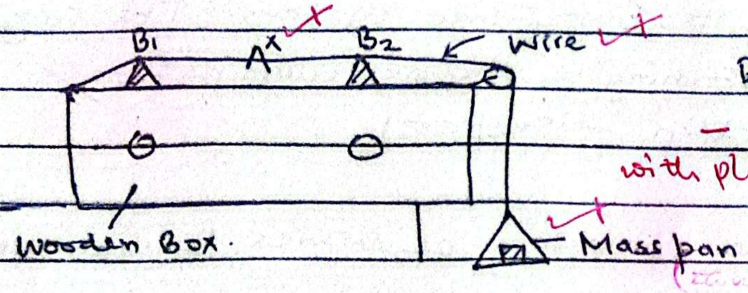
4 (a)

(i) Forced oscillation is oscillation of a body due to impulses from an external vibrating system ✓ (01)

(ii) Resonance is the vibration of a body at its natural frequency due to impulses from a nearby system vibrating at the same frequency ✓ (01)

(b)(i)



$B_1 B_2$ – Bridges.

– Paper rider can be recovered with plucking of the wire.

- A mass is placed on the mass pan, the mass M of the mass pan and the mass on it is noted. Tension in the wire is $T = Mg$ ✓
- A paper ride x is placed between the briges B_1 and B_2.
- A tuning fork whose frequency is to be determined is sounded ✓ and held near (on) bridge B_1, bridge B_2 is moved until the paper rider falls off ✓ (loud sound) (05)
- The length L ✓ between the bridges B_1 and B_2 is measured and recorded.
- The frequency of the tuning fork is given by

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$ ✓ μ is the known mass per unit length of the wire.

(Award even if known or missing)
* Accept other methods.

(ii) A wire vibrates in different modes producing the fundamental note and overtones (harmonics) ✓. A tuning fork produces a pure note ✓. Overtones determine the quality ✓ of a notes (02) or better quality of the notes.

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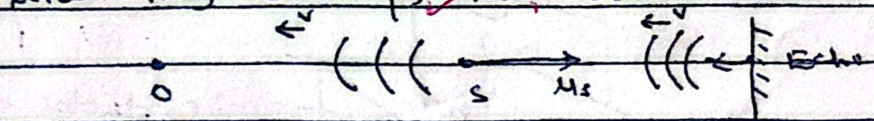
(c)

(i) The observer recieves a note from the source direct, and also recieves a note of sound reflected (Echo). The two notes have nearly equal frequency, and when they overlap (meet) or mix, the observer hears beats. (02)

(ii)



Direct from S: $f' = \left(\frac{v}{v+u_s}\right)\cdot f = \left(\frac{336}{336+1.5}\right)\cdot f$; $f' = 0.996f$

For Echo: $f'' = \left(\frac{v}{v-u_s}\right)\cdot f = \left(\frac{336}{336-1.5}\right)\cdot f$; $f'' = 1.004f$

Beat frequency = 5Hz $1.004f - 0.996f = 5$; $f = 625Hz$ (04)

Accurate Answer, $f = 559.99Hz$.

(d)

A spectral photograph of the star is taken and the wave length λ' of an identified element is noted. A spectral photograph of a spark light from the same element is taken in the laboratory, and wave length λ is noted.

Wave length shift $\Delta\lambda = |\lambda' - \lambda|$ is noted.

Speed of a star is $u = \frac{\Delta\lambda}{\lambda}\cdot c$ (03)

Where c is the speed of light in air.

Accept a candidate who compares the wavelengths

(e)

(i) Speed of sound remains the same

(ii) Speed of sound increases (02)

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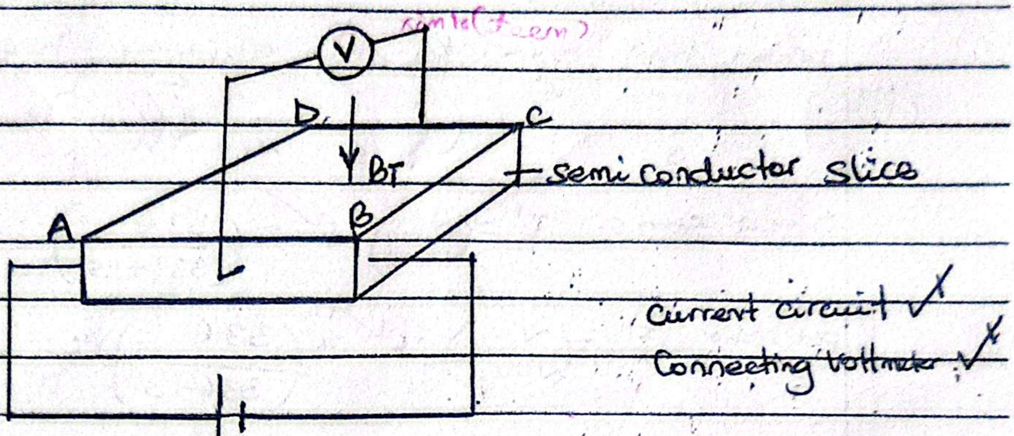
5 (a) Magnetic flux density is the force acting on a 1m long conductor carrying current of 1A in a direction perpendicular to the magnetic field ✓ 01MK

(b) (i)



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

The slice is now placed in the test magnetic 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_o is known. ✓

The voltmeter reading V_o is noted. ✓

The test flux density is now calculated from;

$$B_T = \left(\frac{B_o}{V_o}\right)V$$ ✓

05mks

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5b(ii) $F = BIL\sin\theta$ ✓

Alternatively;
$F = BIL\cos\alpha$ ✓
$= 0.3 \times 8 \times 0.302 \times \cos 34°$ ✓
$= 0.6N$ ✓
(04)

$= 0.3 \times 8 \times \frac{30.2}{100} \times \sin 56$ ✓ (angle) ✓ (converting L)

$= 0.3 \times 8 \times 0.302 \times 0.829$

$= 0.6\ N$ ✓ 04mks

5c(i) Hall effect is the setting up of an e.m.f transversely across a current carrying conductor when a perpendicular magnetic field is applied ✓ (01)

*Accept defn without transversely.

5c(ii) Electric field intensity across the conductor,

$E = \frac{V_H}{d}$ ✓

Electric force on each free electron,

$F = Ee$ ✓ $= \frac{V_H e}{d}$

Magnetic force on the electron

$F = BeV$ ✓

In equilibrium,

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$$\frac{V_H e}{d} = Bev$$ ✓

Hall voltage, $V_H = Bvd$ ✓ where v is drift velocity and d is the width of the slice

(05mks)

But $v = \frac{I}{neA}$ and $A = d \times t$

where t is thickness of the slice

$\therefore$ $$v = \frac{I}{nedt}$$

$$V_H = \frac{BI}{net}$$

5 a(iii)

$$n = \frac{BI}{V_H e t}$$ ✓

$$n = \frac{2.2 \times 12}{10 \times 10^{-6} \times 1.6 \times 10^{-19} \times 0.07 \times 10^{-3}}$$ ✓ numerator ✓ denominator

$n = 2.36 \times 10^{29}$ electrons per m^3 ✓

* down play unit;
* A candidate with cross work, follow and mark
* A candidate who stops on the way mark
* A candidate who says cannot be done, also mark.

(04MKS)

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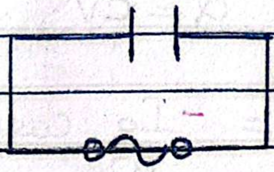
6 a(i) Root mean square Value is the steady Voltage which dissipates electrical energy in a resistor at the same rate as the alternating voltage. (01mk)

(ii) Peak Value: This refers to the maximum Value of an alternating Voltage. (01mK)

b(i) Consider a Capacitor Connected across a source of $V = V_0 \sin \omega t$



Charge, $Q = CV = CV_0 \sin \omega t$ } any can be marked

Current, $I = \frac{dQ}{dt}$ } Any

$$I = \frac{d}{dt}(CV_0 \sin \omega t)$$ (0.3mKs)

$$I = CV_0 \omega \cos \omega t$$

$$I = I_0 \cos \omega t, \quad I_0 = CV_0 \omega$$

$$X_c = \frac{V_0}{I_0} = \frac{V_0}{CV_0 \omega} = \frac{1}{\omega C}$$

But $\omega = 2\pi f$

$$\therefore X_c = \frac{1}{2\pi f C}$$

(03)

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OR: $I = I_0 \sin\omega t$ ✓

Current, $I = \frac{dQ}{dt} = I_0 \sin\omega t$

Charge, $Q = \int I_0 \sin\omega t \, dt$ ✓

But $Q = CV$ ✓

$\Rightarrow CV = -\frac{I_0}{\omega} \cos\omega t$

$V = -\frac{I_0}{\omega C} \cos\omega t$

$V = -V_0 \cos\omega t$

$V_0 = \frac{I_0}{\omega C}$ ✓

$X_c = \frac{V_0}{I_0}$ ✓

$= \frac{1}{\omega C}$

But $\omega = 2\pi f$

$X_c = \frac{1}{2\pi f C}$ ✓

08 mks

* Accept also $V = V_0 \cos\omega t$
* Accept also $I = I_0 \cos\omega t$ and follow the candidate.

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b(ii) $V = 240\sin 360\pi t$

$f = \frac{360}{2} = 180Hz$ ✓

$X_c = \frac{1}{2\pi fC} = \frac{1}{2\times3.14\times180\times12\times10^{-6}}$ ✓

$X_c = 73.7\Omega$ 03mks

$I_o = \frac{V_o}{X_c} = \frac{240}{73.7}$ ✓ $= 3.3A$

$I_{rms} = \frac{I_o}{\sqrt{2}}$ ✓ $= \frac{3.3}{\sqrt{2}} = 2.3A$ ✓

OR

$I_o = \frac{V_o}{X_c} = V_o 2\pi fC = 240\times2\times3.14\times180\times12\times10^{-6}$ ✓

$I_{rms} = \frac{I_o}{\sqrt{2}}$ ✓ $= \frac{240\times2\times3.14\times180\times12\times10^{-6}}{\sqrt{2}}$ ✓

$\therefore I_{rms} = 2.3A$ ✓

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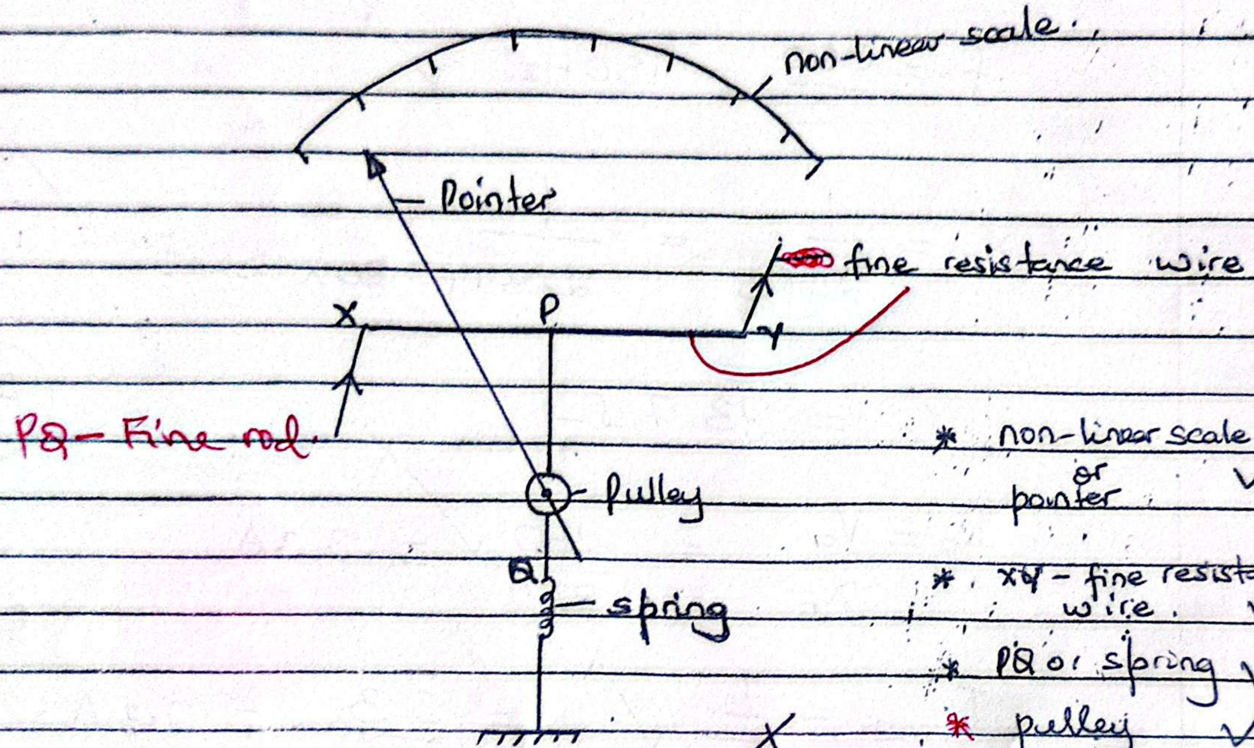
6 C



* non-linear scale or pointer
* XY - fine resistance wire.
* PQ or spring
* pulley

Alternating Current is passed through the fine resistance wire. This Causes heating up of the resistance wire, expands and sags. The sag is taken up by the metal rod PQ. As PQ moves down the pulley rotates Causing the pointer to deflect. The deflection of the pointer is proportional to the sag (the average rate at which heat is developed. Therefore, the deflection, θ, is proportional to the average Value of squares of Current. Hence Root mean square Value Can be taken.

05mks

6d(ii) Alternative: Is the frequency which occurs when capacitive reactance is equal to inductive reactive.

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Level: ☐ PLE ☐ UCE ☑ UACE Year: 2025

6d (i) Resonant frequency is the frequency at which the system produces maximum output/current, or the impedance is minimum. (01mk)

* Accept any of the four words used above.

(ii) Resonance occurs when the Impedance is minimum. $Z = \sqrt{(X_L - X_C)^2 + R^2}$

Z is minimum when $(X_L - X_C) = 0$

Therefore, $Z = R$. Hence, Impedance is purely resistive at resonant frequency. (04mks)

OR At resonant frequency, $X_L - X_C = 0$ or $X_L = X_C$. From $Z = \sqrt{(X_L - X_C)^2 + R^2}$, since $X_L - X_C = 0$ then $Z = R$ hence impedance is purely resistive. (op)

(iii) $f_0 = \frac{1}{2\pi\sqrt{LC}}$

$= \frac{1}{2\pi\sqrt{(0.8 \times 6 \times 10^{-6})}}$

$= 72.644\,Hz$

$= ~~72.7\,Hz~~$

(02mks)

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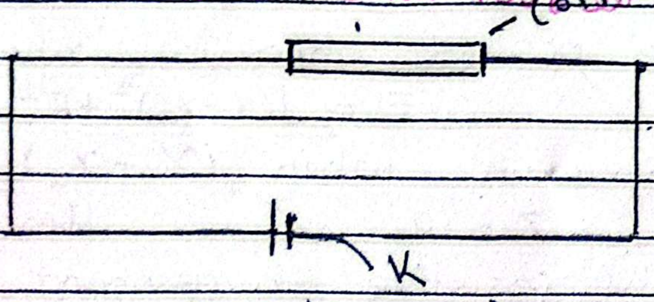
7(a)(i) Magnetic field is a region in space where magnetic force is experienced. ✓ 01

(ii)



A compass needle is brought near the copper wire ✓ switch K is closed ✓ the compass needle deflects in particular direction. ✓

This shows the presence of magnetic field around a current carrying conductor ✓ 03

* Accept other methods used by a Candidate.

b(i) when the metal bar is moved in ~~electric~~ magnetic field, electrons ✓ move along with it and Magnetic force acts ✓ on them which makes them to move to face Y. ✓ leaving positive charge at X ✓ Hence p.d is set up across XY 02

(ii) $V_H = BVd$ ✓

$6\times10^{-6} = B\times5\times10^{-3}\times40\times10^{-3}$ ✓

$B = 0.03T$ ✓ 03

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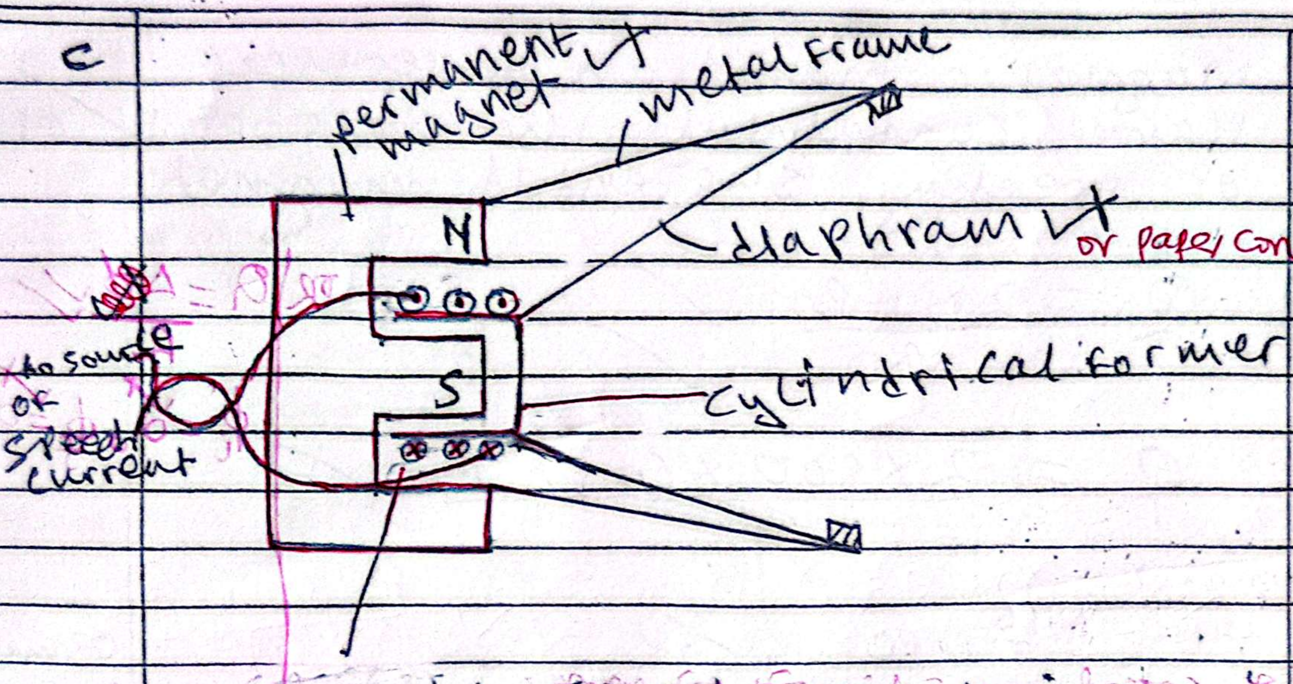
c



Speech current is fed into the coil. The coil experiences a force. Since direction of current reverses periodically, the direction of force acting on the coil reverses periodically. A candidate can use ac to indicate periodically

This makes the coil to move in and out.

This causes the diaphram to vibrate. Air around the diaphram is set into vibrations at frequence of speech current producing sound. 07marks

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(ii) Magnetic meridian is vertical plane containing the axis of of freely suspended magnet. 01

(iii) $Q = \frac{2NAB}{R}$ OR $Q = \frac{A\phi}{R}$

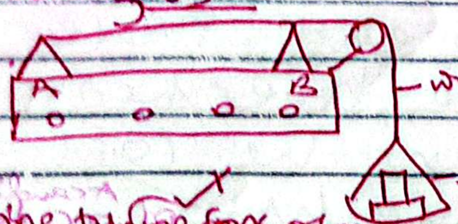
$\phi_i = 0$, $\phi_f = 0$

$Q = \frac{2 \times 500 \times (0) \times B}{9}$

$= 0$ — 03 marks

* — crossed work in line with this mark.
* A candidate who uses the A in the question loses one mark. — 20 marks

4b(i) Alternatively;



~~Vibrating tuning fork of known frequency f~~ is brought near the plucked wire. Bridge B is moved towards A until aloud sound is heard. Length l_1 btn A and B is measured.
The expt is repeated with a test tuning fork and the length l_2 ~~state~~ for which sound is produced btn the bridges is measured.
The test frequency f_2 is calculated from

$f_2 = \frac{l_1}{l_2} f_1$ or

$\frac{f_2}{f_1} = \frac{l_1}{l_2}$

05

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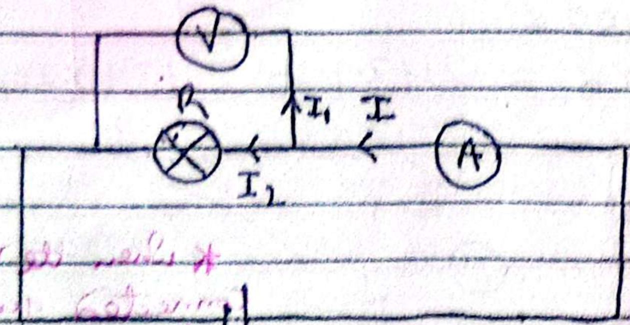
8(a) (i) Resistivity is resistance across opposite faces of 1m cube of a material. ✓ (01)

(ii) Temperature coefficient of resistance is fractional change in resistance at 0°C per Kelvin rise in temperature ✓ (01)

(b)(i)



[illegible]

$R_p = \frac{V}{I}$ ✓

$= \frac{150}{0.76}$ ✓

$= 197.4$

$\frac{1}{R_p} = \frac{1}{R_V} + \frac{1}{R}$ ✓

$\frac{1}{197.4} = \frac{1}{1050} + \frac{1}{R}$ ✓

$R = 243.1\Omega$ ✓

(04 marks)

OR

$I_1 = \frac{V}{R} = \frac{150}{1050}$ ✓

$= 0.143$

$I_2 = 0.76 - 0.143$ ✓

$= 0.617$ ✓

$R = \frac{150}{0.617}$ ✓

$= 243.1\Omega$ ✓

or

$I_2 = \frac{1050}{R+1050} \times 0.76 = \frac{798}{R+1050}$ ✓

$V = I_2 R$ ✓

$\frac{798}{R+1050} R = 150$ ✓

$R = 243.1\Omega$ ✓

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b(ii) $R_\theta = R_0(1 + \alpha\theta)$ ✓

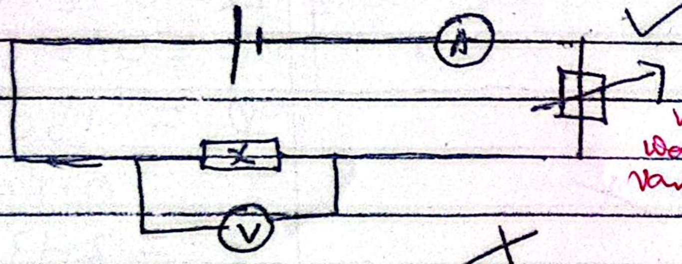
$$\frac{R_{20}}{R_{1200}} = \frac{R_0(1+20\alpha)}{R_0(1+1200\alpha)}$$ ✓ Accept transfer of error

$$\frac{375}{243.1} = \frac{1+20\alpha}{1+1200\alpha}$$ ✓

$375 + 375 \times 1200\alpha = 243.1 + 243.1 \times 20\alpha$

$\alpha = -2.96 \times 10^{-4} K^{-1}$ ✓ (03 marks)

c (i)



✓ * when the voltmeter is connected across the rheostat we give current and voltage and want to see how the conductor varies the rest.

- A current I is passed through the conductor x. p.d V across the conductor is recorded from voltmeter ✓
- The experiment is repeated for other values of I by adjusting rheostat
- Results are tabulated and a graph of I against V is plotted. ✓
- It is straight line graph passing through the origin ✓

Thus the current through the conductor is proportional to pd V across it. ✓ 04

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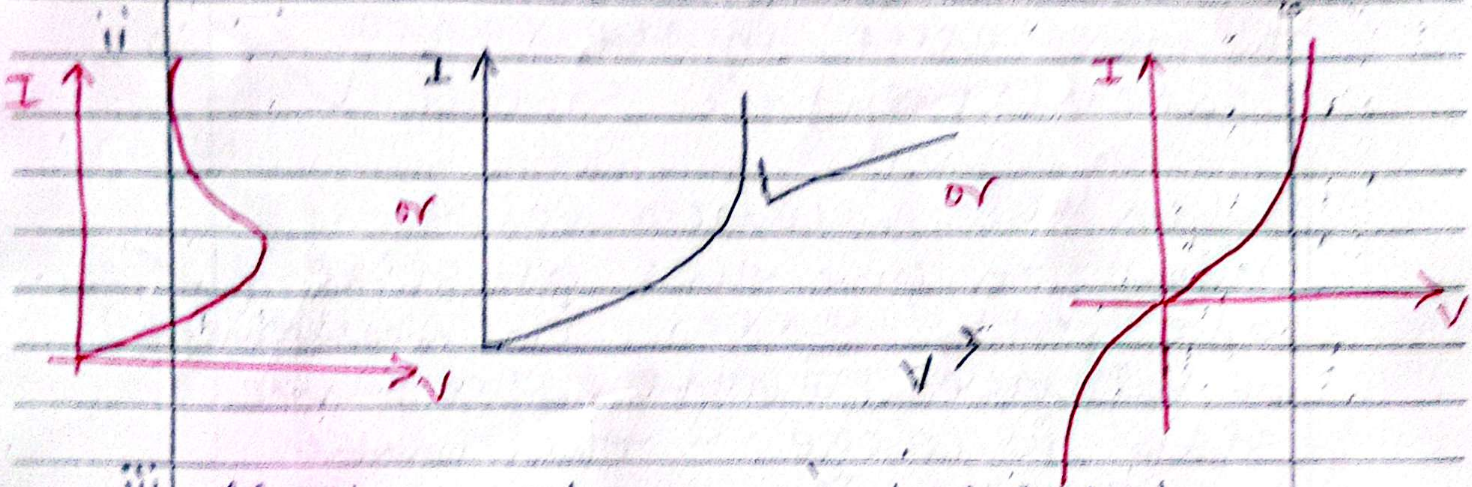
ii



iii As the voltage is increased, the material heats up and (thus reduction in resistance). This causes rapid increase in current. 02

(d) (i) For small resistances, the resistance of connecting wires become comparable to test resistance. This makes the error in calculation of test resistance significant (large) 02

(ii) when the balance point is nearly in the middle of the slide wire, the error in measurement of both balance length is small

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Therefore error in the ratio (calculation) is small ✓ 02

or

When the balance point is near on one end of slide one ; the error in measurement of balance length on same side is large. This makes the error in the ratio (calculation) large ✓ 02

There4 the balance point should be near or close to the middle of the wire so that the error is small.

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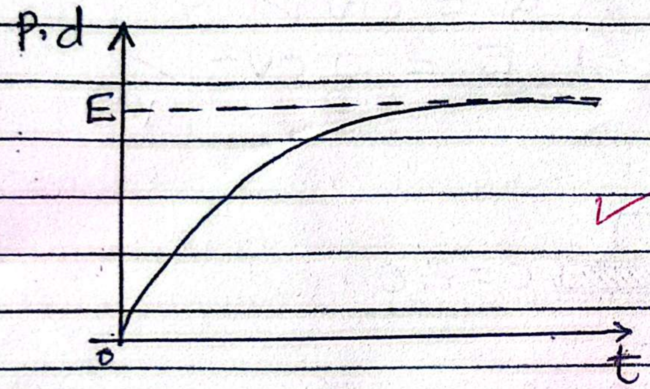
Question 9.

(a) Capacitance is the ratio of magnitude of charge on either plate of the capacitor to the potential difference (across) between the plates. (01)

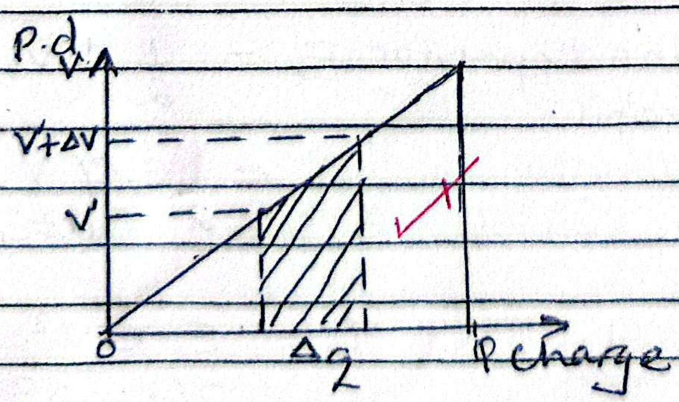
b(i)



(01)

(ii) The voltage increases as the capacitor charges. when this voltage is equal to the emf of the battery, the capacitor is fully charged. (01)

(iii)



Area of shaded region, $\Delta A = \frac{1}{2}\Delta q(V'+V'+\Delta V)$

$= V'\Delta q$ } either

but ΔA = work done to charge the capacitor

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Work done to charge the capacitor from zero to Q = Area under the graph.

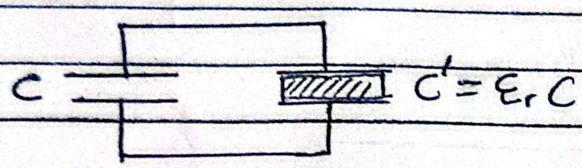
$W = \frac{1}{2}QV$

(04)

But $Q = CV$

$\therefore$ Energy stored $E = \frac{1}{2}CV^2$

(c)



Initial charge $Q_o = CV$

Final charge $Q_f = Q_o$

Total capacitance $= C(1+\varepsilon_r)$

$\Rightarrow C(1+\varepsilon_r)V' = CV$

$V' = \frac{V}{1+\varepsilon_r}$

(03)

Energy stored in a capacitor with dielectric $E = \frac{1}{2}C'V'^2$

$= \frac{1}{2}\varepsilon_r C\left(\frac{V}{1+\varepsilon_r}\right)^2$

$\therefore E = \frac{\varepsilon_r CV^2}{2(1+\varepsilon_r)^2}$

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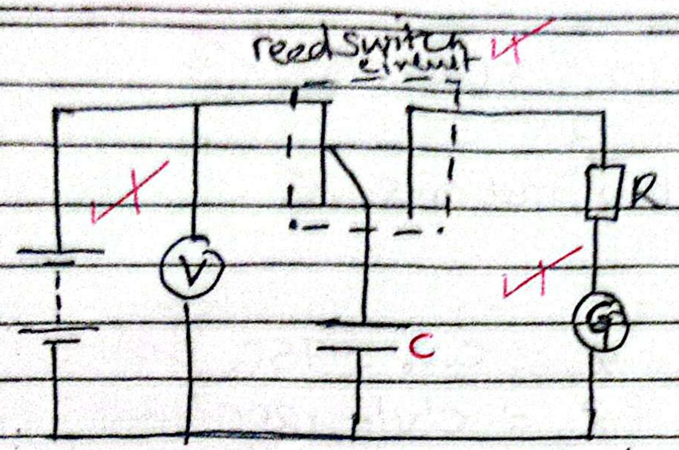
(d)



- The capacitor c is connected in the circuit as shown above
- The reed switch circuit is switched on

(04)

- The voltmeter reading, V and microammeter (G) reading, I are noted. The frequency f of the reed switch is also noted.
- The capacitance is obtained from

$$C = \frac{I}{Vf}$$

e (i) $Q = CV$

$\theta_0 \propto Q_1$ and $\theta \propto Q_2$

$\theta_0 \propto C_0 V_0$ —— ①

$\theta \propto \frac{1}{2} C_0 (1+\varepsilon_r) V'$ —— ② (effective capacitance substitution)

$$\frac{\theta}{\theta_0} = \frac{C_0 (1+\varepsilon_r) V'}{2 C_0 V_0} = \frac{(1+\varepsilon_r) V'}{2 V_0}$$

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$$\theta = \frac{(1+2.5)\times 120 \times 0.6}{2\times 75}$$ ✓

$= 1.68$ radians. ✓ (04)

ALT:

Initial charge $Q_1 = C_0V_0 = 75C_0$ ✓½

New charge $Q_2 = C'V' = 120C'$

But $C' = \frac{1}{2}C_0(1+\varepsilon_r)$ ✓½

$Q = 60C_0(1+2.5)$

$Q = 210C_0$ ✓½ (04)

deflection $\theta \propto Q$ ✓½

$$\frac{\theta}{0.6} = \frac{210C_0}{75C_0}$$ ✓

$$\theta = \frac{210\times 0.6}{75}$$

$\theta = 1.68$ radians. ✓

e(ii) Under normal circumstances, water contains mobile ions. ✓ When placed between plates of a charged capacitor, it will conduct charges between the plates leading to discharge. (or neutralisation) ✓ OR (02)

Water is a conductor of electricity. When placed btn the plates it conducts charges from one plate to another leading to neutralization. ✓ OR water is not suitable as a dielectric in practice coz it's a good insulator only when it is very pure and to remove all matter dissolved in it is almost impossible. ✓

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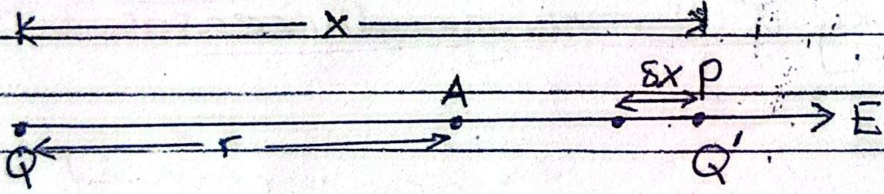
Question 10

a (i) Electric field is the region in space where the electric force is experienced. ✓ (01)

(ii) Electric potential energy is the energy possessed by an electric charge because of its position in the electrostatic field. ✓ (01)

OR Electric potential energy is the work done to move a positive charge from infinity to a point with in the electrostatic field. ✓

b (i)



✓✓ (Can be recovered from the statement)

Suppose a charge Q' is at a distance x from Q in a vacuum.

The force on charge Q', $F = \frac{QQ'}{4\pi\varepsilon_0 x^2}$ ✓

If the test charge, Q' moves a small distance δx against the electrostatic force,

work done, $\delta W = -F\delta x$ ✓✓

$= \frac{-QQ'\delta x}{4\pi\varepsilon_0 x^2}$ ✓✓

The total workdone to bring the charge Q' from infinity to point A is given by

$W = \int_{\infty}^{r} \frac{-QQ' dx}{4\pi\varepsilon_0 x^2}$ ✓✓

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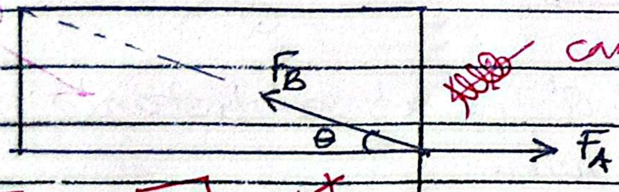
$$W = \frac{QQ'}{4\pi\varepsilon_0}\left[\frac{1}{x}\right]_{\infty}^{r}$$ (05)

$$W = \frac{QQ'}{4\pi\varepsilon_0 r}$$ This is the potential energy for the charge.

b(ii) Q P Q → E

To move a charge from Q to P, work is done against electrostatic field.
This work is stored as potential energy of the charge. Hence, electric potential energy of the charge increases. (03)

(c)



can be recovered at resolving.

$\overline{BD} = \sqrt{12^2+5^2} = 13\text{cm}$

$$F = \frac{KQ_1Q_2}{r^2}$$

$$F_A = \frac{9\times10^9 \times 6\times10^{-6} \times 3\times10^{-6}}{(0.12)^2} = 11.25\text{N}$$

$$F_B = \frac{9\times10^9 \times 2\times10^{-6} \times 3\times10^{-6}}{(0.13)^2} = 3.195\text{N}$$

$$F_c = \frac{9\times10^9 \times 5\times10^{-6} \times 3\times10^{-6}}{(0.05)^2} = 54\text{N}$$

$$F_x = F_A - F_B\cos\theta = 11.25 - 3.195\left(\frac{12}{13}\right) = 8.3\text{N}$$

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$F_y = F_B \sin\theta - F_c$

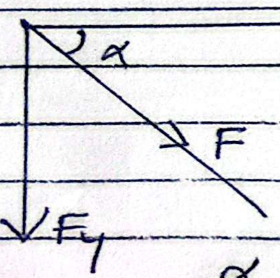
$= 3.195\left(\frac{5}{13}\right) - 54$

$= -52.17\,N$ ✓✓ (06)

$F = \sqrt{F_x^2 + F_y^2}$

$= \sqrt{8.3^2 + (-52.17)^2}$

$= 52.83\,N$ ✓



✓✓ can be recovered when direction is specified

$\alpha = \tan^{-1}\left(\frac{52.17}{8.3}\right) = 81.0°$ ✓✓

(d) On a charged pear shaped conductor, electric charge is more concentrated at the sharp point. ✓ (03)
Electric field intensity is proportional to charge (or charge density). ✓
Hence electric field intensity is stronger around the sharp point. ✓

(e) - Paint spraying on motor vehicles ✓ (1st two)
- Lightning conductors ✓ (01)
- Dust extraction in factory chimneys. ✓

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- Operation of photocopying machines.
- Operation of a Van de graaff generator.

0 f1

* Resonance is a phenomenon which occurs when $x_C = x_L$

* Resonant frequency is a frequency when $X_C = X_L$

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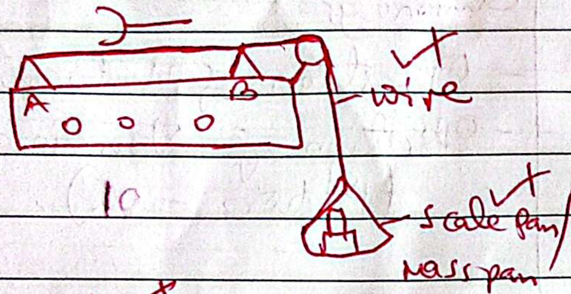
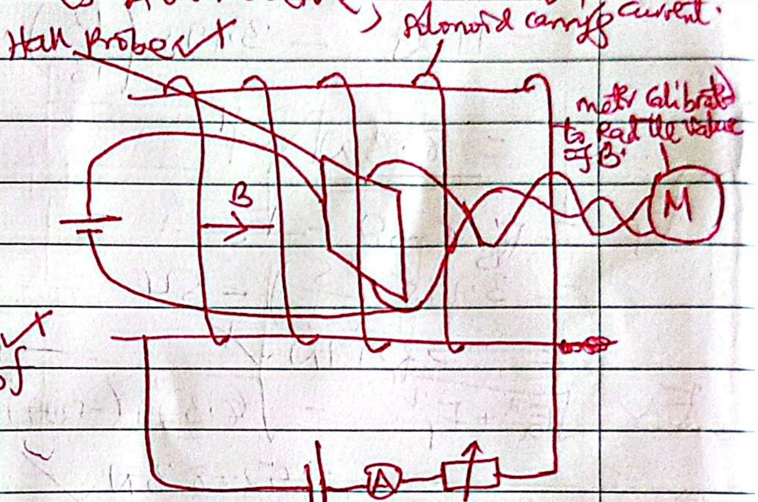
4 b(i) Alternatively;



- Vibrating tuning fork of known frequency, f is brought near the plucked wire
- Bridge B is moved towards A until a loud sound is heard. Length l_1 btn A and B is measured.
- The expt is repeated with a test tuning fork for which sound is produced and the length, l_2, btn the bridges is measured.
- The test frequency f_2 is calculated from $f_2 = \frac{l_1}{l_2} f_1$ or $\frac{f_2}{f_1} = \frac{l_1}{l_2}$

(05)

5b(i) Alternative;



A hall probe is placed inside along a solenoid such that its plane is at right angles to the axis of the solenoid. The hall probe is connected to a meter calibrated in tesla and to d.c source. A suitable current is passed through the solenoid. The value of the magnetic flux density associated with the solenoid is read from the meter.

(05)