केन्द्रीय माध्यमिक शिक्षा बोर्ड, दिल्ली
सीनियर स्कूल सर्टिफिकेट परीक्षा (कक्षा बारहवीं)
परीक्षार्थी प्रवेश–पत्र के अनुसार भरे

विषय Subject : PHYSICS

विषय कोड Subject Code : 042

परीक्षा का दिन एवं तिथि
Day & Date of the Examination : MONDAY & 02.03.2020

उत्तर देने का माध्यम
Medium of answering the paper : ENGLISH

प्रश्न पत्र के ऊपर लिखे कोड को दर्शाए : Write code No. as written on the top of the question paper :	Code Number	Set Number
	55/2/1	● ② ③ ④

अतिरिक्त उत्तर–पुस्तिका (ओं) की संख्या
No . of supplementary answer -book(s) used: NO

बेंचमार्क विकलांग व्यक्ति : हाँ / नहीं
Person with Benchmark Disabilities : Yes / No: NO

विकलांगता का कोड (प्रवेश पत्र के अनुसार)
Code of Disability (As per the admit card): NIL

क्या लेखन – लिपिक उपलब्ध करवाया गया : हाँ / नहीं
Whether writer provided : Yes / No: NO

यदि दृष्टिहीन हैं तो उपयोग में लाए गये सोफ्टवेयर का नाम :
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*एक खाने में एक अक्षर लिखें। नाम के प्रत्येक भाग के बीच एक खाना रिक्त छोड़ दें। यदि परीक्षार्थी का नाम 24 अक्षरों से अधिक है, तो केवल नाम के प्रथम 24 अक्षर ही लिखें।

Each letter be written in one box and one box be left blank between each part of the name. In case Candidate's Name exceeds 24 letters, write first 24 letters.

कार्यालय उपयोग के लिए
Space for office use

(1) (D) R = 0

(2) (A) Resistivity.

(3) (A) move in a straight line.

(4) (B) Ferromagnetic material becomes paramagnetic.

(5) (A) Electric ~~current~~ field is changing.

(6) (A) X-rays.

(7) (C) zero as diffusion and drift currents are equal and opposite.

(8) (B) Just below the conduction band.

(9) (A) Binding energy per nucleon increases.

(10) (A) neutron converts into a proton emitting antineutrino.

(11) If the electric flux entering and leaving a closed surface in air are ϕ_1 and ϕ_2 respectively, the net electric charge enclosed within the surface is $\epsilon_0(\phi_2 - \phi_1)$.

(12) ~~OR~~ In young's double-slit experiment, the path difference between two interfering waves at a point on the screen is $5\lambda/2$, λ being the wavelength of light used. The 3rd dark fringe will ~~to~~ lie at this point.

(13) For a higher resolving power of a compound microscope, the wa[velength]
of light used should be smaller.

(14) Unpolarised light passes from a rarer to a denser medium. If the
reflected and the refracted rays are mutually perpendicular, the
reflected light is linearly polarised perpendicular to the plane [of]
incidence.

(15) Out of red, blue and yellow light, the scattering of blue light is
maximum.

(16) Impedance of a capacitor of capacitance $C = \frac{1}{\omega C}$.

$\omega = 2\pi n$.

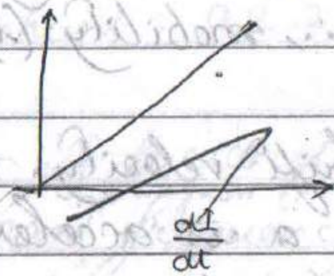
$\therefore$ impedance $= \frac{1}{2\pi n C}$.

(17) A conducting rod of length l is kept parallel to a uniform
magnetic field $\vec{B}$ and moved along it with velocity $\vec{v}$. The va[lue]
of emf induced $= 0$.

(18) Induced emf $= |\mathcal{E}|$.

Rate of change of current $= \frac{dI}{dt}$.

$\therefore \mathcal{E} = -L\frac{dI}{dt} \Rightarrow |\mathcal{E}| = L\frac{dI}{dt}$.



The graph is a straight line passing through origin. The slope is equal to inductance L.

(19) Wavelength, $\lambda = \frac{hc}{E}$. $\therefore \lambda = \frac{6.63\times10^{-34} \times 3\times10^{8}}{3.3\times10^{-19}}$ m

$= \frac{19.89}{3.3} \times 10^{-7}$ m $\approx 6.03\times10^{-7}$ m.

$\therefore$ reqd. wavelength $= 6.03\times10^{-7}$ m.

(20) The minimum frequency that an incoming photon must contain so that it can just overcome the ~~w~~ work function and start photoelectric effect is called 'threshold frequency' in photoelectric emission.

(21) • The drift velocity attained by the charge carriers in unit electric field is defined as 'mobility' of charge carriers in a current-carrying conductor. (1)

∴ mobility (μ) = $\frac{v_d}{E}$. 1

• We know, drift velocity, $v_d = a\tau$, where τ is relaxation time, and a is acceleration of the charge carrier.

Now, in presence of electric field E, acceleration 'a' of a charged particle of charge 'e' = $\frac{eE}{m}$.

$$\therefore v_d = \frac{eE\tau}{m}$$

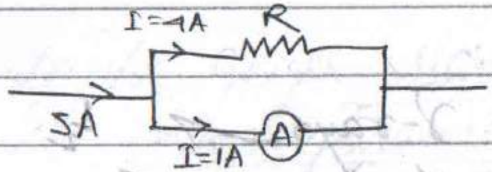
$$\Rightarrow \frac{v_d}{E} = \frac{e\tau}{m} \Rightarrow \boxed{\mu = \frac{e\tau}{m}}$$ 1 (1)

∴ μ is charge times relaxation time divided by mass of the particle m.

(22) Let the shunt resistance be of $R\ \Omega$ and it is connected in parallel with ammeter of resistance $0.8\ \Omega$.

In the converted ammeter, 5 A current can enter.

∴ ammeter can take upto 1A, remaining 4A flows through shunt.



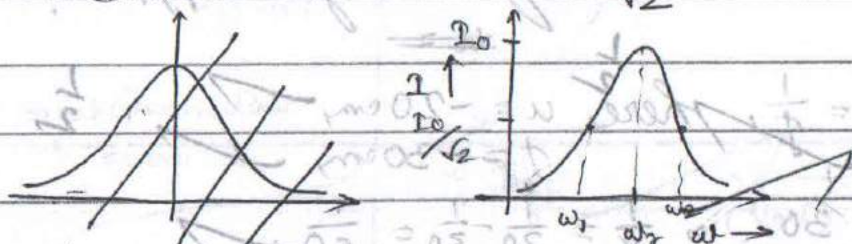
∴ R and ammeter are in parallel,

$4R = 1 \times 0.8$

$\Rightarrow R = \frac{0.8}{4} = 0.2\ \Omega$.

∴ value of shunt = $0.2\ \Omega$ (Ans) 1

(23) (a) • 'Sharpness of resonance' or 'Q-factor of AC circuit' is defined as the ratio of the resonant angular frequency to the difference in angular frequencies of two sides in which the ~~current~~ in the circuit ~~reaches~~ reduces to $\frac{1}{\sqrt{2}}$ times its maximum value.



∴ by the figure, sharpness of resonance = $\frac{\omega_0}{\omega_2 - \omega_1}$. 1

(b) • In a series LCR circuit, $V_L = V_C \neq V_R$.

∴ power factor = 1 1

P.T.O.

(24) The electromagnetic wave having :-

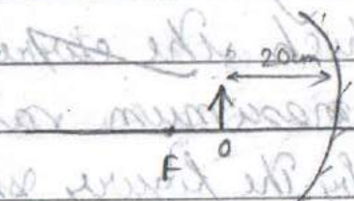
(a) minimum wavelength is — γ-rays. $\frac{1}{2}$

(b) minimum frequency is — Microwaves. $\frac{1}{2}$

• Use :- (a) γ-rays :- γ-ray is used to treat cancer. $\frac{1}{2}$

(b) Microwaves :- It is used to heat food in microwave ovens. $\frac{1}{2}$

(25)



Here, radius of curvature, $R = 60$ cm.

$\therefore$ focal length, $|f| = 30$ cm.

$\therefore \frac{1}{u} + \frac{1}{v} = \frac{1}{f}$, where, $u = -20$ cm, $f = -30$ cm, $\frac{1}{2}$

$-\frac{1}{20} + \frac{1}{v} = -\frac{1}{30} \Rightarrow \frac{1}{v} = \frac{1}{20} - \frac{1}{30} = \frac{1}{60}$

$\Rightarrow v = 60$ cm. $\frac{1}{2}$

$\therefore$ magnification, $m = -v/u = \frac{-60}{-20} = 3$.

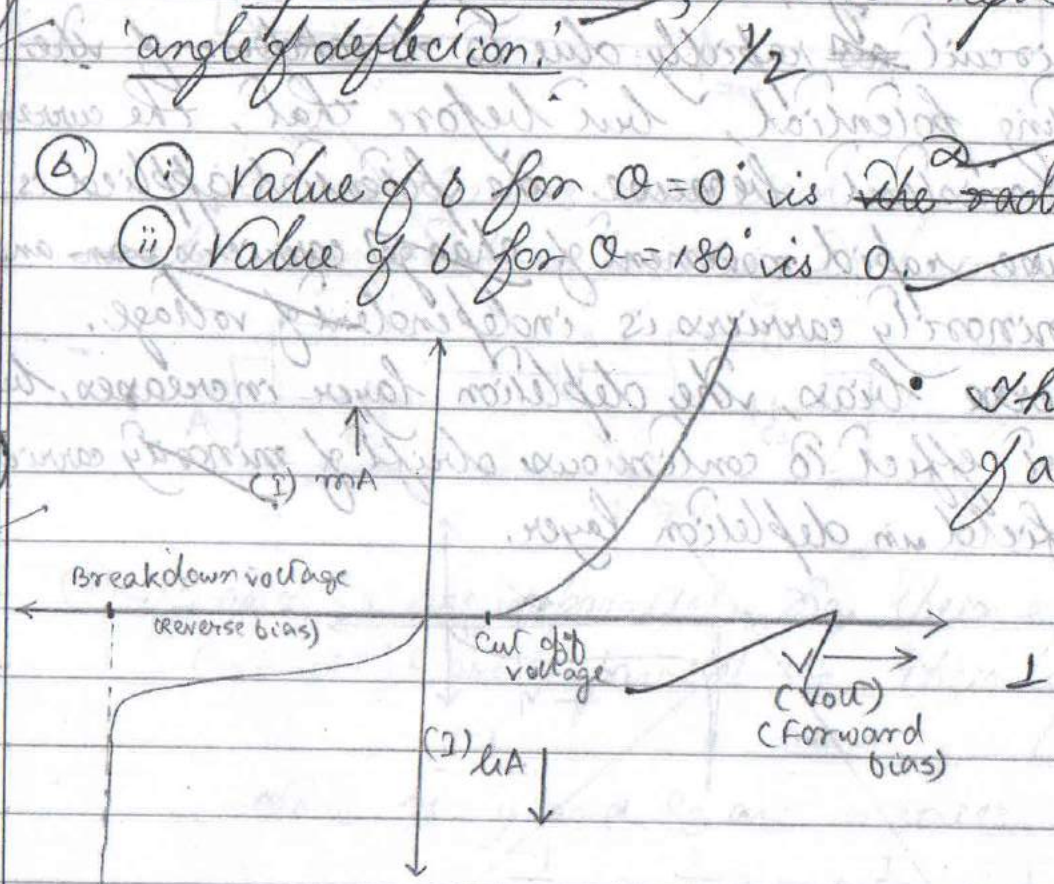
$\therefore$ the image formed is virtual, erect and magnified in nature. $\frac{1}{2}$

P.T.O.

26 (a) In the Geiger-Marsden scattering experiment, 'b' represents the 'impact parameter', and 'θ' represents the 'scattering angle' or 'angle of deflection.'

(b) (i) Value of b for $\theta = 0°$ is ~~the radius of the~~ ~~atom~~ ~~nucleus~~ atom.
(ii) Value of b for $\theta = 180°$ is 0.

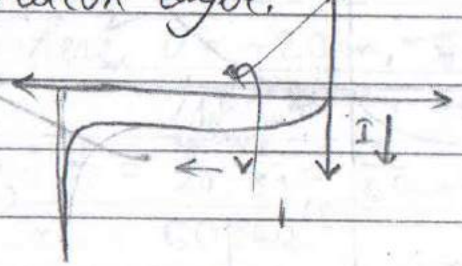
27



• This is the V-I characteristics of a p-n junction diode.

•• The current under reverse bias is almost independent of the applied voltage upto the critical voltage in a p-n junction diode. Actually, the current in reverse bias is due to the drift of the minority carriers in presence of the depletion layer electric field. ~~Until~~ At critical voltage, the minority carriers start moving in the circuit ~~as~~ rapidly due to ~~breakdown of the~~ high ~~v~~ accelerating potential, but before that, the current remains almost constant because the potential applied is not able to cause rapid movement of charge carriers ~~can~~ and also, drift of minority carriers is independent of voltage.

In reverse bias, the depletion layer increases, but this does almost effect to continuous drift of minority carriers due to electric field in depletion layer.



P.T.O.

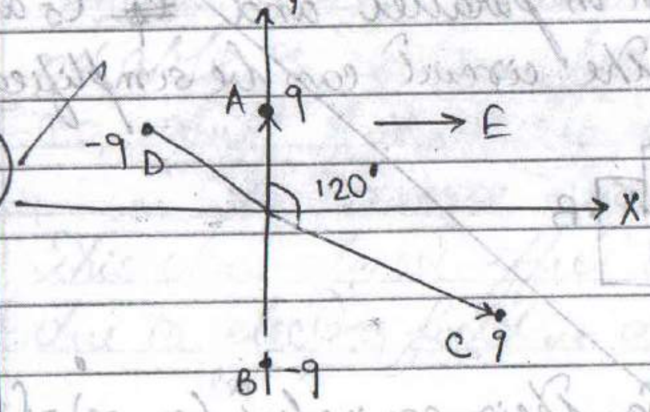
(b) Maximum charge, q, supplied by the battery

$= C_{eq} \times V$

$= \frac{12}{5} \times 7\ \mu C = \frac{84}{5}\ \mu C = 16.8\ \mu C.$

$\therefore$ charge $= 16.8\ \mu C.$

(28) (b)



(a) Dipole moment of dipole

$AB = \vec{p} = p\hat{j}.$

Dipole moment of dipole

$CD = \vec{p} = p\cos 30^\circ\,\hat{i} - p\cos 60^\circ\,\hat{j}$

$= p\frac{\sqrt{3}}{2}\hat{i} - \frac{p}{2}\hat{j}.$

$\therefore$ net dipole moment $(\vec{P}) = p\hat{j} + \left(p\frac{\sqrt{3}}{2}\hat{i} - \frac{p}{2}\hat{j}\right)$

$= p\frac{\sqrt{3}}{2}\hat{i} + \frac{p}{2}\hat{j}.$

$\therefore |\vec{P}| = \sqrt{p^2 \times \frac{3}{4} + \frac{p^2}{4}} = \sqrt{p^2} = p.$ $\frac{1}{2}$

$\therefore$ magnitude of dipole moment $= p.$

$\tan\theta = \frac{1/2}{\sqrt{3}/2} = \frac{1}{\sqrt{3}}.$ $\therefore$ angle made by it with +ve x-axis $= 30^\circ$ (Ans i)

Torque acting on a dipole of dipole moment $\vec{p}$ in electric field $\vec{E}$
$= \vec{p} \times \vec{E}$.

For AB, dipole moment $= p\hat{j}$.
field $= E\hat{i}$.

1/2

$\therefore$ torque, $\vec{\tau}_{AB} = (p\hat{j} \times E\hat{i}) = pE(-\hat{k})$.

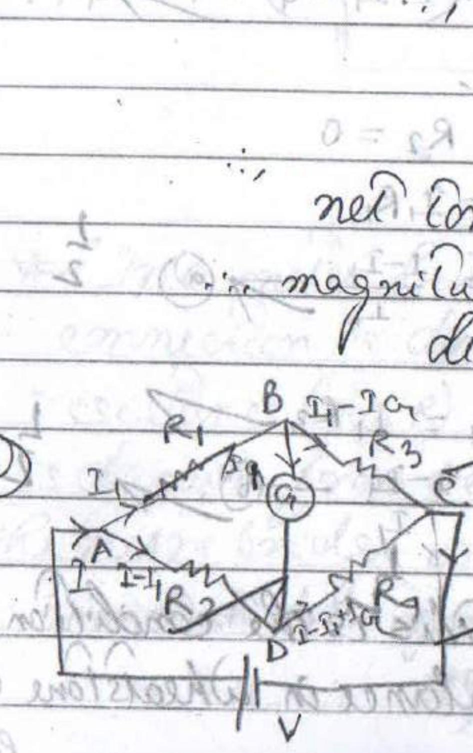
For CD, dipole moment $= (\frac{p\sqrt{3}}{2}\hat{i} - \frac{p}{2}\hat{j})$
field $= E\hat{i}$
$\therefore$ torque, $\vec{\tau}_{CD} = (p\frac{\sqrt{3}}{2}\hat{i} - \frac{p}{2}\hat{j}) \times E\hat{i}$
$= pE\frac{\sqrt{3}}{2} \times 0 - \frac{p}{2}E.(-\hat{k}) = \frac{pE}{2}\hat{k}$.

$\therefore$ net torque $= \vec{\tau}_{AB} + \vec{\tau}_{CD} = -\frac{pE}{2}\hat{k} = \frac{pE}{2}(-\hat{k})$.

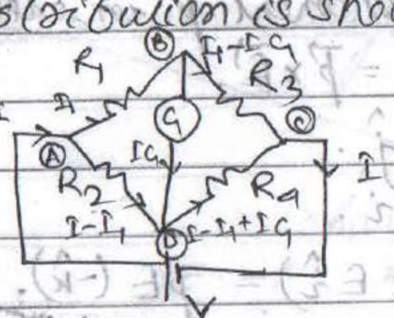
1/2

$\therefore$ magnitude $= \frac{pE}{2}$,
direction = into the plane of paper ~~$(-\hat{k})$~~.

(29) (a)



Let, the four resistances R_1, R_2, R_3 and R_4 are connected as shown in the figure and ~~their~~ they are connected by battery of emf V. ~~Their~~ current distribution is shown in the figure.



In balanced wheatstone bridge, current through galvanometer = 0.

$\therefore I_G = 0.$

By KVL in loop ABDA, $-I_1R_1 - I_G G + (I-I_1)R_2 = 0$, — (i)

G = Resistance of galvanometer.

By KVL in loop BCDB, $-(I_1-I_G)R_3 + (I-I_1+I_G)R_4 + I_G G = 0$. — (ii)

Putting $I_G = 0$ in (i) and (ii),

from (i), $-I_1R_1 + (I-I_1)R_2 = 0$

$\Rightarrow (I-I_1)R_2 = I_1R_1$

$\Rightarrow R_1/R_2 = \frac{I-I_1}{I_1}$ → (a).

from (ii), $-(I_1)R_3 + (I-I_1)R_4 = 0$

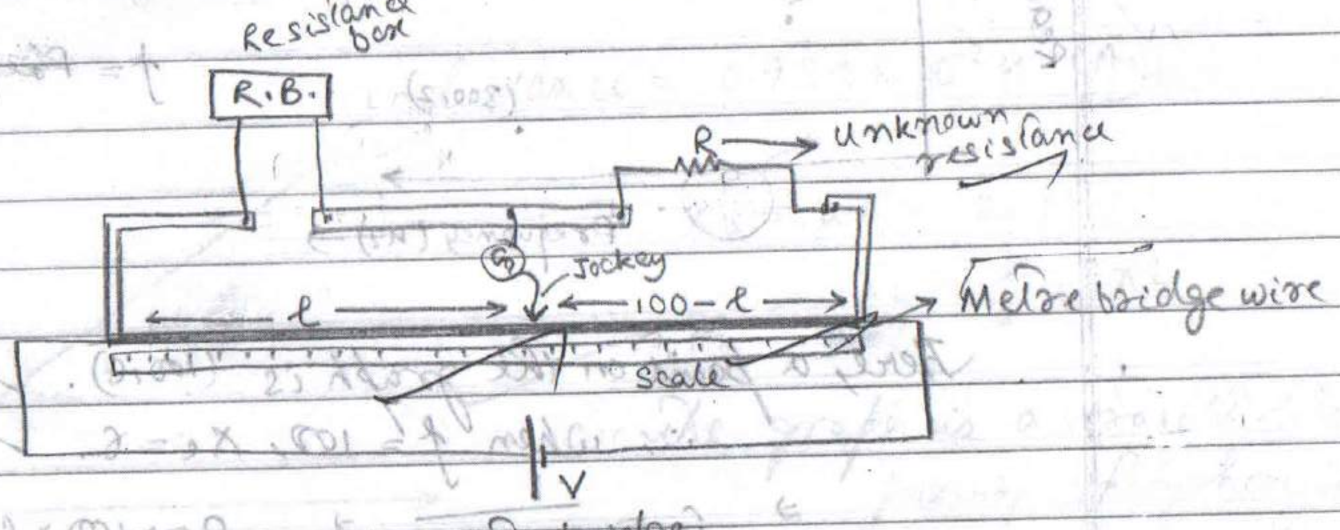
$\Rightarrow (I-I_1)R_4 = I_1R_3$

$\Rightarrow R_3/R_4 = \frac{I-I_1}{I_1}$ — (b).

From (a) and (b), $R_1/R_2 = R_3/R_4$ This is the condition of balance in wheatstone bridge.

P.T.O.

○ A meter bridge works on the condition of balance in wheatstone bridge.

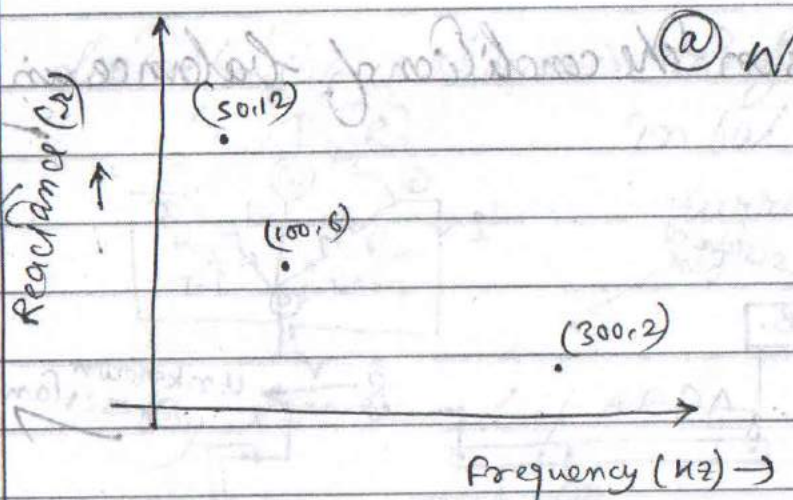


Meter bridge

In a meter bridge, the arrangement is done as shown, and the connection is done as per wheatstone bridge. The unknown resistance (say R) is kept on right side and a known resistance is drawn from resistance box (say R.B.). Now, a jockey is slid down the metre bridge wire until a null point is obtained. If the null point comes at l cm from left side, value of unknown resistance (R):

$$\frac{R.B.}{l} = \frac{R}{100-l} \Rightarrow \boxed{R = \frac{100-l}{l} \times R.B.}$$

(30)



(a) We know, for AC source, capacitor reactance, $X_C = \frac{1}{\omega C}$

$\Rightarrow X_C = \frac{1}{2\pi f C}$,

f = Frequency (in Hz).

Here, a point on the graph is (100,6).

$\therefore$, when $f = 100$, $X_C = 6$.

$\Rightarrow 6 = \frac{1}{2\pi \times 100 \times C} \Rightarrow 2\pi \times 100 \times C = \frac{1}{6}$

$\Rightarrow C = \frac{1}{1200\pi}$

$\therefore C = \frac{7}{1200 \times 22}$ F $= 0.0265 \times 10^{-2}$ F

$= 2.65 \times 10^{-4}$ F.

$\therefore$ required capacitance $= 2.65 \times 10^{-4}$ F. (Ans)

(b) At 100 Hz, ~~frequen~~ ~~inductance~~ reactance of inductor = 6 Ω.

We know, reactance $X_L = \omega L$

P.T.O.

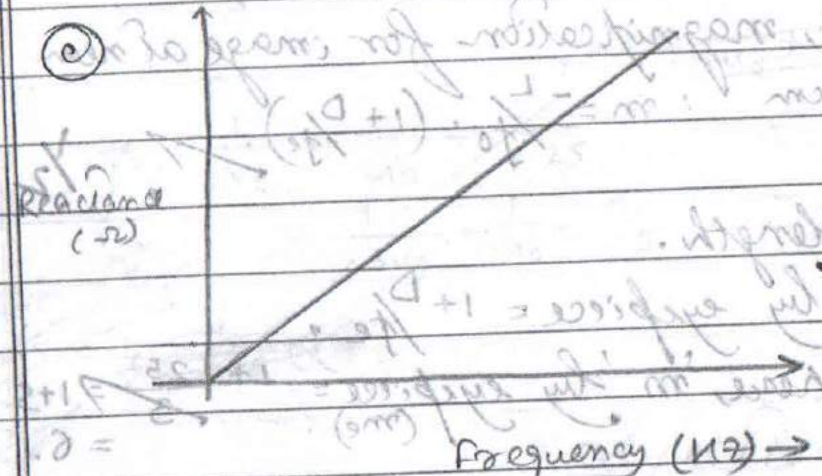
L is inductance of inductor.

$\therefore 6 = 2\pi \times 100 \times L \Rightarrow L = \frac{6}{200\pi} H$

$\therefore L = \frac{{}^{3}6 \times 7}{\frac{200}{100} \times 22} = \frac{21}{22 \times 100} H = 0.954 \times 10^{-2} H$

$\therefore$ inductance $= 0.954 \times 10^{-2} H$ (Ans)

(c)



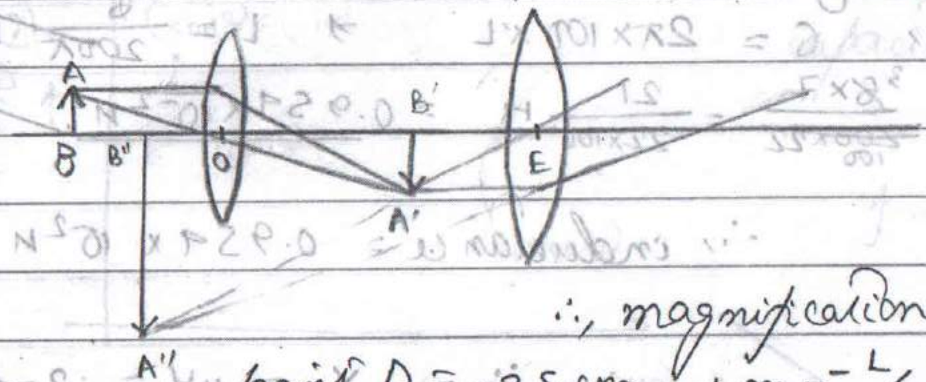
$\because X_L = \omega L = 2\pi f L$,

$\therefore X_L = f \cdot 2\pi L$.

$\therefore$ the graph is a straight line passing through origin.

(31) • The differences in the construction of an astronomical telescope and compound microscope:

In compound microscope, the objective is of smaller aperture and smaller focal length than the eyepiece, but in an astronomical telescope, objective is larger than eyepiece and has a large focal length.



Focal length of objective, $f_o = 1.25$ cm, f_e = Focal length of eyepiece = 5.00 cm.

∴ magnification for image at near point D = 25 cm : $m = -\frac{L}{f_o}\cdot\left(1+\frac{D}{f_e}\right)$.

where, L is tube length.

∴ magnification by eyepiece = $1+\frac{D}{f_e}$,

here, m by eyepiece $(m_e) = 1 + \frac{25}{5} \Rightarrow 1+5 = 6$.

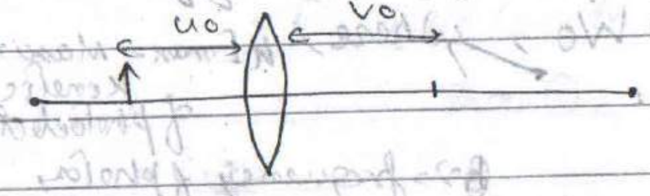
∴ Total magnification $m = m_o \cdot m_e$

$\Rightarrow 30 = m_o \cdot 6 \Rightarrow |m_o| = 5$.
$\Rightarrow m_o = -5$.

~~[∵ final image is formed at D, ∴ from lens formula in eyepiece,~~
~~$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{-25} - \frac{1}{u} = \frac{1}{5} \Rightarrow \frac{1}{u} = -\frac{1}{5} - \frac{1}{25} = \frac{-6}{25}$~~
~~$\Rightarrow u = -\frac{25}{6}$.]~~

P.T.O.

$\therefore m_0 = -5 \Rightarrow \frac{v_0}{u_0} = -5 \Rightarrow v_0 = -5u_0$. [$v_0$ is image distance, u_0 is object distance, for objective]



$\therefore$ for objective,

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

~~$\Rightarrow \frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{1.25} = \frac{4}{5}$~~

~~$\Rightarrow -\frac{1}{5u_0} + \frac{1}{u_0} = \frac{4}{5} \Rightarrow \frac{-1+5}{5u_0} = \frac{4}{5} \Rightarrow \frac{4}{5u_0} = \frac{4}{5}$~~

~~$\Rightarrow u_0 = 1$.~~

$$\therefore \frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{1.25}$$

$$\Rightarrow \frac{1}{-5u_0} - \frac{1}{u_0} = \frac{4}{5} \Rightarrow -\frac{6}{5u_0} = \frac{4}{5} \Rightarrow -\frac{5u_0}{6} = \frac{5}{4}$$

$$\Rightarrow u_0 = -\frac{30}{20} = -\frac{3}{2}.$$

$\therefore$ distance of the object from the objective = 1.50 cm (Ans)

(32) From Einstein's equation of photoelectric effect, we know,

$$KE_{max} = h\nu - W_0$$, where, KE_{max} = Maximum kinetic energy of photoelectrons,
$h\nu$ = frequency of photon,
W_0 = Work function of metal.

$$\Rightarrow KE_{max} = \frac{hc}{\lambda} - W_0 \quad \left[\because \nu = \frac{c}{\lambda}\right].$$

Let, Work function of the metal is W_0.

$\therefore$ When λ_1 wavelength is used,

$$KE_{max_1} = \frac{hc}{\lambda_1} - W_0.$$

When λ_2 wavelength is used,

$$KE_{max_2} = \frac{hc}{\lambda_2} - W_0.$$

$\therefore KE_{max\,2} = 2 \times KE_{max\,1}$,

$$\Rightarrow \frac{hc}{\lambda_2} - W_0 = 2\left(\frac{hc}{\lambda_1} - W_0\right)$$

$$\Rightarrow \frac{hc}{\lambda_2} - W_0 = \frac{2hc}{\lambda_1} - 2W_0$$

$$\Rightarrow W_0 = \frac{2hc}{\lambda_1} - \frac{hc}{\lambda_2} \Rightarrow \boxed{W_0 = hc\left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right)} \text{ ---(1)}$$ 1

This is the expression of work function in terms of λ_1 and λ_2. c = Velocity of light, h = Plank's constant.

P.T.O.

Let, threshold wavelength be λ_0.
It is related to W_0 as $W_0 = \frac{hc}{\lambda_0}$

$\therefore$ from ①, $\frac{hc}{\lambda_0} = hc\left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right)$

$\Rightarrow \frac{1}{\lambda_0} = \frac{2}{\lambda_1} - \frac{1}{\lambda_2} \Rightarrow \frac{2\lambda_2 - \lambda_1}{\lambda_1 \lambda_2}$

$\Rightarrow \boxed{\lambda_0 = \frac{\lambda_1 \lambda_2}{2\lambda_2 - \lambda_1}}$ This is expression of threshold wavelength in terms of λ_1 and λ_2 (Ans)

33 (a)

Half-life	Average life
(i) It is the amount of time of radioactive decay at which half of the nuclei has been decayed and half of the undecayed nuclei are present in the sample.	(i) It is the ~~amount of time~~ ratio of the total life of all the radioactive samples and the total number of nuclei present initially in the sample. It ~~is~~ actually denotes average life time of each nuclei present in the sample.
(ii) It is related to decay constant λ as half-life, $t_{1/2} = \frac{\ln 2}{\lambda}$.	(ii) It is related to decay constant λ as average life, $\tau = \frac{1}{\lambda}$.

(ii) It is less than average life as $t_{1/2} = \tau \ln 2 = 0.693\tau$

(iii) It is more than half life, as $\tau = \frac{t_{1/2}}{\ln 2} = \frac{t_{1/2}}{0.693}$

(6) Time of decay = Average life or mean life = τ.

Let, initial number of sample be N_0.

We know, sample present at time t undecayed,

$$N = N_0 e^{-\lambda t}$$

$\because \tau = \frac{1}{\lambda}$, $\therefore N = N_0 e^{-\lambda\tau} = N_0 e^{-\lambda/\lambda} = N_0 e^{-1} = N_0/e$.

$\therefore$ fraction of amount undecayed

$$= \frac{N_0/e}{N_0} = \frac{1}{e} = 0.368$$

$\therefore$ required fraction = 0.368 (Ans)

P.T.O.

(34) • The function of a solar cell is to convert solar energy (light energy) to electrical energy. 1

•• The solar cell is made of a thick (about 300 μm) p-type region and a thin (about 1 μm) n-type region of a p-n junction diode. Solar photons of energy about 1-1.8 eV are allowed to fall around the depletion region of the diode. It works by three basic processes —

(i) Formation: When photons of appropriate energy range hit the p-n junction depletion region, new electron-hole pairs are generated.

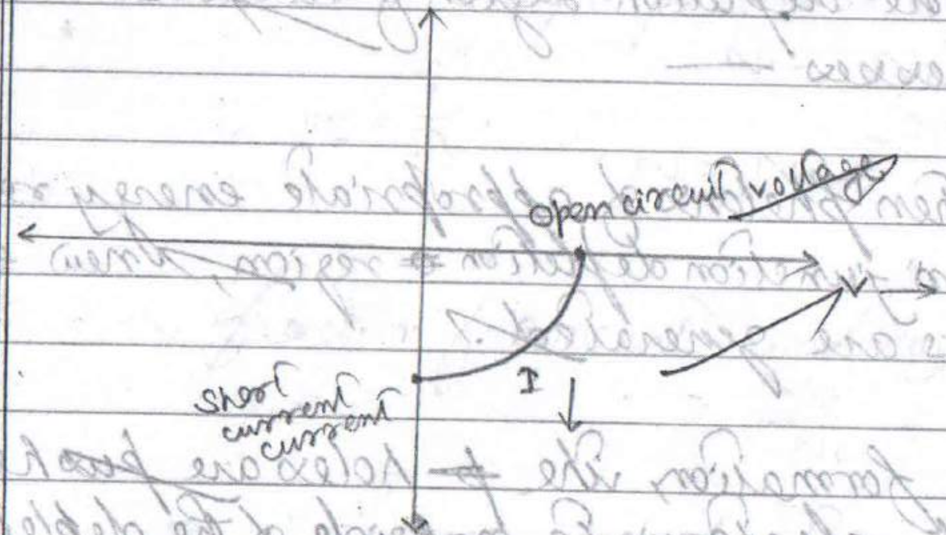
(ii) Separation: On formation, the holes are pushed to p-side and electrons to n-side of the depletion layer by depletion layer electric field acting from n to p.

(iii) Collection: Immediately, the holes are collected by the forward

collector (support) and electrons of n-side by backward support.
So, p-side becomes positive and n-side becomes negative. ½

Hence, electricity can be generated.

I-V characteristics



½

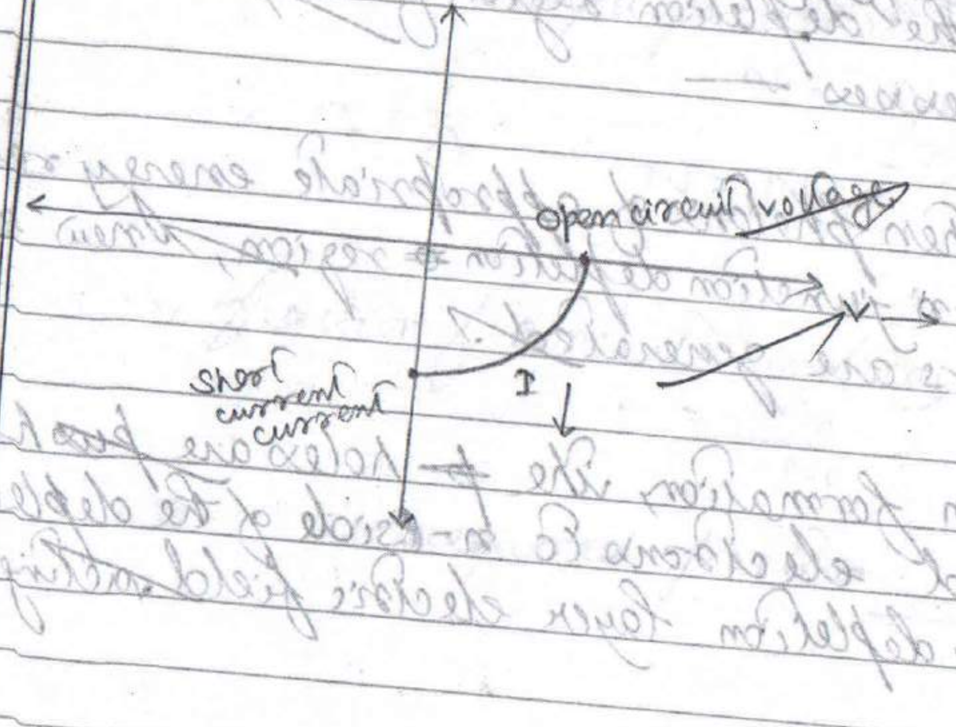
½

———.

collector (support) and electrons of n-side by backward support. So, p-side becomes positive and n-side becomes negative.

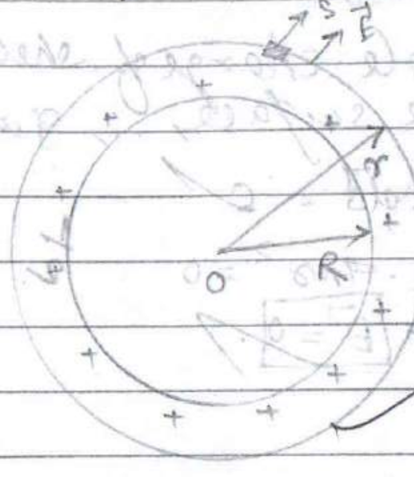
Hence electricity can be generated. ½

I-V characteristic:



(35) (a) Let, a point charge q is situated in a region. Electric field due to q at a radial distance r $= \frac{kq}{r^2}\hat{r} = \frac{q}{4\pi\epsilon_0 r^2}$

Now, consider a uniformly charged spherical shell of radius R, containing charge q.



Let, we take a spherical Gaussian surface of radius $r > R$ centering at centre of shell, say O.

∴ from symmetry of the figure,
(i) magnitude of $\vec{E}$ throughout the Gaussian surface is constant
(ii) The angle between $\vec{E}$ and area vector $\vec{S}$ is constant.

Always, $\vec{E} \parallel \vec{S}$.

So, using Gauss' law for a sphere of radius r,

$$\oint \vec{E}\cdot d\vec{s} = \frac{q_{in}}{\epsilon_0}$$

$$\Rightarrow \oint E\,ds = \frac{q}{\epsilon_0} \quad [\because \vec{E}\cdot d\vec{s} = E\,ds\cos 0^\circ = E\,ds]$$

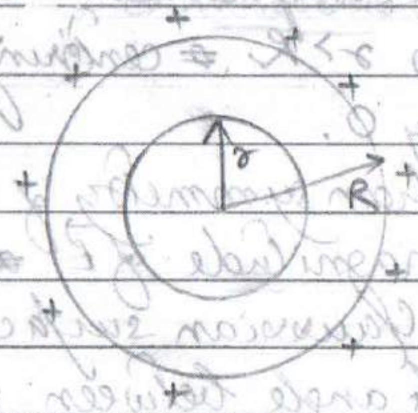
$$\Rightarrow E\cdot 4\pi r^2 = \frac{q}{\epsilon_0} \Rightarrow \boxed{E = \frac{q}{4\pi\epsilon_0 r^2}}.$$

∴ field due to a distance $r = \frac{q}{4\pi\epsilon_0 r^2}$.

∴ the field at distance r is equal to the field as if whole charge Q is placed at its centre O.

Now again, taking Gaussian surface of radius $r<R$, inside the shell,

$$\oint \vec{E}\cdot d\vec{s} = \frac{q_{in}}{\epsilon_0}$$



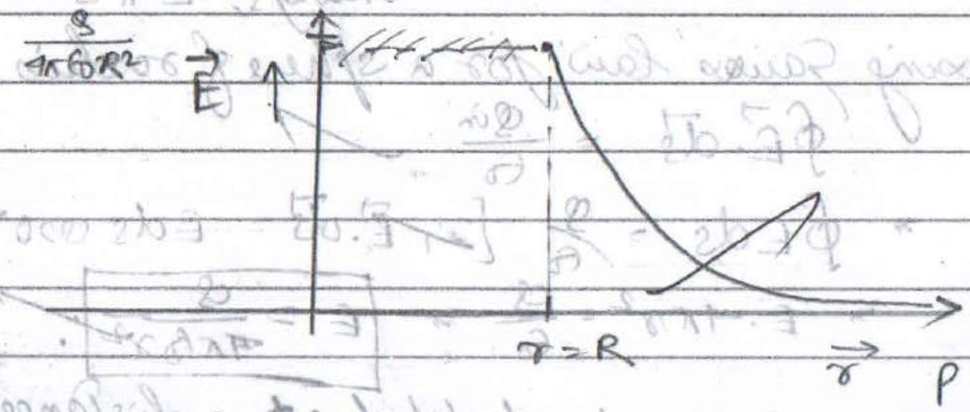
∵ whole charge of shell is at the surface, ∴ $q_{in} = 0$.

$$\Rightarrow \oint \vec{E}\cdot d\vec{s} = 0$$

$$\Rightarrow E \cdot 4\pi r^2 = 0$$

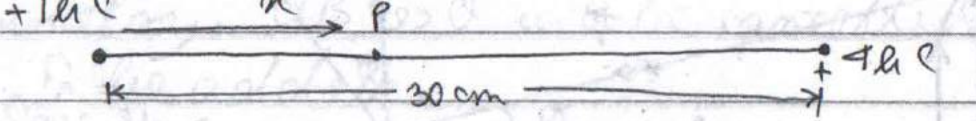
$$\Rightarrow \boxed{\vec{E} = 0}$$

graph:-



P.T.O.

(3)



Let, the electric field is 0 at distance ~~x from~~ x cm from 1μC charge. Let, the point be P.

∴ field at P due to 1μC charge $= \frac{k \times 1\mu C}{x^2}\hat{i}$

field at P due to 4μC charge $= \frac{k \times 4\mu C}{(30-x)^2}(-\hat{i})$

∴ net field is 0,

$$\therefore \frac{k \times 1\mu C}{x^2} = \frac{k \times 4\mu C}{(30-x)^2}$$

$$\Rightarrow \frac{x^2}{(30-x)^2} = \frac{1}{4} \Rightarrow \frac{x}{30-x} = \pm\frac{1}{2}$$

$$\therefore \frac{x}{30-x} = \frac{1}{2} \qquad \frac{x}{30-x} = -\frac{1}{2}$$

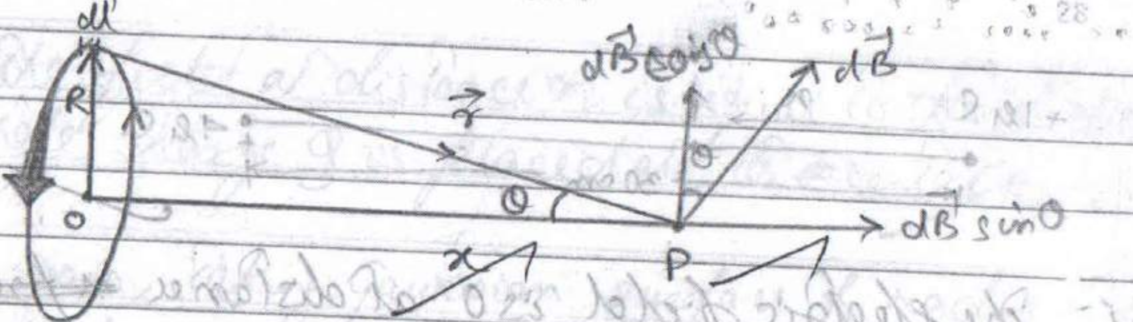
$$\Rightarrow 2x = 30 - x \qquad \Rightarrow 2x = x - 30$$

$$\Rightarrow x = 10 \qquad \Rightarrow x = -30$$

(absurd, since field in same direction)

∴ field is 0 at distance 10 cm ~~from~~ from 1μC charge (Ans)

(36) (a)



Let, a current carrying loop of radius R is carrying current I and placed in y-z plane having centre at O.

We have to find magnetic field at P, a point at a distance x from centre O along x-axis.

∴ let us take a small segment $\vec{dl}$ carrying current I.

∴ $\vec{dB}$ due to this segment at P, by Biot-Savart law,

$$\vec{dB} = \frac{\mu_0 I}{4\pi r^2}\cdot \vec{dl}\times\hat{r}$$

∵ $\vec{dl}$ and $\hat{r}$ are perpendicular ∴ $\vec{dl}\times\hat{r} = dl$.

$$\therefore |\vec{dB}| = \frac{\mu_0 I\, dl}{4\pi r^2}.$$

We see, the magnetic field $\vec{dB}$ is making angle θ with vertical, where θ is semi-vertical angle of cone formed by P and the loop.

By symmetry, $d\vec{B}\cos\theta$ will be cancelled; hence $d\vec{B}\sin\theta$ is only to be added,

$$\therefore d\vec{B}\sin\theta = \frac{\mu_0 I\,dl}{4\pi r^2}\sin\theta$$

But $\frac{x}{r} = \cos\theta \Rightarrow r = x\sec\theta \Rightarrow r^2 = x^2\sec^2\theta = (R^2+x^2)$.

$$\therefore d\vec{B} = \frac{\mu_0 I\,dl}{4\pi(R^2+x^2)}\cdot\frac{R}{(R^2+x^2)^{1/2}}$$

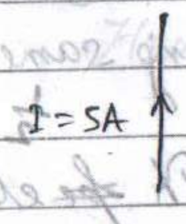
$$\therefore \text{total field } \vec{B} = \int d\vec{B} = \frac{\mu_0 I R}{4\pi(R^2+x^2)^{3/2}}\cdot\int dl$$

$$= \frac{\mu_0 I R}{4\pi(R^2+x^2)^{3/2}}\cdot 2\pi R$$

$$\boxed{\vec{B} = \frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}\hat{i}}$$

∴ This is expression of magnetic field.

(b)



∴ earth's magnetic field $= 0.6\times10^{-4}$ T,
angle of dip $= \pi/6$,

∴ vertical component $= 0.6\times10^{-4}\times\sin\pi/6$
$= 0.3\times10^{-4}$ T.

∴ The rod carries current from north to south and horizontal component of earth's magnetic field is parallel to it, force due to this component = 0.

The vertical component is pointing downward ~~say (k̂)~~. So it will exert force.

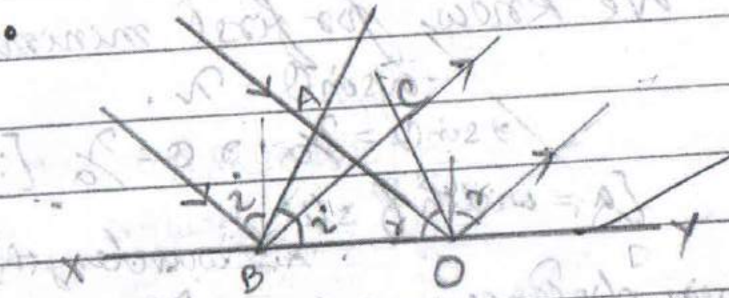
∴ The force on the rod = $|I(\vec{l} \times \vec{B})|$
$= |5 \times lB \sin 90°|$
$= 5lB = (5 \times 2 \times 0.3 \times 10^{-4})N$
$= 0.3 \times 10^{-3} N.$

∴ magnitude of force = $0.3 \times 10^{-3} N.$
direction according to Fleming's left hand rule: east to west (Ans)

(37) (OR) (a) • The locus of all the points in a medium travelling with same frequency and having same phase is called a wavefront.

•• It propagates along the wave, with ~~the~~ electric and magnetic fields perpendicular mutually and to the direction of wave propagation. It is perpendicular to the ~~wav~~ ray direction.

Q)



Let, us consider, a plane wavefront AB incident on plane XY at angle of incidence i. The rays are perpendicular to the wavefront.

By the time ray AO reaches O, ray from B ~~BC~~ has travelled a distance ct ~~along~~.

So, drawing an ~~a~~ arc from B and drawing tangent from O on it, it cuts BC at C. ∴ $AO = BC$ (1) [as speed of wave is same]. $\angle ABO = i$, $\angle AOB = r$. r is the angle of reflection.

∴ in $\triangle ABO$ and $\triangle BCO$,

$AO = BC$ [From (1)]

$BO = BO$,

$\angle BAO = \angle BCO$ [90°]

∴ $\triangle ABO \cong \triangle BCO$.

∴ $\angle ABO = \angle AOB$. ∴ $\boxed{\angle i = \angle r}$.

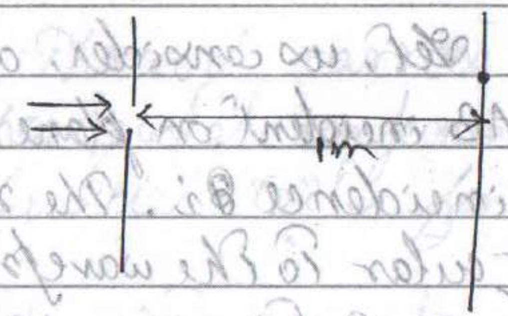
Hence, law of ~~refract~~ reflection is proved.

In the figure, the reflected wavefront is OC.

P.T.O.

10

(6)



• We know, for first minimum,

$a \sin\theta = \lambda$.

$\Rightarrow \sin\theta = \lambda/a \Rightarrow \theta = \lambda/a$ [$\because \theta$ is very small]

[a = width of slit, λ = wavelength].

$\therefore$ linear distance $= D\theta = D\lambda/a$.

[D is distance between slit and screen].

Here, $D\lambda/a = 2.5$ mm

$\Rightarrow \frac{1 \times 500 \times 10^{-9}}{a} = 2.5 \times 10^{-3}$

$\Rightarrow a = \frac{500 \times 10^{-9}}{2.5 \times 10^{-3}} = 200 \times 10^{-6}$ ~~m~~ $\Rightarrow 2 \times 10^{-4}$ m $= 0.2$ mm

$\therefore$ slit width $= 0.2$ mm (Ans i)

Now, angular distance ~~from se~~ for first secondary maximum:

~~θ~~ $a \sin\theta = 3\lambda/2 \Rightarrow \theta = \frac{3\lambda}{2a}$.

$\therefore$ linear distance $= \frac{3\lambda D}{2a}$.

$\therefore$ linear distance $= \frac{3}{2} \lambda \frac{D\lambda}{a} = \frac{3}{2} \times 2.5$ mm

$= 3.75$ mm

$\therefore$ distance $= 3.75$ mm (Ans ii)