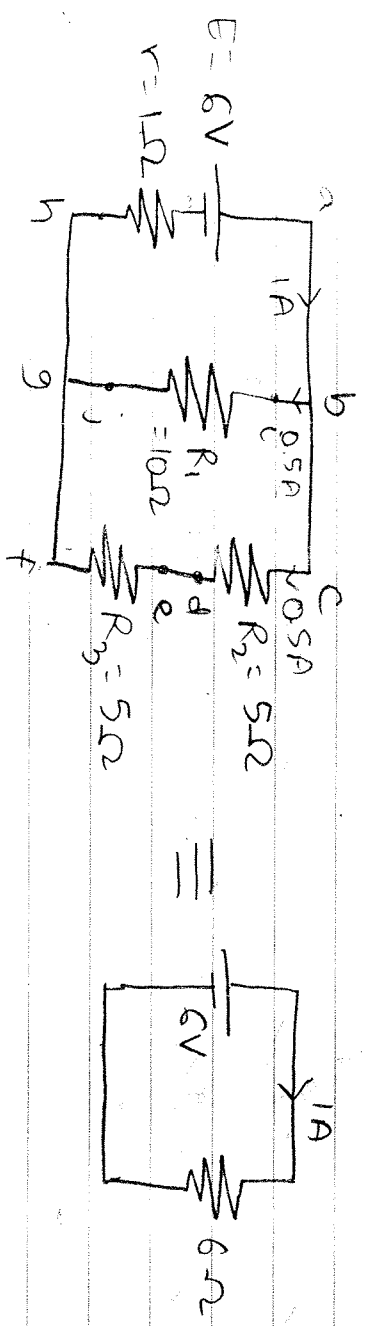


# **Class-XII**

# **Physics(042)**

Section - E

34.



a) Points having the same potential are:

i) a, b, c, i ✓

ii) h, g, f, j ✓

iii) d, e ✓

b)  $R_{eff} = 6\Omega \Rightarrow I_{tot} = 1A$

Current splits equally between arms bg and cf

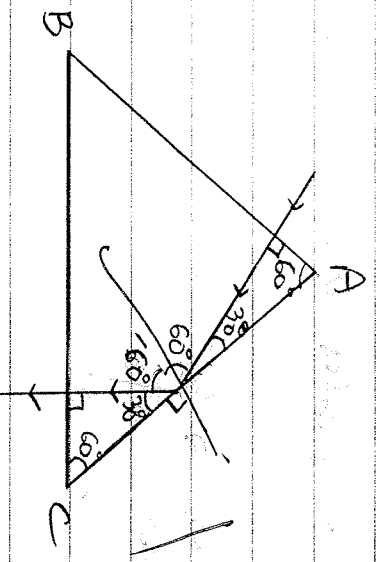
$$\therefore I_{bg} = 0.5A \quad \checkmark$$

c)  $I_{cp} = 0.5A = I_3$

$$\therefore V_3 = I_3 R_3 = 0.5 \times 5 = 2.5V \quad \checkmark$$

The potential difference across resistor  $R_3$  is 2.5V

b5.  $\mu = 2.41, \epsilon_c = 24.5$



$(60^\circ > 24.5^\circ)$   
 $\Rightarrow$  Total internal reflection occurs

b)  $V = \frac{C}{\mu} = \frac{3 \times 10^8}{2.41} \approx 1.245 \times 10^8 \text{ m/s}$

241 | 241  
 590  
 488  
 102  
 150

$\log 3 = 0.4771$   
 $\log 2.41 = 0.382$   
 $-0.0951$   
 0.382

c) Total internal reflection is the phenomenon in which a ray of light moving from an optically denser to an optically rarer medium and incident on the interface of the two media at an angle greater than the critical angle for the pair of media, is reflected back into the same medium entirely.

The two conditions necessary for its occurrence are:

- The ray of light should be moving from a denser medium to a rarer medium.
- The angle of incidence should be greater than the critical angle.

$$i > i_c, \text{ where } \sin i_c = \frac{\mu_{\text{rarer}}}{\mu_{\text{denser}}} \Rightarrow i_c = \sin^{-1} \frac{\mu_r}{\mu_d}$$

SECTION-D:

## Q1. a) (i) INTERFERENCE PATTERN

The intensity of the bright fringes is the same for all the maxima.

- The ~~er~~ fringe width of the ~~central~~ maxima is equal to that of the other maxima / bright fringes.

## DIFFRACTION PATTERN

The intensity of the bright fringes decreases as the distance from the central maxima ~~increases~~.

- The width of the central maxima is twice that of the secondary maxima.

$$(2) \quad \beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \lambda, \quad \beta \propto D, \quad \beta \propto \frac{1}{d}$$

Fringe width in Young's Double Slit Experiment depends on :

- The distance between the two slits, and the distance between the slits and screen.
- The wavelength of light used.

Topic: Optics, Chapter: Ray Optics and Optical Instruments

(ii)  $d = 100 \lambda$

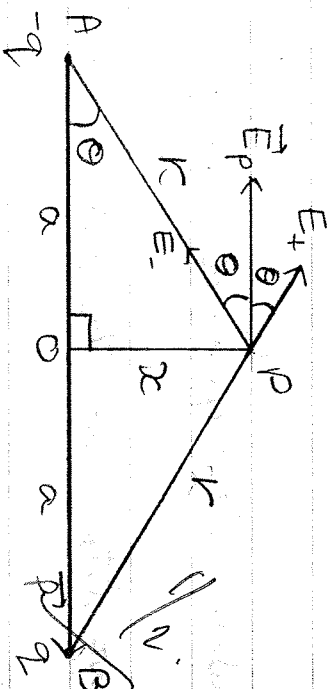
(1)  $\theta = \frac{\lambda}{d} = \frac{\lambda}{100 \lambda} = \frac{1}{100} \text{ rad}$  (∵ Central maxima -  $\theta = 0$   
First maximum -  $\theta = \frac{\lambda}{d}$ )

(2)  $D = 50 \text{ cm}$

Distance between the maxima =  $\theta \times D = \frac{1}{100} \times 50 \text{ cm}$

= 0.5 cm or 5 mm

32. b) (i)



Considers an electric dipole of dipole moment  $\vec{P}$ , separated consisting of 2

charges  $q$  and  $-q$  separated by a distance  $2a$ .

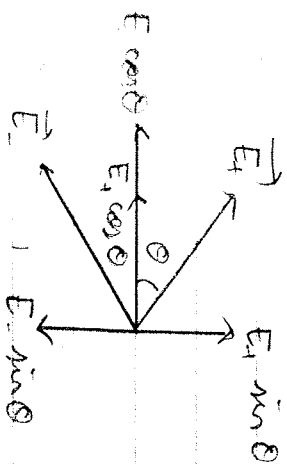
The equatorial <sup>plane</sup> ~~line~~ is the perpendicular bisector of the dipole.

Consider a point  $P$  on the equatorial plane, at a distance  $r$  from the midpoint of the dipole  $\odot$ .

$$\vec{E}_P = \vec{E}_+ + \vec{E}_-$$

$$E_+ = E_- = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \quad \checkmark$$

Resolving  $\vec{E}_+$  and  $\vec{E}_-$  into their rectangular components:



The vertical components cancel out, leaving only the horizontal components.

~~$$\vec{E} = \vec{E}_+ + \vec{E}_- = E_+ \cos \theta + E_- \cos \theta$$~~

$$E_+ = E_- \Rightarrow E = 2E_+ \cos \theta$$

From  $\Delta PAO$ ,  $\cos \theta = \frac{a}{r}$

$$\therefore E = 2 \times \frac{1}{4\pi\epsilon_0} \frac{q \times a}{r^2} = \frac{(q \cdot 2a)}{4\pi\epsilon_0 r^3}$$

$P = \text{charge} \times \text{distance} = q \times 2a$

Also, from  $\Delta PAO$ ,  $r = \sqrt{a^2 + x^2}$

$$\therefore E = \frac{P}{4\pi\epsilon_0 (\sqrt{a^2 + x^2})^3}$$

$$E = \frac{P}{4\pi\epsilon_0 (a^2 + x^2)^{3/2}}$$

$$\vec{E} = \frac{-\vec{P}}{4\pi\epsilon_0 (a^2 + x^2)^{3/2}}$$



(ii) For a far off point,  $x \gg a \Rightarrow E = \frac{\rho}{4\pi\epsilon_0 x^3} \Rightarrow E \propto \frac{1}{x^3}$

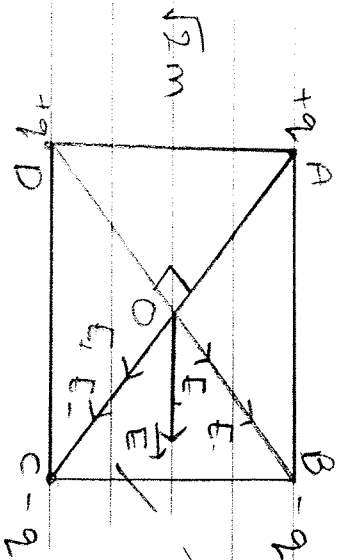
Distance is halved, i.e,  $x \rightarrow \frac{x}{2}$

$$E = \frac{1}{x^3}$$

$$E' = \frac{1}{(x/2)^3} = \frac{8}{x^3} \Rightarrow E' = 8E$$

Electric field will be 8 times its initial value.

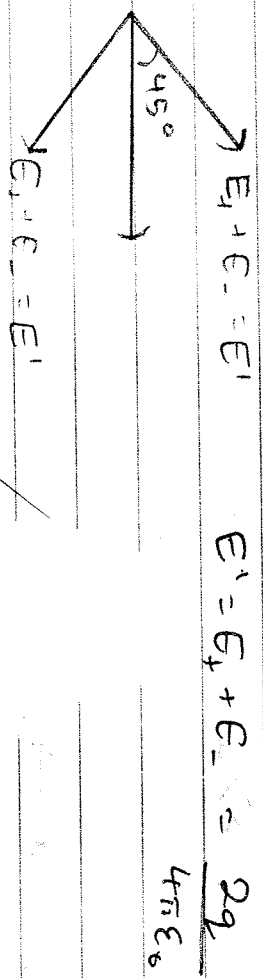
(iii)



$$s = \sqrt{2} \text{ m} \Rightarrow AC = BD = \sqrt{2+2} = 2 \text{ m}$$

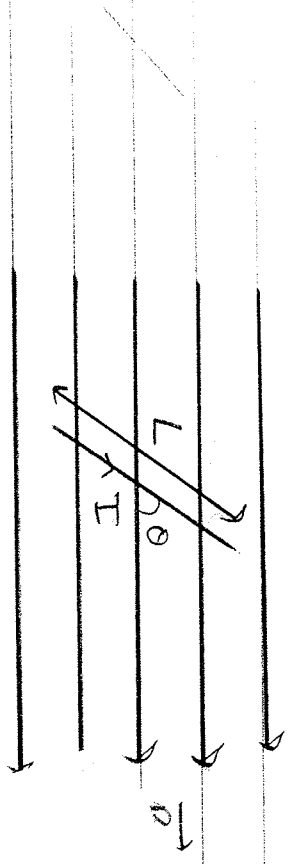
$$\therefore AO = BO = CO = DO = 1 \text{ m}$$

$$E_A = E_B = E_C = E_D = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} = \frac{q}{4\pi\epsilon_0}$$



$$E = \sqrt{E_1^2 + E_1^2 + 2E_1^2 \cos 90^\circ} = E' \sqrt{2} = \frac{2\sqrt{2} q}{4\pi \epsilon_0}$$

Thus  $E$  at  $O$  is  $\frac{2\sqrt{2} q}{4\pi \epsilon_0}$  or  $\frac{\sqrt{2} q \sqrt{2}}{2\pi \epsilon_0}$  in the direction  $\vec{AB}$



$$P = q \cdot 2 \Rightarrow q = \frac{P}{2}$$

$$\therefore E_0 = \frac{\sqrt{2} P}{4\pi \epsilon_0} \text{ in } \vec{AB} \text{ direction}$$

33. b) (i)

Consider a straight conductor of length  $L$  carrying current  $I$ , placed in a magnetic field  $\vec{B}$  at an angle  $\theta$  to the field.

Let  $\vec{F}$  be the force on a single electron.

$$\vec{F}_e = -e (\vec{v}_d \times \vec{B}) \quad (\text{Lorentz force, where } e \text{ is magnitude of charge of the electron})$$

$$= e (-\vec{v}_d \times \vec{B}) \quad \checkmark$$

Summing up the forces on all the electrons, considering  $N$  <sup>free</sup> electrons in the conductor,

$$\vec{F} = Ne (-\vec{v}_d \times \vec{B}) = Ne v_d (-\hat{v}_d \times \vec{B}), \quad \text{where } \hat{v}_d \text{ is the unit vector in the direction of } \vec{v}_d$$

$$v_d = \frac{I}{n e A} \quad \Rightarrow I = n e A v_d, \quad \text{where } n \text{ is the number free electron density}$$

$$n = \frac{N}{V}$$

$$\vec{F} = (nV) e v_d (-\hat{v}_d \times \vec{B}) \Rightarrow \vec{F} = n A L e v_d (-\hat{v}_d \times \vec{B})$$

$$\vec{F} = I L (-\hat{v}_d \times \vec{B}) \quad (\because n e A v_d = I)$$

$\vec{L}$ , in the direction of current, is opposite to  $\vec{V}_d$ .

$$\Rightarrow \vec{L} = -\vec{V}_d$$

$$\therefore \vec{F} = I L (\vec{L} \times \vec{B})$$

$$\Rightarrow \vec{F} = I L (\vec{L} \times \vec{B}) \quad \checkmark \quad ( \vec{L} = \vec{L} ) \quad , \quad F = I L B \sin \theta$$

→ The rule used to find the the direction of the force is  Fleming's Left Hand Rule.

The rule states that "When the thumb, index finger and middle finger of the left hand are stretched such that they are mutually perpendicular, the ~~index~~ index finger points in the direction of current, the index finger in the middle direction of the magnetic field, and the thumb in the direction of the force exerted on the current carrying conductor".

$$F = I L B \sin \theta$$

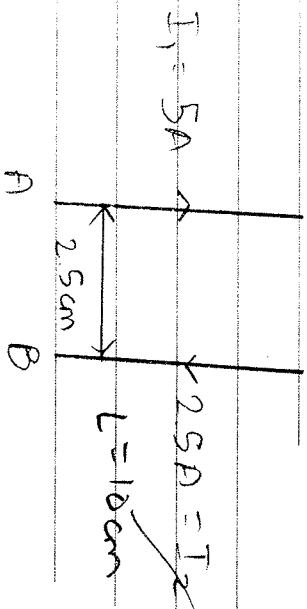
(1) Force is maximum when the conductor is perpendicular to the direction of magnetic field.

$$\theta = 90^\circ \Rightarrow \sin \theta = 1 \Rightarrow F = ILB$$

(2) Force is minimum when the conductor is parallel to the direction of magnetic field.

$$\theta = 0^\circ \Rightarrow \sin \theta = 0 \Rightarrow F = 0$$

(ii)



$$|\vec{F}| = BIL = \frac{\mu_0 I_1 \times I_2 \times L}{2\pi r} = \frac{4\pi \times 10^{-7} \times 5 \times 2.5 \times 10^{-2}}{2\pi \times 2.5 \times 10^{-2}} = 10^{-3} \times 10^{-7} = 10^{-5} \text{ N}$$

SECTION - C

26.  $V_m = 310 \text{ V}, f = 50 \text{ Hz}$

$\omega = 2\pi f \Rightarrow \omega = 2\pi \times 50 = 100\pi \text{ rad/s}$

$V = 310 \sin 100\pi t \text{ V}$

$C = 15 \mu\text{F}$

(i)  $X_C = \frac{1}{\omega C} = \frac{1}{100\pi \times 15 \times 10^{-6}} = \frac{10^4}{15\pi} = 212.3 \Omega$

(ii)  $I_m = \frac{V_m}{X_C} = \frac{310 \times 15\pi}{10^4} = \frac{465\pi}{1000} \text{ A} = 0.465\pi \text{ A}$   
 ~~$= 1.46 \text{ A}$~~

Current in a capacitor leads the voltage by  $\frac{\pi}{2}$

$I = 0.465\pi \sin(\omega t + \frac{\pi}{2}) \text{ A}$

$0.465 = 46.5 \times 10^{-2}$   
 $-2 + \log 46.5$   
 $-2 + 0.6675$   
 $\log 3.14 = -1.5 \log 3.14$   
 $= -0.4969$

$\log 3.14 = -1.5 \log 3.14$   
 $= -0.4969$

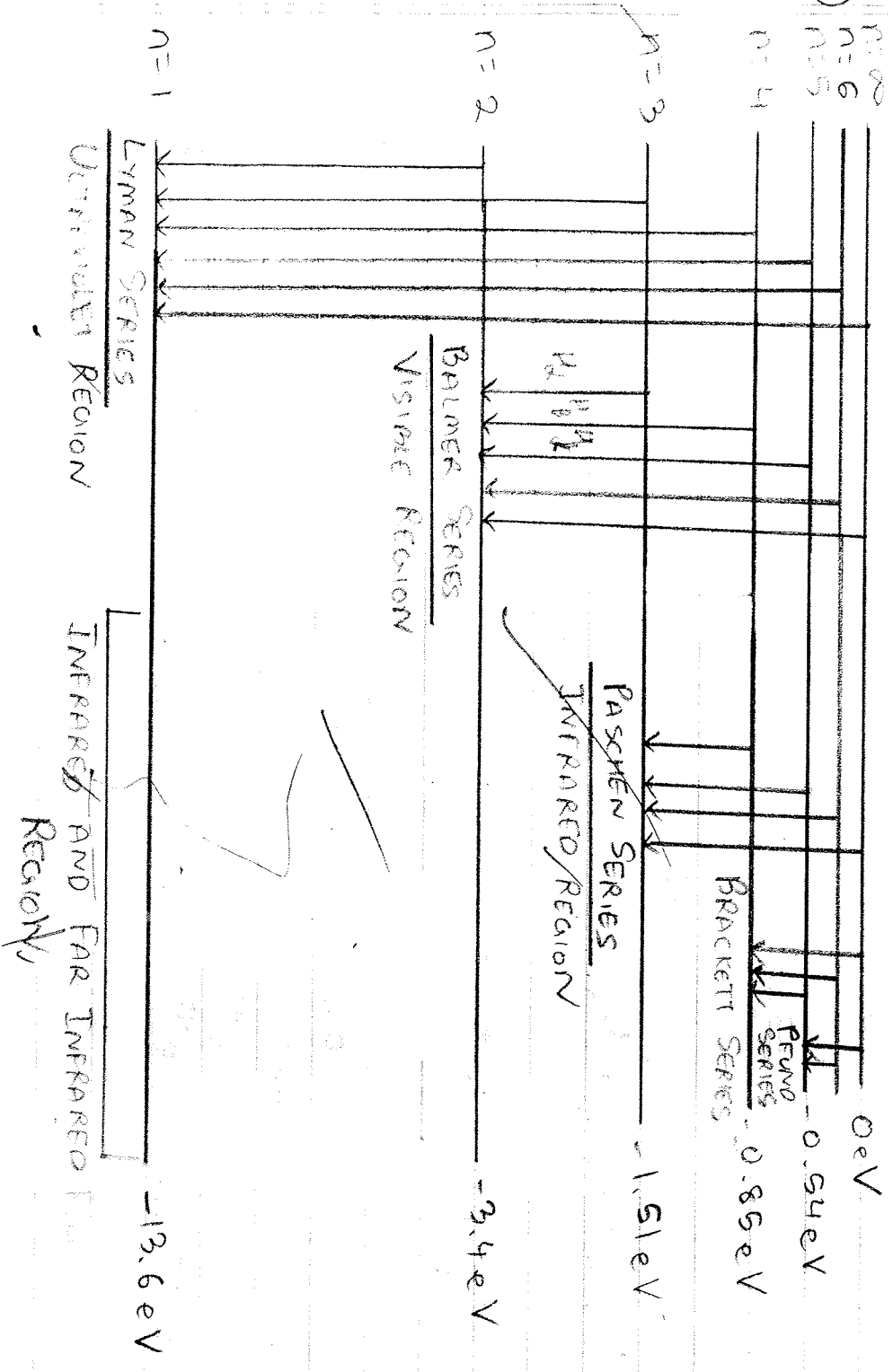
$-2 + 0.1644$   
 $= -1.8356$   
 $2.123 \times 10^3$   
 $212.3$

$4 - \log(45\pi)$   
 $= 4 - \log 15 - \log \pi$   
 $= 4 - 1.1761 - 0.4969$   
 $= 2.327$

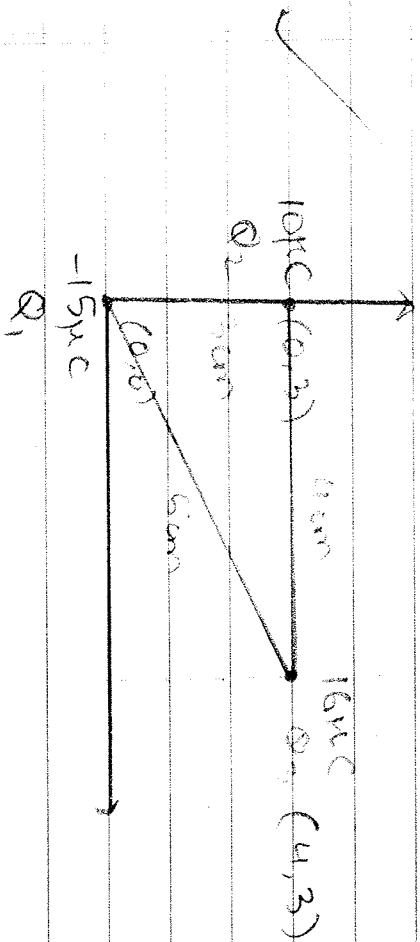
$2.123 \times 10^3$   
 $212.3$

$I = 0.465 \pi \text{ cm } 100\pi \text{ t A on } \lambda = 1.46 \text{ cm } 3.14 \text{ t A}$

27. a)



28.



Distances in cm

$$U = U_{Q_1, Q_2} + U_{Q_1, Q_3} + U_{Q_2, Q_3}$$

$$= \frac{1}{4\pi\epsilon_0} \left( \frac{Q_1 Q_2}{r_{12}} + \frac{Q_1 Q_3}{r_{13}} + \frac{Q_2 Q_3}{r_{23}} \right)$$

$$= \frac{1}{4\pi\epsilon_0} \left( \frac{-15 \times 10^{-6} \times 10 \times 10^{-6}}{3 \times 10^{-2}} + \frac{10 \times 10^{-6} \times 16 \times 10^{-6}}{4 \times 10^{-2}} + \frac{-15 \times 10^{-6} \times 16 \times 10^{-6}}{8 \times 10^{-2}} \right)$$

$$= \frac{10^{-10}}{4\pi\epsilon_0} \left( \frac{-150 + 40 - 50 + 40 - 48}{3} \right)$$



$$= 9 \times 10^{-1} \times -58 = -52.225$$

$\therefore$  V of system = 52.225

29. b) At resonance,  $I_m$  is maximum.

$$I_m = \frac{V_m}{Z} \Rightarrow Z \text{ should be minimum}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}, \quad Z \text{ will be minimum when } X_L = X_C, \text{ i.e., } Z_{\min} = R$$

$$\therefore X_L = X_C$$

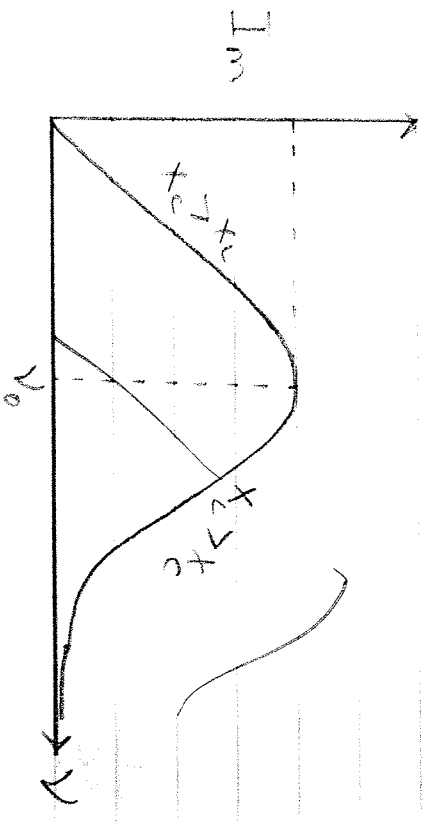
$$L\omega_0 = \frac{1}{C\omega_0} \Rightarrow \omega_0^2 = \frac{1}{LC}$$

$$\omega_0 = \frac{1}{\sqrt{LC}}, \quad \text{where } \omega_0 \text{ is the resonant angular frequency}$$

$$V = \frac{V_0}{2\pi} \Rightarrow V_0 = \frac{1}{2\pi} \frac{1}{\sqrt{LC}} \Rightarrow V_0 = \frac{1}{2\pi\sqrt{LC}} \text{ where } V_0 \text{ is the resonant frequency}$$

→  $V_0$  (resonant frequency) depends on :

- Inductance of the inductor
- Capacitance of the capacitor



→

3

30.  $\lambda_{dB} = 1.2 \text{ nm}$ ,  $KE \rightarrow 4 \text{ KE}$

$$\lambda_{dB} = \frac{h}{p} = \frac{h}{\sqrt{2mKE}} \Rightarrow \lambda_{dB} \propto \frac{1}{\sqrt{KE}}$$

$$\lambda \propto \frac{1}{\sqrt{KE}} \quad \Rightarrow \quad \lambda' = \frac{1}{2\sqrt{KE}} \times \lambda \times \sqrt{KE} = \frac{\lambda}{2}$$

$$\therefore \lambda'_{dB} = \frac{\lambda}{2} = \frac{0.6 \text{ nm}}{2}$$

### Section-B

19.  $R_1 = 20 \text{ cm}$ ,  $R_2 = 30 \text{ cm}$ ,  $P = \frac{25}{6} \text{ D} \Rightarrow f = \frac{6}{25} \text{ m} = \frac{6 \times 100 \text{ cm}}{25} = 24 \text{ cm}$

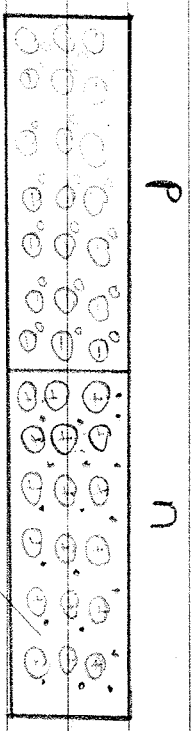
$$\frac{1}{f} = (\mu_g - 1) \left( \frac{1}{R_1} + \frac{1}{R_2} \right) \sqrt{N}$$

$$\frac{1}{24} = (\mu_{g-1}) \left( \frac{1}{20} + \frac{1}{30} \right) \Rightarrow \frac{1}{24} = (\mu_{g-1}) \left( \frac{5}{60} \right)$$

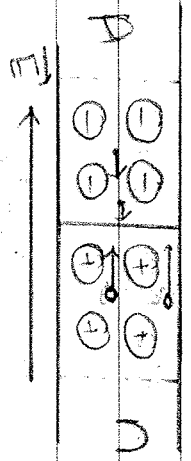
$$\mu_{g-1} = \frac{60}{5} \times \frac{1}{24} = \frac{1}{2} \Rightarrow \mu_g = 1 + \frac{1}{2} = \frac{3}{2}$$

$\therefore$  The refractive index of the glass is  $\frac{3}{2}$  or 1.5

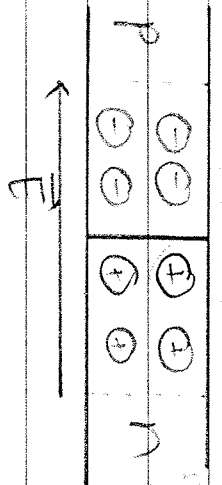
20.



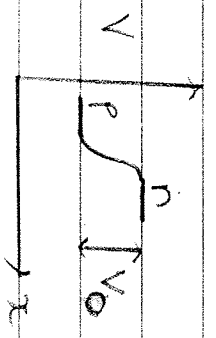
In a p-n junction, the p-side has an excess of holes, and the n-side has an excess of electrons. Due to this concentration gradient, these majority charge carriers diffuse to the other side. The diffusing holes and electrons recombine at the junction, depleting the number of charge carriers near the junction as a result of the diffusion current. The immobile donor and acceptor ions remain, and create an electric field due to the absence of the majority charge carriers.



The electric field created is in the  $n \rightarrow p$  direction. As a result, the minority charge carriers experience a force and move ~~forward~~ towards the junction and recombine. This depletes all the charge carriers near the junction, creating a depletion region. This movement of the minority charges due to the electric field constitutes the drift current.



The electric field leads to the creation of a potential barrier, which makes it difficult for majority charge carriers to move to the other side of the junction.



21.  $\vec{v} = (3 \times 10^5 \hat{e}) \text{ m/s}$ ,  $\vec{B} = 0.4 \hat{e} + 0.3 \hat{g}$  T,  $q = 4.8 \times 10^7 \text{ C/kg}$

$$\vec{F} = q(\vec{v} \times \vec{B}) \Rightarrow \vec{a} = \frac{\vec{F}}{m} = \frac{q}{m} (\vec{v} \times \vec{B})$$

$$\vec{a} = 4.8 \times 10^7 (3 \times 10^5 \hat{e} \times (0.4 \hat{e} + 0.3 \hat{g}))$$

$$= 4.8 \times 10^7 \times 3 \times 10^5 \times 0.3 \hat{k} \quad (\because \hat{e} \times \hat{e} = 0, \hat{e} \times \hat{g} = \hat{k})$$

$$\vec{a} = (4.32 \times 10^{12} \hat{k}) \text{ m/s}^2$$

22.  $-1.51 \text{ eV} - n \approx 3$

↓

$$-3.4 \text{ eV} - n = 2$$

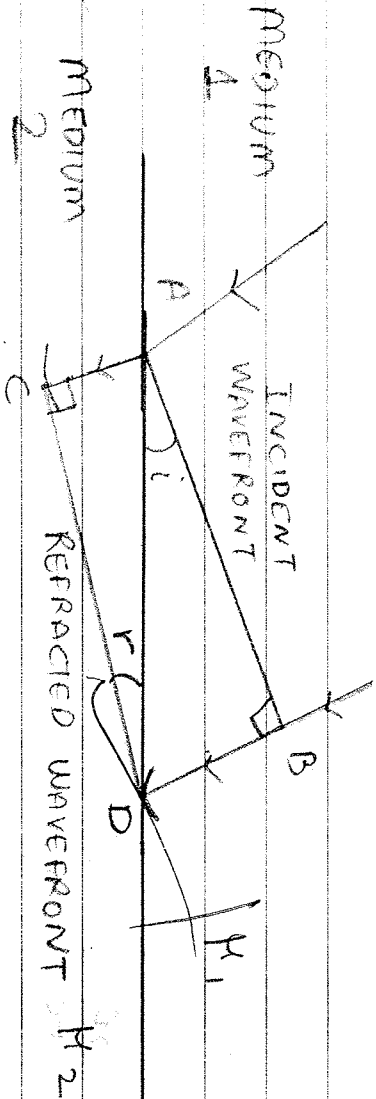
$$\frac{1}{\lambda} = R \left( \frac{1}{2^2} - \frac{1}{3^2} \right) = R \left( \frac{1}{4} - \frac{1}{9} \right) = \frac{5R}{36}$$

748  
9  
43.2

$4.8 \times 10^7 \times 3 \times 10^5$

$$\lambda = \frac{36}{5} \times \frac{1}{R} = \frac{36}{5} \times 911 \text{ \AA} = 0.2 \times 911 \text{ \AA}$$

$$\lambda = 6559.2 \text{ \AA} = 655.92 \text{ nm}$$



By Huygen's principle, the new wavefront is the forward surface tangent/envelope of the secondary wavelets.

→ Let the refractive index in the first medium be  $\mu_1$ , and that in the second medium be  $\mu_2$ . The speed of light in the former is  $v_1$ , and in the latter is  $v_2$ .

The distances AC and BD are traversed in the same time  $t$

23. a)

$$\begin{array}{r} 911 \\ \times 0.2 \\ \hline 1822 \\ 63770 \\ \hline 6559.2 \end{array}$$

$$AC = v_2 t, \quad BD = v_1 t$$

$$\text{In } \triangle ABD, \quad \mu_{nr} = \frac{BD}{AD}$$

$$\text{In } \triangle ACD, \quad \mu_{nr} = \frac{AC}{AD}$$

$$\frac{\mu_{nr}}{\mu_{nr}} = \frac{BD/AD}{AC/AD} = \frac{BD}{AC} = \frac{v_1 t}{v_2 t} = \frac{v_1}{v_2}$$

$$\frac{\mu_{nr}}{\mu_{nr}} = \frac{v_1}{v_2}$$

By definition,  $\mu_2 = \frac{v_1}{v_2}$  ( $\because \mu_2 = \frac{c}{v_2}, \mu_1 = \frac{c}{v_1}$ )

$$\therefore \frac{\mu_{nr}}{\mu_{nr}} = \frac{\mu_2}{\mu_1}$$



Hence Snell's Law is verified

24. ~~Microscopes~~

a) Infrared

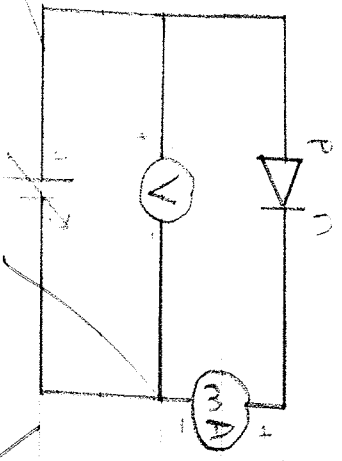
Use: RADAR navigation systems

Use: ~~penetrate~~ and switches  
Cancer in mist / fog conditions

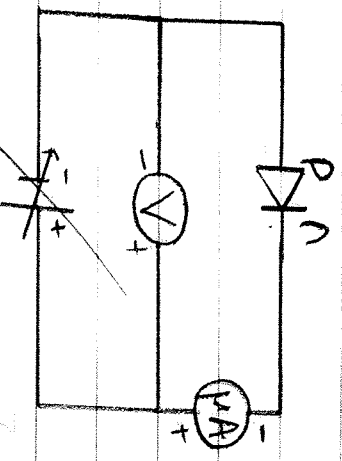
b) X-rays

Use: Diagnostic test in medicine, studying crystal structure

25. b)



FORWARD BIAS

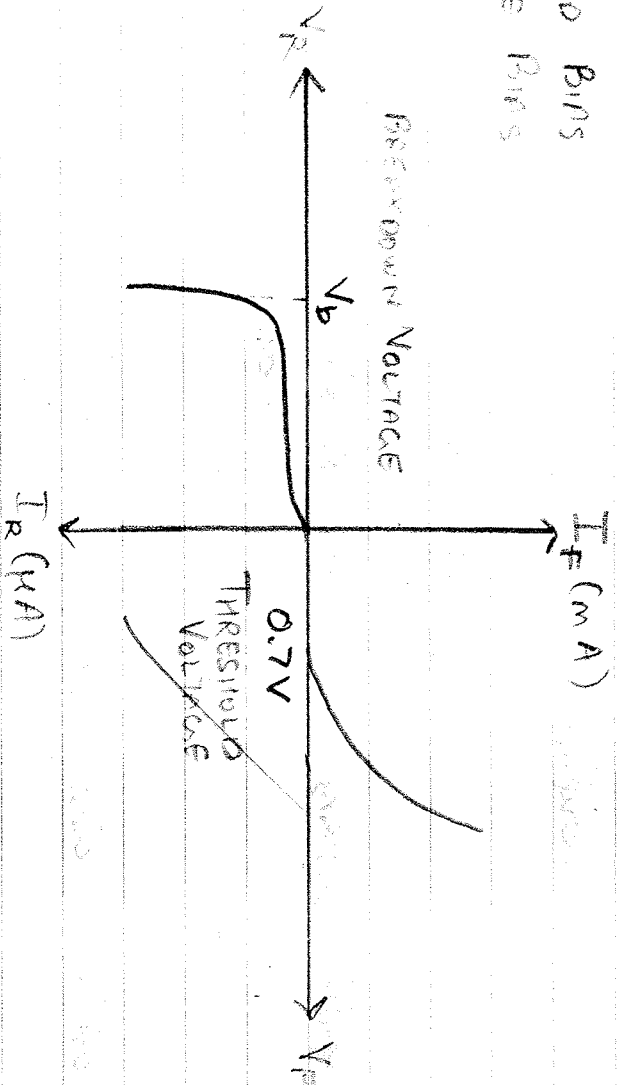


REVERSE BIAS

- ↗ - VARIABLE BATTERY
- V - VOLTMETER
- mA - MILLIAMMETER
- μA - MICROAMMETER
- ▷ - DIODE

These are the circuits used for studying a diode's V-I characteristic

F - FORWARD BIAS  
 R - REVERSE BIAS



SECTION - A

✓ 100 eV ✓

Q.  $J = \frac{I}{A}$ , A increases  $\Rightarrow$  J decreases,  $J = neV_d \Rightarrow J \propto V_d \Rightarrow V_d$  decreases

$$\frac{I}{neA} = V_d \Rightarrow V_d \propto \frac{1}{A}$$



c) 0.19 V

8) 1:1 (Nuclear density is a constant)

9) b)  $\frac{E}{8}$

( $\because E \propto \frac{1}{r^3}$ ,  $r \rightarrow 2r \Rightarrow E \rightarrow \frac{E}{8}$ )  
in next suppose.

10)  $\frac{dN}{dt} = 3.3 \times 10^{19}$ ,  $I = \frac{dq}{dt} = e \frac{dN}{dt} = 3.3 \times 10^{19} \times 1.6 \times 10^{-19} = 5.28 A$

d) 5.3 A

11) b) it becomes a p-type semiconductor

12) a) repelled by both the poles

13) d) Diamond to ash ( $\mu_d > \mu_g > \mu_w > \mu_a$ ), ( $\mu \propto \frac{1}{\epsilon} = \frac{N}{\epsilon_0} \Rightarrow \epsilon \downarrow, \mu \uparrow$ )

14) c) less than  $g$  (Induced current creates a magnetic field opposing change in flux)

16  
32  
48  
54  
54

15 ~~R~~  $\cancel{SA} \rightarrow R \times A \rightarrow R \times R^2$      $R = \frac{9L}{A} \Rightarrow R \times 1 \Rightarrow R \times \frac{1}{r^2}$

c) ✓

b) A & R are true but R is not the correct explanation of A.

7) ~~A & R are true but R is not the correct explanation of A.~~ d) A is false and R is also false (Copper is diamagnetic and repels field lines)

18) a) A & R are true and R is the correct explanation of A.

— X —

