PRACTICE PAPER-2 (SOLUTION)

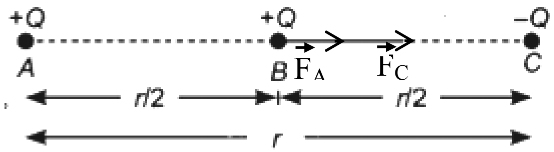
CLASS: XII

SUBJECT : PHYSICS

SECTION-A

1. (c) Initially, force between A and C,

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



When a similar sphere B having charge +Q is kept at the mid-point of line joining A and C, then net force on B is

$$F_{net} = F_A + F_C = \frac{kQ^2}{\left(r/2\right)^2} + \frac{kQ^2}{\left(r/2\right)^2}$$

$$F_{net} = \frac{8kQ^2}{r^2}$$

$$F_{net} = 8F$$

The direction is shown in figure. **[1]**

2. (d) On the equipotential surface, electric field is normal to the charged surface (where potential exists) so that no work will be done. **[1]**

3. (a) Drift velocity $v_d = \frac{eE\tau}{m}$, i.e. $v_d \propto E$ **[1]**

4. (a) equal for both **[1]**

5. (c) Net force on a current carrying closed loop is always zero, if it is placed in an uniform magnetic field. **[1]**

6. (c) Force of repulsion by wire D and G on wire C is equal and opposite. **[1]**

7. (c) Since, Resonance frequency, $\nu_r = \frac{1}{2\pi\sqrt{LC}}$ when C is changed 2C, L should be change to L/2.

[1]

8. (a) Energy is equally distributed among electric field and magnetic field. **[1]**

9. (c) γ-rays have maximum frequency and energy of proton, therefore maximum penetrating power. **[1]**

10. (c) because focal length of lens does not change but amount of light passing through lens becomes half. **[1]**

11. (c) Since $W_0 = \frac{hc}{\lambda}$ & $2W_0 = \frac{hc}{\lambda_1}$

$\Rightarrow 2 = \frac{\lambda}{\lambda_1}$ or $\lambda_1 = \frac{\lambda}{2}$ **[1]**

12. (c) $E_n = \frac{-13.6}{n^2}$ eV

$\Delta E = E_\infty - E_2 = 0 + \frac{13.6}{2^2}$ eV $= 3.4$ eV **[1]**

13. (d) mass, energy and momentum **[1]**

14. (d) 0° **[1]**

15. (b) Using, $V_c = \frac{V}{2}$, $U = \frac{1}{2}CV^2$. **[1]**

ASSERTION-REASON BASED QUESTIONS

16. (a)

In semiconductors, by increasing temperature, covalent bond breaks and conduction hole and electrons increase. **[1]**

17. (a)

Both A and R are true and R is the correct explanation of A **[1]**

18. (b)

The kinetic energy of emitted photoelectrons varies from zero to a maximum value. Work function depends on metal used. **[1]**

SECTION-B

19. (a) $\nu = 2 \times 10^{10}$ Hz , $E_0 = 48$ V/m

$\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{2 \times 10^{10}} = 1.5 \times 10^{-2} m$

(b) $E_0 = cB_0$

$B_0 = \frac{E_0}{c} = \frac{48}{3 \times 10^8} = 16 \times 10^{-8}\ T$ **[2]**

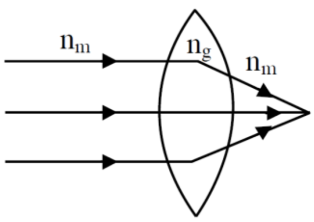
20. Using , M = NIA, we get

$M = 800 \times 3 \times 2.5 \times 10^{-4}$

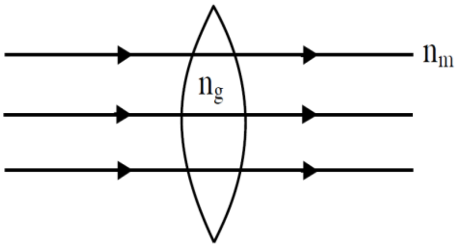
$M = 0.60\ A.m^2$ **[2]**

21. As the distance of closest approach is inversely proportional to the kinetic energy of the incident Alpha - particle, so the distance of closest approach is halved when the kinetic energy of alpha particle is doubled. **[2]**

22. (i) When $n_g > n_m$ the lens behaves as a convex lens.



(ii) When $n_g = n_m$ the lens behaves as a plane plate so no refraction takes place



[2]

23. In forward bias direction of applied voltage (V) is opposite to the barrier potential V_0. As a result, the depletion layer width decreases and barrier height is reduced. Due to the applied voltage, electrons from N-side cross the depletion layer & reach p-side. Similarly holes from p side cross the junction & reach the N side. This motion of charge carriers on either side gives rise to current. The total diode forward current is sum of hole diffusion current & conventional current due to electron diffusion. The magnitude of P–N junction diode is usually in mA. **[2]**

24. Given, $d = 10^{-3}$ m; $\Delta D = 5 \times 10^{-2}$m; $\Delta\beta = 3 \times 10^{-5}$m.

If D is decreased by ΔD, the fringe width will also decrease by Δβ , such that

$$\Delta\beta = \frac{\Delta D\lambda}{d}$$

or $\lambda = \frac{\Delta\beta\, d}{\Delta D} = \frac{3\times10^{-5}\times10^{-3}}{5\times10^{-2}} = 6 \times 10^{-7}$m **[2]**

25. For air $\therefore C = \frac{\varepsilon_0 A}{d}$

Thickness t = d/2 only when $k = \infty$

$$\therefore C_{net} = \frac{\varepsilon_0 A}{d - t\left(1 - \frac{1}{K}\right)} = \frac{\varepsilon_0 A}{d - \frac{d}{2}\left(1 - \frac{1}{\infty}\right)} = \frac{2\varepsilon_0 A}{d} = 2C$$

Hence capacitance will get doubled. **[2]**

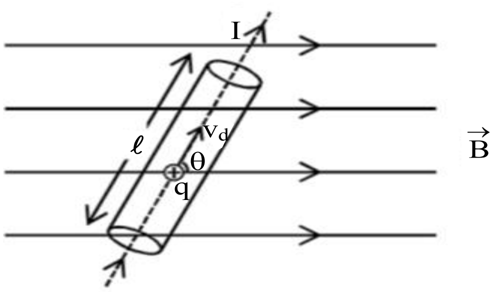
SECTION-C

26. We can derive an expression for the magnetic force on a current by taking a sum of the magnetic forces on individual charges.

Force on each charge particle

$\vec{F}'_m = q(\vec{v}_d \times \vec{B})$

$\boxed{F'_m = qv_d B\sin\theta}$



Let n be the number of charge per unit volume.

Total no. of charge in a conductor of length ℓ and cross section area (A) is $q' = (nA\ell)q$

Total force on all moving charges (or force on wire)

$F_m = (nA\ \ell\ q)\ v_d\ B \sin\theta$

$F_m = (nqAv_d)\ell B \sin\theta$

$F_m = I\ell B \sin\theta$ $\{nqAv_d = I$

In vector form

$\vec{F}_m = I(\vec{\ell} \times \vec{B})$

Direction of force is given by right hand palm rule or Fleming left hand rule.

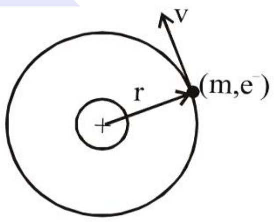
Case (i) : If $\theta = 90^o$ then $F_m = I\ \ell\ B$ (maximum)

Case (ii) : If $\theta = 0^o$ or $\theta = 180^o$ then $F_m = 0$ (minimum) **[3]**

27. Magnetic moment of an orbital electron :

Equivalent current due to moving e^- in circular path –

$I = \frac{e}{T} \Rightarrow I = \frac{e}{\left(\frac{2\pi r}{v}\right)} \Rightarrow I = \frac{ev}{2\pi r}$ ....(1)



Magnetic moment of orbital electron (N=1)

$\mu_l = IA$

From eqn.(1)

$\mu_l = \frac{ev}{2\pi r} \times \pi r^2$

$\Rightarrow \mu_l = \frac{evr}{2}$ ....(2)

angular momentum of the electron of mass m_e,

$l = m_e v r \Rightarrow v r = \frac{l}{m_e}$

From eqn. (2)

$\Rightarrow \mu_l = \frac{e}{2} \frac{l}{m_e}$ ......(3)

In vector form-

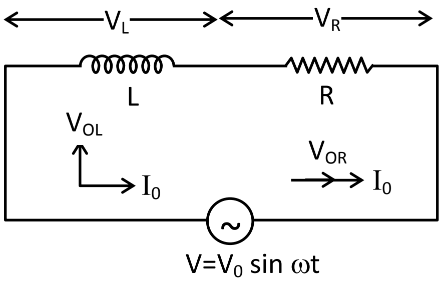
$\vec{\mu}_l = -\frac{e\,\vec{l}}{2\,m_e}$

For orbital electron its $\vec{\mu}_l$ and $\vec{l}$ both are antiparallel axial vectors. **[3]**

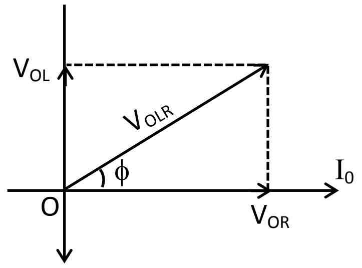
28. Series L-R a c Circuit

Let applied a c voltage,

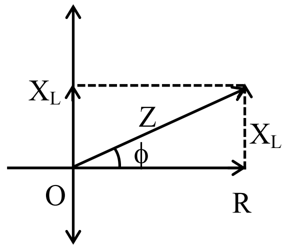
$V = V_0 \sin \omega t$



Voltage phasor diagram :



Impedance phasor diagram :



From phasor diagram,

$$V_0 = V_{OLR} = \sqrt{V_{OR}^2 + V_{OL}^2}$$

Impedance of series L-R circuit

$$Z = \sqrt{R^2 + X_L^2}$$

Equation of alternating current

$$\boxed{I = I_0 \sin(\omega t - \phi)}$$

In series L-R circuit, Voltage leads current by angle ϕ.

$$\tan\phi = \frac{V_{0L}}{V_{0R}} = \frac{I_0 X_L}{I_0 R} = \frac{X_L}{R} \Rightarrow \phi = \tan^{-1}\left(\frac{X_L}{R}\right) \text{ and } \cos\phi = R/Z$$ **[3]**

OR

Power of a.c. circuit :

Let $V = V_0 \sin\omega t$ and $I = I_0 \sin(\omega t + \phi)$

Instantaneous power $(p_i) = VI$

$$P_i = (V_0 \sin\omega t)\,[I_0 \sin(\omega t + \phi)]$$

$$P_i = V_0 I_0 \sin\omega t\,[\sin\omega t \cos\phi + \cos\omega t \sin\phi]$$

$$P_i = V_0 I_0\,[\sin^2\omega t \cos\phi + \sin\omega t \cos\omega t \sin\phi]$$

$$P_i = V_0 I_0\left[\sin^2\omega t\,\cos\phi + \frac{2\sin\omega t\cos\omega t}{2}\sin\phi\right]$$

$$P_i = V_0 I_0\left[\sin^2\omega t\,\cos\phi + \frac{\sin 2\omega t}{2}\sin\phi\right]$$

Average power over a complete cycle of a.c.,

$$< P_i > = V_0 I_0\left[< \sin^2\omega t > \cos\phi + < \sin 2\omega t > \frac{\sin\phi}{2}\right]$$

$$< \sin^2\omega t > = \frac{1}{2} \text{ and } < \sin 2\omega t > = 0$$

$$P_{av} = V_0 I_0\left[\frac{\cos\phi}{2} + 0\right]$$

$$P_{av} = \frac{V_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}}\cos\phi \Rightarrow \boxed{P_{av} = V_{rms} I_{rms} \cos\phi}$$

Average power is also called actual power / dissipated power / power loss.

Virtual power $(P_{vir.}) = V_{rms}\, I_{rms}$

Virtual power is also called apparent power / rms power. **[3]**

29. Kinetic Energy, $\frac{1}{2}mv^2 = qV$, Linear momentum , p = $\sqrt{2mqV}$

de-Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqV}}$

(i) V = same potential, $q_p = q_d$ and $m_d = 2m_p$

de-Broglie wavelength, $\lambda \propto \frac{h}{\sqrt{mq}}$

$\frac{\lambda_p}{\lambda_d} = \frac{\sqrt{m_d q_d}}{\sqrt{m_p q_p}} = \frac{\sqrt{2m_p q_p}}{\sqrt{m_p q_p}} = \sqrt{2}$

$\lambda_p > \lambda_d$

(ii) de-Broglie wavelength, $\lambda = \frac{h}{p}$, , $\lambda \propto \frac{1}{p}$

If $\lambda_p > \lambda_d$,then momentum of proton is less ($p_p < p_d$) **[3]**

OR

The de-Broglie wavelength, $\lambda = \frac{h}{\sqrt{2mE}}$ ……..(i)

If $E' = 2E$ then

$$\lambda' = \frac{h}{\sqrt{2mE'}} = \frac{h}{\sqrt{2m(2E)}} \quad \ldots\ldots\ldots(ii)$$

From eqn. (i) and (ii)

$\lambda' = \frac{\lambda}{\sqrt{2}}$ **[3]**

So, when kinetic energy is increased two times, de-Broglie's wavelength is reduced by $\sqrt{2}$ times.

30. Total energy E=-13.6 $\frac{Z^2}{n^2}$ eV , for hydrogen atom (Z=1)

potential energy = 2× (Total energy)

(i) potential energy of an electron in the 3rd excited state

P.E.= - 27.2 $\frac{1^2}{3^2}$ eV

P.E.= $-\frac{27.2}{9}$ eV = $-3.022\ eV$

(ii) Energy in photon = Change in Potential energy from ground state.

$\frac{hc}{\lambda} = -27.2\ eV\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$

$\frac{hc}{\lambda} = -27.2\ eV\left(\frac{1}{3^2} - \frac{1}{1^2}\right)$ = 24.17 eV

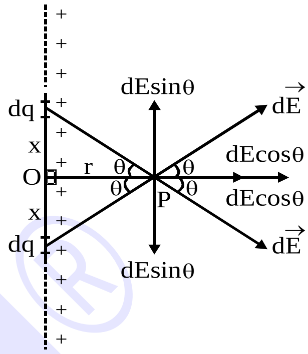
$\lambda = \frac{19.86\times10^{-26}}{24.17\times1.6\times10^{-19}} = 513 \times 10^{-10}$ m **[3]**

SECTION-D

31. (i) Expression for electric field at a point due to uniformly charged straight conductor of infinite length :-

At a point P, electric field intensity due to infinite charged straight wire is perpendicular to it.

Let linear charge density on wire is λ. Now, considering a cylindrical Gaussian surface of radius r and length ℓ.



Using Gauss' law,

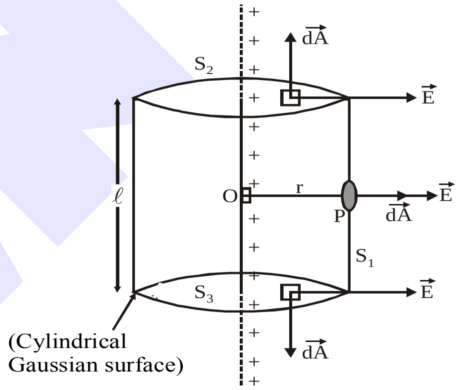
$$\oint EdA\cos\theta = \frac{q_{enclosed}}{\varepsilon_0}$$

$$\int_{S_1} EdA\cos 0° + \int_{S_2} EdA\cos 90° + \int_{S_3} EdA\cos 90° = \frac{\lambda\ell}{\varepsilon_0}$$

$$\Rightarrow E\int_{S_1} dA + 0 + 0 = \frac{\lambda\ell}{\varepsilon_0} \quad \{E \Rightarrow \text{constant}$$

$$\Rightarrow E \times 2\pi r\ell = \frac{\lambda\ell}{\varepsilon_0}$$

$$\Rightarrow E = \frac{\lambda}{2\pi\varepsilon_0 r} \Rightarrow \boxed{E = \frac{2k\lambda}{r}}$$



(ii)

The direction of the electric field intensity due to positively charged is always directed away from the charged wire. **[3]**

(ii) Here, in the vertical direction,

initial velocity, u = 0

acceleration, $a = \frac{F}{m} = \frac{qE}{m}$ ....(1)

Time taken to cross the field, $t = \frac{Distance}{velocity} = \frac{L}{v_x}$ ....(2)

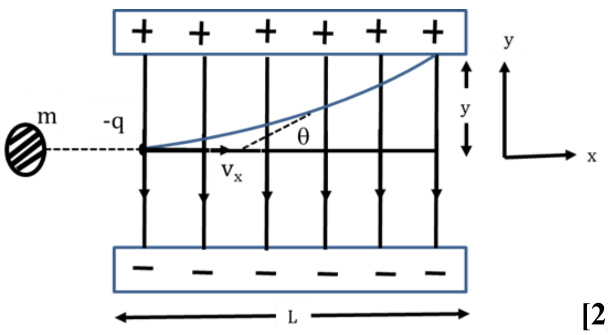
($\because$velocity along the horizontal direction is constant)

Using eqn. $s = ut + \frac{1}{2}at^2$

From eqn.(1) & (2)-

Deflection, $y = 0 + \frac{1}{2}\left(\frac{qE}{m}\right)\left(\frac{L}{v_x}\right)^2$

$$y = \frac{qEL^2}{2mv_x^2}$$



[2]

OR

(i) **Capacitor :** It is a device from which we increase capacity to store energy without increasing it's size.

Capacitance of parallel plates capacitor :-

electric field intensity between two plates of capacitor.

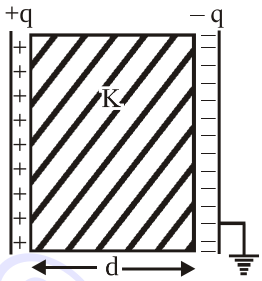


Plate Area $\Rightarrow A$

dielectric constant $\Rightarrow K$

$$E_m = \frac{\sigma}{\varepsilon} \quad \left\{ \begin{array}{l} \sigma = \frac{q}{A} \\ \varepsilon = \varepsilon_0 K \end{array} \right.$$

$$\boxed{E_m = \frac{q}{\varepsilon_0 KA}}$$

Potential difference between two plates of capacitor

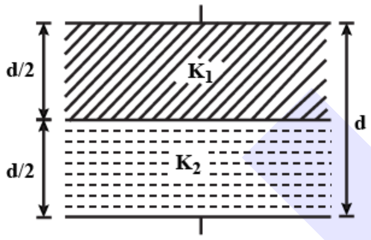
$$V = E_m \times d$$

$$\boxed{V = \frac{qd}{\varepsilon_0 KA}}$$

$$\text{Capacity, } C' = \frac{q}{V} \Rightarrow C' = \frac{q}{\left(\frac{qd}{\varepsilon_0 KA}\right)}$$

$$\boxed{C' = \frac{\varepsilon_0 KA}{d}} \Rightarrow [C' = KC] \quad \therefore \; C = \frac{\varepsilon_0 A}{d}$$ = capacitance of parallel plate capacitor in air. **[3]**

(ii)



Equivalent capacitance with dielectrics

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{1}{\left(\frac{2\varepsilon_0 K_1 A}{d}\right)} + \frac{1}{\left(\frac{2\varepsilon_0 K_2 A}{d}\right)}$$

$$= \frac{d}{2\varepsilon_0 K_1 A} + \frac{d}{2\varepsilon_0 K_2 A}$$

$$\frac{1}{C} = \frac{d}{2\varepsilon_0 A}\left[\frac{1}{K_1} + \frac{1}{K_2}\right]$$

$$C = \frac{2\varepsilon_0 A}{d}\left(\frac{K_1 K_2}{K_1 + K_2}\right)$$ **[2]**

32. **(i)** Terminal voltage of first cell

$V_1 = E_1 - Ir_1$ ...(1)

Terminal voltage of second cell

$V_2 = E_2 - Ir_2$ ...(2)

Potential difference on the ends of outer resistance 'R'

$V = V_1 + V_2$

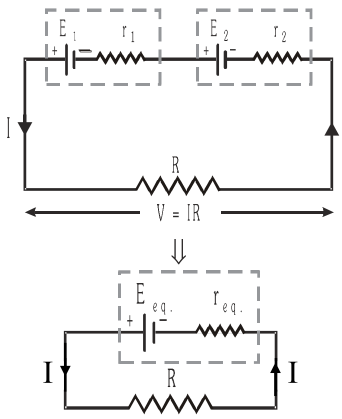
$IR = (E_1 - Ir_1) + (E_2 - Ir_2)$

$IR = E_1 + E_2 - I(r_1 + r_2)$

$I[R + (r_1 + r_2)] = E_1 + E_2$

$$I = \frac{E_1 + E_2}{R + (r_1 + r_2)} \quad ...(3)$$

From equivalent circuit $I = \dfrac{E_{eq.}}{R + r_{eq}}$ ...(4)



Equivalent circuit

Compare equation (3) and (4)

$\boxed{E_{eq} = E_1 + E_2}$ and $\boxed{r_{eq} = r_1 + r_2}$

If the cell terminal has to be reversed then $\boxed{E_{eq} = E_1 - E_2}$

where $E_1 > E_2$ and $\boxed{r_{eq} = r_1 + r_2}$ **[3]**

(ii) Electric Current $I = \dfrac{E}{R+r}$

$0.5 = \dfrac{10}{R+3} \Rightarrow 0.5R + 1.5 = 10$

$0.5\ R = 8.5 \Rightarrow R = 17$ ohm

Terminal voltage V = I R = (0.5) (17) = 8.5 volt **[2]**

OR

(i) Drift velocity is defined as the average velocity with which the electrons drift towards the positive terminal under the effect of applied electric field.

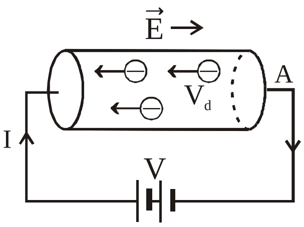
Relation between electric current and drift velocity :-

Let n be the number of free electron per unit volume of conducting wire.

Number of free electrons related to small element = nAdx

Number of free charge carrier related to small element (q) = (nAdx)e

Current



$$I = \frac{dq}{dt}$$

$$I = neA\left(\frac{dx}{dt}\right)$$

$$\boxed{I = neAV_d}$$

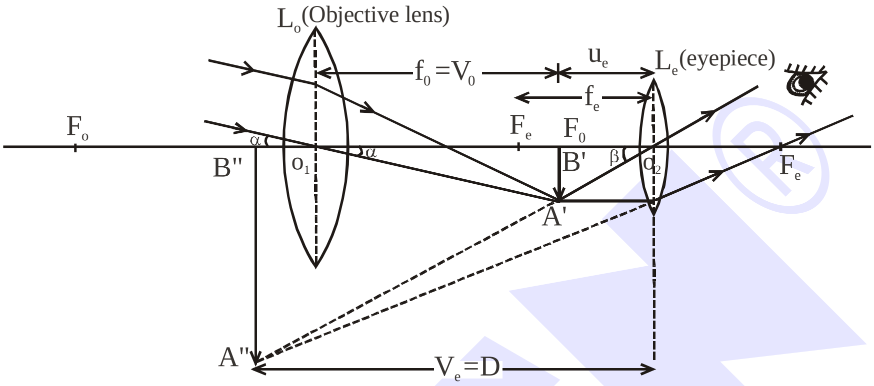
$V_d \Rightarrow$ drift velocity **[3]**

(ii) Using $v_d = \frac{I}{neA}$, We get

$$v_d = \frac{3}{(8.5\times10^{28})(1.6\times10^{-19})(2\times10^{-6})} = 1.1\times10^{-4}\ \text{m s}^{-1}$$

Time taken, $t = \frac{\ell}{v_d} = \frac{3}{1.1\times10^{-4}} = 2.72\times10^{4}$ s **[2]**

33. (i) Refracting telescope :



Refracting type telescope consists of an objective lens of large aperture and large focal length whereas eyepiece is of small aperture and small focal length.

Magnifying Power : It is the ratio of visual angle subtended by final image at eye to the visual angle subtended by an object.

$$\boxed{M = \frac{\beta}{\alpha}} \qquad \begin{cases}\text{if } \alpha \text{ and } \beta \text{ are very small} \\ \alpha \approx \tan\alpha \text{ and } \beta \approx \tan\beta\end{cases}$$

$$M = \frac{\tan\beta}{\tan\alpha} \Rightarrow M = \frac{\left(\frac{A'B'}{O_2B'}\right)}{\left(\frac{A'B'}{O_1B'}\right)} \Rightarrow M = \frac{O_1B'}{O_2B'} \Rightarrow \boxed{M = \frac{f_0}{u_e}} \qquad ...(i)$$

Drawbacks of refracting telescope :

(1) Defect of chromatic aberration occurs in refracting type telescope.

(2) It has small resolving power. **[3]**

(ii) Given : $\mu_1 = 1$, $\mu_2 = 1.5$, R = 20 cm, u = 100 cm

$\Rightarrow$ from $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

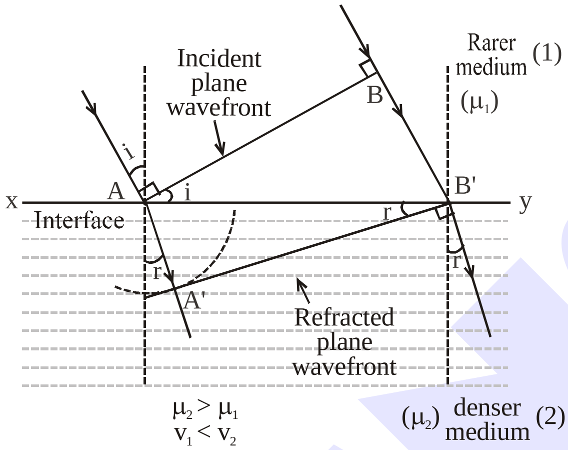
$$\Rightarrow \frac{1.5}{v} - \frac{1}{-100} = \frac{0.5}{20}$$

$$\Rightarrow \frac{1.5}{v} = \frac{5}{200} - \frac{1}{100} = \frac{3}{200} \quad \textit{or}\ v = 100\ \text{cm}$$ **[2]**

OR

(i) Refraction of plane wavefront at plane surface on the basis of Huygen's principle–

Consider a plane wavefront AB (at t = 0) incident on interface xy. Let time taken by wavelets to reach from B to B' is t. If velocity of light in rarer medium is v_1, then $\boxed{BB' = v_1 t}$



If velocity of light in denser medium is v_2, then distance travelled by wevelets in time t : $\boxed{AA' = v_2 t}$

Taking 'A' as centre and draw a spherical arc of radius AA' = v_2t. Now draw a tangential plane A'B' which touches the spherical arc at point 'A'. This tangential plane A'B' acts as a refracted plane wavefront.

In $\Delta ABB'$, $\sin i = \frac{BB'}{AB'}$ ...(1)

In $\Delta AA'B'$, $\sin r = \frac{AA'}{AB'}$ ...(2)

Eq. (1) ÷ (2)

$$\frac{\sin i}{\sin r} = \frac{BB'}{AA'} \Rightarrow \frac{\sin i}{\sin r} = \frac{v_1 t}{v_2 t} \Rightarrow \boxed{\frac{\sin i}{\sin r} = \frac{v_1}{v_2}} \text{ (Huygen's law)}$$

$$\frac{\sin i}{\sin r} = \frac{c/\mu_1}{c/\mu_2} \Rightarrow \frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1} \Rightarrow \boxed{\frac{\sin i}{\sin r} = {}_1\mu_2} \text{ (Snell's law)}$$

Incident ray, refracted ray and normal all lie in same plane. **[3]**

(ii) In single slit diffraction, path diff. = $a\sin\theta \cong a\theta = \lambda \Rightarrow \theta = \lambda/a$

Width of central maxima of single slit = 2λ/a

Width of 10 maxima = 10 × fringe spacing = 10 × λ/d

Width of central maximum of single slit = Width of 10 maxima of double slit

$$\frac{10\lambda}{d} = \frac{2\lambda}{a} \Rightarrow a = \frac{d}{5} = 0.2\ mm$$ **[2]**

SECTION-E

34. (i) Here $\nu = 5\times10^{14}\,Hz; \lambda = 450\times10^{-9}\,m$

Refractive index of the liquid,

$$\mu = \frac{c}{v} = \frac{c}{\nu\lambda} = \frac{3\times10^{8}}{5\times10^{14}\times450\times10^{-9}} = 1.33$$ **[1]**

(ii) Principle of reversibility of light – If the path of a ray of light is reversed after suffering multiple reflections, the phenomenon is called principle of reversibility of light. **[1]**

(iii) Here $i = 60^0$; $\mu = 1.5$

By snell's law, $\mu = \frac{\sin i}{\sin r}$

$$\sin r = \frac{\sin i}{\mu} = \frac{\sin 60^0}{1.5} = \frac{0.866}{1.5}$$

$\sin r = 0.5773$ or $r = \sin^{-1}(0.58)$ **[2]**

OR

(iii) As object is at the centre of the sphere, the image must be at the centre only.

$\therefore$ Distance of virtual image from centre of sphere = 6 cm **[2]**

35. (i) Biasing means providing external energy to charge carriers to overcome the barrier potential and make them move in a particular direction.

We have two types of biasing:

(a) Forward bias

(b) Reverse bias **[1]**

(ii) A pure semiconductor has electrons and holes as charge carriers. Their number densities are equal. **[1]**

(iii) (a) A diode is unidirectional, ie. current flows in only one direction.

(b) When a forward bias is applied, the diode conducts, and when a reverse bias is applied, there is no conduction. **[2]**

OR

(iii) Whenever p-n junction is formed, some of the free electrons diffuse from the n-side to the p-side while the holes from the p-side to the n side. The diffusion of charge carriers happens due to the n-side has higher electron concentration and the p-side has higher hole concentration.

The diffusion of the majority charge carriers across the junction gives rise to an electric current, called diffusion current. **[2]**