Practice Paper -3 (SOLUTION)

CLASS: XII

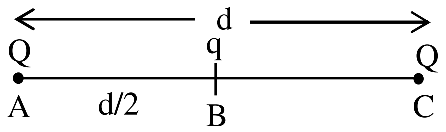
Session: 2022-23

SUBJECT : PHYSICS

SECTION – A

1. (d) **[1]**

Sol.



Net fore on Q at A

$\vec{F}_A = \vec{F}_{AB} + \vec{F}_{AC} = 0$

So, $F_{AB} = F_{AC}$

$\frac{KQq}{\left(\frac{d}{2}\right)^2} = \frac{KQQ}{d^2}$

So, $q = \frac{Q}{4}$

q must be negative

So $q = -\frac{Q}{4}$

2. (c) **[1]**

3. (a) **[1]**

4. (c) **[1]**

Sol. $B = \frac{\mu_0 I}{2r}$ is same for both coils but in opposite direction, So $B_{net} = 0$

5. (c) **[1]**

6. (b) **[1]**

Sol. $\chi_m + 1 = \mu_r$

So, $\mu_r = 500$

$\mu_r = \frac{\mu}{\mu_0}$

$= 500 \times 4\pi \times 10^{-7}$

$\mu = 2\pi \times 10^{-4}$

7. (d) **[1]**

8. (c) **[1]**

9. (d) **[1]**

Sol. $e = \frac{-d\phi}{dt} = \frac{-d}{dt}(10t^2 - 50t + 250)$

$e = -20t + 50 = -20(3) + 50 = -10V$

10. (c) **[1]**

11. (a) **[1]**

Sol. $E = \frac{hc}{\lambda} = \frac{12400 \text{Å} eV}{2000} = 6.2eV$

$K_{max} = E - W_0 = 6.20 - 4.21 = 1.99 = 2eV$

So stopping potential = 2V

12. (c) **[1]**

13. (d) **[1]**

14. (a) **[1]**

15. (b) **[1]**

Sol. Electric Potential inside the sphere is same as on the surface.

16. A is true but R is false **[1]**

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

18. Both A and R are false **[1]**

SECTION – B

19. (a) Radio waves, micro waves, uv rays, x-ray, gamma ray. **[1]**

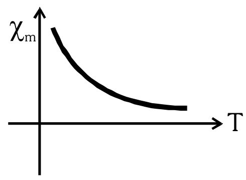
(b) micro wave **[1]**

20. Paramagnetic, **[1]**

Properties :

(i) $\chi_m \rightarrow$ small, positive & varies inversely with temp.

$\chi_m \propto \frac{1}{T}$ (Curie law)



(ii) $2 > \mu_r > 0$ $(\mu > \mu_0)$ **[1]**

21. $r_n \propto n^2$

$r_2/r_1 = 4$

$r_2 = 2.12 \times 10^{-10}$ m **[2]**

(OR)

Kinetic energy = negative of total energy.

K.E = –T.E. = –(–13.6eV) = 13.6 eV **[1]**

Potential energy = 2(T.E.) = 2 (–13.6eV) = –27.2eV **[1]**

22. $\frac{1}{f} = (n_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ **[½]**

$\frac{1}{20} = (1.55 - 1)\left(\frac{1}{R} - \frac{1}{-R}\right)$ **[½]**

R = 22cm **[2]**

23. For diffraction minimum, $\sin\theta = n\lambda/d$

For diffraction maximum, $\sin\theta = (2n+1)\lambda/2d$

$\lambda = 2/3 \times 660 = 440$ nm **[2]**

24. Surface charge density on the inner surface = $\frac{-q}{4\pi r_1^2}$ **[1]**

Surface charge density on outer surface = $\frac{Q+q}{4\pi r_2^2}$ **[1]**

25. (a) $E = \sigma/2\varepsilon_0 - (-\sigma/2\varepsilon_0) = \sigma/\varepsilon_0$ **[1]**

(b) It states that electric flux through any closed surface is always equal to $1/\varepsilon_0$ times to the enclosed charge by Gaussian surface. **[1]**

$\phi_E = \Sigma q/\varepsilon_0$

SECTION C

26. Magnetic field on axis of a current carrying loop :-

Let current I is flowing through a loop of radius R.

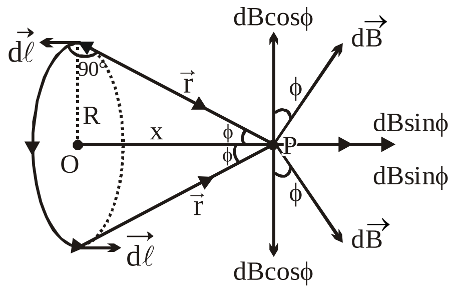
We want to find magnetic field at an axial point P. The angle between each element $d\vec{\ell}$ and $\vec{r}$ is $\theta = 90°$.

Using Biot-savart's law -

$$d\vec{B} = \frac{\mu_0 I}{4\pi r^2}\left(d\vec{\ell} \times \hat{r}\right)$$

$$dB = \frac{\mu_0 I}{4\pi r^2} d\ell \sin 90°$$

$$\boxed{dB = \frac{\mu_0 I\, d\ell}{4\pi r^2}}$$ **[1]**



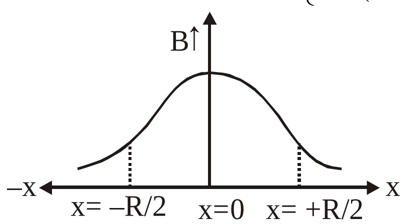
It is clear that the magnetic field developed at point 'P' due to symmetrical elements each of length $d\ell$ have equal magnitude. The equatorial components (dBcosϕ) due to both elements get cancelled while axial components (dBsinϕ) get added. In this way the net magnetic field is only because of axial component dBsinϕ.

Magnetic field developed at 'P' due to whole circular loop is given by -

$$B_{axis} = \int_0^{2\pi R} dB\sin\phi \Rightarrow B_{axis} = \int_0^{2\pi R} \frac{\mu_0 I d\ell}{4\pi r^2}\sin\phi \Rightarrow B_{axis} = \frac{\mu_0 IR}{4\pi r^3}\int_0^{2\pi R} d\ell \quad \begin{cases}\text{From figure} \\ \sin\phi = R/r \\ r = (R^2+x^2)^{1/2}\end{cases}$$

$$B_{axis} = \frac{\mu_0 IR}{4\pi r^3}\left(2\pi R - 0\right) \Rightarrow B_{axis} = \frac{\mu_0 IR^2}{2r^3}$$

$$B_{axis} = \frac{\mu_0 IR^2}{2\left(R^2+x^2\right)^{3/2}}$$ **[1]**



If the coil have N turns then

$$B_{axis} = \frac{\mu_0 NIR^2}{2\left(R^2+x^2\right)^{3/2}}$$ **[1]**

The direction of magnetic field can be obtained by right hand thumb rule.

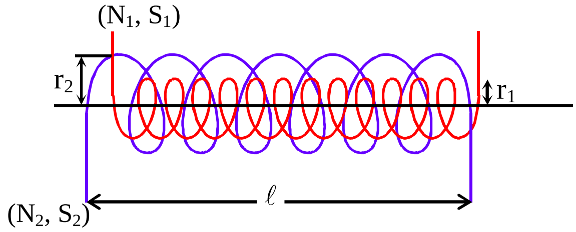
27. Mutual inductance numerically equal to the magnetic flux linked with one coil when a unit current flows through the other coil. $\boxed{M = \frac{N\phi}{I}}$

Mutual inductance between two solenoids **[1]**

$$\boxed{M = \frac{\mu_0 N_1 N_2 A}{\ell}}$$

Mutual Inductance of two coaxial solenoids :

When a current I_1 is passed through the solenoid S_1, then flux linked with coil S_2.



$N_2\phi_2 = M_{21} I_1$ .....

$(N_2\phi_2) = M_{21} I_1$

$(n_2\ell)(B_1A) = M_{21} I_1$

$(n_2\ell)(\mu_0 n_1 I_1 \times A) = M_{21} I_1$

$\boxed{M_{21} = \mu_0 n_1 n_2 A\ell}$ ....(1) M_{21} = Mutual inductance of S_2 w.r.t. S_1

Note : For calculating M smaller value of area of cross section should be taken.

When current I_2 is passed through S_2, then magnetic flux linked with solenoid S_1

$N_1\phi_1 = M_{12}I_2 \Rightarrow (n_1\ell)(B_2A) = M_{12}I_2 \Rightarrow (n_1\ell)(\mu_0 n_2 I_2 \times A) = M_{12}I_2$

$\boxed{M_{12} = \mu_0 n_1 n_2 A\ell}$ .....(2) $M_{12} \Rightarrow$ Mutual inductance of S_1 w.r.t. S_2

From equation (1) and (2)

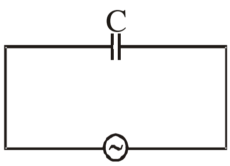
$\boxed{M_{21} = M_{12} = M} \Rightarrow \boxed{M = \mu_0 n_1 n_2 A\ell}$

In medium $\boxed{M = \mu_0 \mu_r n_1 n_2 A\ell}$ **[2]**

28. (i) $L = \frac{X_L}{2\pi f} = \frac{1}{2\pi} \times$ slope of the graph = 3.18×10^{-3} Hz **[2]**

(ii) $Z = (R^2 + X_L^2)^{1/2}$ = 10 ohm **[1]**

OR



$V = V_0 \sin\omega t$

∵ $V = q/c$

∴ $V_0 \sin\omega t = q/c$

∵ $i = dq/dt$

$$i = \frac{d}{dt}(V_0 c \sin \omega t) = \omega c V_0 . \cos \omega t$$

$i = i_0 \sin(\omega t + \pi/2)$ **[2]**

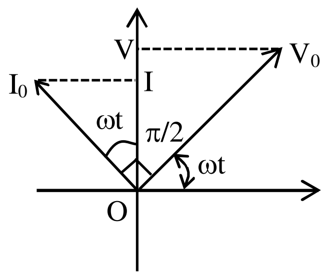
$$i_0 = \frac{V_0}{1/\omega c}$$

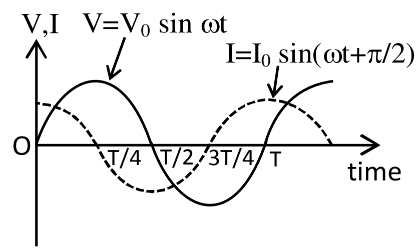
$\frac{1}{\omega c}$ is called capacitive reactance and is denoted by X_c.

$$X_C = \frac{1}{\omega c}$$

$$i_0 = \frac{V_0}{x_c}$$

Phase difference = $\pi/2$





[1]

29. (i) Intensity, frequency **[1]**

(ii) (a) $\lambda_0 = hc/\phi_0 = 12400$ Å eV/ 2eV = 6200 Å = 6.2×10^{-7} m **[1]**

(b) $K_{max} = E - W_0$

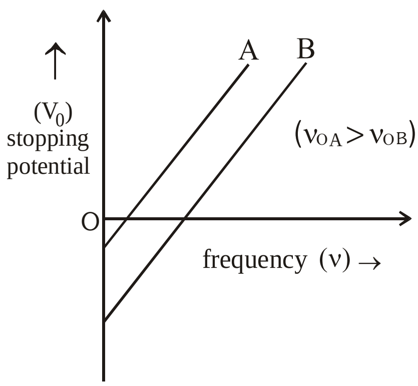
$$= \frac{hC}{\lambda} - W_0 \Rightarrow \frac{12400 \text{Å} eV}{5000 \text{Å}} - 2$$

$= 2.48 - 2$

$K_{max} = 0.48$ eV

So stopping potential = 0.48 V **[1]**

(OR)

(i)  **[1]**

(ii) $V_0 = \frac{h}{e}(\nu - \nu_0)$; So, V_0 is more for B **[1]**

(iii) Slope = $\frac{h}{e}$; So, it does not depend on the material **[1]**

30. $E_n = -13.6/n^2$

$E_4 - E_1 = 12.75\text{eV}$ **[1]**

$$\lambda = \frac{hc}{E_4 - E_1} = \frac{12400\text{Å}eV}{12.75} = 0.97 \times 10^{-7}\ \text{m}$$ **[1]**

$\nu = c/\lambda = 3.07 \times 10^{15}$ Hz **[1]**

SECTION D

31. (a) Making a region free from electric field. It is based on the fact that electric field vanishes inside the cavity of a hollow conductor. **[1]**

Application :

(i) Elevators operate as such an unintentional faraday cage.

(ii) Shielding signals from smartphones as well as radios. **[1]**

(b) (i) $V_0 = E_0 \times d = 3 \times 10^4 \times 0.05 = 1500$ V **[1]**

(ii) $V = E_0(d - t) = 3 \times 10^4\ (0.05 - 0.01) = 1200$ V **[1]**

(iii) $E_0(d - t) + (E_0/K)\ t = 3 \times 10^4\ (0.05 - 0.01) + \dfrac{3\times10^4}{2} \times 0.01 = 1350$ V **[1]**

(OR)

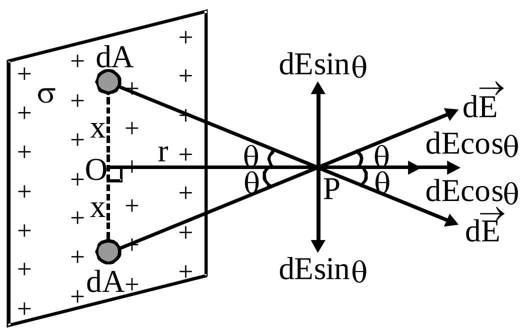
(a) (i) $$V = k\left[\frac{20\times10^{-6}}{x} - \frac{4\times10^{-6}}{50-x}\right] = 0$$

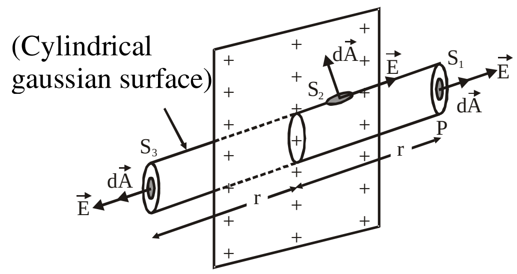
$x = 41$ cm **[1]**

(ii) $$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r} = -1.44\text{J}$$ **[1]**

(b) **Electric Field due to uniformly charged infinite plane sheet of charge :**

Let infinite sheet of charge has surface charge density σ. The electric field at a point due to charged plane sheet is directed perpendicular to the sheet.





[1]

Assuming a cylindrical Gaussian surface of length 2r and area of cross section A to find electric field at point P.

From Gauss's law -

$$\oint E\,dA\cos\theta = \frac{\Sigma q}{\varepsilon_0}$$

$$\int_{S_1} E\,dA\cos 0^\circ + \int_{S_2} E\,dA\cos 90^\circ + \int_{S_3} E\,dA\cos 0^\circ = \frac{\sigma A}{\varepsilon_0} \quad \left\{ \Sigma q = \sigma A \right.$$ **[1]**

$$E\int_{S_1} dA + 0 + E\int_{S_3} dA = \frac{\sigma A}{\varepsilon_0}$$

$$EA + EA = \frac{\sigma A}{\varepsilon_0} \Rightarrow \boxed{E = \frac{\sigma}{2\varepsilon_0}}$$ **[1]**

32. (a) **Relaxation time:** The average time taken by the electrons between two successive collisions. **[1]**

Drift velocity is defined as the average velocity with which free electrons in a conductor get drifted in a direction opposite to the direction of the applied electric field.

When conductor is subjected to an electric field E, each electron experience a force.

$$\vec{F} = -e\vec{E}$$

and acquires an acceleration

$$a = \frac{\vec{F}}{m} = \frac{-e\vec{E}}{m} \qquad .....(i)$$

Here m = mass of electron, e = charge, E = electric field.

The average time difference between two consecutive collisions is known as relaxation time of electron.

$$\tau = \frac{\tau_1 + \tau_2 + ... + \tau_n}{n} \qquad .....(ii)$$

As v = u + at (from equations of motion)

The drift velocity V_d is defined as –

$$\vec{v}_d = \frac{\vec{v}_1 + \vec{v}_2 + ... + \vec{v}_n}{n}$$

$$\vec{v}_d = \frac{(\vec{u}_1 + \vec{u}_2 + ... + \vec{u}_n) + a(\tau_1 + \tau_2 + ... + \tau_n)}{n}$$

$$\vec{v}_d = 0 + \frac{a(\tau_1 + \tau_2 + ... + \tau_n)}{n}$$

($\because$ average thermal velocity = 0)

$\therefore$ $\vec{v}_d = 0 + at$

$$\vec{v}_d = -\left(\frac{e\vec{E}}{m}\right)\tau \Rightarrow \boxed{|\vec{V}_d| = \left(\frac{e\tau}{m}\right)E}$$ **[2]**

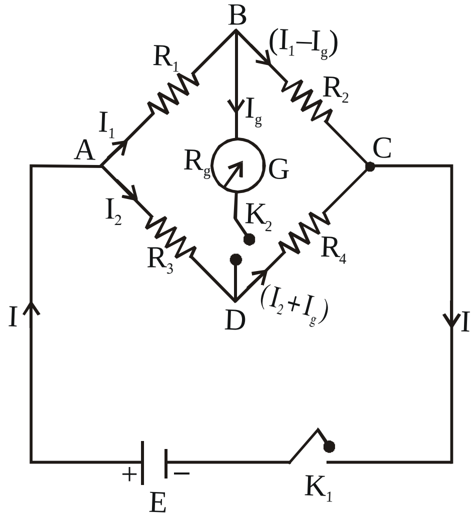
(b) Let the current in galvanometer be I_g and resistance of galvanometer is R_g.

Apply Kirchhoff's voltage law in loop ABDA-

$-I_1R_1 - I_gR_g + I_2R_3 = 0$ ......(1)

Apply KVL in loop BCDB -

$-(I_1 - I_g)R_2 + (I_2 + I_g)R_4 + I_gR_g = 0$ ......(2)



In balanced Wheat Stone Bridge ($I_g = 0$)

From eq. (1) & (2)

$I_1R_1 = I_2R_3$ ......(3)

$I_1R_2 = I_2R_4$ ......(4)

eq. (3) (4)

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

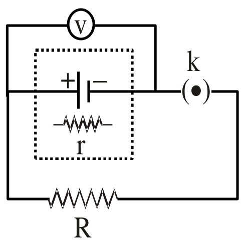
This is the condition of balanced Wheat Stone Bridge. **[2]**

(OR)

(a) (i) **Internal Resistance (r)** The opposition of flow of current inside the cell. It depends on

- Distance between electrodes $\uparrow \Rightarrow r\uparrow$
- Area of electrodes $\uparrow \Rightarrow r\downarrow$
- Concentration of electrolyte $\uparrow \Rightarrow r\uparrow$
- Temperature $\uparrow \Rightarrow r\downarrow$ **[1]**

(ii) According to ohm's law the current in the circuit is given by



$$I = \frac{E}{R+r} \quad ..... (1)$$

According to the definition of terminal voltage, it is the potential difference between two poles when current is being drawn from the cell. The terminal voltage V is less then emf E of the cell.

i.e. $V = E - Ir$ ..... (2)

If no current is drawn from the cell, i.e. I = 0, then from eq (1) we have V = E – 0(r) = E

Also terminal voltage is equal to potential drop across external resistance

$V = IR$ ..... (3)

Comparing eq. (1) and (2) we have

$$\frac{E-V}{r}=\frac{V}{R}$$

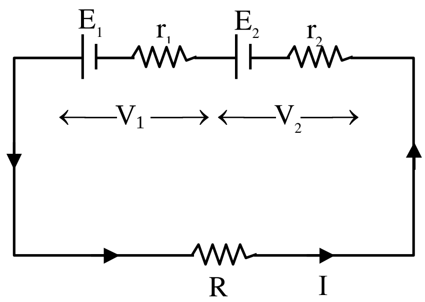
$$V=\left(\frac{E}{R+r}\right)R$$

or $$R + r = \frac{E}{V}R$$

or $$\boxed{r=\left(\frac{E}{V}-1\right)R}$$

or $$\boxed{E=V+Ir}$$ **[1]**

(b)



We know that

$E = V + Ir$

$V = E - Ir$ …(1)

Terminal voltage across I cell :

$V_1 = E_1 - Ir_1$ …(2)

Across II cell :-

$V_2 = E_2 - Ir_2$ …(3)

So total terminal voltage

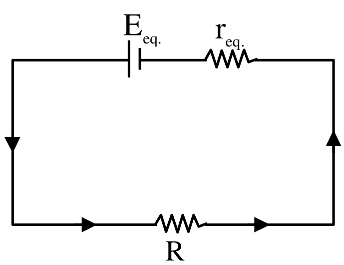
$V = V_1 + V_2$

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

If we use a single cell of emf E_{eq}. & internal resistance $r_{eq.}$ in place of both cells.

$V = E_{eq.} - I\, r_{eq.}$ …(5)

By equation (4) & (5)



$E_{eq.} - I\, r_{eq.} = (E_1 + E_2) - (r_1 + r_2)$

So, $E_{eq.} = E_1 + E_2$

$r_{eq.} = r_1 + r_2$

So, $$I=\frac{E_{eq.}}{r_{eq.}+R}$$

$$I=\frac{E_1+E_2}{r_1+r_2+R}$$ **[2]**

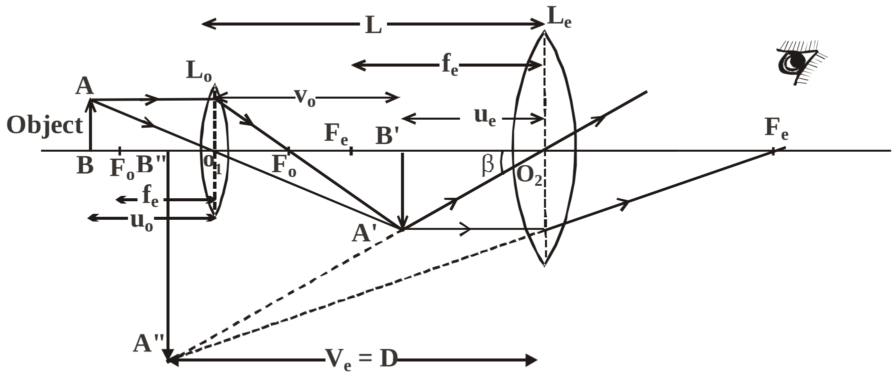
33. (a) (i) Every point on a primary wave front acts as a fresh source of wavelets. These wavelets are called secondary wavelets.

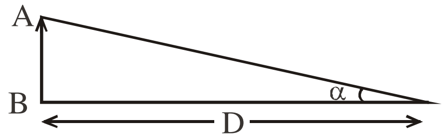
(ii) The secondary wavelets spread in all directions with a speed of light.

(iii) The surface which touches these wavelets at any instant in forward direction gives the new wave front called secondary wave front. **[1]**

(b) Locus of all the particles which are in same phase of vibration at a given instant is called wave front. **[1]**

(c) **Compound microscope :** Figure shows ray diagram of a compound microscope. It consists of two convex lenses one nearer to object is known as objective and other close the eye is eyepiece lens. Here objective lens is of small focal length (f_0) and small aperture whereas eyepiece is also a small focal length but larger than objective lens and relatively large aperture.





The image A' B' formed by the objective lens L_0 of object AB and Final image is A"B".

Magnification power (M)

$$= \frac{\text{Angle subtended by final image at eye}}{\text{Angle subtended by the object when it is placed at the least distance of distinct vision}}$$

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

$$M = \frac{\tan\beta}{\tan\alpha}$$

$$M = \frac{\left(\frac{A''B''}{D}\right)}{\left(\frac{AB}{D}\right)} \Rightarrow M = \frac{A''B''}{AB}$$

$$M = \frac{A''B''}{A'B'} \times \frac{A'B'}{AB} \Rightarrow M = m_e \times m_o \qquad \begin{cases} m_0 = \dfrac{v_0}{u_0} \\ m_e = \dfrac{v_e}{u_e} \end{cases}$$

$$\boxed{M = \frac{v_o}{u_o} \times \frac{v_e}{u_e}} \qquad ...(1)$$

Applying lens formula for eyepiece -

$$\frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e} \qquad \begin{cases} v_e \Rightarrow -D \\ u_e \Rightarrow -u_e \end{cases}$$

$$\frac{1}{f_e} = -\frac{1}{D} + \frac{1}{u_e} \Rightarrow \frac{D}{f_e} = -1 + \frac{D}{u_e}$$

$$\boxed{\frac{D}{u_e} = 1 + \frac{D}{f_e}} \qquad ....(2)$$

(i) When final image is formed at least distance of distinct vision (v_e=D)

$$M = \frac{v_o}{u_o} \times \frac{D}{u_e}$$

$$\boxed{M = \frac{v_o}{u_o}\left(1 + \frac{D}{f_e}\right)} \qquad ....(3)$$

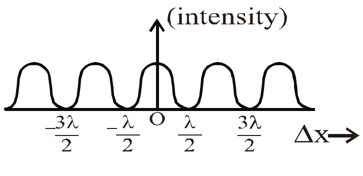
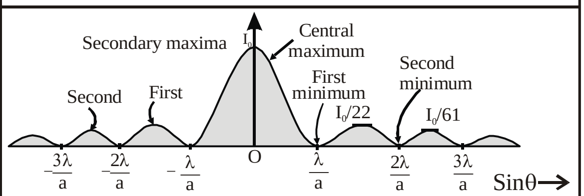
(ii) When final image is formed at infinity (u_e=f_e)

$$\boxed{M = \frac{v_o}{u_o} \times \frac{D}{f_e}} \qquad ....(4)$$

[3]

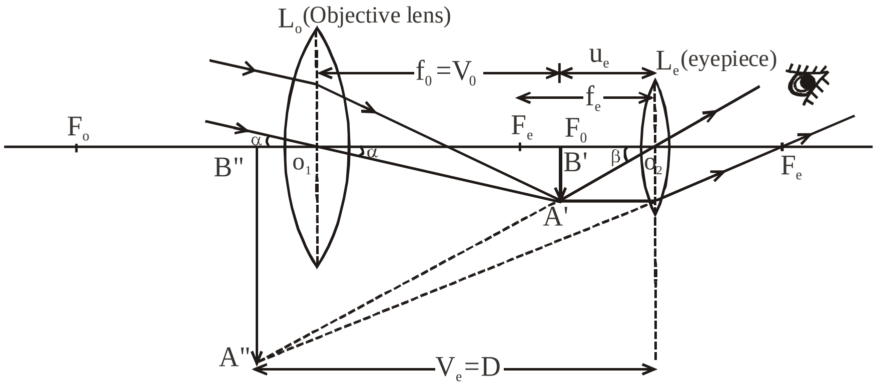
OR

(a)

	Interference	**Diffraction**
1.	It is a result of superposition between secondary wavelets coming from two coherent sources.	It is result of superposition between secondary wavelets coming from different parts of same source.
2.		
3.	All bright fringes are of same width and same intensity.	These are of varying width and varying intensity.
4.	A large number of interference fringes are observable.	Only a few diffraction bands are seen.

[2]

(b) 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.

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

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

(i) When final image is formed at least distance of distinct vision ($V_e = D$)-

Applying lens formula for eyepiece :

$$\frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e} \qquad \begin{cases} \text{applying sign convention} \\ v_e = -D, \quad u_e = -u_e \end{cases}$$

$$\frac{1}{f_e} = -\frac{1}{D} + \frac{1}{u_e} \Rightarrow \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D}$$

Hence magnification power from eq. (i)

$$\boxed{M = f_0\left[\frac{1}{f_e} + \frac{1}{D}\right]} \Rightarrow \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$$

(ii) When final image is formed at infinity ($u_e = f_e$)

From eq. (i) -

$$\boxed{M = \frac{f_0}{f_e}}$$

Drawbacks of refracting telescope :

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

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

SECTION E

34. CASE STUDY

(i) Since its critical angle with reference to air is very small. **[1]**

(ii) $\mu = \dfrac{1}{\sin i_c} = \operatorname{cosec} i_c = \operatorname{cosec} 24.4° = 2.42$ **[1]**

(iii) • Angle of incidence must be greater than critical angle.

• Ray should travel from denser to rarer medium. **[2]**

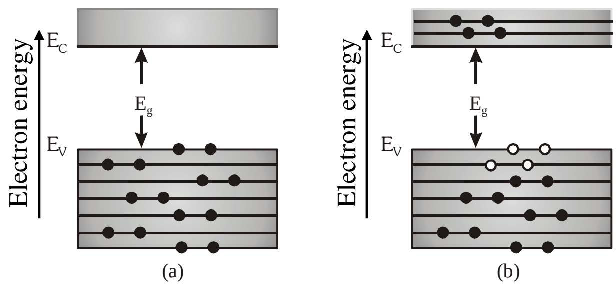
OR

(iii) Optical fibre, **[1]**

Use : Endoscopy **[1]**

35. (i) Nearly 0.75 eV **[1]**

(ii) **[1]**



(a) An intrinsic semiconductor at T = 0 K behaves like insulator.

(b) At T > 0 K, four thermally generated electron-hole pairs. The filled circles (•) represent electrons and empty fields (○) represent holes.

(iii) Energy gap will be least for Ge, followed by Si and highest for carbon. **[1]**

Hence number of free electrons is negligible in carbon. **[1]**

(OR)

(iii) • As, Sb, P (any one) **[1]**

• Ga, In, Aℓ (any one) **[1]**