# Answers to RPH/Set-3

**1.** (*c*)

**2.** (*a*)

**3.** (*c*) The total impedance is given by,

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\Rightarrow \quad Z = \sqrt{50^2 + (160 - 40)^2} = 130\ \Omega$$

Therefore, the current in the circuit is given by,

$$\Rightarrow \quad i_0 = \frac{V_0}{Z} = \frac{2600}{130} = 20\ \text{A}$$

**4.** (*d*)

**5.** (*c*)

**6.** (*c*) The shift in the central maximum due to the thin film is given by the equation:

$$\Delta y = \frac{t\,(\mu - 1)}{d} D$$

where,

$t = 1.2 \times 10^{-6}$ m is the thickness of the film,

$\mu = 1.5$ is the refractive index of the film,

$\lambda = 500 \times 10^{-9}$ m is the wavelength of the light,

$D = 2.5$ m is the distance between the slits and the screen.

$d = 0.6 \times 10^{-3}$ m is the slit separation.

Substitute the values into the formula:

$$\Delta y = \frac{1.2 \times 10^{-6} \times (1.5 - 1)}{0.6 \times 10^{-3}} \times 2.5$$

$$\Delta y = \frac{1.2 \times 10^{-6} \times 0.5}{0.6 \times 10^{-3}} \times 2.5$$

$$\Delta y = 2.5 \times 10^{-3}\ \text{m} = 2.5\ \text{mm}$$

Therefore, the shift of the central maximum due to the presence of the film is 2.5 mm.

**7.** (*a*)

**8.** (*a*) Paramagnetic material

**9.** (*a*)

**10.** (*a*) Given: Initially, $C_1 = 2C$ and $C_2 = C$, $q_1 = 2CV$ and $q_2 = CV$

When the capacitor of capacity 'C' is filled with dielectric of constant '*K*', then $C'_2 = KC$

$\therefore$ New charge on $C_1$

$Q_1 = 2C\,V'$ and new charge on $C_2$, $Q_2 = C'_2V'$

As charge is conserved,

$$\therefore \qquad q_1 + q_2 = Q_1 + Q_2$$

$$\text{or} \qquad 2CV + CV = 2CV' + C'_2V'$$

$$\text{or} \qquad 3CV = 2CV' + 2KCV'$$

$$\text{or} \qquad V' = \frac{3V}{K+2}$$

**11.** (*b*) E (in eV) $= \dfrac{12420}{\lambda(\text{Å})}$ $\therefore\ \lambda = \dfrac{12420}{2} = 6210$ Å

**12.** (*d*)

**13.** (*b*) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

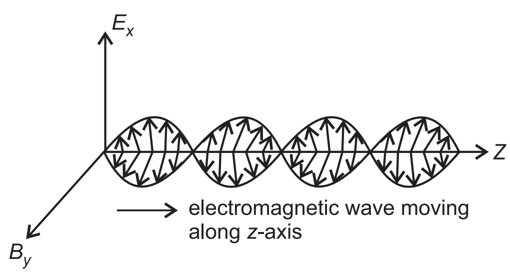
**14.** (*c*) Assertion is true but Reason is false.

**15.** (*b*) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

**16.** (*a*) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

**17.** (*a*) Electromagnetic waves are produced by an oscillating charge. This gives rise to an oscillating emf, which causes an oscillating electric field. This oscillating electric field produces an oscillating magnetic field, which in turn is a source of oscillating electric field and the process continues.

(*b*)

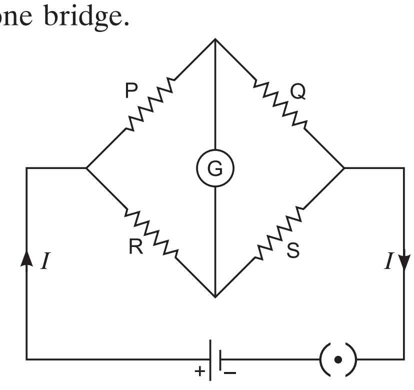



**18.** It is an arrangement of four resistances which is used to calculate one of these resistance accurately in terms of the other three resistances.

A Wheatstone bridge is said to be balanced when no current flows through the galvanometer and hence,

$$\frac{P}{Q} = \frac{R}{S}$$

Let us consider a wheatstone bridge.



Take loop $ABDA$ and using $KVL$,

$$P(i - i_1) + Xi_3 - Ri_1 = 0 \qquad ...(i)$$

Take loop $BCDB$ and using $KVL$,

$$Q(i - i_1 - i_3) - S(i_1 + i_3) - Xi_3 = 0$$

$$Q(i - i_1) - Qi_3 - Si_1 - (S + X)i_3 = 0 \qquad ...(ii)$$

When the point $B$ and $D$ are at same potential, the bridge is said to be balanced.

As in balanced state, $i_3 = 0$, from equations ($i$) and ($ii$), we get

$$P(i - i_1) = Ri_1$$

$$Q(i - i_1) = Si_1$$

$$\frac{P}{Q} = \frac{R}{S}$$

**19.** Given that $\vec{E} = 5 \times 10^3 \hat{i}$ N/C; $\vec{A} = (10 \text{ cm} \times 10 \text{ cm})\hat{i} = 1 \times 10^{-2} \text{ m}^2 \hat{i}$

($i$) $\phi_1 = \vec{E} \cdot \vec{A} = EA \cos 0°$ (as $\cos 0° = 1$)

$$= 5 \times 10^3 \times 10^{-2} = 50 \text{ Vm}$$

($ii$) $\phi_2 = \vec{E} \cdot \vec{A} = EA \cos 60° = 50 \times \frac{1}{2} = 25$ Vm $\quad [\because \theta = 90° - 30° = 60°]$

**20.** (I) When radius of circular loop $= r$

$\therefore$ Magnetic field at its centre

$$B = \frac{\mu_0 I}{2r} \qquad ...(i)$$

When the radius is doubled, the resistance in the circuit is also doubled. Therefore, the current in the circuit becomes halved.

$\therefore$ Magnetic field at its centre

$$B' = \frac{\mu_0 I'}{2r'}$$

Here, $I' = \frac{I}{2}$ and $r' = 2r$

$$\therefore \qquad B' = \frac{\mu_0\left(\frac{I}{2}\right)}{2(2r)} = \frac{1}{4}\left[\frac{\mu_0 I}{2r}\right]$$

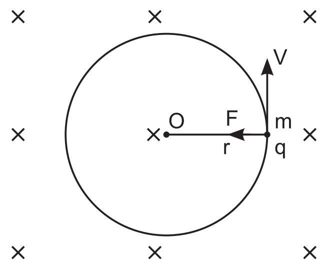
Using equation ($i$), we get

$$B' = \frac{B}{4}$$

***Or***

(II) When a charged particle enters a uniform magnetic field with velocity perpendicular to the field, it experiences a centripetal force due to the magnetic Lorentz force. Hence, the particle moves in a circular path.

Let a charge $q$ of mass $m$ is moving with a velocity $V$, at right angles to a uniform magnetic field $B$ going into the plane of paper.




Using Fleming's left hand rule on particle of mass $m$ and charge $q$. The magnetic force $\vec{F} = q\vec{v} \times \vec{B}$ will act on it towards the centre of the orbit $O$.

As the path taken by the charge is circular, a centripital force of magnitude $\frac{mv^2}{r}$ will keep the path circular of radius $r$.

Magnetic force will be maximum as given below.

$$F_{max} = qvB \qquad (\because \text{ Angle between } v \text{ and } B \text{ is } 90° \text{ and } \sin 90° = 1)$$

Equating magnetic and centripital forces, we get

$$\frac{mv^2}{r} = qvB$$

$\therefore \quad r = \frac{mv}{qB}$, here $r$ is the radius of the circular orbit.

**21.** (I) Mass defect in the process

$$\Delta m = 235.0439 + 1.00867 - (139.9054 + 93.9063 + 2.01734)$$
$$= 0.22353 \text{ u}$$

The corresponding energy released $= \Delta mc^2$

$$= 0.22353\text{u} \times 931 = 208 \text{ MeV}$$

$(\because 1 \text{ u} = 931 \text{ MeV/c}^2)$

***Or***

(II) By Einstein's Photoelectric equation,

$$h(\nu - \nu_0) = \frac{1}{2}mv_{max}^2$$

or $$\nu_0 = \nu - \frac{mv_{max}^2}{2h}$$

$$= 8 \times 10^{14} - \frac{9.1 \times 10^{-31} \times (7 \times 10^5)^2}{2 \times 6.63 \times 10^{-34}}$$

$$= 4.64 \times 10^{14} \text{ Hz}$$

**22.** (*a*) **For Circuit I:** In Circuit I, both diodes $D_1$ and $D_2$ are forward biased, meaning they are conducting. The total voltage drop across the diodes is the sum of their threshold voltages.

$$V_{D_1} + V_{D_2} = 0.2 \text{ V} + 0.6 \text{ V} = 0.8 \text{ V}$$

The remaining voltage will drop across the resistor. Therefore, the voltage across the resistor is:

$$V_R = 9 \text{ V} - 0.8 \text{ V} = 8.2 \text{ V}$$

The current through the resistor (and hence through the diodes) can be calculated using Ohm's law:

$$I_D = \frac{V_R}{R} = \frac{8.2\text{V}}{3\times10^3\Omega} = 2.73 \text{ mA}$$

The output voltage $V_O$, which is the voltage across the resistor, will be:

$$V_O = V_R = 8.2 \text{ V}$$

(*b*) **For Circuit II:** In Circuit II, $D_1$ is forward biased and $D_2$ is reverse biased. Since $D_2$ is reverse biased, no current flows through the circuit.

$$I_D = 0 \text{ A}$$

The output voltage $V_O$ is zero because no current flows through the resistor:

$$V_O = 0 \text{ V}$$

**23.** Using, $R = R_0(1 + \alpha\Delta t)$

At 100 °C, $10 = R_0(1 + 100\,\alpha)$ ...(*i*)

At 200 °C, $12 = R_0(1 + 200\,\alpha)$ ...(*ii*)

Dividing equation (*i*) by equation (*ii*), we get

$$\frac{10}{12} = \frac{R_0(1+100\,\alpha)}{R_0(1+200\,\alpha)}$$

or $5(1 + 200\,\alpha) = 6(1 + 100\,\alpha)$

$$5 + 1000\,\alpha = 6 + 600\,\alpha$$

or $1000\,\alpha - 600\,\alpha = 6 - 5$

or $400\,\alpha = 1$

or $\alpha = \frac{1}{400}\ ^\circ\text{C}^{-1}$

Using this in equation (*i*), we get

$$10 = R_0\left[1+100\left(\frac{1}{400}\right)\right]$$

$$10 = R_0\left[1+\frac{1}{4}\right] = \frac{5R_0}{4}$$

or $R_0 = \frac{40}{5} = 8\ \Omega$

∴ The temperature for 14 Ω,

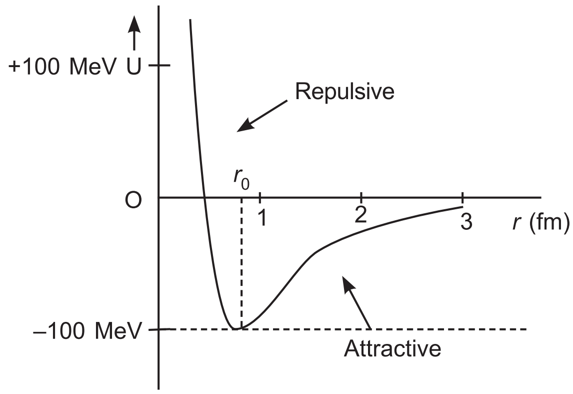
⇒ $14 = 8\left(1+\frac{1}{400}\Delta T\right)$

or $\left(\frac{14}{8}-1\right)\times 400 = \Delta T$

$$\frac{6}{8}\times 400 = \Delta T$$

$$\Delta T = 300\ ^\circ\text{C}$$

**24.** (*a*)




$r_0 = 0.8$ fm

If $r < r_0$, the nuclear force between nucleons is repulsive and if $r > r_0$, up to $r \approx 3$ fm, the nuclear force is attractive. Strong repulsion at shorter distances saves the nucleus from destruction and weak attraction beyond 3 to 4 fm makes the nuclear forces saturated as it remains active near the nucleon only.

(*b*) ${}_0^1n + {}_{92}^{235}U \longrightarrow {}_{54}^{a}Xe + {}_{b}^{94}Sr + 2{}_0^1n$

We know that for atomic mass

$$1 + 235 = a + 94 + 2$$

$\therefore$ $$a = 236 - 96 = 140$$

And for atomic number

$$0 + 92 = 54 + b + 0$$

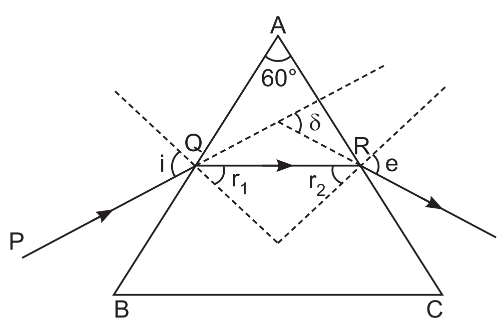
$\therefore$ $$b = 92 - 54 = 38$$

$\therefore$ The correct equation will be

${}_0^1n + {}_{92}^{235}U \longrightarrow {}_{54}^{140}Xe + {}_{38}^{94}Sr + 2{}_0n^1$

**25.** Given: $A = 60°$, $\mu = \sqrt{3}$, $AQ = AR \Rightarrow QR||BC$

Hence in this case, there will be minimum deviation




$\therefore$ $$r_1 = r_2 = r$$

Using, $$r_1 + r_2 = A$$

or $$2r = A$$

or $$r = \frac{A}{2}$$

or $$r = \frac{60}{2} = 30°$$

Now, using $$\mu = \frac{\sin i}{\sin r}$$

or $$\sqrt{3} = \frac{\sin i}{\sin 30°}$$

or $$\sin i = \sqrt{3}\ \sin 30° = \frac{\sqrt{3}}{2}$$

or $$i = 60°$$

Now, using $i + e = A + \delta$

For minimum deviation, $i = e$, $\delta = \delta_m$

$\therefore \quad i + i = A + \delta_m$

or $\quad \delta_m = 2i - A$

Putting the values, $\quad \delta_m = 2 \times 60° - 60°$

$= 120° - 60° = 60°$

or $\quad \sin e = \mu \sin 30°$

or $\quad \sin e = \sqrt{3} \times \frac{1}{2}$

or $\quad e = 60°$

**26.** Given: $u_o = 6$ cm, $f_o = 4$ cm, $f_e = 10$ cm

For an objective lens, $\quad \frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o} \Rightarrow \frac{1}{4} = \frac{1}{v_o} - \frac{1}{-6}$

$\therefore \quad \frac{1}{v_o} = \frac{1}{4} - \frac{1}{6} = \frac{6-4}{24} = \frac{1}{12} \Rightarrow v_o = 12$ cm

For a maximum magnification, the final image is formed at least distance of distinct vision.

For an eyepiece, $\quad \frac{1}{f_e} = \frac{1}{-D} - \frac{1}{u_e} \Rightarrow \frac{1}{10} = -\frac{1}{25} - \frac{1}{u_e}$

$\therefore \quad \frac{1}{u_e} = -\frac{1}{25} - \frac{1}{10} = \frac{-2-5}{50} = -\frac{7}{50}$

$\therefore \quad u_e = -\frac{50}{7}$ cm

Therefore, length of microscope $= v_o + |-u_e| = 12 + \frac{50}{7} = 12 + 7.14 = 19.14$ cm

and $\quad m = -\frac{v_o}{u_o}\left(1 + \frac{D}{f_e}\right)$

$= -\frac{12}{6}\left(1 + \frac{25}{10}\right) = -\frac{12}{6} \times \frac{7}{2} = -7$

Hence, the magnification of microscope is $-7$.

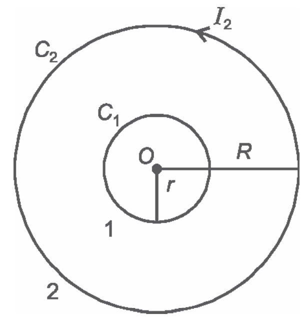
**27.** (I) (*a*) Mutual inductance between two long coaxial solenoids is defined as the magnetic flux linked to the second coil when unit current is flowing in the first coil.

It is the phenomenon by virtue of which a coil resists any change in the strength of current in its neighbouring coil.

(*b*) Let $I_2$ current flow in the second coil of radius $R$. The magnetic field at its centre will be

$$B_2 = \frac{\mu_0 I_2}{2R} \qquad \begin{pmatrix} r_1 = r \\ r_2 = R \end{pmatrix}$$

As $r << R$, the magnetic field $B_2$ is almost constant over the first coil of radius $r$. Hence the magnetic flux linked with the small coil will be




$$\phi_1 = B_2 A_1$$
$$= \frac{\mu_o I_2}{2R} . \pi r^2$$

Also by definitions $\phi_1 = MI_2$

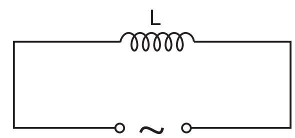
$$\therefore \quad MI_2 = \frac{\mu_o I_2}{2R} \pi r^2$$

$$\therefore \quad M = \frac{\mu_o \pi r^2}{2R}$$

***Or***

(II) Let $\quad V = V_0 \sin \omega t$

Due to self induction a back emf is set up in the coil of magnitude $L\frac{di}{dt}$. The net emf thus will be $V_0 \sin \omega t - L\frac{di}{dt}$, which should be equal to zero as there is no resistnace in an ideal inductance.




$$V_0 \sin \omega t - L\frac{di}{dt} = 0$$
$$L\frac{di}{dt} = V_0 \sin \omega t$$

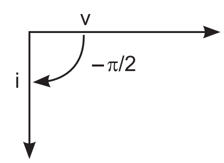
or $$\frac{di}{dt} = \frac{V_0}{L} \sin \omega t$$

or $$di = \frac{V_0}{L} \sin \omega t dt$$

Integrating on both sides

$$i = -\frac{V_0}{\omega L} \cos \omega t$$

or $$i = i_0 \sin(\omega t - \pi/2),$$




where, $i_0 = \frac{V_0}{\omega L}$ is the peak value of current.

We see that in a pure inductor the current lags behind the voltage by $\pi/2$ phase difference. Showing in phasor diagram.

**28. Moving Coil Galvanometer.** It is an instrument used for the detection and measurement of current. Its action is based on the torque acting on a current-carrying coil placed in a magnetic field.

The current passed through the galvanometer is directly proportional to the deflection produced. This is working principle of moving coil galvanometer.

A torque is exerted in a current carrying coil if placed in a magnetic field.

Given that $$V = i_g(G + R_1) \quad ...(i)$$

and $$\frac{V}{2} = i_g(G + R_2) \quad ...(ii)$$

Dividing (*i*) by (*ii*), we get

$$2 = \frac{G + R_1}{G + R_2} \quad \text{or} \quad G = R_1 - 2R_2 \qquad ...(iii)$$

Suppose $R$ is the resistance in series for range $2V$, then

$$2V = i_g(G + R) \qquad ...(iv)$$

Dividing (*iv*) by (*i*) we get

$$2 = \frac{G + R}{G + R_1}$$

or $$R = G + 2R_1 \Rightarrow R_1 - 2R_2 + 2R_1 \; [\because G = R_1 - 2R_2]$$

$\therefore$ $$R = 3R_1 - 2R_2$$

**29.** (*i*) (*a*)

(*ii*) (*d*)

(*iii*) (*c*)

(*iv*) (*b*) $$\lambda = \frac{12.27}{\sqrt{V}} \text{ Å} = \frac{12.27}{\sqrt{100}} \text{ Å}$$

$$= \frac{12.27}{10} = 1.227 \text{ Å} = 0.123 \text{ nm}$$

**30.** (*i*) The barrier potential is an internal built-in potential created by the diffusion of charge carriers at the junction. Since it exists only within the depletion region and has no external terminals, it cannot drive current in the external circuit. It only influences carrier motion inside the semiconductor.

(*ii*) This is because the immobile positive ions in the *n*-region and negative ions in the *p*-region create an electric field across the junction.

(*iii*) It decreases, as the applied potential opposes the barrier potential.

**31.** (I) (*a*) (*i*) The arm *BE* contains a capacitor, hence no current flows through it. Let in mesh *DEFABCD*, the current $I$ flows.

The total emf of the mesh $= 2V - V = V$

The effective resistance, $R' = 2R + R = 3R$

$\therefore$ $$I = \frac{V}{3R}$$

Now the potential difference across *BE* can be either

$$V_{BE} = 2V - I \times 2R = 2V - \frac{V}{3R} \times 2R = \frac{4V}{3}$$

or $$V_{BE} = V + I \times R = V + \frac{V}{3} = \frac{4V}{3}$$

As the cell and capacitor are in series, the potential difference across the capacitor,

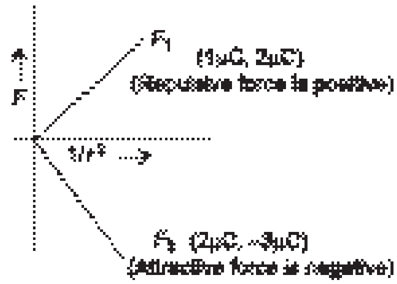
$$V_{BE} = V_C + V$$

or $$V_C = \frac{4}{3}V - V = \frac{V}{3}$$

(*ii*) Charge on capacitor, i.e. $Q = C \times \frac{V}{3} = \frac{CV}{3}$

(*iii*) Energy stored in the capacitor, $U = \frac{1}{2}CV^2 = \frac{1}{2}C\left(\frac{V}{3}\right)^2 = \frac{CV^2}{18}$

(*b*) The slope of the line is directly proportional to the force acting between the charges for a given separation. The force with 1st pair of charges, i.e. $F_1$ is repulsive and hence positive (+ve), while the force for 2nd pair of charges, i.e. $F_2$ is attractive and hence negative (–ve). Here $F_2$ is greater than $F_1$, therefore slope of $F_2$ is greater than $F_1$.




***Or***

(II) (*a*) Let $C$ be capacity of the parallel plate capacitor charged to a potential $V$ of the battery. When the battery is disconnected, the charge on the capacitor remains the same.

(*i*) On inserting a dielectric, slab the capacitance of the capacitor becomes $K$ times the original value.

i.e. $C' = KC$

(*ii*) The new potential $V'$ is given by

$$V' = \frac{Q}{C'} = \frac{Q}{KC} = \frac{V}{K} \qquad \left[\because V = \frac{Q}{C}\right]$$

i.e. potential is reduced $K$ times.

Now, the new electric field $E'$ is given by

$$E' = \frac{V'}{d} = \frac{V}{Kd} = \frac{E}{K} \qquad \left(\because E = \frac{V}{d}\right)$$

i.e. the electric field is reduced $K$ times.

(*iii*) Let $U$ and $U'$ be the energies stored in the capacitor before and after the dielectric is introduced.

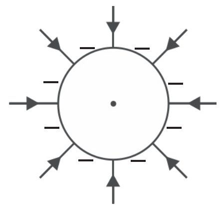
Then $U = \frac{1}{2}CV^2$ and $U' = \frac{1}{2}C'V'^2 = \frac{1}{2}KC\left(\frac{V}{K}\right)^2 \qquad \left[\because V' = \frac{V}{K}\right]$

$$U' = \frac{1}{2}\frac{CV^2}{K} = \frac{U}{K}$$

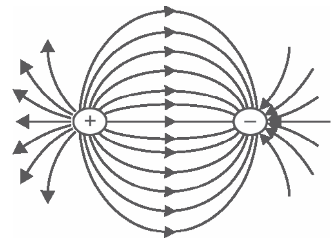
i.e. the energy stored in the capacitor is reduced $K$ times.

(*b*) The pattern of electric lines of force of a conducting sphere having a negative charge.

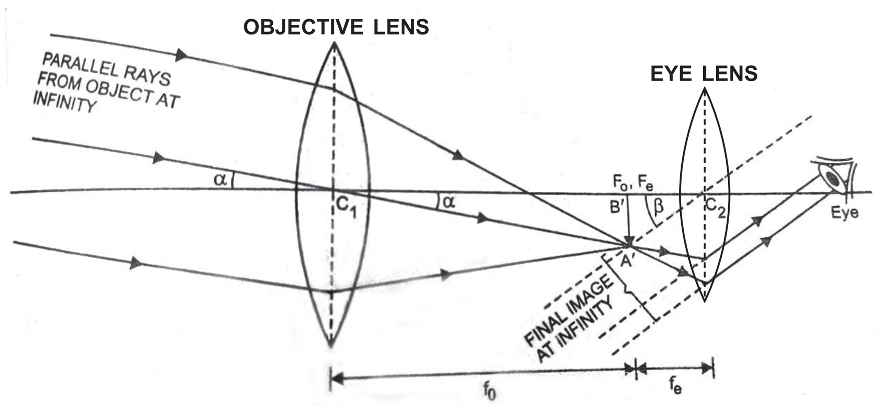
(*i*) There is no electric field lines of force inside the conducting sphere.



(*ii*) The pattern of the electric field lines of force of the electric dipole.



**32.** (I) (*a*)




**Astronomical Telescope**

(*b*) (*i*) The angular magnification of a refracting (astronomical) telescope is given by:

$$M = \frac{f_o}{f_e}$$

Substituting the given values:

$$M = \frac{2}{0.05} = 40$$

The angular magnification is 40, meaning the object appears 40 times larger through the telescope than to the naked eye.

(*ii*) The angular magnification for a reflecting telescope is also given by:

$$M = \frac{f_p}{f_e}$$

Substituting the values:

$$M = \frac{1.5}{0.04} = 37.5$$

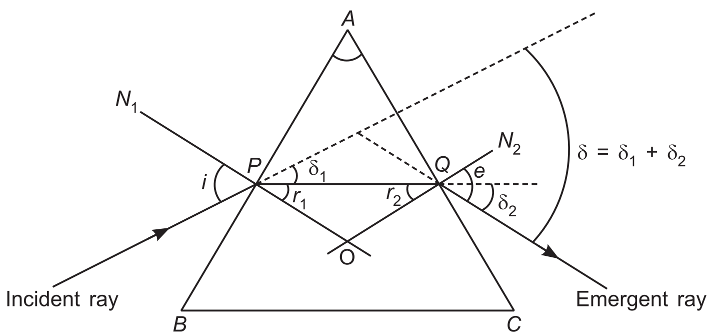
Thus, the angular magnification is 37.5.

(*iii*) The following are the two advantages of a reflecting type telescope over a refracting type telescope:

1. As there is no refraction, it is free from the chromatic aberration.
2. The light gathering power of the objective must be higher to get better resolution. It is easier to handle and cheaper to make mirrors of larger diameters.

***Or***

(II) (*a*)




From the diagram, $\delta_1 = i - r_1$ and $\delta_2 = e - r_2$

$\therefore \quad \delta = \delta_1 + \delta_2 = (i + e) - (r_1 + r_2)$ ...(*i*)

In quadrilateral *POQA*, the sum of all four angles is 360°.

or $\quad \angle P + \angle O + \angle Q + \angle A = 360°$

As $\angle P$ and $\angle Q$ are right angles $\therefore \angle P + \angle Q = 180°$

$\therefore \quad \angle O + \angle A = 180°$ ...(*ii*)

In triangle *POQ*,

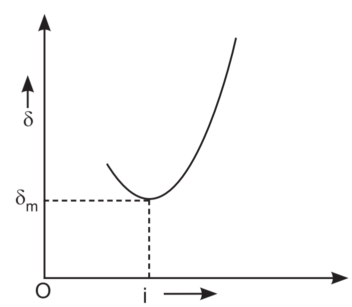
$\angle O + \angle r_1 + \angle r_2 = 180°$ ...(*iii*)

$\therefore \quad A = r_1 + r_2$ ...(*iv*)

and $\quad \delta = i + e - A$ ...(*v*)

or $\quad \boxed{\delta + A = i + e}$

The graph between δ and *i* is parabolic in shape.




Graph of δ vs i

**Conclusions from the graph:**

At $\delta_m$, (*i*) $i = e$

(*ii*) $r_1 = r_2 = r$ (say)

(*iii*) Ray *PQ* is parallel to base *BC* of the prism.

Using equation (*iv*), (*v*) and above conclusions, we get

$$A = 2r \quad \text{or} \quad r = \frac{A}{2}$$

$$\delta_m + A = 2i \quad \text{or} \quad i = \frac{\delta_m + A}{2}$$

Therefore, $$\mu = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

(*b*) (*i*) The angle of refraction inside the prism at face AB is calculated using Snell's law:

$$\mu_{air} \sin i = \mu \sin r$$

where $\mu_{air} = 1$, $i = 50°$ and $\mu = 1.6$. Substituting these values:

$$\sin r = \frac{\sin 50°}{1.6} = \frac{0.766}{1.6} = 0.478$$

Taking the inverse sine of 0.478, we get:

$$r = \sin^{-1}(0.478) = 28.6°$$

Thus, the angle of refraction inside the prism at face AB is 28.6°.

(*ii*) The angle of incidence at the second face AC is calculated using the prism angle. Since the total angle inside the prism must satisfy:

$$r + r_2 = A$$

we have: $r_2 = 60° - 28.6° = 31.4°$

Using Snell's law again to calculate the angle of emergence, with the angle of incidence inside the prism being $r_2 = 31.4°$ and $\mu = 1.6$:

$$\mu \sin r_2 = \mu_{air} \sin e$$

Substituting the values:

$$1.6 \times \sin 31.4° = 1 \times \sin e$$

$$\sin e = 1.6 \times 0.520 = 0.832$$

Taking the inverse sine of 0.832, we get

$$e = \sin^{-1}(0.832) = 56.3°$$

(*iii*) The total deviation δ caused by the prism is given by,

$$\delta = i + e - A = 50° + 56.3° - 60° = 46.3°$$

**33.** (I) (*a*) $\because \quad I_{rms} = \frac{V_{rms}}{\sqrt{R^2 + (2\pi\nu L)^2}}$, here $L = \mu_0 n^2 Al$

When the iron rod is inserted in a solenoid, the inductance increases according to $L' = \mu_r \mu_0 n^2 Al$, as $\mu_r$ for iron is very large. Therefore, the current in the circuit decreases and bulb will glow dimmer.

(*b*) Given: $V = V_o \sin(1000t + \phi)$, $L = 100$ mH, $C = 2$ μF

$\omega = 1000 \text{ rad s}^{-1}$, $R = 400\ \Omega$

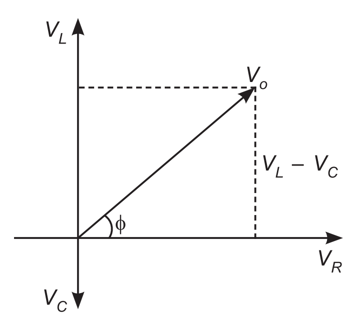
$X_L = \omega L = 1000 \times 100 \times 10^{-3} = 100\ \Omega$

$X_C = \frac{1}{\omega C} = \frac{1}{1000 \times 2 \times 10^{-6}} = 500\ \Omega$

(*i*) $V = V_o \sin(1000t + \phi)$

$$\tan \phi = \frac{V_L - V_C}{V_R}$$

or $$\tan \phi = \frac{X_L - X_R}{R}$$



$$= \frac{100 - 500}{400} = \frac{-400}{400} = -1$$

$$\therefore \quad \phi = \frac{-\pi}{4}$$

$\because X_C > X_L$, $\therefore$ circuit is capacitive in nature and current will lead the voltage by a phase angle of $\pi/4$.

(*ii*) Power factor = 1 when $X_L = X_C'$

$$\therefore \quad 100 = \frac{1}{\omega(C + C')}$$

$$\Rightarrow \quad C + C' = \frac{1}{100 \times 1000} = 10\ \mu F$$

$$\therefore \quad C' = (10 - 2) = 8\ \mu F$$

***Or***

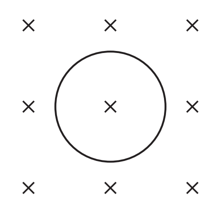
(II) (*a*) **Faraday's law of electromagnetic induction:**

(*i*) Whenever there is a change in the magnetic flux linked with a circuit, an induced emf is set up in it and lasts as long as the magnetic flux linked with it is changing.

(*ii*) The magnitude of the induced emf $\varepsilon$ in a circuit is directly proportional to the rate of change of magnetic flux linked with the circuit.

i.e. $$\varepsilon \propto \frac{-d\phi}{dt}$$

(*b*) Radius $r$ = 12 cm = 0.12 m, Resistance $R$ = 8.5 Ω, $\theta = 0°$



$$A = \pi r^2 = 3.14 \times (0.12)^2 = 0.045\ m^2$$

Magnetic flux passing through the loop

$$\phi = BA \cos 0° = BA$$

$$\therefore \quad \text{Induced current } i = \frac{-1 d\phi}{R dt} = \frac{-A}{R}\frac{dB}{dt}$$

In time interval, 0 – 2 sec : $\Delta t = 2 - 0 = 2$ sec

$$\Delta B = 1 - 0 = 1\ T$$

$$\therefore \quad i = \frac{-A}{R}\frac{\Delta B}{\Delta t} = \frac{-0.045}{8.5} \times \frac{1}{2}\ A$$

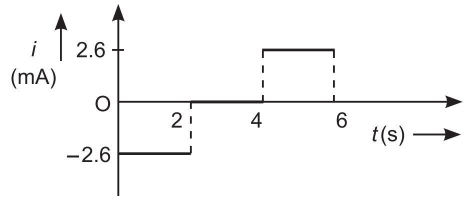
$$i = -2.6 \times 10^{-3}\ A = -2.6\ mA$$

From 2 – 4 sec, $\Delta B = 0$;

$\therefore \quad i = 0$

From 4 sec – 6 sec; $\Delta B = (0 - 1)T = -1\ T$; $\Delta t = 6 - 4 = 2$ s

$$\therefore \quad i = \frac{-0.045}{8.5} \times \left(\frac{-1}{2}\right) = 2.6 \times 10^{-3}\ A = 2.6\ mA$$




(*c*) Lenz's law complies with the principle of conservation of energy. For example, when the N-pole of a bar magnet is pushed into a coil as shown, the direction of induced current in the coil will be such that the end 2 of the coil will act as N-pole. Thus, work has to be done against the magnetic repulsive force to push the magnet into the coil. The electrical energy produced in the coil is at the expense of this work done.