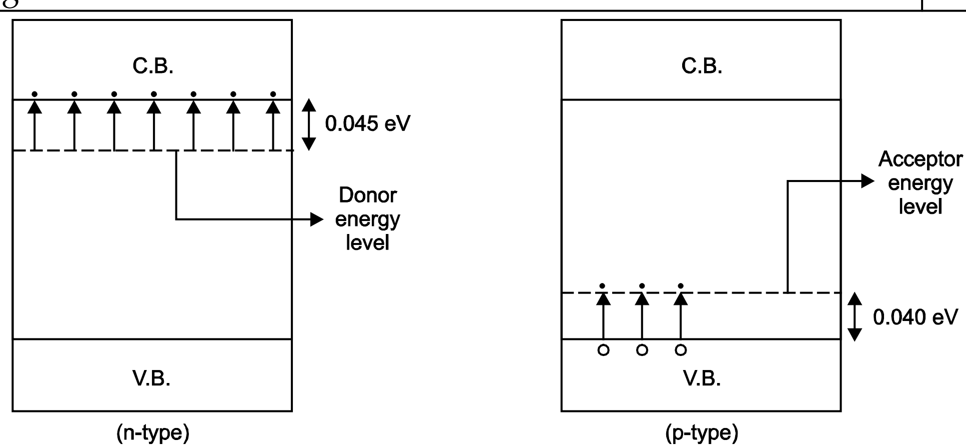
MARKING SCHEME CODE: D

SECTION A

1.	(*c*) $-q\,LE$	**1**
2.	(*a*) red colour	**1**
3.	(*c*) 1 : 3	**1**
4.	(*d*) $R = 0$	**1**
5.	(*a*) Resistivity	**1**
6.	(*b*) ferromagnetic material becomes paramagnetic	**1**
7.	(*a*) electric field is changing	**1**
8.	(*a*) move in a straight line	**1**
9.	(*a*) binding energy per nucleon increases	**1**
10.	(*c*) zero as diffusion and drift currents are equal and opposite	**1**
11.	(*b*) just below the conduction band	**1**
12.	(*a*) $\frac{1}{\in_0}$	**1**
13.	(*d*) $\frac{1}{n^2}$	**1**
14.	(*b*) zero	**1**
15.	(*a*) both A and R are true and R is the correct explanation of A	**1**
16.	(*a*) Both A and R are true and R is the correct explanation of A	**1**
17.	(*d*) A is false and R is also false	**1**
18.	(*a*) Both A and R are true and R is the correct explanation of A	**1**

SECTION B

19.	Energy band diagram Significance	½ + ½ ½ + ½



$\frac{1}{2} + \frac{1}{2}$

Significance

n-type semiconductor– small energy gap b/w donor level and conduction band which can be easily covered by thermally excited electrons. ½

p-type semiconductors– small energy gap b/w acceptor level and valence band which can be easily covered by thermally excited electrons. ½

OR

When p-type semiconductor is joined with n-type semiconductor, e from the n-side diffuse towards p-side and holes from p-side diffuse towards n-sides leaving behind a layer of immobile +ve ions on n-side and immobile –ve ions on p-side leading to formation of depletion layer. **2**

(Note: Award 1 mark, if a student draws a diagram showing depletion layer)

20.

Arrangement	**1**
two uses	**½ + ½**

Radiowaves < microwaves < X-rays < gamma rays **1**

Uses of microwaves

1. Microwave oven ½
2. in Rader system ½

21.

Definition	**1**
Calculation of focal length	**1**

One Dioptre is the power of a lens whose focal length is one metre. **1**

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ½$$

$$R_1 = \infty, \quad R_2 = -25 \text{ cm}, \quad \mu = 1.5$$

$$\frac{1}{f} = (1.5–1)\left(\frac{1}{\infty} + \frac{1}{25}\right)$$

$$f = 50 \text{ cm} \quad ½$$

22. As $V = \dfrac{q}{C}$ ½

dW is the W.D. in giving additional charge dq

$$dW = V\,dq = \frac{q}{C}dq \quad ½$$

$$W = \int dW = \frac{1}{C}\int_0^Q q\,dq = \frac{1}{C}\left[\frac{q^2}{2}\right]_0^Q$$

$$= \frac{Q^2}{2C}$$

This work done is stored in the form of energy of capacitor.

$$\boxed{E = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV}$$ **1**

OR

field inside a conductor just outside the sphere	**1** **1**

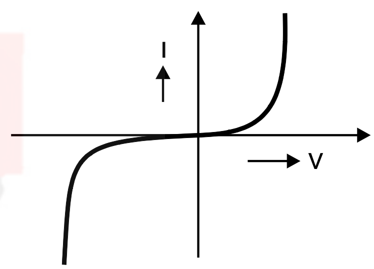
(*a*) Inside a conductor the electric field is zero because charges resides on the surface of sphere. **1**

(*b*) $$E = \frac{1}{4\pi \epsilon_0}\frac{q}{R^2}$$ ½

$$E = 9 \times 10^9 \times \frac{(1.6 \times 10^{-7})}{(12 \times 10^{-2})^2}$$

$$= 10^5 \text{ NC}^{-1}$$ ½

23. There are some devices which do not obey ohm's law and have non-linear I-V characteristics are called non-ohmic devices. **1**

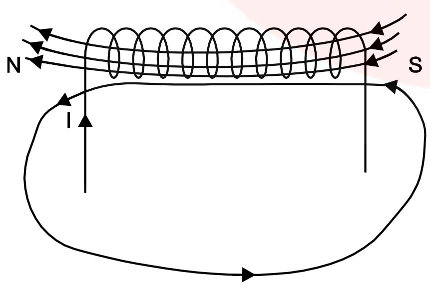


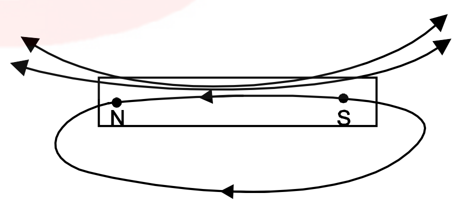
e.g., semiconductor devices like *p-n* junction diode, thermistors etc.

$$\frac{V}{I} = R \neq \text{constant}$$

(for *p-n* junction diode) **1**

24. Magnetic field lines for a bar magnet and a current carrying solenoid resembles very closely. **1**



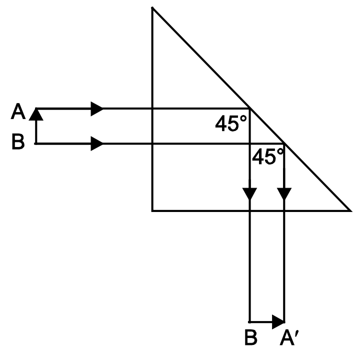


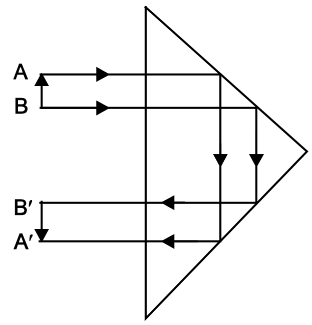
Magnetic field on the axial line of a bar magnet is equal to the magnetic moment of an equivalent solenoid that produces the same magnetic field.

$$B = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$$ **1**

25. Totally reflecting prisms are used to change the path of a ray by 90° or 180°. These are the right angled glass prisms of refractive index 1.5 and critical angle

41.8°. In totally reflecting glass prisms, angle of incidence is made 45° (> C). Hence light suffers total internet reflection. **1**

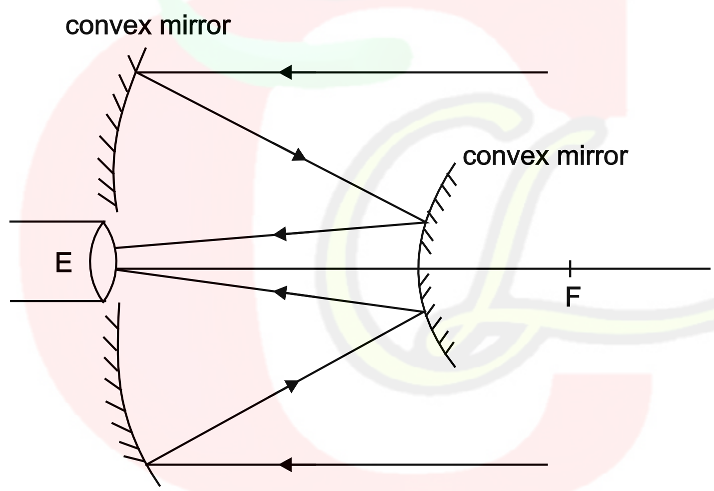




SECTION C

26.

Diagram	**1**
Two advantages	**1 + 1**



Cassegrainian Telescope

Advantages:

1. There is no chromatic aberration as the objective is a mirror.
2. Image is bright as compared to refracting type telescope. **1 + 1**

OR

(i) Calculating fringe width	**1**
(ii) Distance of fringes	**1 + 1**

(i)

$$\beta = \frac{\lambda D}{d} = \frac{600\times 10^{-9}\times 1.6}{0.8\times 10^{-3}}$$

$$= 1.2 \text{ mm}$$ **1**

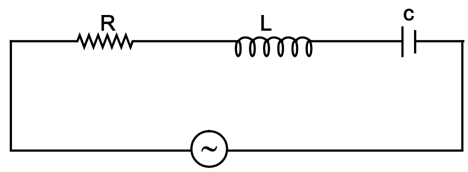
(*i*) (*a*) $x_3 = \frac{5}{2}\frac{\lambda D}{d} = \frac{5}{2} \times 1.2$

$= 3$ mm

(*b*) $x_5 = \frac{5\lambda D}{d} = 5 \times 1.2$

$= 6.0$ mm **1**

27.

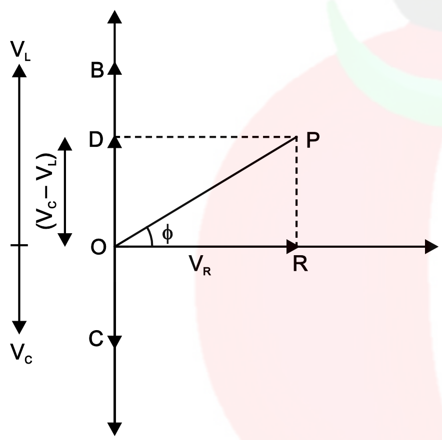


Let $I = I_0 \sin \omega t$

$V_R = IR$ represented by OR

$V_L = I X_L$ represented by OB

$V_C = I X_C$ represented by OC



1

In ΔOPR $(OP)^2 = (OR)^2 + (PR)^2$

$V^2 = V_R^{\ 2} + (V_L - V_C)^2$

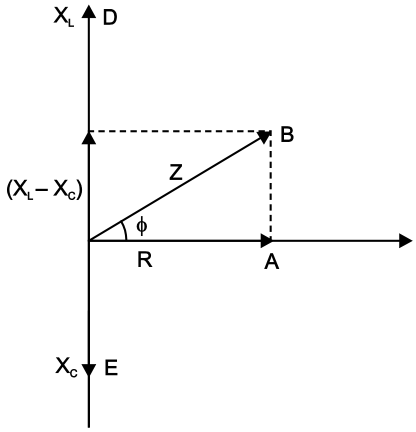
$E = V = I\sqrt{R^2 + (X_L - X_C)^2}$

$I = \frac{E}{\sqrt{R^2 + (X_L - X_C)^2}}$

Here $Z = \sqrt{R^2 + (X_L - X_C)^2}$ = Impedance of the circuit **1**

Resistance offered by the L, C and R to the flow of current.

Impedance triangle



1

OR

At low frequency X_L is small but X_C is high and at high frequency X_L is high but X_C is small. But at a frequency when $X_L = X_C$ called as resonant frequency Impedance of LCR is minimum and current through the circuit is maximum.

$$X_L = X_C$$

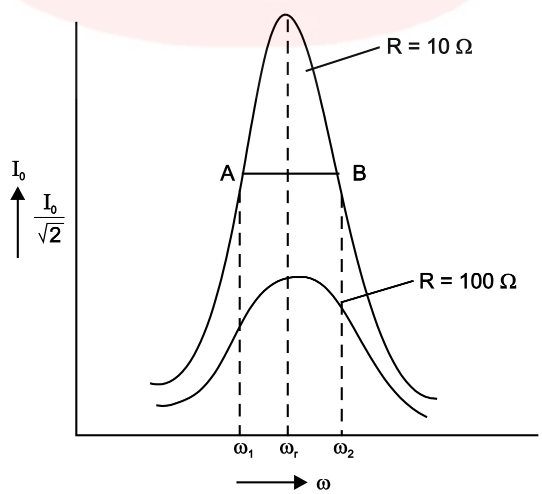
$$\omega L = \frac{1}{\omega C}$$

$$\omega^2 = \frac{1}{LC}$$

$$\omega = \frac{1}{\sqrt{LC}}$$ ω – Resonating angular frequency

$$v = \frac{1}{2\pi\sqrt{LC}}$$ 1½

$$I_0 = \frac{E_0}{R}$$ (max. at resonance)

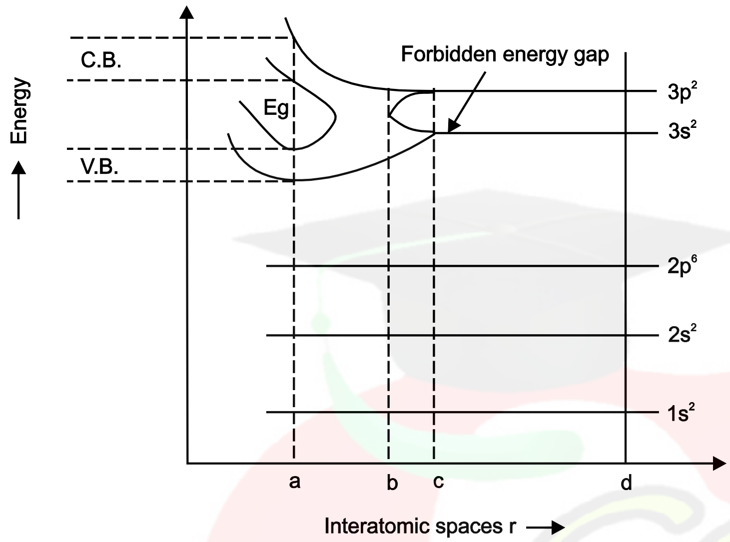


Q-factor is the sharpness of curve at resonance.

$$\text{Q-factor} = \frac{\text{Pot}^n \text{ drop across } L \text{ or } C}{\text{Pot}^n \text{ drop across } R \text{ at resonance}}$$

$$= \frac{I_0 X_L}{I_0 R} = \frac{\omega L}{R} \qquad \text{and} \qquad \omega = \frac{1}{\sqrt{LC}}$$

$$\boxed{\text{Q-factor} = \frac{1}{R}\sqrt{\frac{L}{C}}}$$ $1\frac{1}{2}$

28. 

1

The process of splitting of energy levels can be understood by considering the different situations.

(*i*) **When $r = d$** – No modification of energy levels.

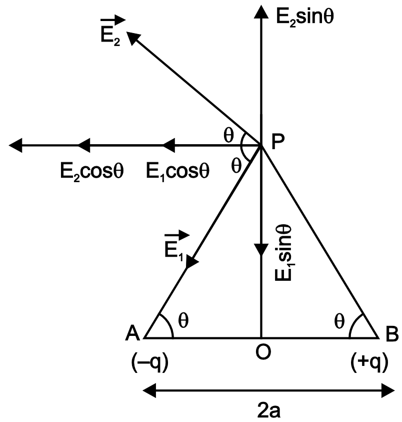
(*ii*) **When $r = c$** – Interaction b/w outermost shell electrons of neighbouring Si atoms increases and energy gap b/w $2N - 3s$ levels and $6N - 3p$ levels goes on decreasing.

(*iii*) **When $b < r < c$** – Instead of single $3s$ and $3p$ level, we get large no. of closely packed level.

(*iv*) **When $r = b > a$ –** The energy gap b/w $3s$ and $3p$ levels completely disappears and all the 8N levels are continuously distributed. One can say that 4N levels are filled and 4N levels are empty.

(*v*) **When $r = a$ –** 4N filled levels get separated from 4N empty levels. 4N filled level form a band called valance band and 4N empty levels form a band called conduction band. **2**

29. Let us consider two charges $-q$ and $+q$ separated by certain distance $2a$ form a dipole of moment $p = q\,(2a)$



1

$$\vec{E_1} = \frac{1}{4\pi \epsilon_0} \frac{q}{(r^2 + a^2)}$$ along PA due to $-q$ charge

$$\vec{E_2} = \frac{1}{4\pi \epsilon_0} \frac{q}{(r^2 + a^2)}$$ along extended BP due to $+q$ charge

$$|\vec{E_1}| = |\vec{E_2}|$$ **1**

Resolve $\vec{E_1}$ and $\vec{E_2}$ as shown in fig.

Net electric field

$$E = E_1 \cos\theta + E_2 \cos\theta$$
$$= 2\, E_1 \cos\theta$$
$$E = 2 \frac{1}{4\pi \epsilon_0} \frac{q}{(r^2 + a^2)} \cdot \frac{a}{(r^2 + a^2)^{3/2}}$$
$$E = \frac{p}{4\pi \epsilon_0 (r^2 + a^2)^{3/2}}$$

for ideal dipole $2a \approx 0$

$$\boxed{E = \frac{p}{4\pi \epsilon_0\, r^3}}$$ **1**

30.	Application of KVL on loops	$\mathbf{1\frac{1}{2}}$
	Calculation of I_1, I_2, I_3	$\mathbf{1\frac{1}{2}}$

Apply KVL on loop EABCE

$$10 = 10\,(I_1 + I_2) + 10\, I_1 + 5\,(I_1 - I_3)$$
$$2 = 5I_1 + 2I_2 - I_3 \qquad ...(1)$$

Apply KVL on loop ABDA

$$10\, I_1 + 5\, I_3 - 5\, I_2 = 0$$
$$I_2 = 2\, I_1 + I_3 \qquad ...(2)$$

Apply KVL on loop BCDB

$$5(I_1 - I_3) = 10\ (I_2 + I_3) - 5\,I_3 = 0$$

$$I_1 = 2I_2 + 4\,I_3 \qquad \text{...(3)}$$

On solving we get

$$I_1 = \frac{4}{17}\text{A}, \quad I_2 = \frac{6}{17}\text{A}, \quad I_3 = \frac{-2}{17}\text{A}$$

$$\therefore \quad I_1 + I_2 = \frac{10}{17}\text{A}$$

$$I_1 - I_3 = \frac{6}{17}\text{A}$$

$$I_2 + I_3 = \frac{4}{17}\text{A}$$

SECTION D

31. (*i*) (*c*) mutual Induction **1**

(*ii*) (*c*) frequency **1**

(*iii*) (*d*) soft iron **1**

(*iv*) (*b*) 2*A* **1**

OR

(*a*) reduce the energy loss due to eddy currents

32. (*i*) (*a*) Photoelectric effect **1**

(*ii*) (*a*) Photons exert no pressure **1**

(*iii*) (*d*) zero **1**

(*iv*) (*b*) No. of photons **1**

OR

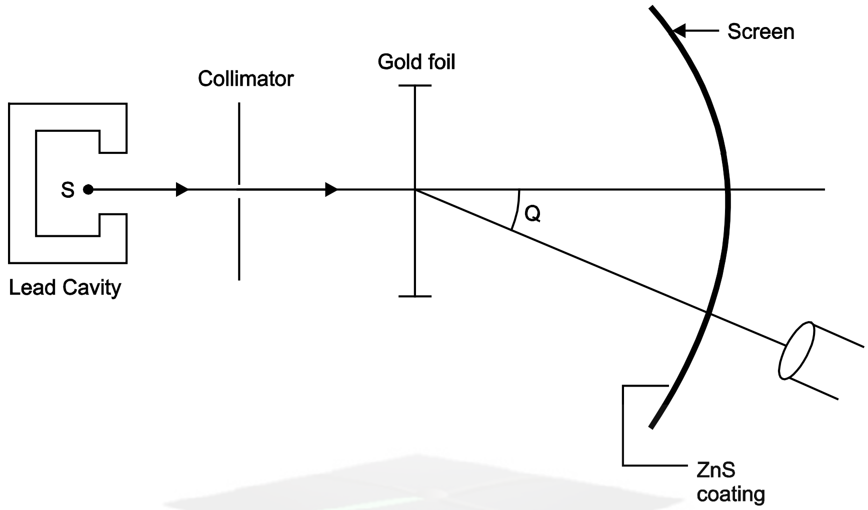
$$E = n\,h\nu \quad \text{or} \quad n = \frac{E}{h\nu}$$

$$n = \frac{6.62}{(6.62 \times 10^{-34}) \times 10^{12}}$$

$$= 10^{22}$$

SECTION E

33.	Diagram	**1**
	Observations	**2**
	Distance of closest approach	**2**



1

Observations:

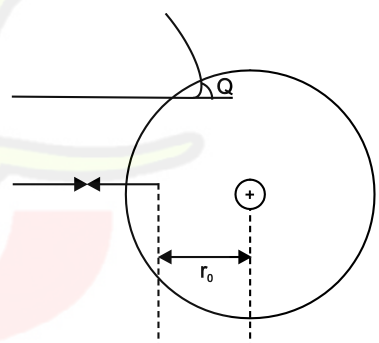
1. Most of the α-particles pass without deflection.
2. Large no. of α-particles are scattered by very small angle.
3. Small no. of α-particles are scattered by large angle.
4. A very few no. of α-particles (1 in 8000) retraced their path. **2**

Distance of closest approach: It is the minimum distance of α-particle from nucleus at which K.E. converts into P.E.

$$\text{K.E.} \Rightarrow \text{P.E.}$$

$$\frac{1}{2}mv^2 = \frac{1}{4\pi\epsilon_0}\frac{(Ze)(2e)}{r_0}$$

$$\boxed{\therefore \quad r_0 = \frac{Ze(2e)}{4\pi\epsilon_0\left(\frac{1}{2}mv^2\right)}}$$



2

OR

Difference b/w nuclear fusion and fission	$1\frac{1}{2} + 1\frac{1}{2} = 3$
de Broglie explanation	2

(*i*) **Nuclear fission:** It is a phenomenon of splitting of a heavy nuclei ($A > 200$) into two or more lighter nuclei.

$$^{235}U_{92} + {}^{1}n_0 \longrightarrow {}^{141}Ba_{56} + {}^{92}Kr_{36} + 3\,{}^{1}n_0 + Q(200\text{ Mev})$$ $1\frac{1}{2}$

Nuclear fussion: It is the phenomenon of fusing two or more lighter nuclei to form a single heavy nucleus

$$^2H_1 + {}^2H_1 \longrightarrow {}^4He_2 + 24 \text{ Mev}$$ **$1\frac{1}{2}$**

(*ii*) Acc. to de Broglie, a stationary orbit is that which contains an integral number of de Broglie waves associated with revolving electron

Total distance covered $2\pi r_n$ **1**

$\therefore$ For permissible orbit $2\pi r_n = n\lambda$ ...(1)

Acc. to de brogile $\lambda = \dfrac{h}{m v_n}$ Put in (1)

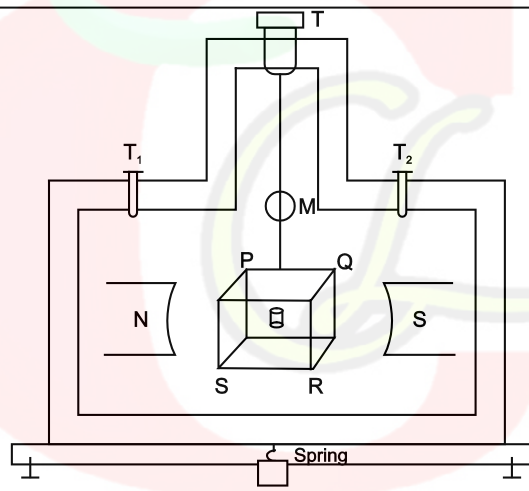
$\Rightarrow$ $2\pi r_n = \dfrac{nh}{m v_n}$

or $\boxed{m v_n r_n = \dfrac{nh}{2\pi}}$ **1**

which is the quantum condition proposed by Bohr in second postulate.

34.

Diagram	**1**
principle	**½**
Construction	**1½**
working	**2**



1

Principle: When a current carrying coil placed in magnetic field, it experiences a torque. ½

Construction: It consists of a rectangular coil PQRS of large no. of turns of insulated copper wire wound over a non-magnetic material frame. A soft iron cylindrical core is placed such that coil can rotate without touching it. Coil is suspended b/w two cylindrical magnets by a phosphor brozne wire. Upper end of the coil is connected to movable torsion head and lower end is connected to hair spring. 1½

Working: Function of cylindrical core and magnet is to provide radial magnetic field.

$$\tau = n I AB$$

If k is the restoring torque per unit twist and θ be the twist in the wire.

In equilibrium $\tau = \tau_R$ (Restoring torque)

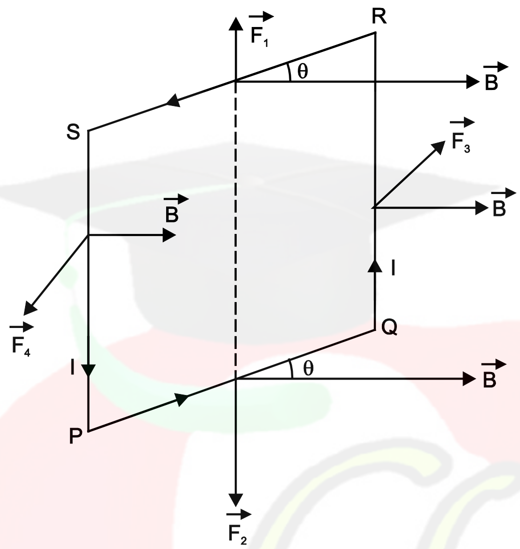
$$n\,I\,AB = k\theta$$

$$I = \frac{k\theta}{n\,AB}$$

$$= G\theta \quad \text{where } G = \frac{k}{n\,AB} \text{ galvanometer constant}$$

$\boxed{I \propto Q}$ *i.e*, linear scale deflection **2**

OR



1

Consider a rectangular coil of length l breadth b.

$$SP = QR = l; \qquad PQ = RS = b$$

θ angle made by plane of coil with mag. field

$\vec{F_1} = IbB\sin\theta$ on RS acting $\perp$ to both acting upward given by Right Hand Thumb Rule.

$\vec{F_2} = Ib\,B\sin\theta$ on PQ acting downward given by Right Hand Thumb Rule.

$\vec{F_1}$ & $\vec{F_2}$ are equal and opposite hence cancel each other. **1**

$\vec{F_3} = I\,lB\sin 90° = I\,lB$ acting on QR inwards by Fleming Left hand Rule.

$\vec{F_4} = I\,lB\sin 90° = I\,lB$ acting on SP outwards by Fleming Left hand Rule.

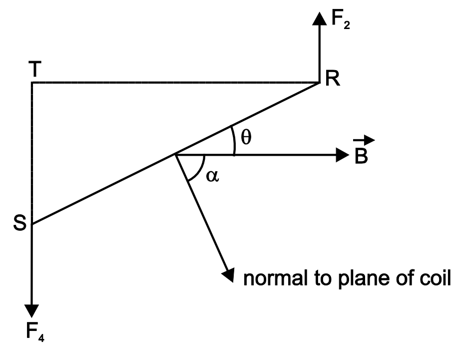
$\vec{F_3}$ & $\vec{F_4}$ are equal but not acting along same line and form a couple which moves the coil in magnetic field. **1**

Torque = force × arm of couple.

$$\tau = I\,l\,B\,(\text{RT})$$

$$= I\,lB\,b\cos\theta$$

$$\tau = I\,A\,B\cos\theta$$



where $A = lb$ = area of coils

Let α is the angle b/w normal to the coil and magnetic field

then $\alpha + \theta = 90°$

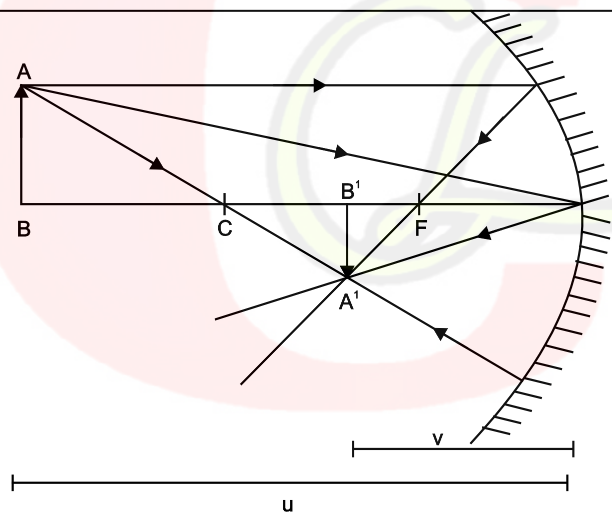
$\therefore \quad \theta = 90 - \alpha$

If n – no. of turns then

$$\therefore \quad \tau = n\, I\, AB \cos (90 - \alpha)$$
$$= n\, I\, AB \sin \alpha$$
$$\tau = MB \sin\alpha \quad \text{M- mag. dipole moment}$$
$$\boxed{\vec{\tau} = \vec{M} \times \vec{B}}$$ **2**

35. (*i*)

Ray diagram	**1**
Derivation	**2**



In ΔABP and $\Delta A'B'P$

$$\frac{AB}{A'B'} = \frac{PB}{PB'} \qquad ...(1)$$

In ΔABC and $A'B'C$

$$\frac{AB}{A'B'} = \frac{CB}{CB'} \qquad ...(2)$$

from (1) & (2)

$$\frac{PB}{PB'} = \frac{CB}{CB'} = \frac{PB - PC}{PC - PB'}$$ **1**

$PB = -u, \qquad PB' = -v, \qquad PC = -R$

$$\frac{-u}{-v} = \frac{-u-(-R)}{-R-(-v)}$$

$$2uv = vR + uR$$

Divide by uvR

$$\frac{2}{R} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \qquad \mathbf{1}$$

(*ii*)

position of image	**1**
Nature and magnification	**½ + ½ = 1**

$u = -10$ cm $\qquad f = \frac{R}{2} = \frac{-15}{2}$ cm

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

$$\frac{-2}{15} = \frac{1}{-10} + \frac{1}{v}$$

$$\frac{1}{v} = \frac{-2}{15} + \frac{1}{10}$$

$$v = -30 \text{ cm} \qquad \mathbf{1}$$

Image is real and inverted **½**

$$m = \frac{-v}{u} = -\frac{(-30)}{(-10)} = -3$$

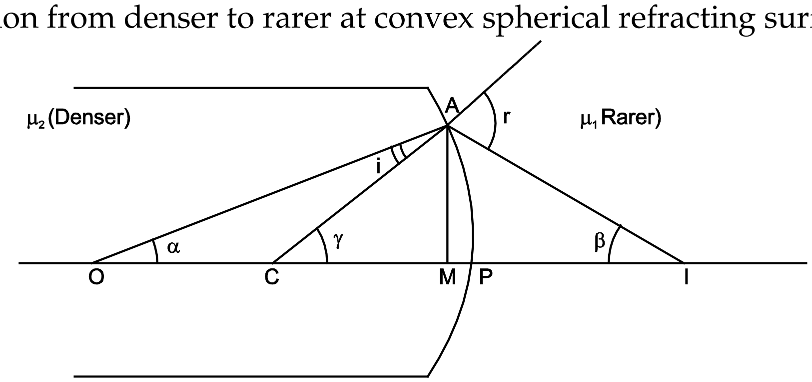
Image is magnified 3 times. **½**

OR

Def. of Refraction	**1**
Diagram	**1**
Derivation	**3**

Refraction of light is the phenomenon of change in path of light when it goes from one medium to another. **1**

Refraction from denser to rarer at convex spherical refracting surface.



1

Apply Snell's law

$$\frac{\mu_1}{\mu_2} = \frac{\sin i}{\sin r} \approx \frac{i}{r}$$

$$\mu_1 r = \mu_2 i \qquad \text{...(1)}$$

$$i = \gamma - \propto \qquad \text{and} \qquad r = \gamma + \beta$$ **1**

Put in (1)

$$\mu_1 (\gamma + \beta) = \mu_2 (\gamma - \propto)$$

$$\mu_1 \left(\frac{AM}{MC} + \frac{AM}{MI} \right) = \mu_2 \left(\frac{AM}{MC} - \frac{AM}{MO} \right)$$

If aperture is small, then

$$\mu_1 \left(\frac{1}{PC} + \frac{1}{PI} \right) = \mu_2 \left(\frac{1}{PC} - \frac{1}{PO} \right)$$

$PO = -u$, $PC = -R$, $PI = +v$

$$\mu_1 \left(\frac{1}{-R} + \frac{1}{v} \right) = \mu_2 \left(\frac{1}{-R} - \frac{1}{-\mu} \right)$$

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

$$\boxed{\frac{\mu_2}{-\mu} + \frac{\mu_1}{v} = \frac{\mu_1 - \mu_2}{R}}$$ **2**