PARISHRAM

2026

Lecture - 01

Moving Charges and Magnetism

PHYSICS LECTURE - 1

BY - RAKSHAK SIR

Topics *to be covered*

A. Introduction to Electromagnetism

B. Biot-Savart Law (BSL)

C.

D.

Marking scheme

Unit-III	**Magnetic Effects of Current and Magnetism**	17
	Chapter–4: Moving Charges and Magnetism	
	Chapter–5: Magnetism and Matter	
Unit-IV	**Electromagnetic Induction and Alternating Currents**	
	Chapter–6: Electromagnetic Induction	
	Chapter–7: Alternating Current	

Unit III: **Magnetic Effects of Current and Magnetism**

Chapter–4: Moving Charges and Magnetism

Concept of magnetic field, Oersted's experiment.

Biot - Savart law and its application to current carrying circular loop.

Ampere's law and its applications to infinitely long straight wire. Straight solenoid (only qualitative treatment), force on a moving charge in uniform magnetic and electric fields.

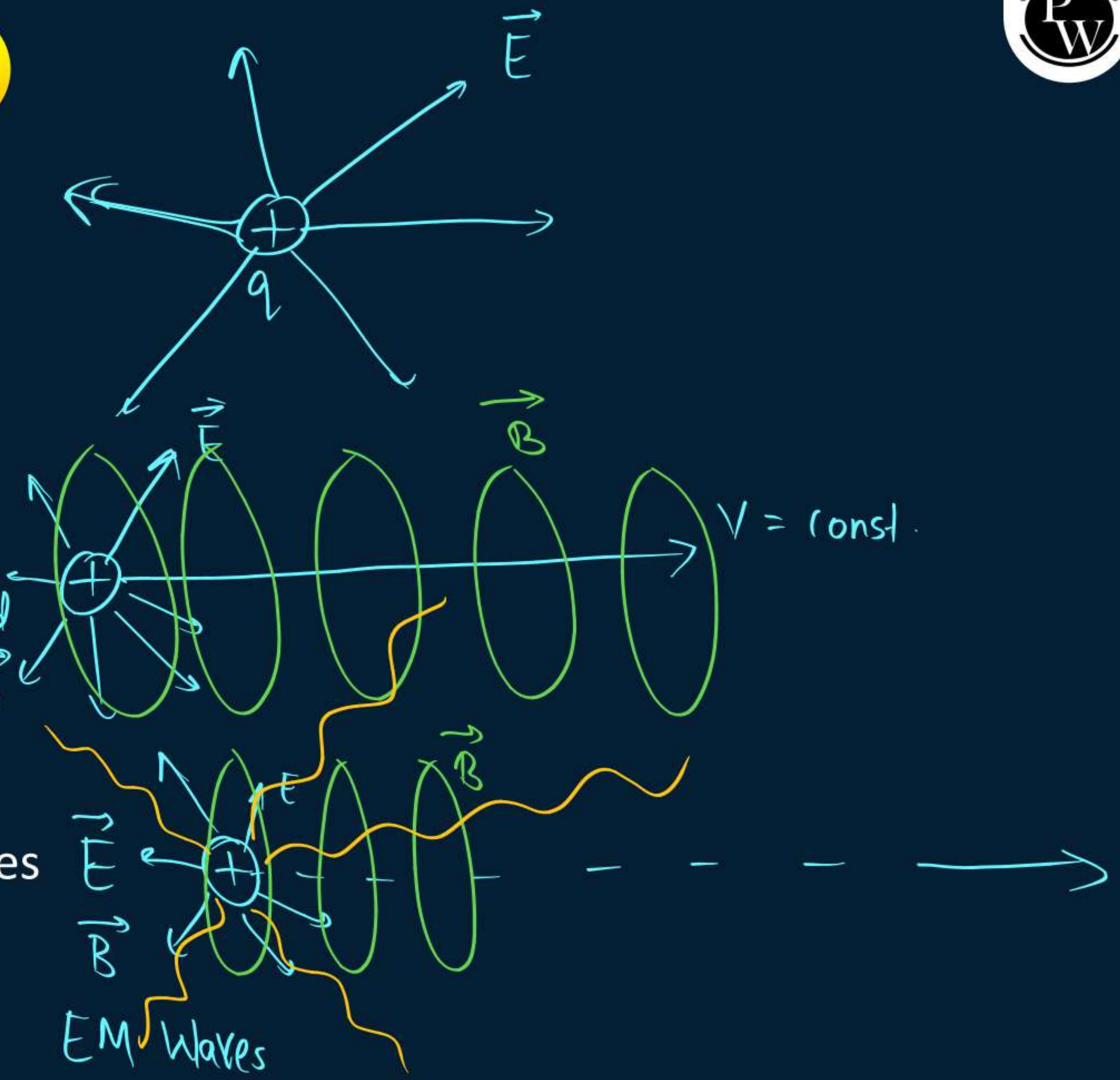
Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; Current loop as a magnetic dipole and its magnetic dipole moment, moving coil galvanometer- its current sensitivity and conversion to ammeter and voltmeter.

Sources and Fields

Charge at Rest : Produces $\vec{E}$ only

Charge in Uniform Motion : Produces $\vec{E}$ and $\vec{B}$
(Constant velocity)

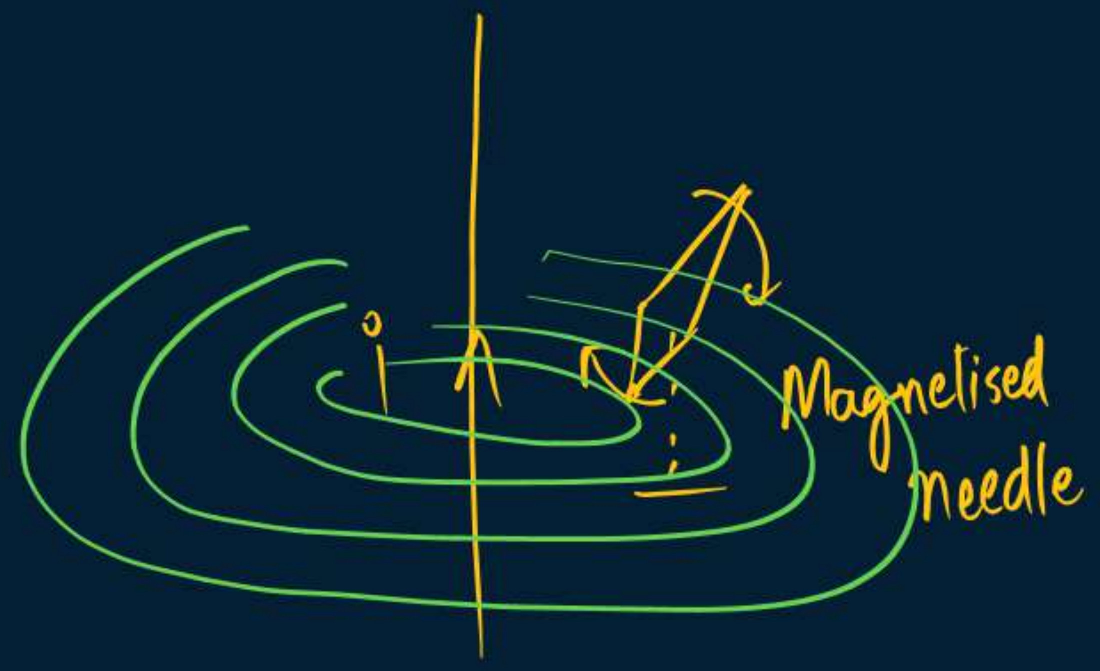
Charge in Non-Uniform Motion : Produces $\vec{E}$ $\vec{B}$
(Accelerate)



Oersted's Experiment

During a lecture demonstration in the summer of 1820, Danish physicist Hans Christian Oersted noticed that a current in a straight wire caused a noticeable deflection in a nearby magnetic compass needle.

Oersted concluded that moving charges or currents produced a magnetic field in the surrounding space.



SBS

F **Assertion (A):** A Charge whether stationary or in motion is a source of magnetic field. $\vec{E}$

T **Reason (R):** A moving charge is a source of magnetic field in the surrounding space.

[AIIMS 2009]

A If both assertion and reason are true and reason is the correct explanation of the assertion.

B If both assertion and reason are true but reason is not correct explanation of the assertion.

C If assertion is true, but reason is false.

D Assertion is false, reason is true

Concept of Magnetic Field

Asar Dekhna Ja Sake

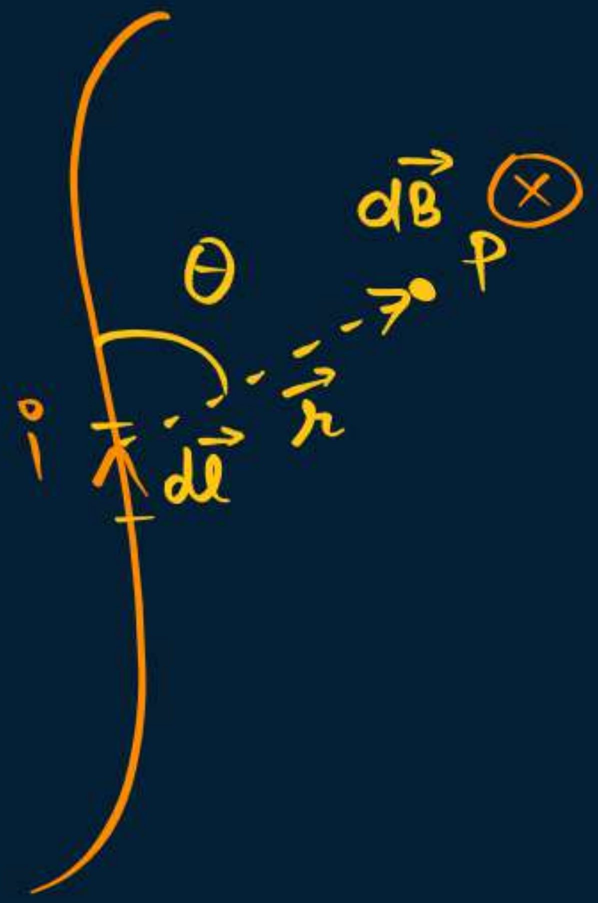
- Space around a magnet within which its Influence can be experienced is called Magnetic Field.
- Magnetic Field is a Vector Quantity
- Denoted by $\vec{B}$
- SI Unit – Tesla (T)
- CGS Unit – Gauss (G)

$$\boxed{1\,T = 10^4\,G}$$

Biot-Savart's law

(BSL) $\rightarrow$ Magnitude of $\vec{B}$ ✓
$\rightarrow$ Direction of $\vec{B}$ ✓

According to Biot-Savart's law, the magnitude of the magnetic field dB is proportional to the current I, the element length |dl|, and inversely proportional to the square of the distance r.



$$|dB| \propto i$$
$$\propto dl$$
$$\propto \frac{1}{r^2}$$
$$\propto \sin\theta$$

$\mu_0 \rightarrow$ permeability of free space

$$\boxed{\mu_0 = 4\pi \times 10^{-7}\ \text{TmA}^{-1}}$$

$i\vec{dl} \rightarrow$ current element

(direction is same as of 'i')

$$dB \propto \frac{i\,dl\sin\theta}{r^2}$$

$$\boxed{dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin\theta}{r^2}}$$

Unit of 'μ_0'

Acc. to B.S.L. :-

$$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin\theta}{r^2}$$

$$T = \mu_0\,\frac{A\times m}{m^2}$$

$$\frac{T\cdot m}{A} = \mu_0$$

$$TmA^{-1} = \mu_0$$

* Vector form of B.S.L. :-

Y.K.B.

$\vec{A}\times\vec{B} = |A||B|\sin\theta$

$$dB = \frac{\mu_0}{4\pi}\frac{I\,dl\sin\theta}{r^2}$$

$$dB = \frac{\mu_0}{4\pi}\,I\left[\frac{\vec{dl}\sin\theta}{r^2}\times\frac{\vec{r}}{r}\right]$$

$$\boxed{\vec{dB} = \frac{\mu_0}{4\pi}\,\frac{I\,(\vec{dl}\times\vec{r})}{r^3}}$$

Vector form of $\vec{dB}$

Direction of magnetic Field (also YKB)

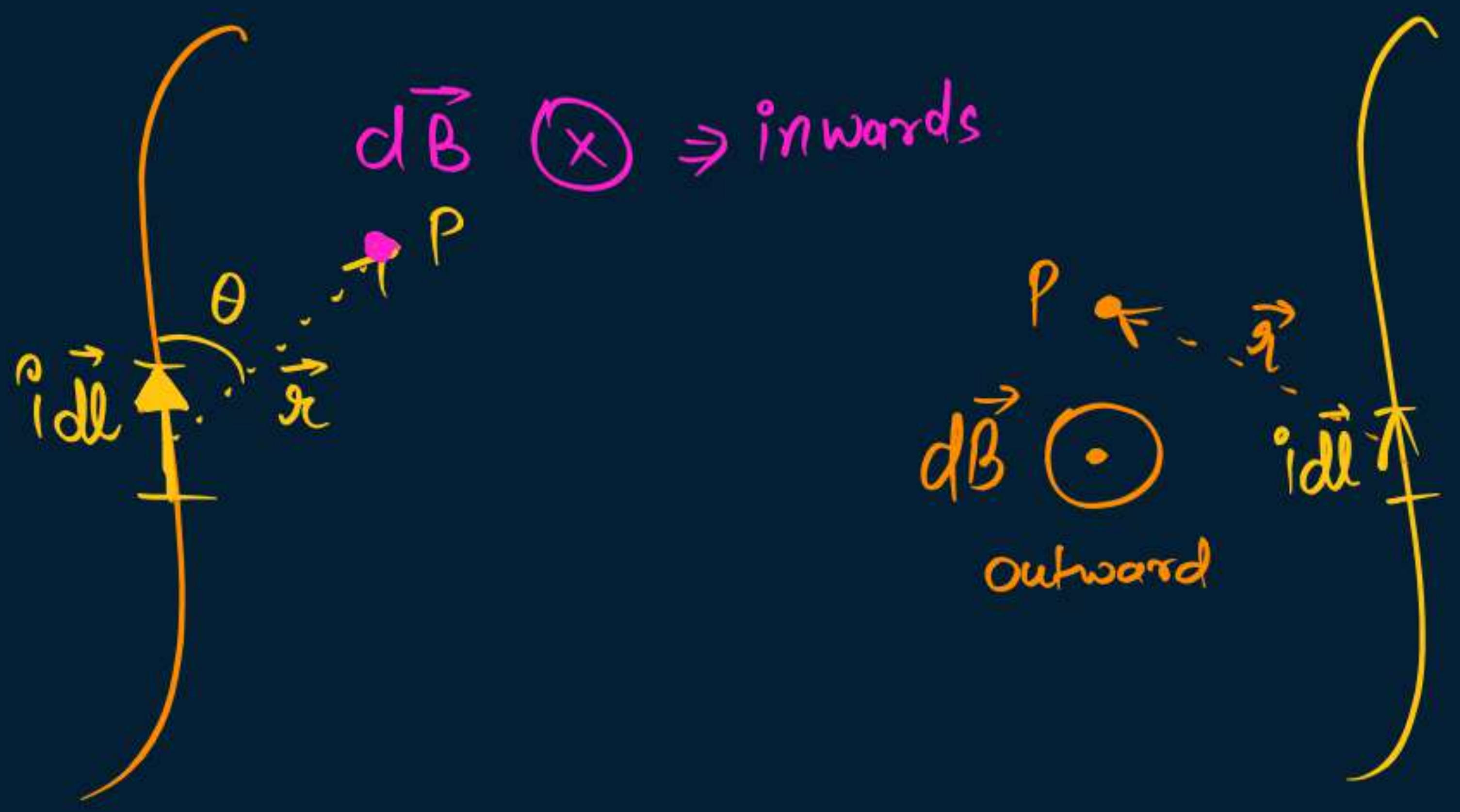
Y.K.B.

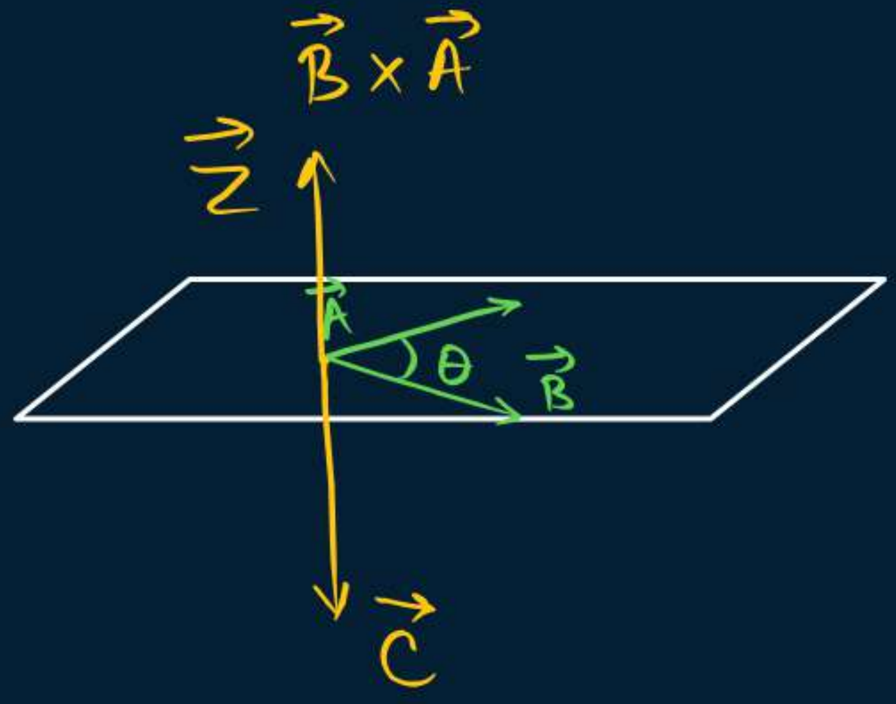
$$\boxed{d\vec{B} = \frac{\mu_0}{4\pi}\frac{I(d\vec{l}\times\vec{r})}{r^3}}$$

means : $d\vec{B}$ ki direction $(d\vec{l}\times\vec{r})$ Dega !!!

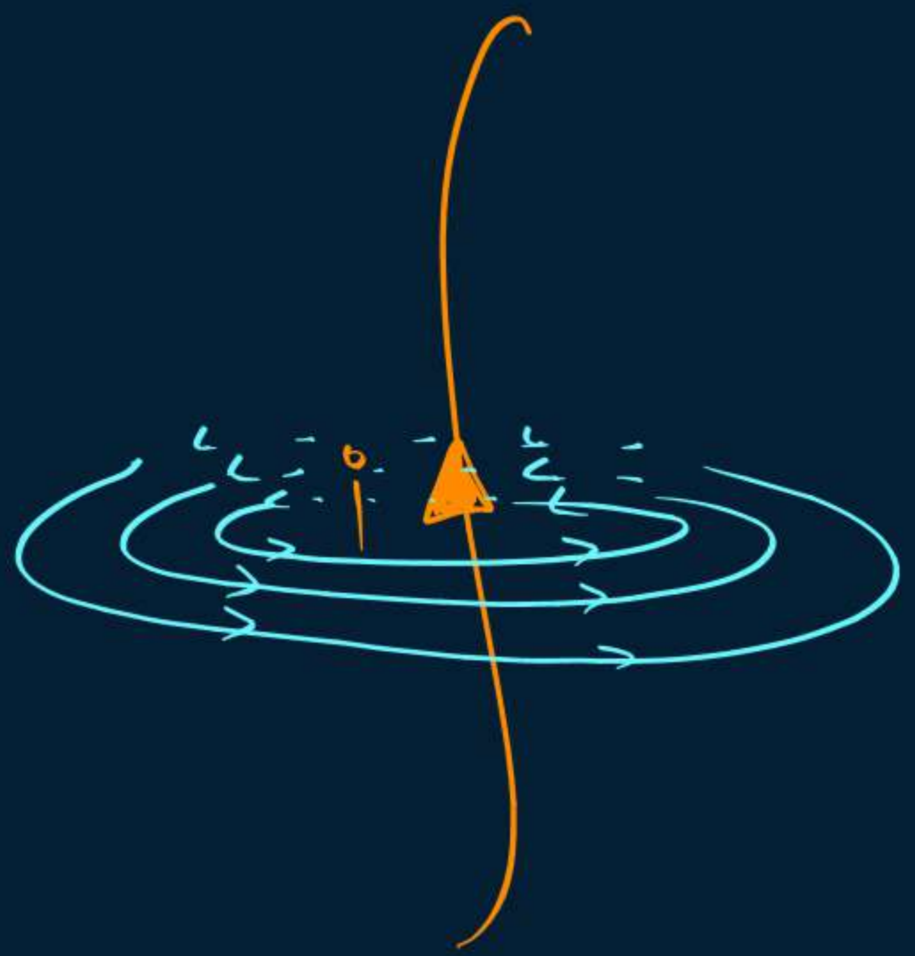
$\vec{C} = \vec{A}\times\vec{B} = |A||B|\sin\theta$

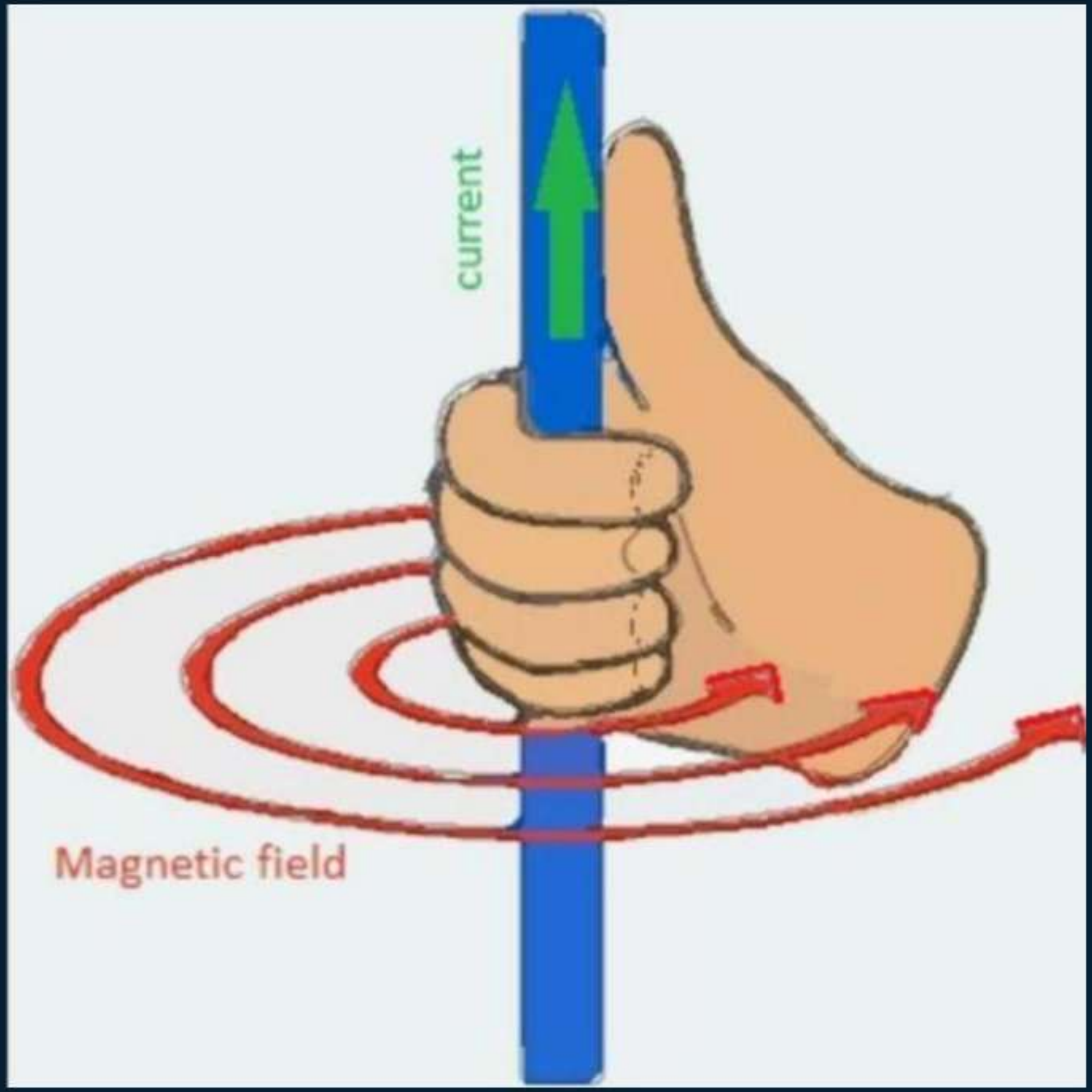
$\vec{C}$ ↓ direction of C





Maxwell's Right hand Thumb Rule





QUESTION

The magnetic field $\overrightarrow{dB}$ due to a small current element $\overrightarrow{dl}$ at a distance $\vec{r}$ and element carrying current i is (1996)

A. $\overrightarrow{dB} = \frac{\mu_0}{4\pi} i^2 \left(\frac{\overrightarrow{dl} \times \vec{r}}{r}\right)$

B. $\overrightarrow{dB} = \frac{\mu_0}{4\pi} i \left(\frac{\overrightarrow{dl} \times \vec{r}}{r^3}\right)$

C. $\overrightarrow{dB} = \frac{\mu_0}{4\pi} i \left(\frac{\overrightarrow{dl} \times \vec{r}}{r}\right)$

D. $\overrightarrow{dB} = \frac{\mu_0}{4\pi} i^2 \left(\frac{\overrightarrow{dl} \times \vec{r}}{r^2}\right)$

QUESTION

H.W.

Statement I: Biot-Savart's law gives us the expression for the magnetic field strength of an infinitesimal current element (Idl) of a current carrying conductor only.

Statement II: Biot-Savart's law is analogous to Coulomb's inverse square law of charge q, with the former being related to the field produced by a scalar source, Idl while the latter being produced by a vector source, q.

In light of above statement choose the most appropriate answer from the options given below:

A. Both statement I and II are correct

B. Both statement I and II are incorrect

C. Statement I is correct and statement II is incorrect

D. Statement I is incorrect and statement II is correct

Relation between Permittivity and Permeability

ϵ_0 μ_0

$\epsilon_0 \Rightarrow$ permittivity of free space

$\mu_0 \Rightarrow$ permeability of free space

$$k = \frac{1}{4\pi\epsilon_0} = 9\times10^9$$

$$\epsilon_0 = \frac{1}{4\pi\times9\times10^9} \quad \text{---} \ (\text{I})$$

$$\mu_0 = 4\pi\times10^{-7} \quad \text{----} \ (\text{II})$$

Multiply (I) and (II)

$$\mu_0\epsilon_0 = \cancel{4\pi}\times10^{-7}\times\frac{1}{\cancel{4\pi}\times9\times10^9}$$

$$\mu_0\epsilon_0 = \frac{1}{9\times10^{16}} = \frac{1}{(3\times10^8)^2} = \frac{1}{c^2}$$

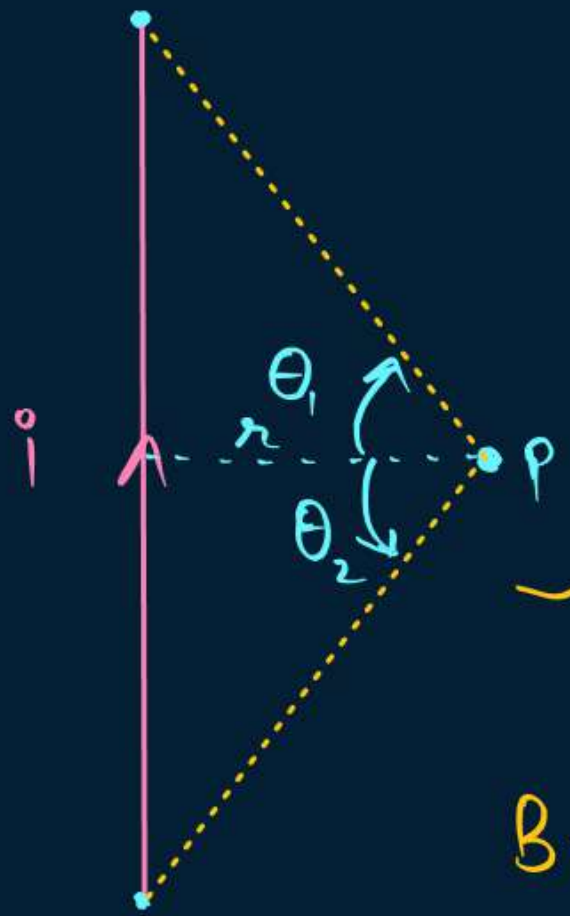
$$\mu_0\epsilon_0 = \frac{1}{c^2} \longrightarrow c^2 = \frac{1}{\mu_0\epsilon_0}$$

$$\boxed{c = \frac{1}{\sqrt{\mu_0\epsilon_0}}}$$

Magnetic Field due to straight current carrying wire

General formula

$$\boxed{B_P = \frac{\mu_0 i}{4\pi r}\left[\sin\theta_1 + \sin\theta_2\right]}$$



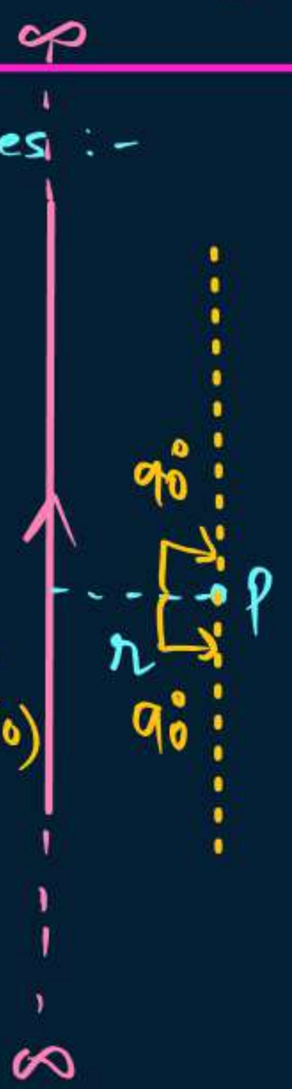
Sp. Cases :-

1) Infinite Wire

$B = \frac{\mu_0 i}{4\pi r}(\sin 90 + \sin 90)$

$B = \frac{\mu_0 i (\cancel{2})}{\cancel{4}_2 \pi r}$

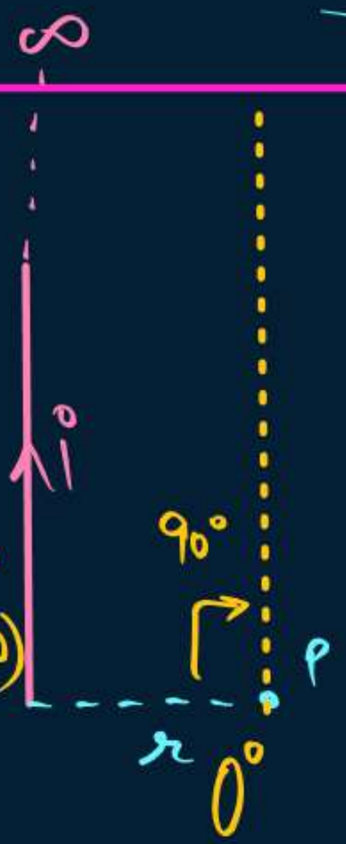
$$\boxed{B = \frac{\mu_0 i}{2\pi r}}$$



2) finite from one end

$B = \frac{\mu_0 i}{4\pi r}(\sin 90 + \sin 0)$

$$\boxed{B = \frac{\mu_0 i}{4\pi r}}$$



3) on the axis of Wire

$B = \frac{\mu_0 i}{4\pi r}(\sin 0° + \sin 0°)$

$$\boxed{B = 0}$$

BSL Special Cases (Maxima/Minima)

$$\boxed{B_p = \frac{\mu_0 i}{2\pi r}}$$

Maxima

$$\boxed{B_p = 0}$$

Minima

QUESTION

H.W.

The magnetic induction due to an infinitely long straight wire carrying a current i at a distance r from the wire is given by (PYQ)

A. $|B| = \left(\frac{\mu_0}{4\pi}\right)\frac{2i}{r}$

B. $|B| = \left(\frac{\mu_0}{4\pi}\right)\frac{r}{2i}$

C. $|B| = \left(\frac{4\pi}{\mu_0}\right)\frac{2i}{r}$

D. $|B| = \left(\frac{4\pi}{\mu_0}\right)\frac{r}{2i}$

QUESTION

H.W.

A straight section PQ of circuit lies along X-axis from $x = -a/2$ to $x = a/2$ and carries a steady current i. The magnetic field due to the section PQ at a point X = + a will be

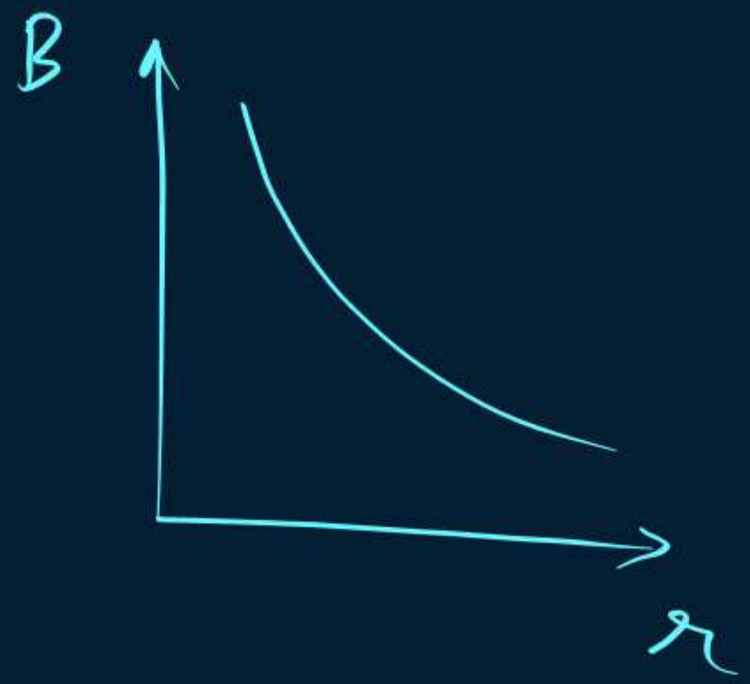
(A) Proportional to a

(B) Proportional to a^2

(C) Proportional to $1/a$

(D) zero

Graph



$$B = \frac{\mu_0 i}{2\pi r}$$

$$B \propto \frac{1}{r}$$ → rectangular hyperbola

Homework

Notes

Revision

DPP ✓

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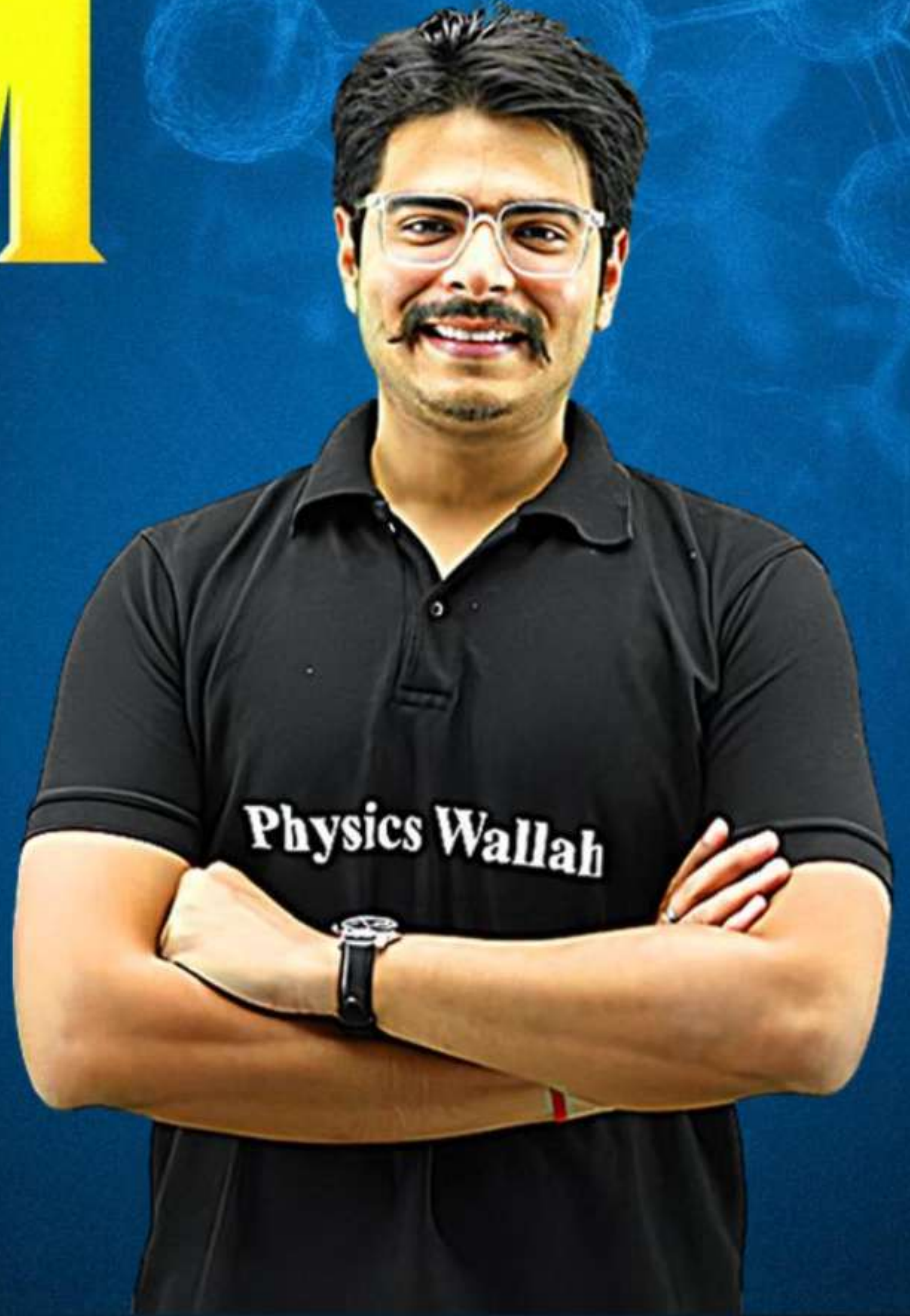
2026

Lecture - 02

Moving Charges and Magnetism

PHYSICS | **Lecture - 2**

BY - RAKSHAK SIR



Topics *to be covered*

- **A** Magnetic Field due to Current Carrying Loop
- **B** Practice Questions
- **C**
- **D**

HW QUESTION

Statement I: Biot-Savart's law gives us the expression for the magnetic field strength of an infinitesimal current element (Idl) of a current carrying conductor only. T

→ Bohot Chota

Statement II: Biot-Savart's law is analogous to Coulomb's inverse square law of charge q, with the former being related to the field produced by a scalar source, Idl while the latter being produced by a vector source, q. T

In light of above statement choose the most appropriate answer from the options given below:

$F \propto \frac{1}{r^2}$

$dB \propto \frac{1}{r^2}$

(A) Both statement I and II are correct

(B) Both statement I and II are incorrect

(C) Statement I is correct and statement II is incorrect

(D) Statement I is incorrect and statement II is correct

HW QUESTION

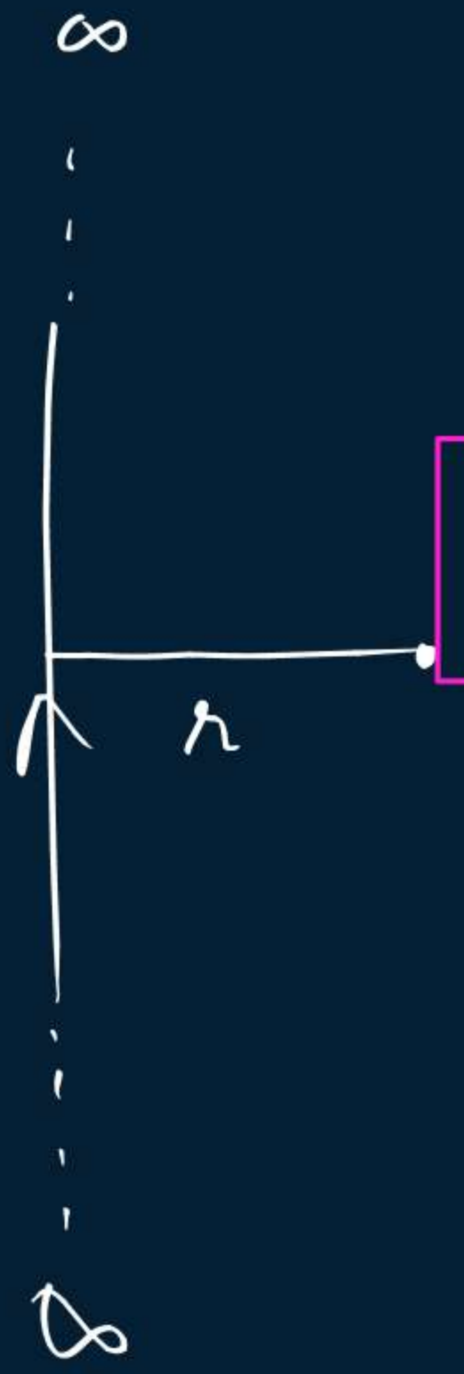
The magnetic induction due to an infinitely long straight wire carrying a current i at a distance r from the wire is given by **(PYQ)**

(A) $|B|=\left(\frac{\mu_0}{4\pi}\right)\frac{2i}{r}$

(B) $|B|=\left(\frac{\mu_0}{4\pi}\right)\frac{r}{2i}$

(C) $|B|=\left(\frac{4\pi}{\mu_0}\right)\frac{2i}{r}$

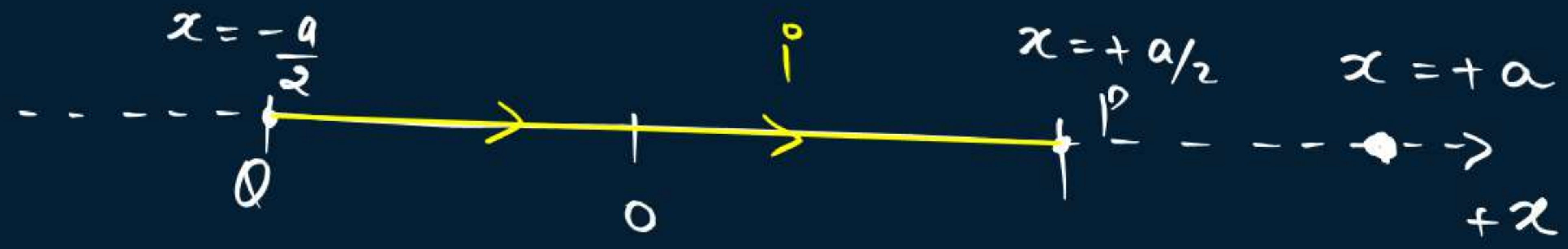
(D) $|B|=\left(\frac{4\pi}{\mu_0}\right)\frac{r}{2i}$



$$\boxed{B = \frac{\mu_0 i}{2\pi r}}$$

HW QUESTION

A straight section PQ of circuit lies along X-axis from $x = -a/2$ to $x = a/2$ and carries a steady current i. The magnetic field due to the section PQ at a point X = + a will be



A. Proportional to a

B. Proportional to a^2

C. Proportional to $1/a$

D. zero

HW QUESTION

$$B = \frac{\mu_0 i}{2\pi r}$$

The magnetic field at centre, P will be (2000)

(A) $\frac{\mu_0}{4\pi}$

(B) $\frac{\mu_0}{\pi}$

(C) $\frac{\mu_0}{2\pi}$

(D) $4\mu_0\pi$

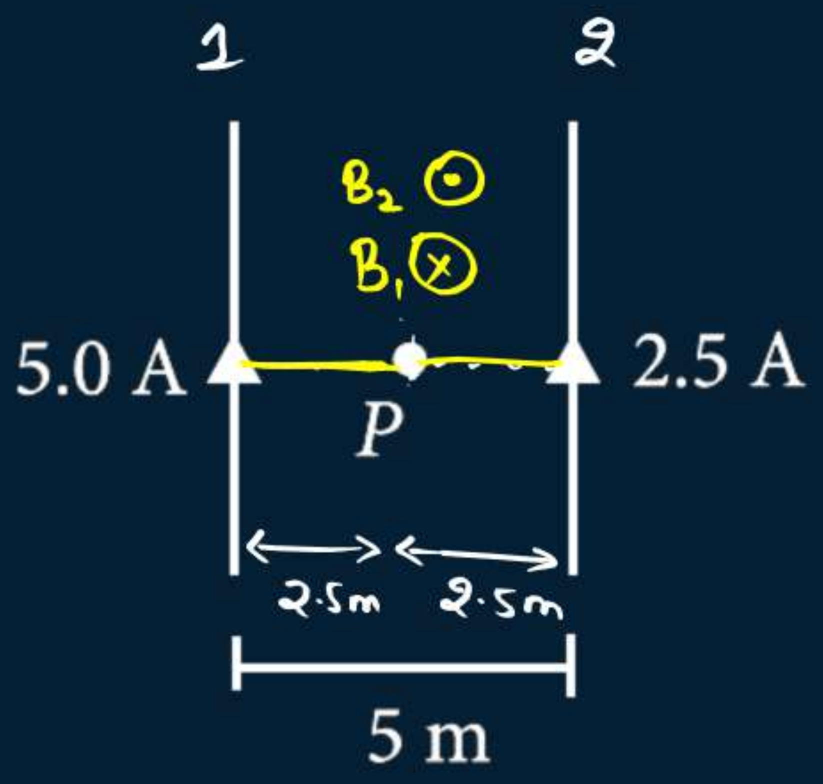
$$B_{net} = B_1 - B_2$$

$$= \frac{\mu_0 i_1}{2\pi r} - \frac{\mu_0 i}{2\pi r}$$

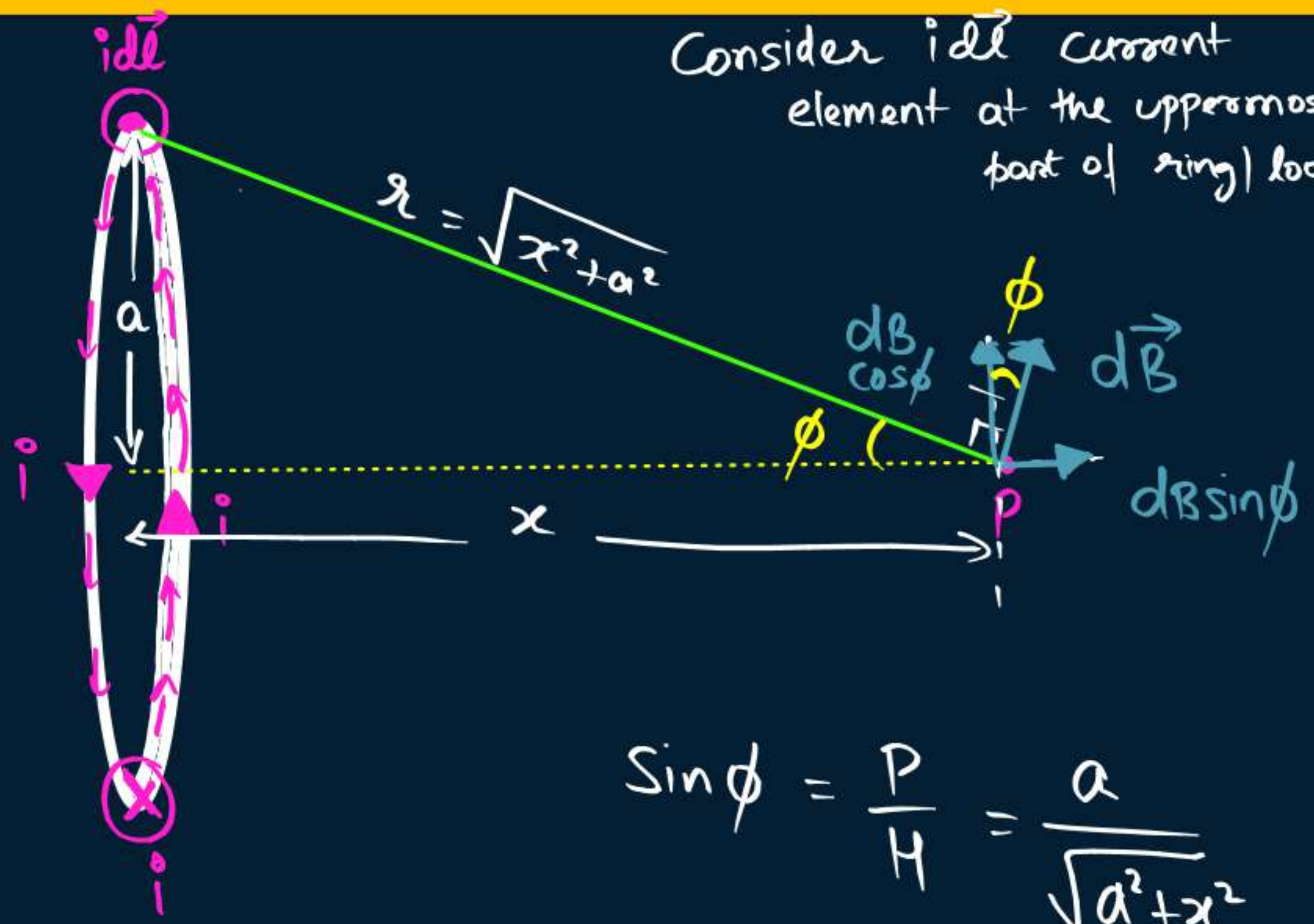
$$= \frac{\mu_0}{2\pi \cancel{x}}\cancel{(i_1 - i_2)}$$

$$= \frac{\overset{2}{\cancel{4\pi}} \times 10^{-7}}{\cancel{2\pi} \times \cancel{2.5}}\cancel{(5 - 2.5)}$$

$$= 2 \times 10^{-7}\ T$$



Magnetic field on the axis of current carrying circular loop



Consider $i\vec{dl}$ current element at the uppermost part of ring/loop

By using B.S.L :-

$i(\vec{dl} \times \vec{r})$

$$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin\theta}{r^2}$$

$$\theta = 90^\circ, \ \sin 90^\circ = 1$$

$$dB = \frac{\mu_0}{4\pi}\frac{I\,dl}{r^2}$$

$$\sin\phi = \frac{P}{H} = \frac{a}{\sqrt{a^2+x^2}}$$

$$B_P^{net} = \int dB\sin\phi$$

$$B_P^{net} = \int \frac{\mu_0}{4\pi}\frac{I\,dl}{r^2}\cdot\sin\phi$$

$$B_P^{net} = \int \frac{\mu_0}{4\pi} \frac{i\,dl}{r^2} \cdot \sin\phi$$

$$= \int \frac{\mu_0}{4\pi} \frac{i\,dl}{(x^2+a^2)} \cdot \frac{a}{\sqrt{a^2+x^2}}$$

$$= \int \frac{\mu_0}{4\pi} \frac{i\,dl\,a}{(x^2+a^2)^{3/2}}$$

$$= \frac{\mu_0 i a}{4\pi (x^2+a^2)^{3/2}} \int dl$$

$$= \frac{\mu_0 i a \, \overset{1}{\cancel{2}}\cancel{\pi} a}{\underset{2}{\cancel{4}}\cancel{\pi} (x^2+a^2)^{3/2}}$$

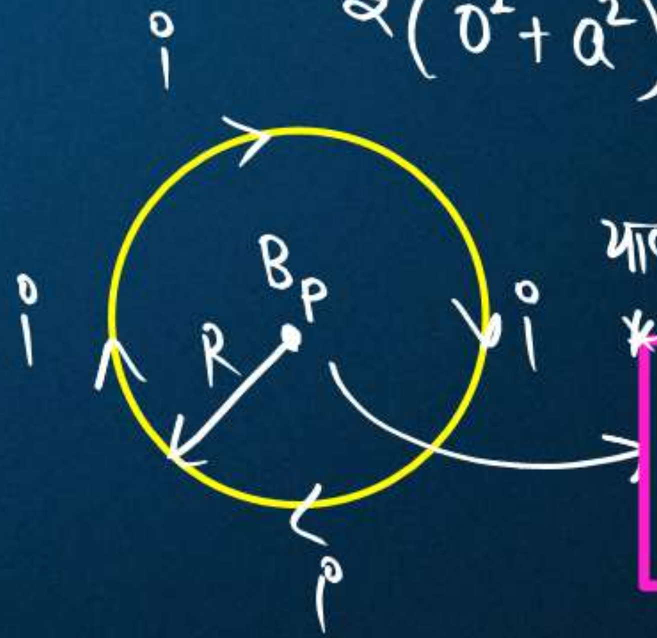
याद

$$\boxed{B_P^{net} = \frac{\mu_0 i a^2}{2(x^2+a^2)^{3/2}}}$$

Spl. case :-

1. At the centre of loop $(x = 0)$

$$B_P = \frac{\mu_0 i a^2}{2(0^2+a^2)^{3/2}} = \frac{\mu_0 i \cancel{a^2}}{2a^{\cancel{3}}} = \frac{\mu_0 i}{2a}$$



याद

$$\boxed{B_{\substack{at\\centre}} = \frac{\mu_0 i}{2R}}$$

Spl. case

2. Distance from Loop is too Large.

$$x >> a$$

$$x^2 + a^2 \approx x^2$$

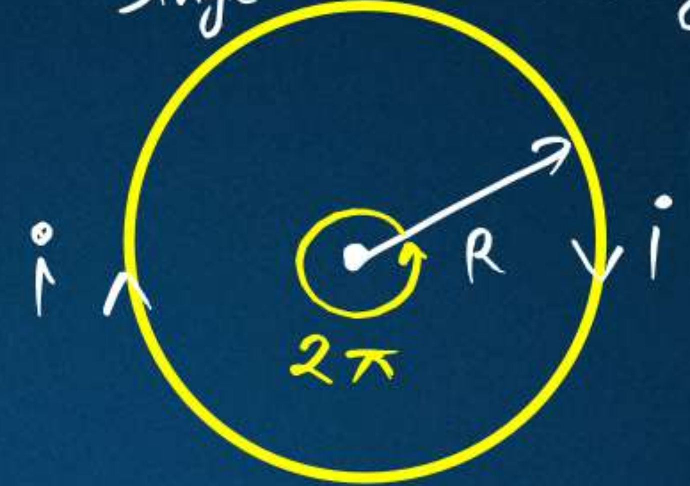
$$\boxed{B_p = \frac{\mu_0 i a^2}{2x^3}}$$

We infer from here that,

$$B_p \propto \frac{1}{x^3}$$

Multiple imp. cases :-

Single circular ring

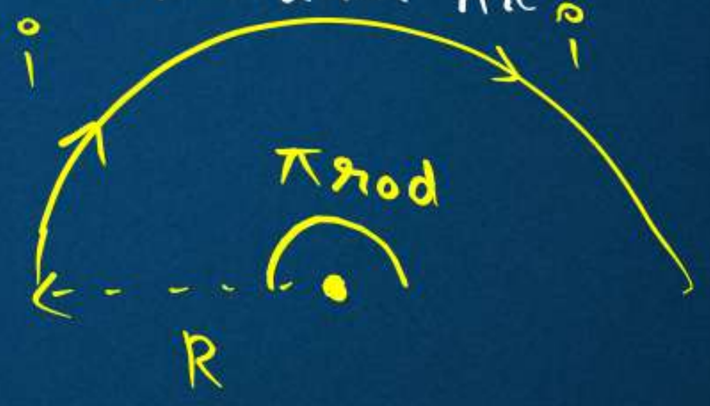


$$\boxed{B = \frac{\mu_0 i}{2R}}$$

if 'N-turns' are there

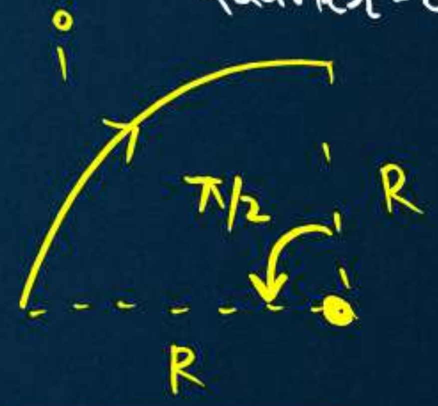
$$\boxed{B = \frac{\mu_0 N i}{2R}}$$

Semicircular Arc



$$\boxed{B = \frac{\mu_0 i}{4R}}$$

Quarter-circle



$$\boxed{B = \frac{\mu_0 i}{8R}}$$

Suppose there is an arc that subtends 'θ' angle

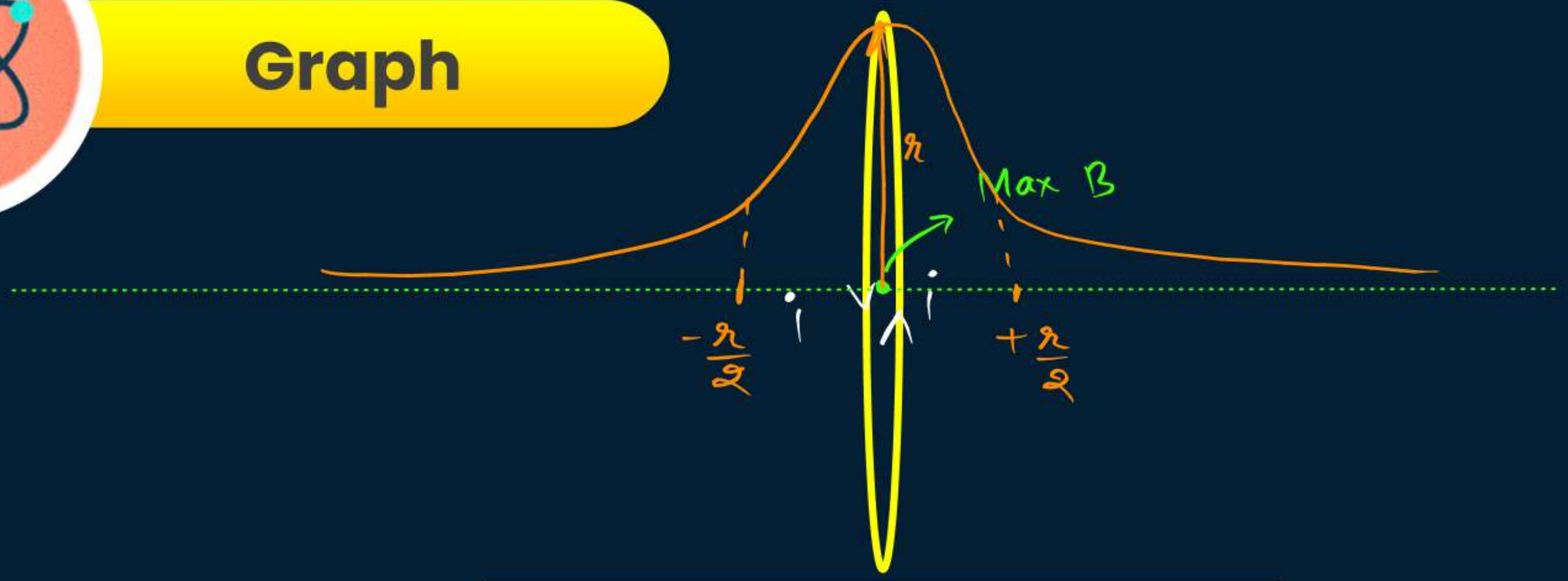
$180^\circ \longrightarrow \pi$ rad

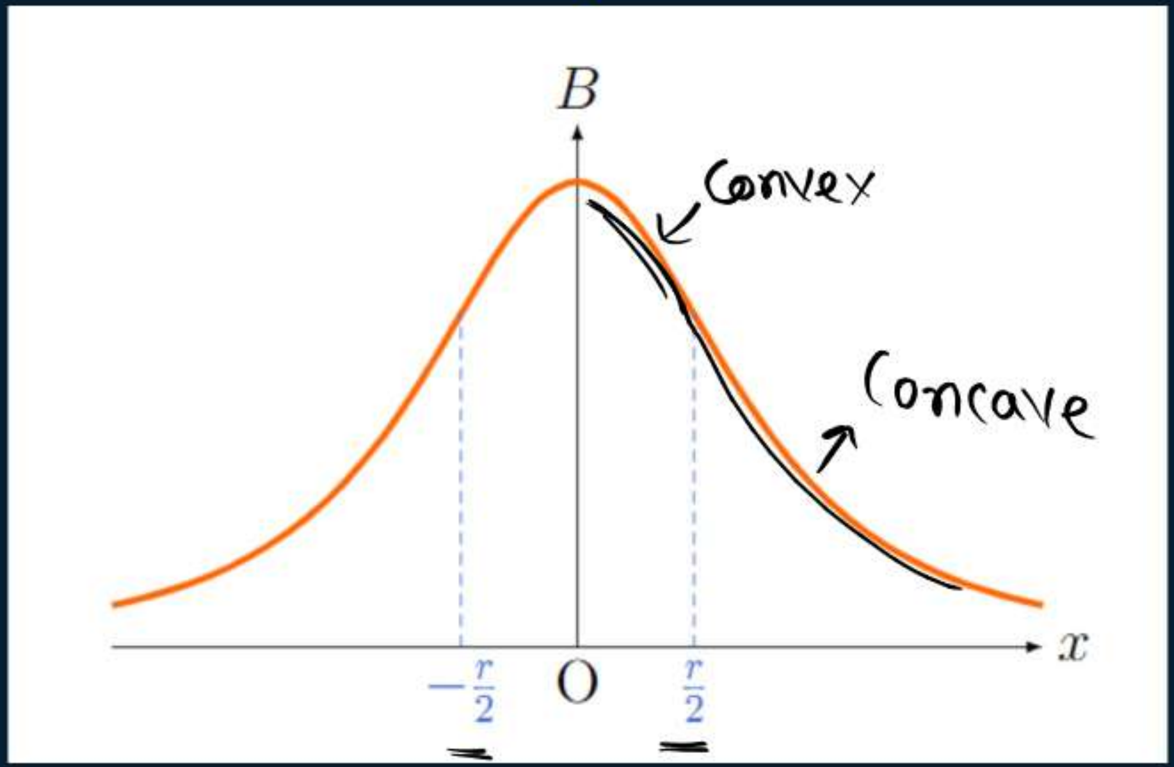
$\theta \rightarrow$ radian ✓

$\theta \rightarrow$ degree ✗

$$\boxed{B_P = \frac{\mu_0 i \theta}{4\pi r}}$$

Graph

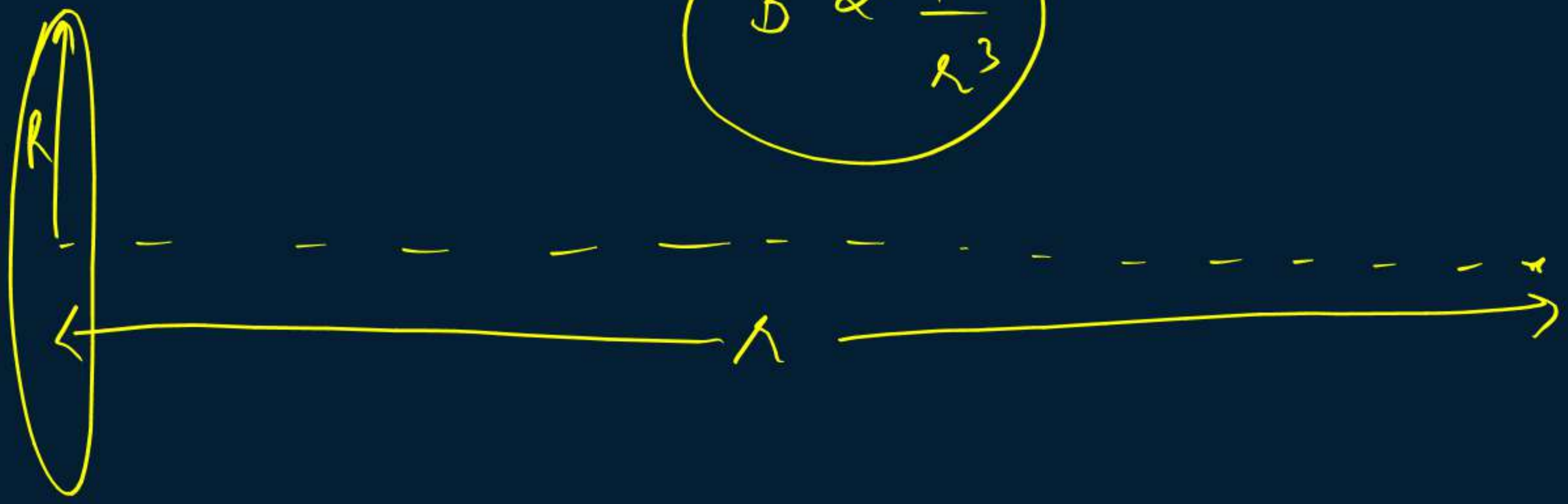




QUESTION

A circular coil of radius R caries an electric current. The magnetic field due to the coil at a point on the axis of the coil located at a distance r from the centre of the coil, such that $r >> R$, varies

$B \propto \frac{1}{r^3}$



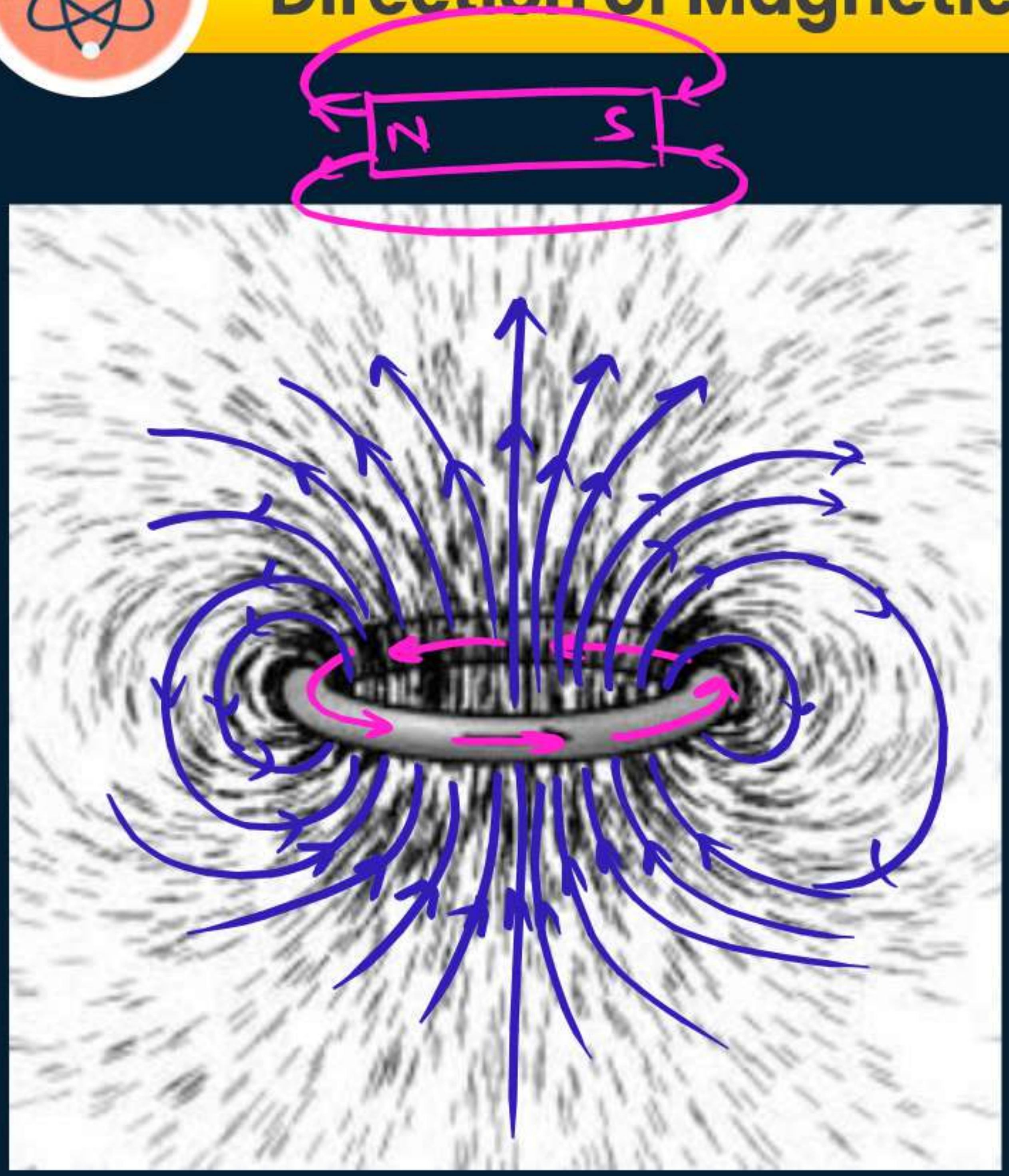
A. $1/r$

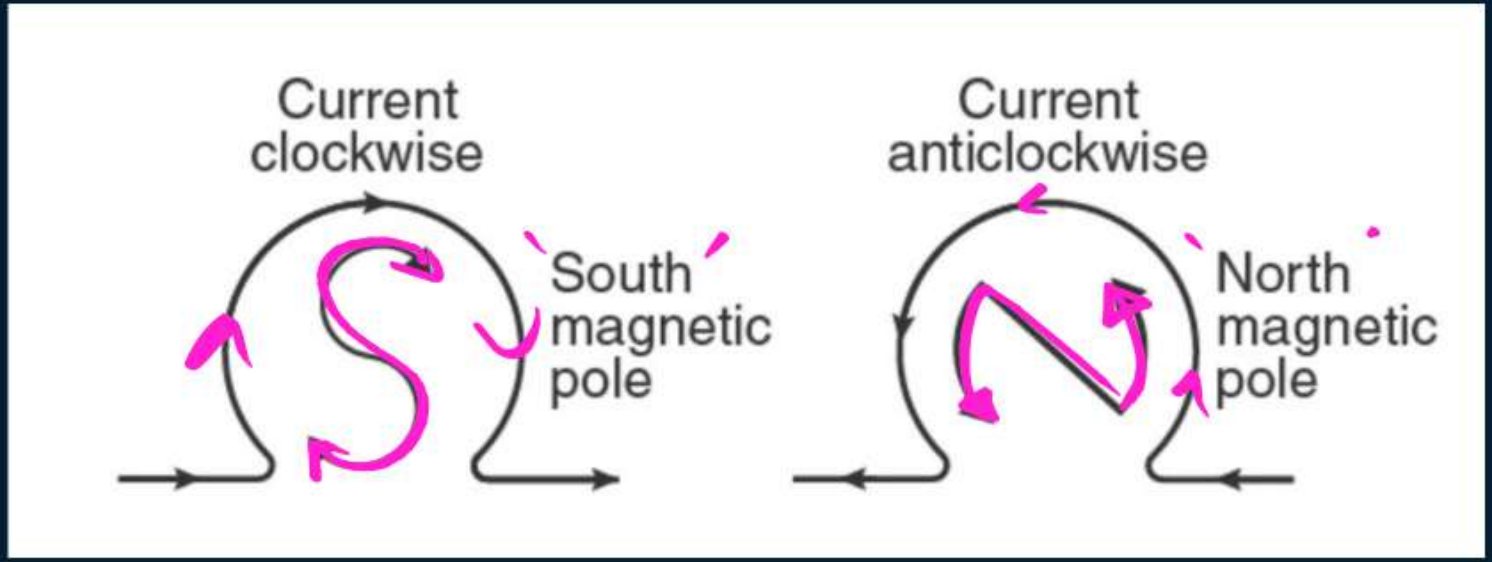
B. $1/r^{3/2}$

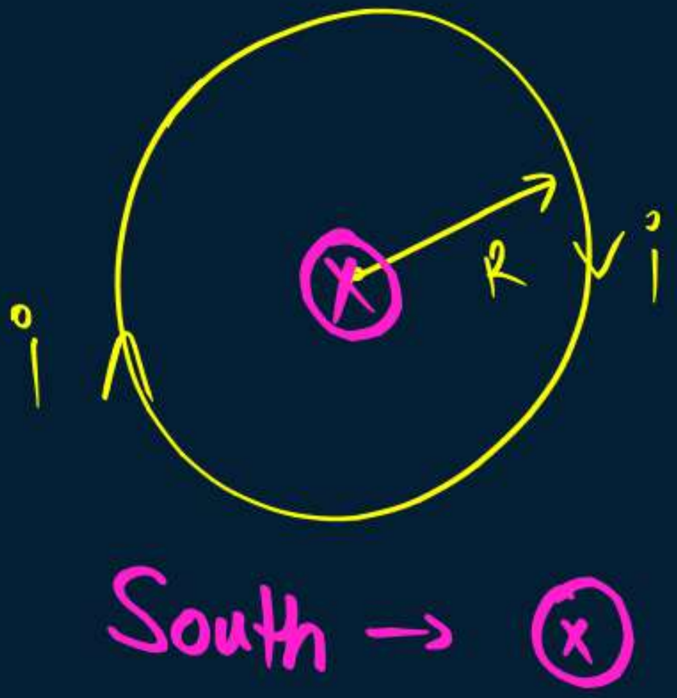
C. $1/r^2$

D. $1/r^3$

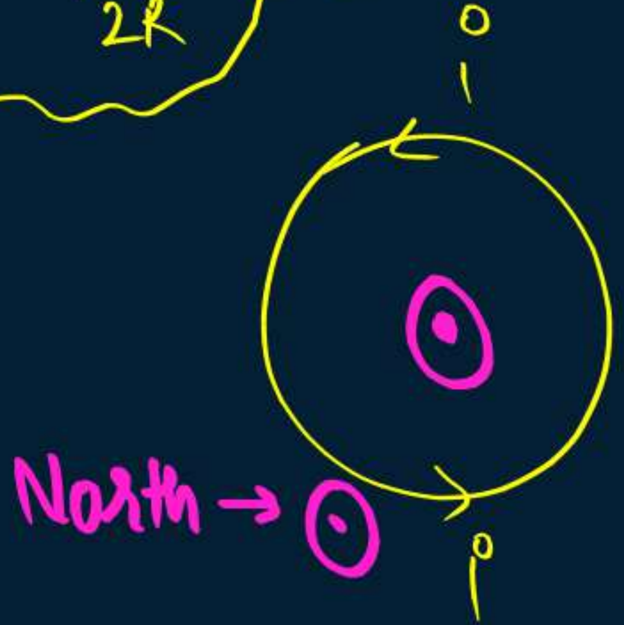
Direction of Magnetic Field due to loop at is center







$$B = \frac{\mu_0 i}{2R}$$



QUESTION

Magnetic field due to 0.1 A current flowing through a circular coil of radius 0.1 m and 1000 turns at the centre of the coil is [1999]

A) 6.28×10^{-4} T

B) 4.31×10^{-2} T

C) 2×10^{-1} T

D) 9.81×10^{-4} T

$$B = \frac{\mu_0 N i}{2R}$$

$$= \frac{\cancel{4}^{2}\pi \times 10^{-7} \times 1000 \times \cancel{0.1}}{\cancel{2}_{1} \times \cancel{0.1}}$$

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

$$= 6.28 \times 10^{-4}\ T$$

QUESTION

Two concentric circular coils of ten turns each are situated in the same plane. Their radii are 20 and 40 cm and they carry respectively 0.2 and 0.3 ampere current in opposite direction. The magnetic field in weber/m^2 at the centre is:

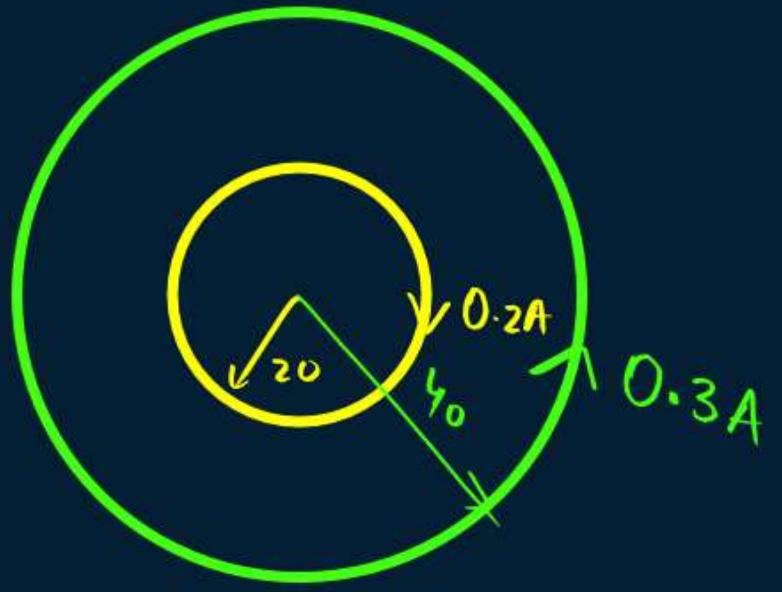
↳ Tesla

(A) $35/4\ \mu_0$

(B) $\mu_0/80$

(C) $7/80\ \mu_0$

(D) $5/4\ \mu_0$



$$B = \frac{\mu_0 i}{2R} \times N$$

$$B_{net} = B_1 - B_2$$

$$= \frac{\mu_0 (0.2) 10}{2 \times \frac{20}{100}} - \frac{\mu_0 (0.3) 10}{2 \times \frac{40}{100}}$$

$$= \frac{\mu_0}{\frac{2\times 20}{100}} \left[\frac{2}{1} - \frac{3}{2} \right]$$

$$= \frac{\cancel{100}\mu_0 \times 0.5}{2 \times 2\cancel{0} \times 1\cancel{0}} = \frac{5}{4}\mu_0 \quad \text{Ans}$$

QUESTION

$5\,T$

(1) 10 turns $\rightarrow (10)^2 \times 5 = 500\,T$

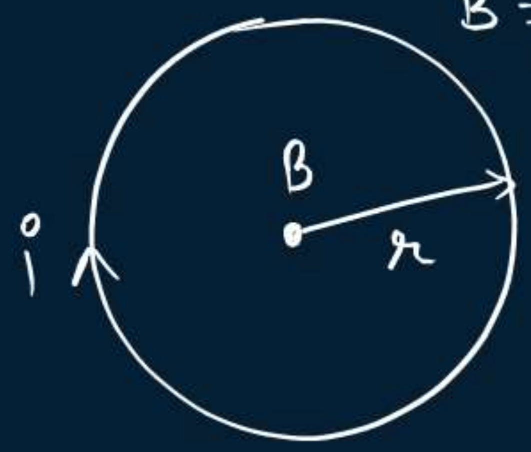
A long wire carrying a steady current is bent into a circular loop of one turn. The magnetic field at the centre of the loop is B. It is then bent into a circular coil of n turns. The magnetic field at the centre of this coil of n turns will be **(2016)**

(A) $2n^2$

(B) nB

(C) n^2B

(D) $2nB$



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

$l = 2\pi r$

$B' = ?$

n-turns

$l = n\,2\pi r'$

$\cancel{2\pi} r = n \cancel{2\pi} r'$

$r = nr'$

$B' = \dfrac{\mu_0 i n}{2r'}$ ...(II)

Divide (II) by (I)

$\dfrac{B'}{B} = \dfrac{\dfrac{\mu_0 i n}{2r'}}{\dfrac{\mu_0 i}{2r}} = \dfrac{\dfrac{n}{r'}}{\dfrac{1}{r}} = \dfrac{nr}{r'}$

$\dfrac{B'}{B} = \dfrac{n\,n\cancel{r'}}{\cancel{r'}}$

$\boxed{B' = n^2 B}$

QUESTION

The magnetic field of given length of wire for single turn coil at its centre is B then its value for two turns coil for the same wire is (2002)

A. B/4

B. B/2

C. 4 B

D. 2 B

$$B' = n^2 B$$
$$= (2)^2 B$$
$$= 4B$$

QUESTION

→ Same plane concentric

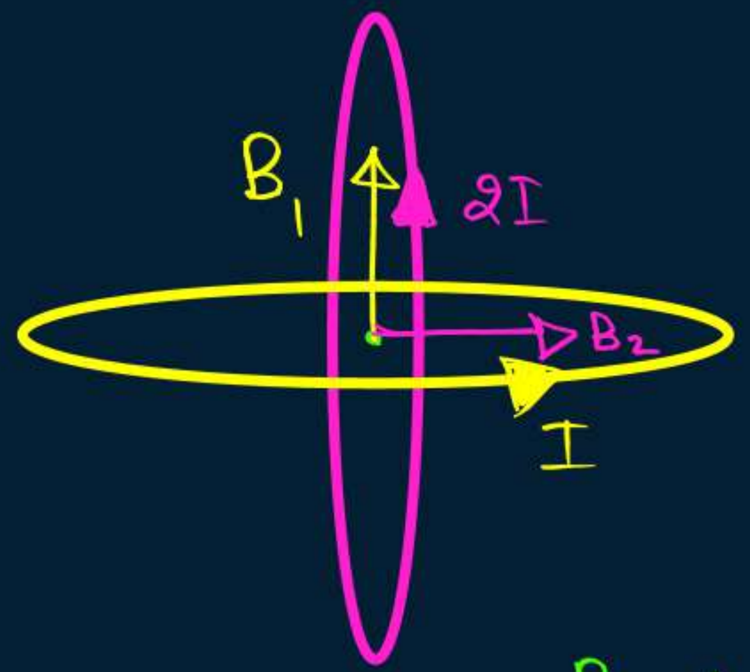
Two similar coils of radius R are lying concentrically with their planes at right angles to each other. The currents flowing in them are I and $2I$, respectively. The resultant magnetic field induction at the centre will be **(2012)**

(A) $\dfrac{\sqrt{5}\mu_0 I}{2R}$

(B) $\dfrac{\sqrt{5}\mu_0 I}{R}$

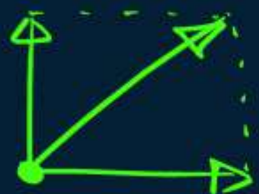
(C) $\dfrac{\mu_0 I}{2R}$

(D) $\dfrac{\mu_0 I}{R}$



$B = \dfrac{\mu_0 I}{2R}$

$B_1 = B$ $\quad R = \sqrt{B_1^2 + B_2^2 + 2B_1B_2\cos\theta}$



$B_2 = 2B$

$R = \sqrt{B^2 + (2B)^2 + \cancel{2B(2B)\cos 90^\circ}}$ $\quad 0$

$= \sqrt{B^2 + 4B^2}$

$= \sqrt{5}\cdot B = \sqrt{5}\,\dfrac{\mu_0 i}{2R}$

QUESTION

H.W.

An electron moving in a circular orbit of radius r makes n rotations per second. The magnetic field produced at the centre has magnitude

(A) $\frac{\mu_0 n e}{2\pi r}$

(B) Zero

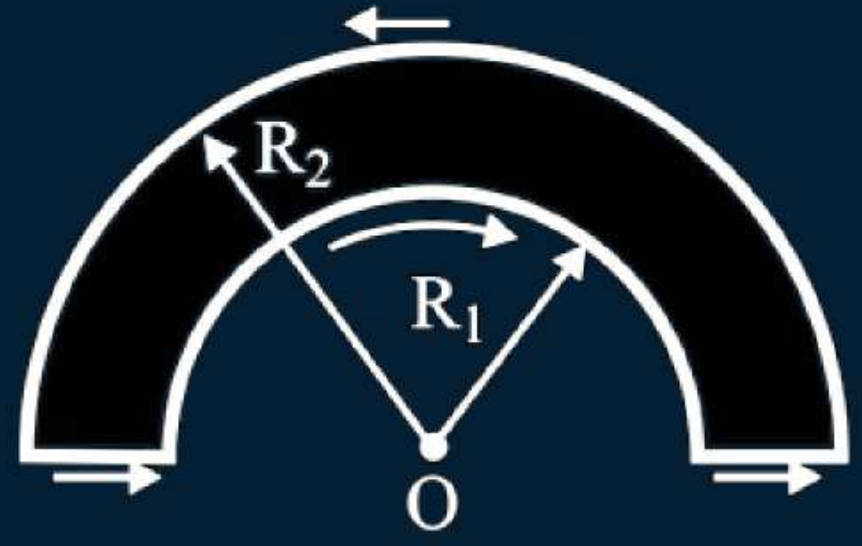
(C) $\frac{\mu_0 n^2 e}{r}$

(D) $\frac{\mu_0 n e}{2r}$

QUESTION

H.W.

The magnetic induction at the centre O in the figure shown in:



(A) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

(B) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$

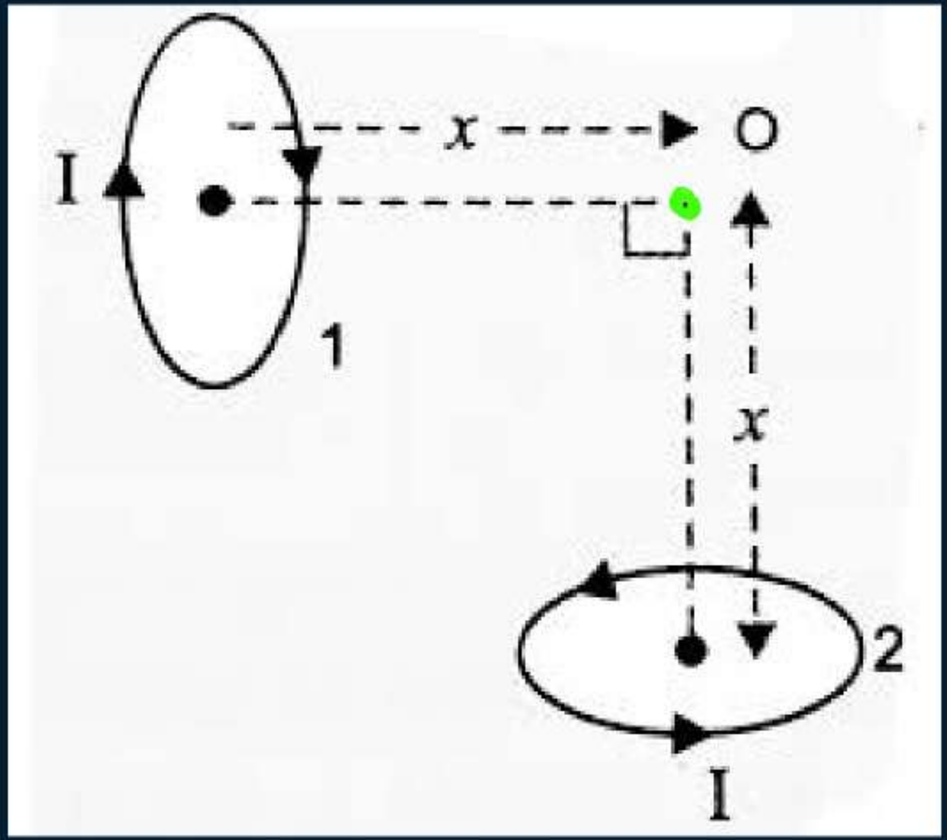
(C) $\frac{\mu_0 i}{4}(R_1-R_2)$

(D) $\frac{\mu_0 i}{4}(R_1+R_2)$

SUBJECTIVE QUESTION

H.W.

Two very small identical circular loops (1)and(2) carrying equal currents I are placed vertically (w.r.t. the plane of the paper) with their geometrical axes perpendicualr to each other as shown in figure. Find the magnitude and direction of the net magnetic field produced at point O.



Homework

- Notes
- Sawaal re-try
- H.W.

PARISHRAM

2026

Lecture - 03

Moving Charges and Magnetism

PHYSICS Lecture - 3

BY - RAKSHAK SIR

Topics *to be covered*

- **A** Ampere’s Circuital Law (ACL)
- **B** Solenoid
- **C**
- **D**

HW QUESTION

T

Statement I: Biot-Savart's law gives us the expression for the magnetic field strength of an infinitesimal current element (Idl) of a current carrying conductor only.

Statement II: Biot-Savart's law is analogous to Coulomb's $\boxed{\text{inverse square law}}$ of charge q, with the former being related to the field produced by a scalar source, $I\vec{dl}$ while the latter being produced by a vector source, q.

F

In light of above statement choose the most appropriate answer from the options given below:

$B \propto \frac{1}{r^2}$ $F \propto \frac{1}{r^2}$

A. Both statement I and II are correct

B. Both statement I and II are incorrect

C. Statement I is correct and statement II is incorrect

D. Statement I is incorrect and statement II is correct

HW QUESTION

An electron moving in a circular orbit of radius r makes $\boxed{n \text{ rotations per second.}}$ The magnetic field produced at the centre has magnitude

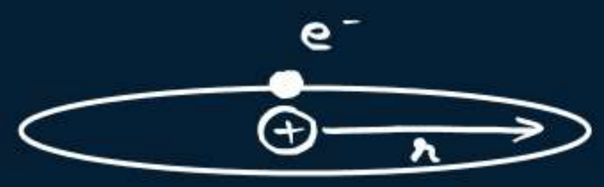
$\nu = n$ rotations per sec.

A $\dfrac{\mu_0 ne}{2\pi r}$

B Zero

C $\dfrac{\mu_0 n^2 e}{r}$

D $\dfrac{\mu_0 ne}{2r}$ ✓



$$\left[i = \frac{q}{t} = \frac{e}{t} = e\nu \right]$$

$$B = \frac{\mu_0 i}{2R}$$

$$i = \frac{q}{t}$$

$$i = \frac{e}{T} \qquad \left[\nu = \frac{1}{T}\right]$$

$$i = e\nu$$

$$B = \frac{\mu_0 e\nu}{2R}$$

$$B = \frac{\mu_0 e n}{2r}$$ ✓

HW QUESTION

$B = \frac{\mu_0 i}{2R}$, $B_{semi} = \frac{\mu_0 i}{4R}$

The magnetic induction at the centre O in the figure shown in:

(A) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

(B) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$

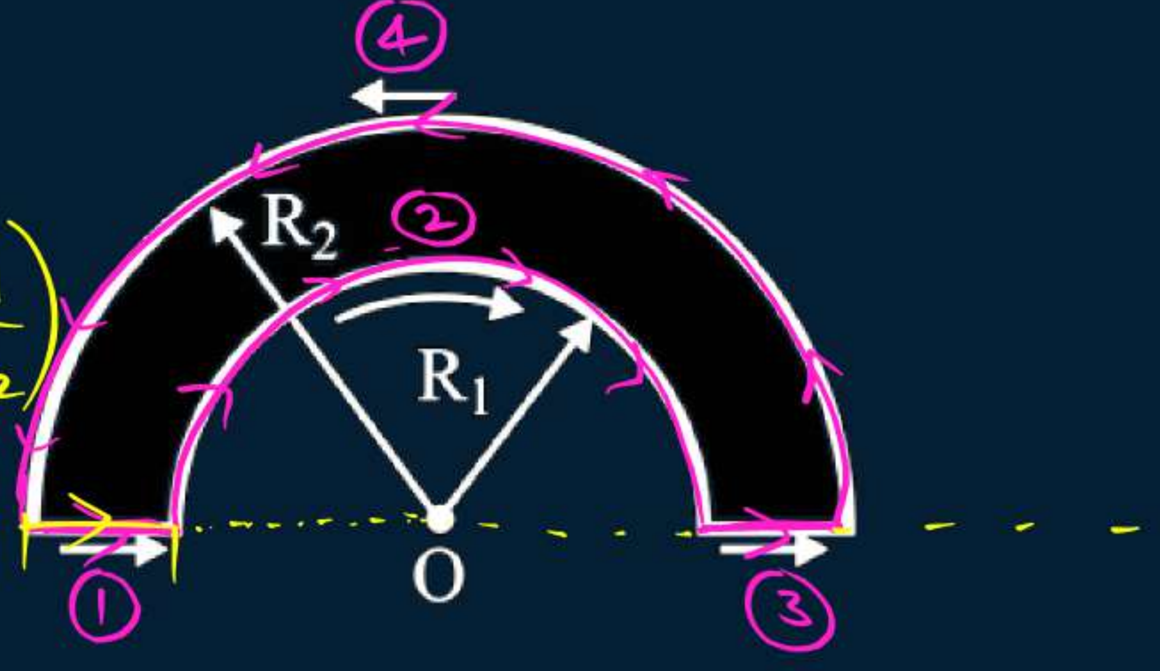
(C) $\frac{\mu_0 i}{4}(R_1-R_2)$

(D) $\frac{\mu_0 i}{4}(R_1+R_2)$

$$\vec{B}_{net} = \vec{B}_1 + \vec{B}_2 + \vec{B}_3 + \vec{B}_4$$

$$|B_{net}| = 0 + \frac{\mu_0 i}{4R_1} + 0 + \left(-\frac{\mu_0 i}{4R_2}\right)$$

$$= \frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$



HW QUESTION

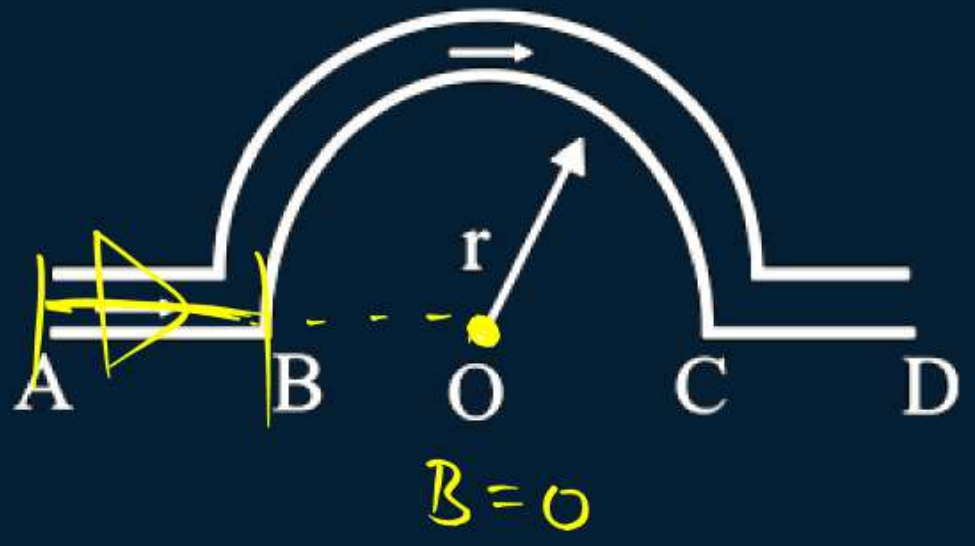
In the figure, the magnetic induction at the centre of the arc due to the current in portion AB will be

A $\mu_0 i / r$

B $\mu_0 i / 4r$

C $\mu_0 i / 2r$

D Zero



Ampere's Circuital Law

(ACL) → Sign convention ✓

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\epsilon_0}$$

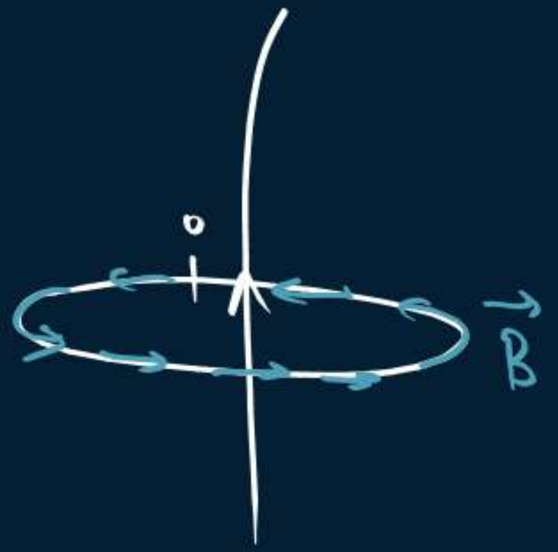
The line integral of the magnetic field around a closed loop is μ_0 times the current enclosed by that loop.

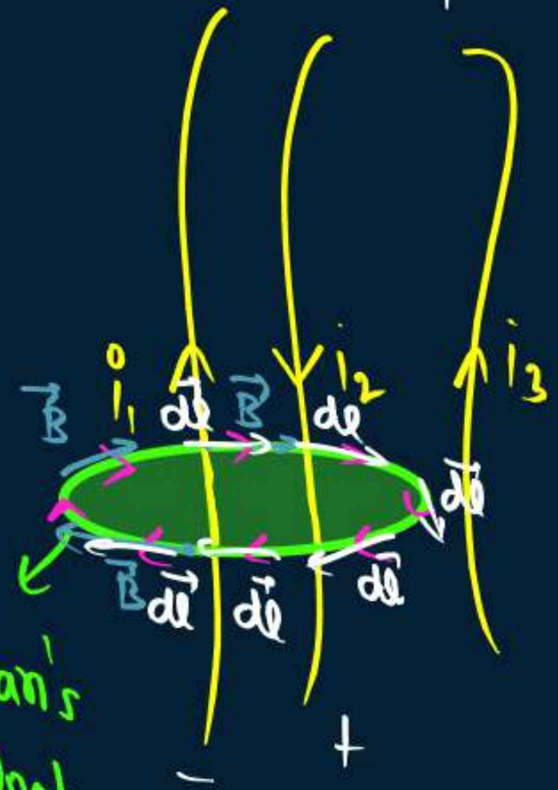
$$\oint \vec{B} \cdot d\vec{l} = \mu_0 (-i_1 + i_2)$$

A.C.L. ⟷ * $$\boxed{\oint \vec{B} \cdot d\vec{l} = \mu_0 (i_{enclosed})}$$

Net $\vec{B}$ Banegi, Voh by all the Currents hogi (i_1, i_2, i_3)

Jo Amperian's loop ke andar hoga (i_1, i_2)





Amperian's loop (imaginary)

Note -

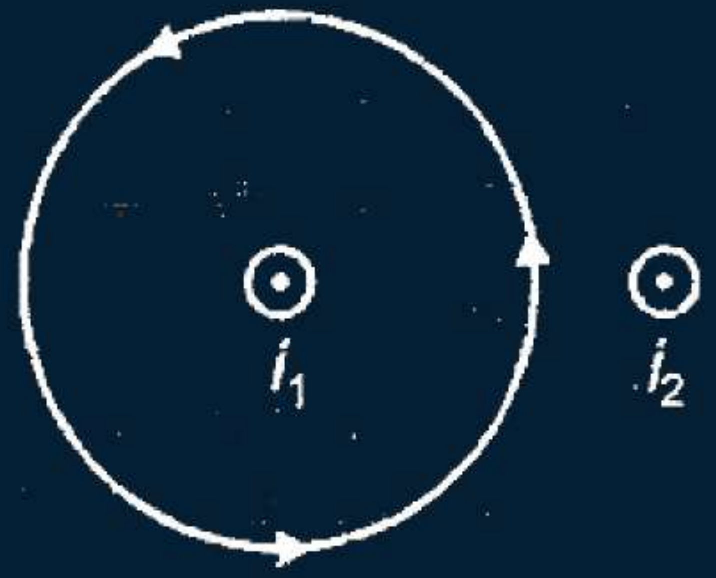
Jis direction me traversal ho raha, usi direction me Cobra Rule, Thumb ki direction wallah Current ⊕

QUESTION

Find $\oint \vec{B}.\vec{dl}$ over following loops (direction in which integration has to be performed is indicated by arrows)

$$\oint \vec{B}\cdot\vec{dl} = \mu_0 \, i_{enc}$$

$$= \mu_0 (i_1)$$

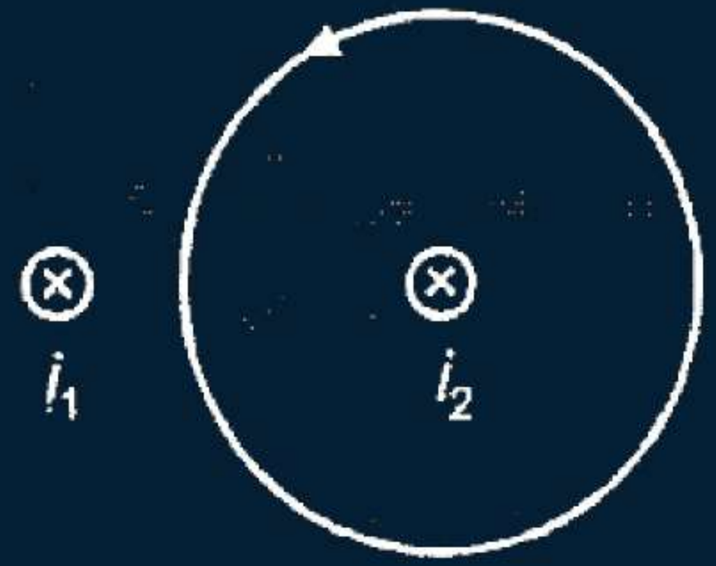


QUESTION

Find $\oint \vec{B}.\vec{dl}$ over following loops (direction in which integration has to be performed is indicated by arrows)

$$\oint \vec{B}.\vec{dl} = \mu_0 (i_{enc})$$

$$= \mu_0 (-i_2)$$



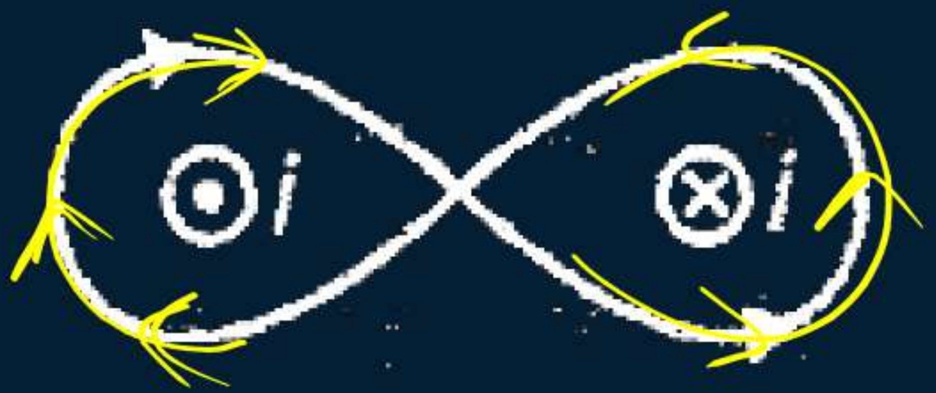
QUESTION

Find $\oint \vec{B}.\overrightarrow{dl}$ over following loops (direction in which integration has to be performed is indicated by arrows)

$$\oint \vec{B}\cdot\vec{dl} = \mu_0 i_{enc}$$

$$= \mu_0(-i-i)$$

$$= \mu_0(-2i)$$



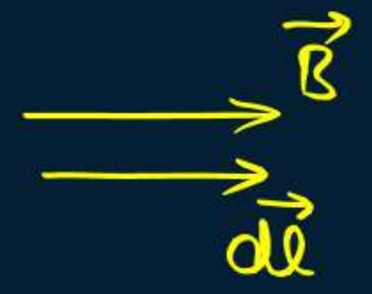
RDx to Use ACL

$$\oint \vec{B}\cdot\vec{dl}$$

$$\oint |B||dl|\cos\theta$$

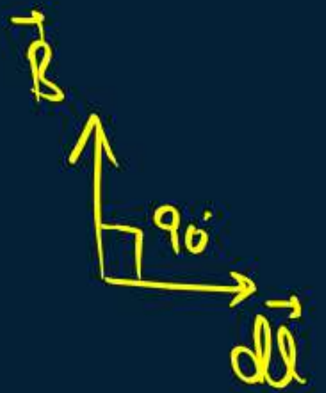
Choose Amperian's Loop Esa :-

1) $B \parallel dl$



$\theta = 0^\circ$, $\cos 0^\circ = 1$

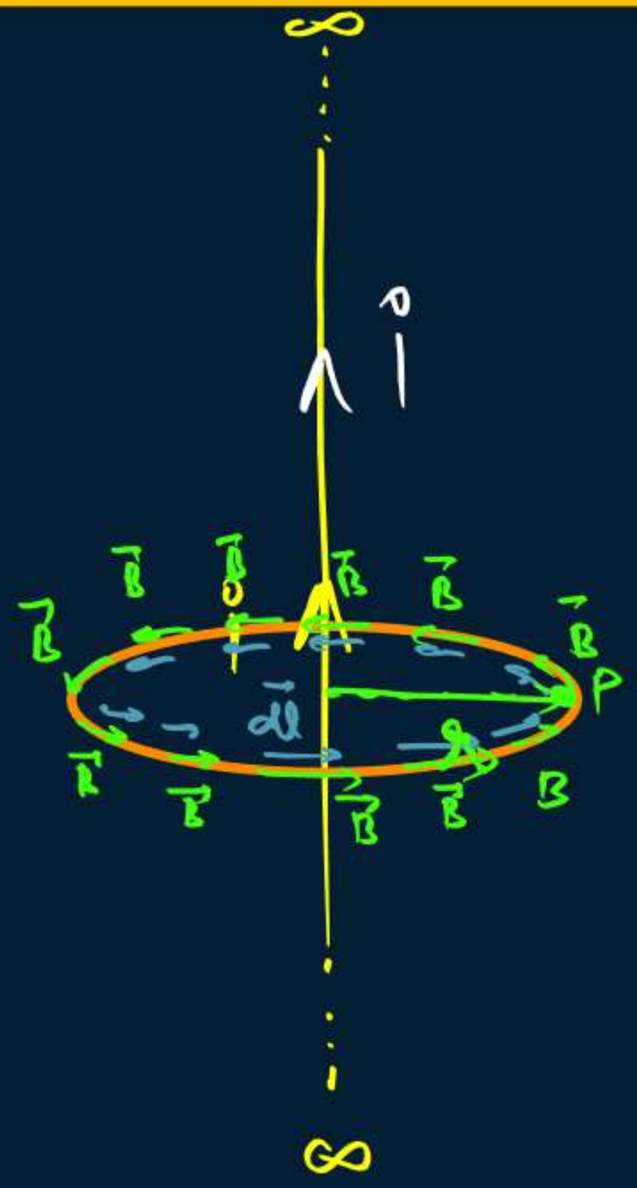
2) $B \perp dl$



$\theta = 90^\circ$, $\cos 90 = 0$

3) B Vanish

Magnetic Field due to Current Carrying Conductor



We have taken a circular loop as Amperian's Loop

Using ACL :-

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 i_{enclosed}$$

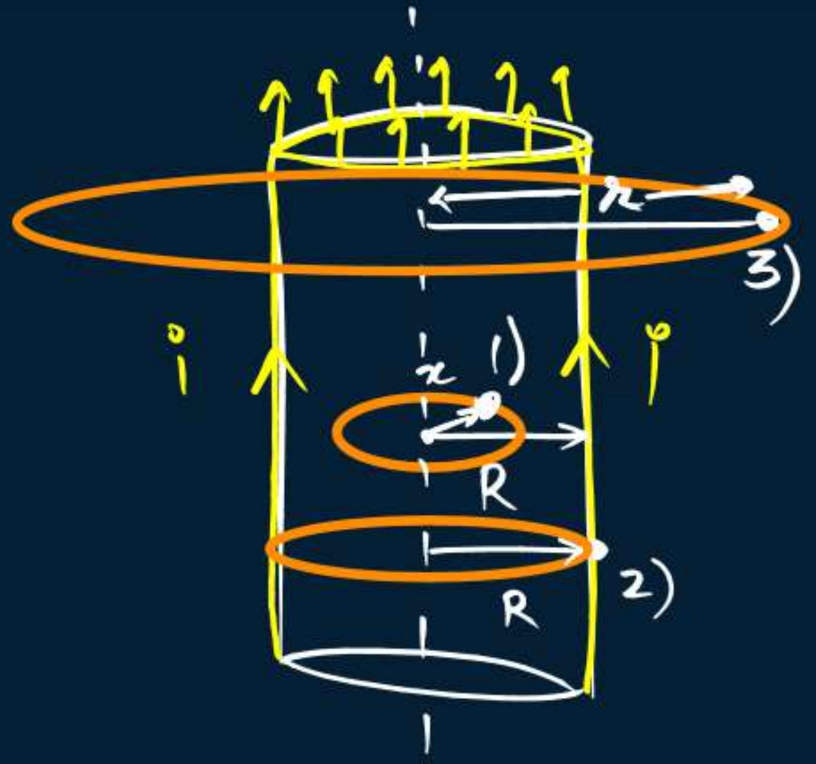
$$\oint B\, dl \cos 0^\circ = \mu_0 (+i)$$

$$\oint B\, dl = \mu_0 i$$

$$B \oint dl = \mu_0 i$$

$$B(2\pi r) = \mu_0 i \longrightarrow \boxed{B = \frac{\mu_0 i}{2\pi r}}$$

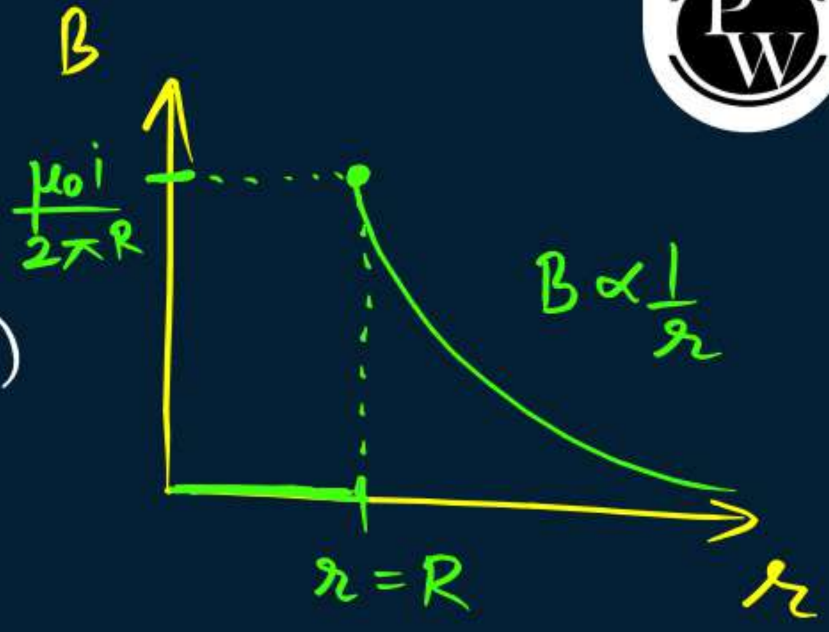
Magnetic Field due to hollow current carrying pipe (cylinder)



1) $B_{inner} \Rightarrow$ $\vec{B}\cdot\vec{dl} = \mu_0 (i_{enc})$

$= \mu_0 (0)$

$\boxed{B_{in} = 0}$



2) $B_{surface} \Rightarrow$ $\oint \vec{B}\cdot\vec{dl} = \mu_0 (i)$

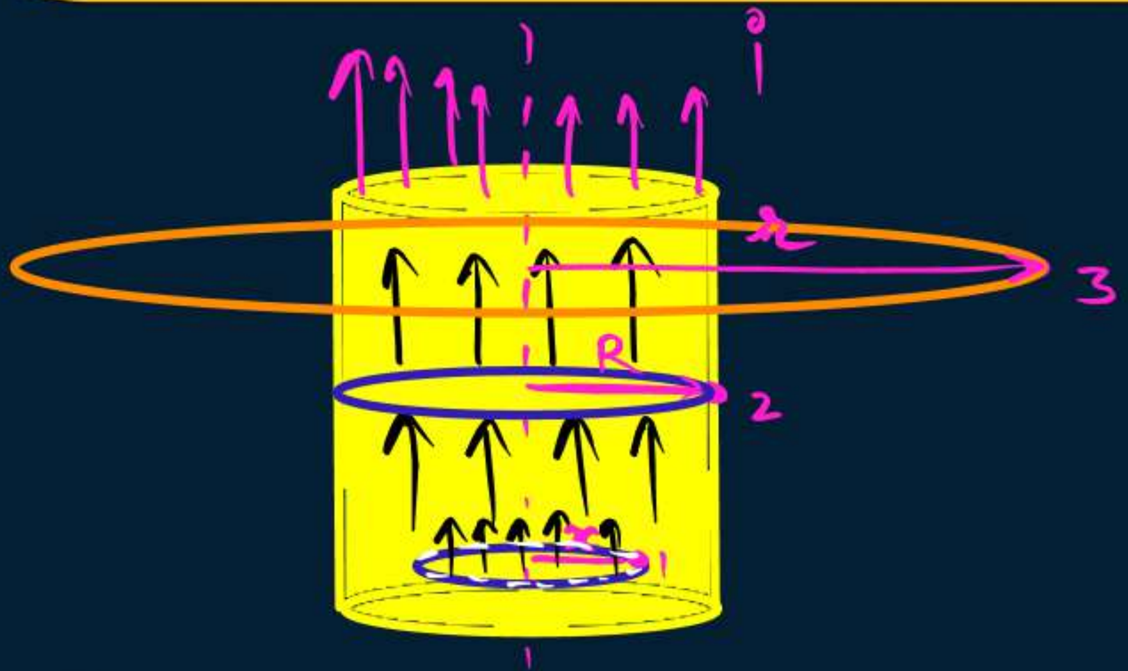
$B \int dl = \mu_0 i$

$B(2\pi R) = \mu_0 i \longrightarrow \boxed{B_{surface} = \frac{\mu_0 i}{2\pi R}}$ → B_{max}

3) $B_{outer} \Rightarrow$ $\oint \vec{B}\cdot\vec{dl} = \mu_0 i_{enc}$

$B \oint dl = \mu_0 i \longrightarrow \boxed{B_{outer} = \frac{\mu_0 i}{2\pi r}}$ → $B \propto \frac{1}{r}$

Magnetic Field due to solid current carrying pipe (cylinder)



$\oint \vec{B}\cdot\vec{dl} = \mu_0 i_{enc}$

$B\int dl = \mu_0\left(i\frac{x^2}{R^2}\right)$

$B(2\pi \cancel{x}) = \mu_0 i\frac{x^{\cancel{2}}}{R^2} \rightarrow \boxed{B_{in} = \frac{\mu_0 i x}{2\pi R^2}} \rightarrow B_{in} \propto x$

1) $B_{inner} \Rightarrow \oint \vec{B}\cdot\vec{dl} = \mu_0(i_{enc})$

$\vec{J}$ is constant throughout

$J_{inner} = J_{surface}$

$\frac{i_{enc}}{\cancel{\pi} x^2} = \frac{i}{\cancel{\pi} R^2}$

$i_{enc} = i\frac{x^2}{R^2}$

2) $B_{surface} \Rightarrow$

$\oint \vec{B}\cdot\vec{dl} = \mu_0 i_{enc}$

$B\int dl = \mu_0(i)$

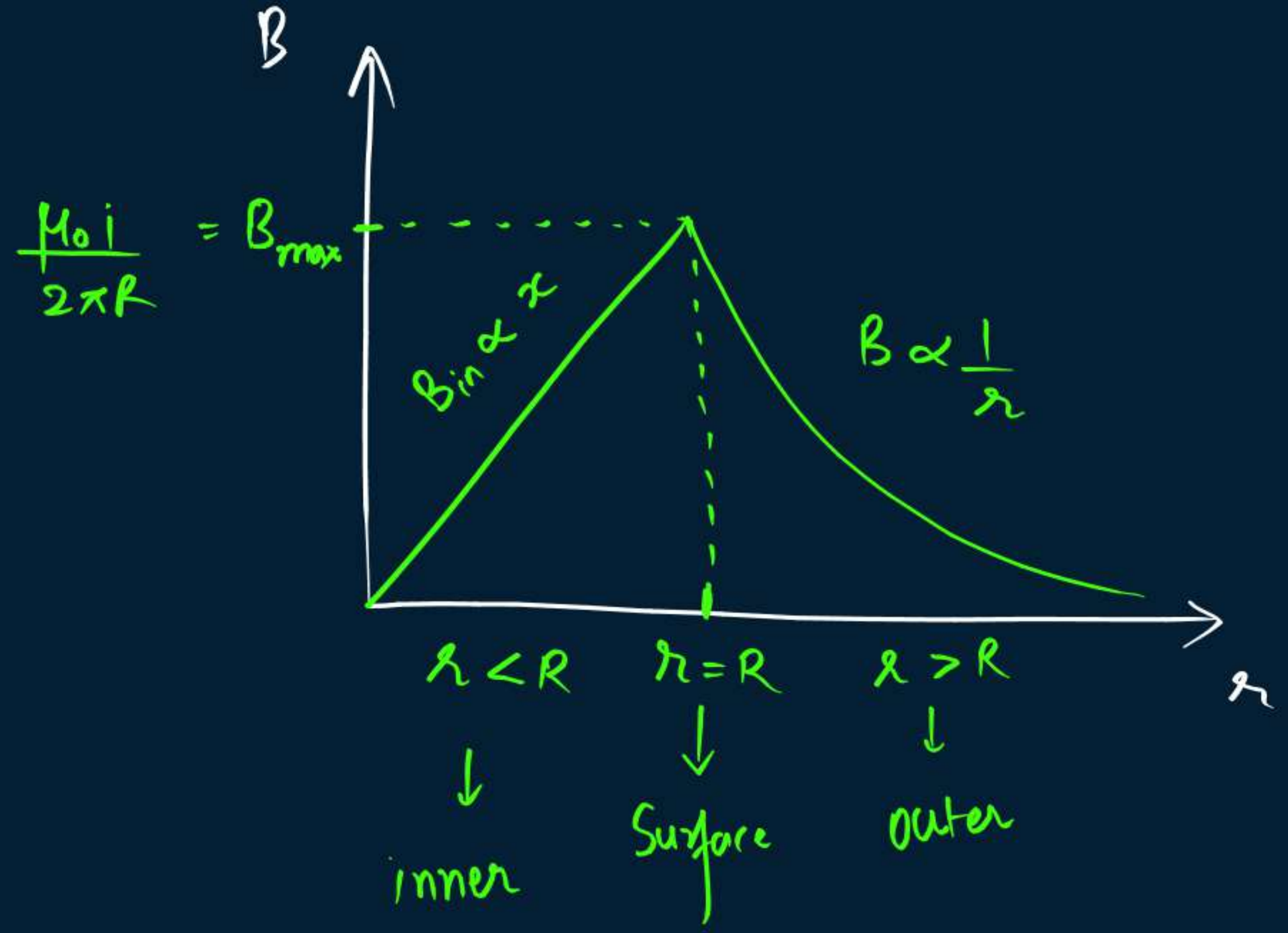
$\boxed{B = \frac{\mu_0 i}{2\pi R}} \rightarrow B_{max}$

3) $B_{outer} \Rightarrow$

$\oint \bar{B}\cdot\bar{dl} = \mu_0 i_{enc}$

$B\oint dl = \mu_0 i$

$\boxed{B = \frac{\mu_0 i}{2\pi r}} \rightarrow B \propto \frac{1}{r}$



B
$\frac{\mu_0 i}{2\pi R} = B_{max}$
$B_{in} \propto x$
$B \propto \frac{1}{r}$
r
$r < R$
inner
$r = R$
Surface
$r > R$
outer

Magnetic Field(B) in terms of Current Density (J)

$$B = \frac{\mu_0 (i) x}{2(\pi R^2)}$$

$$J = \frac{I}{A}$$

$$J = \frac{I}{\pi R^2}$$

NEET *

$$\boxed{B = \frac{\mu_0 J x}{2}}$$

QUESTION

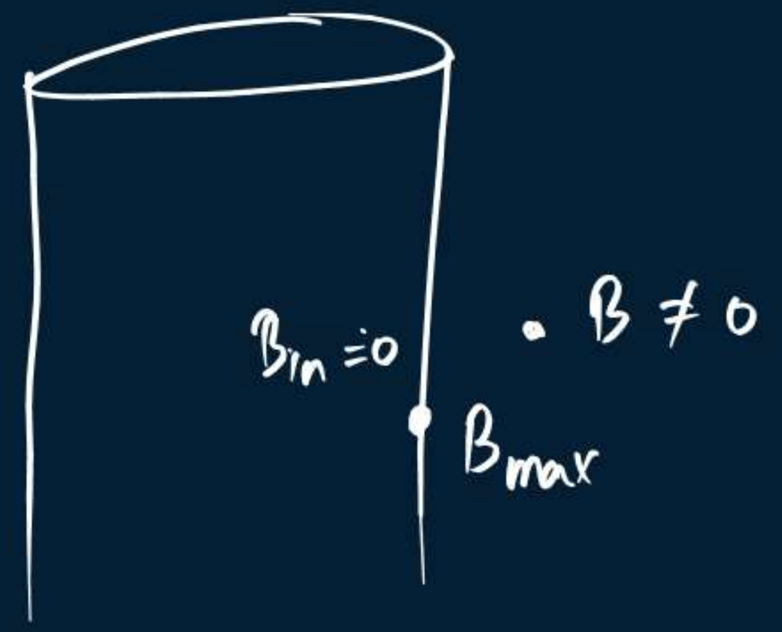
If a long hollow copper pipe carries a current, then produced magnetic field will be **(1999)**

(A) both inside and outside the pipe

(B) outside the pipe only

(C) inside the pipe only

(D) neither inside nor outside the pipe.



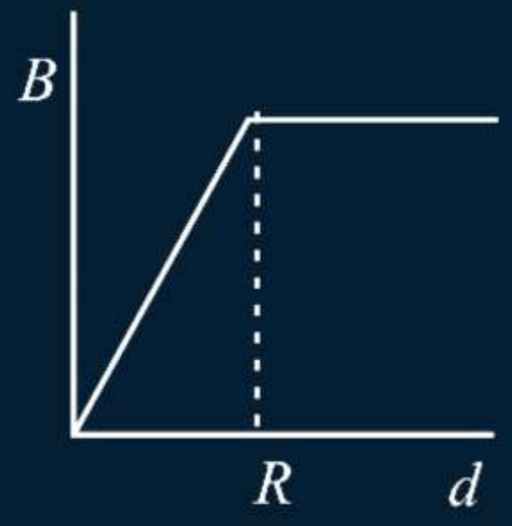
QUESTION

Kuch Nahi To solid

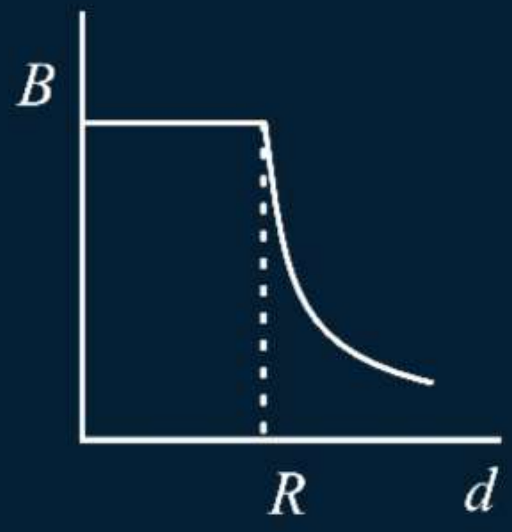
A cylindrical conductor of radius R is carrying a constant current. The plot of the magnitude of the magnetic field, B with the distance, *d* from the centre of the conductor, is correctly represented by the figure

(NEET 2019)

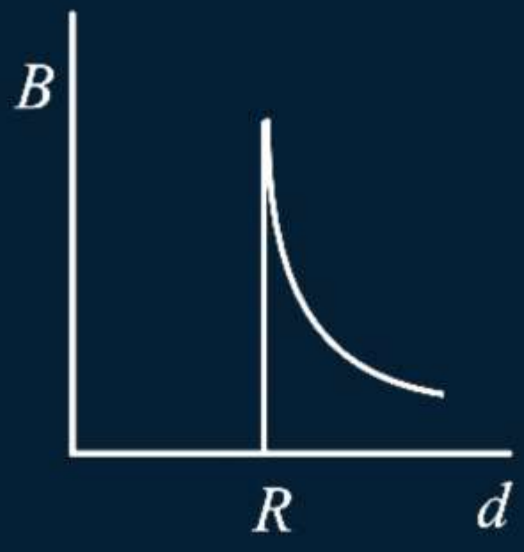
A



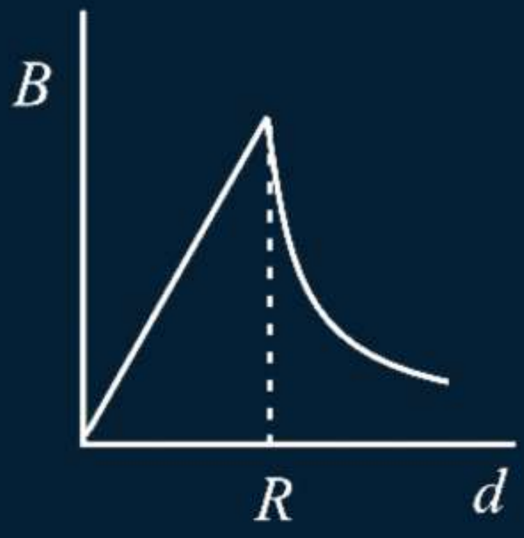
B



C



D



QUESTION

H.W.

A long straight wire of radius a carries a steady current *I*. The current is uniformly distributed over its cross-section. The ratio of the magnetic fields B and B′, at radial distances $a/2$ and $2a$ respectively, from the axis of the wire is **(NEET 2016)**

A) 1

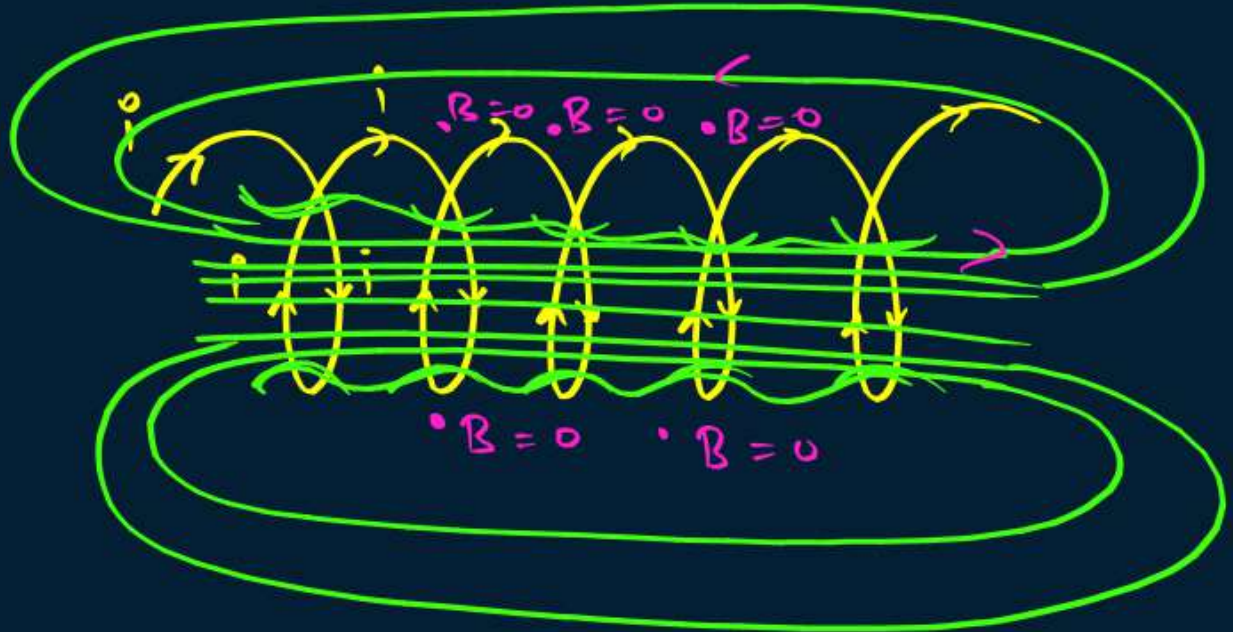
B) 4

C) 1/4

D) 1/2

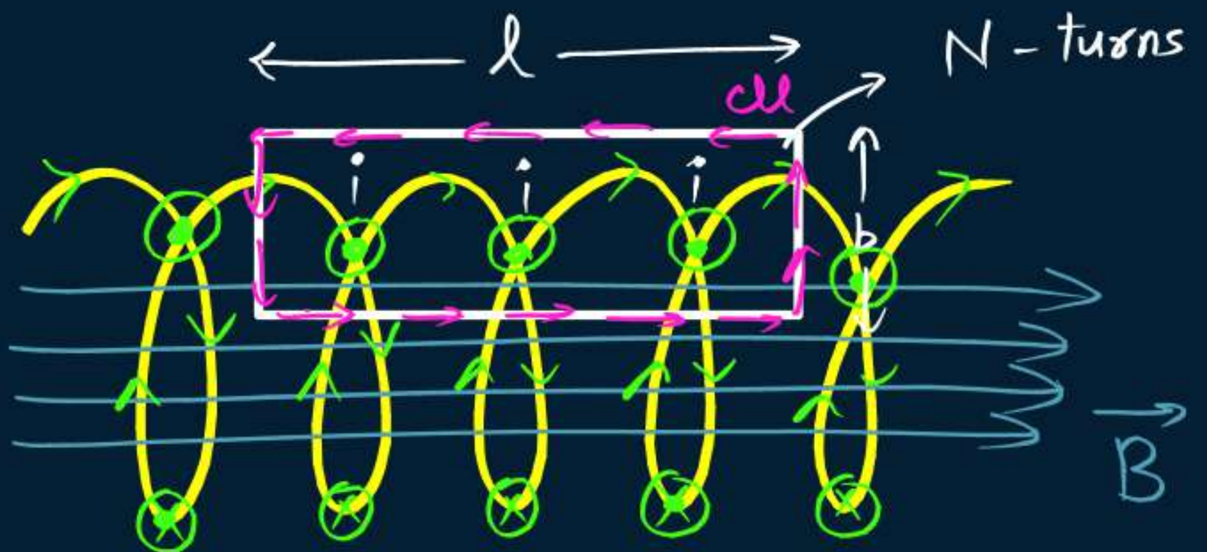
Magnetic Field due to an infinite (long) solenoid

A long solenoid is an electromagnet made up of Long Helical Coil of Wire



$$\boxed{B_{\circ\,\text{inside}} = \mu_0 n i}$$

$$\boxed{B_{\text{endings}} = \frac{\mu_0 n i}{2}}$$



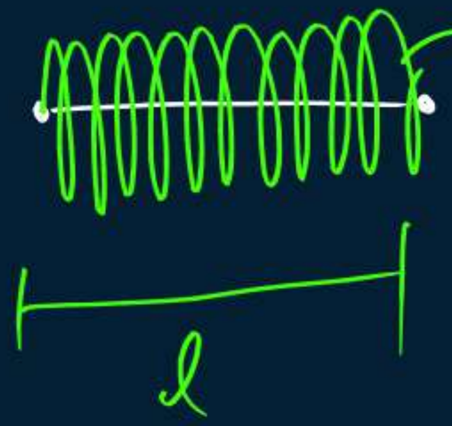
Using ACL :-

$$\oint \vec{B}\cdot\vec{dl} = \mu_0(i_{enc})$$

We are taking a rectangular amperian's loop of length 'l' and breadth 'b'

N↓

L.L.



N↑ turn density (n)

Mauvan

$$\int B\,dl\cos 0^\circ + \int B\,dl\cos 90^\circ + \int B\,dl\cos\theta + \int B\,dl\cos 90 = \mu_0(i_{enc})$$

$$B\int dl \times 1 + B\int dl \times 0 + \int 0 \times dl\cos\theta + B\int dl \times 0 = \mu_0(i_{enc})$$

$$Bl + 0 + 0 + 0 = \mu_0(Ni)$$

$$Bl = \mu_0 N i$$

$$B = \mu_0\left(\frac{N}{l}\right)i$$

$$\boxed{B = \mu_0 n i}$$

1) $B \propto i$

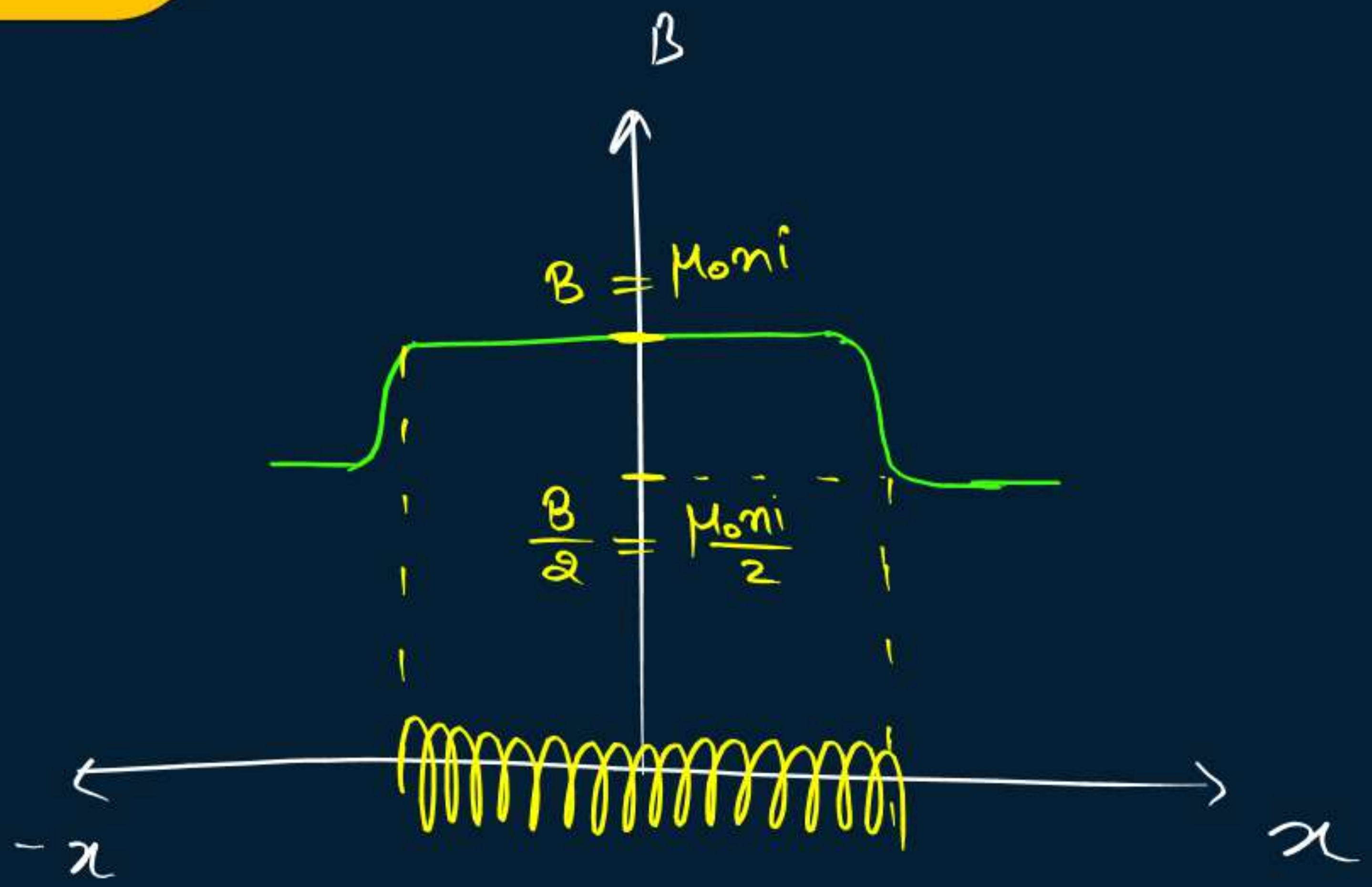
2) $B \propto N$

3) $B \propto 1/l$

$$\text{Turn density } (n) = \frac{\text{No. of Turns } (N)}{\text{length } (l)}$$

$$\boxed{n = \frac{N}{l}}$$

Graph



QUESTION

H.W.

A long solenoid of 50 cm length having 100 turns carries a current of 2.5 A. The magnetic field at the centre of the solenoid is ($\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}) **(NEET 2020)**

A 6.28×10^{-4} T

B 3.14×10^{-4} T

C 6.28×10^{-5} T

D 3.14×10^{-5} T

QUESTION

H.W.

Ratio of magnetic field produced at centre & end points of long solenoid is

A) 1 : 1

B) 1 : 2

C) 2 : 1

D) 4 : 1

Homework

- Notes
- Revision
- Re-try khudse derivations
- DPP

PARISHRAM

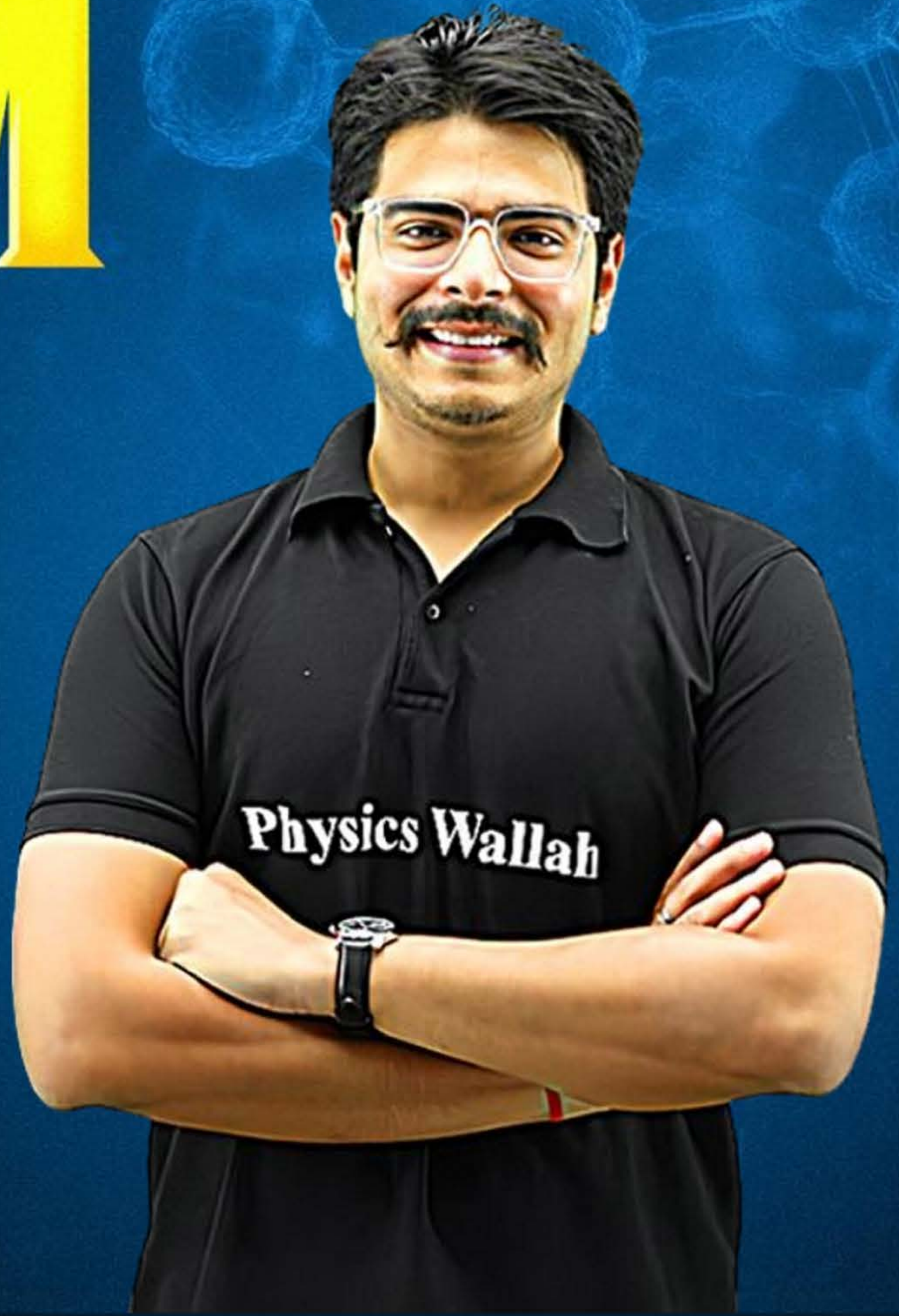
2026

Lecture - 04

Moving Charges and Magnetism

PHYSICS **Lecture 04**

BY - RAKSHAK SIR



Topics *to be covered*

- **A** Force on Charged Particle ✓
- **B** Motion of a Charged Particle in Magnetic Field ✓
- **C**
- **D**

HW QUESTION

solid cylinder

$B_{in} \propto r$, $B_{out} \propto \frac{1}{r}$

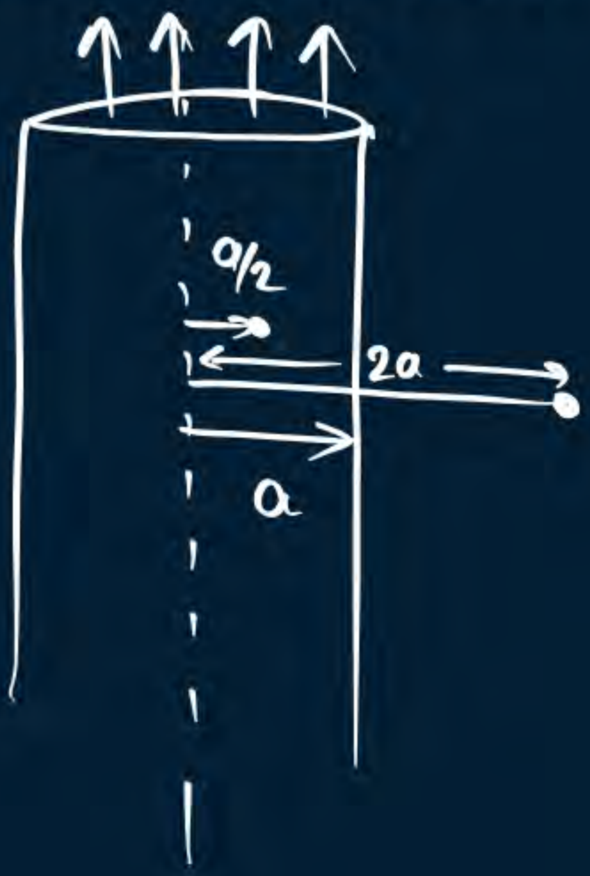
A long straight wire of radius 'a' carries a steady current 'I'. The current is uniformly distributed over its cross-section. The ratio of the magnetic fields 'B' and 'B'' at radial distances 'a/2' and '2a' respectively, from the axis of the wire is **(NEET 2016)**

(A) 1

(B) 4

(C) 1/4

(D) 1/2



$$B_{in} = \frac{\mu_0 i \left(\frac{a}{2}\right)}{2\pi a^2} = \frac{\cancel{\mu_0 i} \cancel{a}}{\cancel{2} \cancel{2\pi} \cancel{a^2}}$$

$$B_{out} = \frac{\mu_0 i}{2\pi(2a)} = \frac{\cancel{\mu_0 i}}{\cancel{2} \cancel{2\pi a}}$$

$$\frac{B_{in}}{B_{out}} = \frac{1}{1} = 1$$

HW QUESTION

A long solenoid carrying a current produces a magnetic field B along its axis. If the current is doubled and the number of turns per cm is halved, the new value of the magnetic field is

(2003)

A) B/2

B) B

C) 2B

D) 4B

$$B = \mu_0 n i$$

$$B' = \mu_0 \frac{n}{\cancel{2}} \cancel{2} i = \mu_0 n i$$

HW QUESTION

A long solenoid of 50 cm length having 100 turns carries a current of 2.5 A. The magnetic field at the centre of the solenoid is ($\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}) **(NEET 2020)**

(A) 6.28×10^{-4} T

(B) 3.14×10^{-4} T

(C) 6.28×10^{-5} T

(D) 3.14×10^{-5} T

$$B = \mu_0 n i$$

$$= \mu_0 \frac{N}{l} i$$

$$= 4\pi \times 10^{-7} \times \frac{100}{\left(\frac{50}{100}\right)} \times 2.5$$

$$= 4\pi \times 10^{-7} \times 200 \times \frac{25}{10}$$

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

$$= 2000\pi \times 10^{-7}$$

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

HW QUESTION

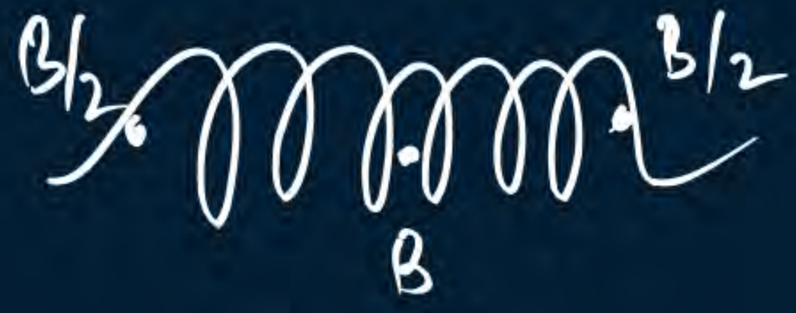
Ratio of magnetic field produced at centre & end points of long solenoid is

A) 1 : 1

B) 1 : 2

C) 2 : 1

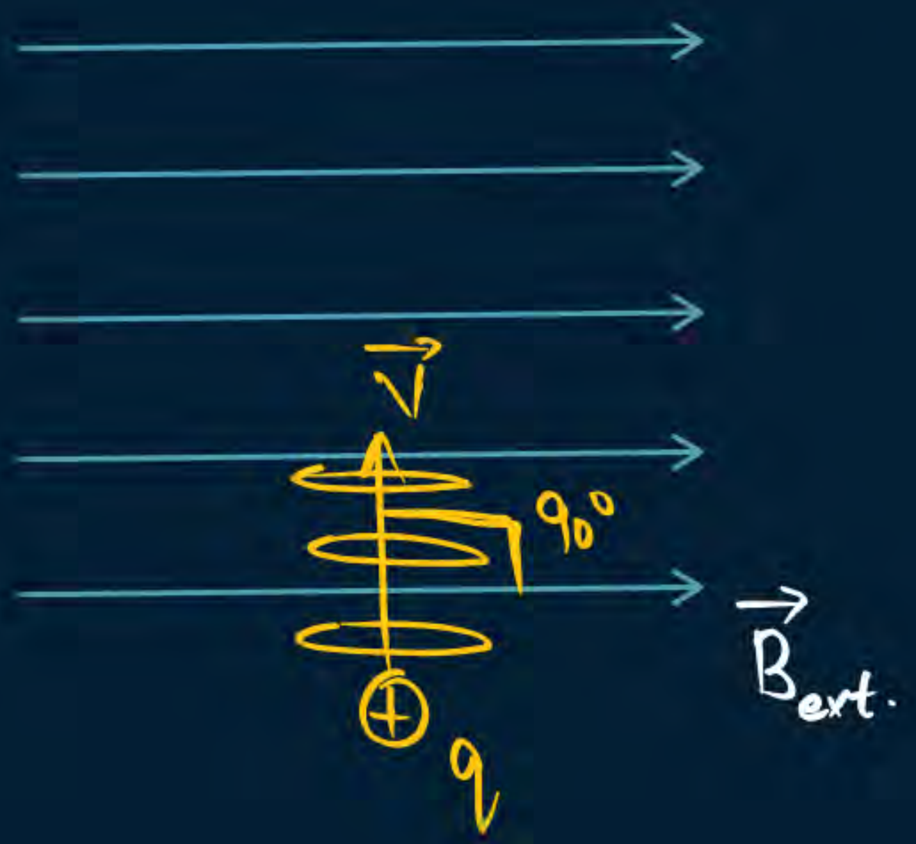
D) 4 : 1



$$\frac{\cancel{B}}{\frac{\cancel{B}}{2}} = 2$$

2 : 1

Charge particle in External magnetic Field



$F_B \longrightarrow$ Magnetic force on charge by External M.F.

$$\left.\begin{aligned} F_B &\propto q \\ &\propto v \\ &\propto B \\ &\propto \sin\theta \end{aligned}\right\} \quad F_B \propto qVB\sin\theta$$

$$\boxed{F_B = qVB\sin\theta}$$

$$\boxed{\vec{F}_B = q(\vec{V}\times\vec{B})}$$

$\sin\theta \downarrow$ Angle b/w $\vec{V}$ and $\vec{B}$

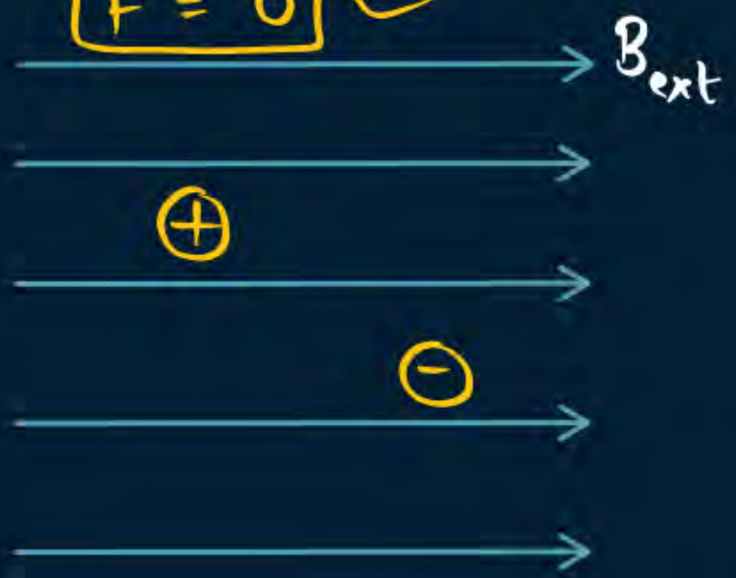
direction of Force $\longrightarrow$ $\vec{V}\times\vec{B}$ ki direction

Different Cases

1. Charge particle at rest $(V=0)$

$F = qVB\sin\theta$

$\boxed{F=0}$ ✓



2. Charge particle moving parallel or anti-parallel to magnetic field

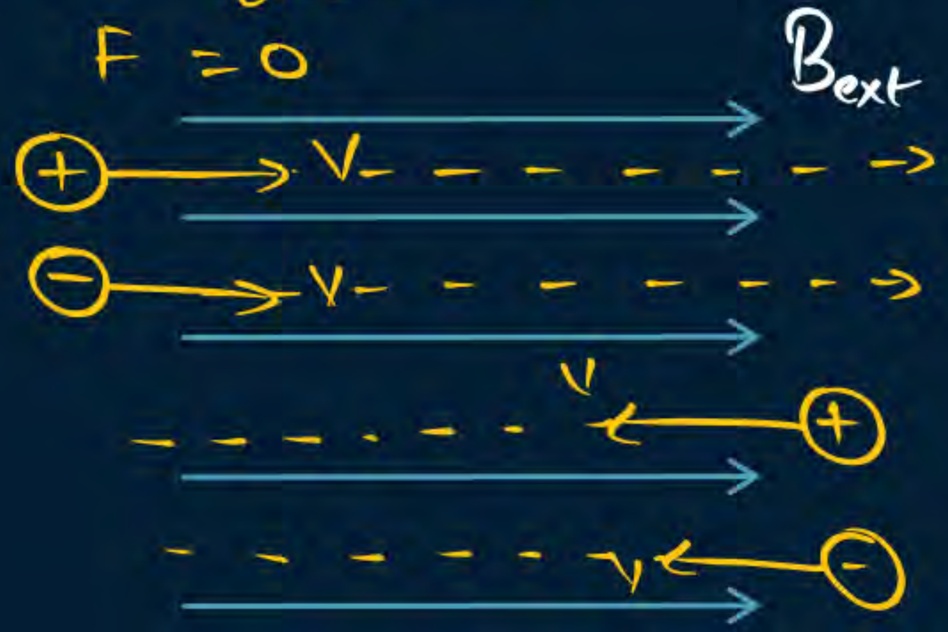
$F = qVB\sin\theta$

$F = 0$

$\theta = 0^\circ$ P

$\sin 0^\circ = 0$

$F = 0$



$V = \text{Const.}$

$a = 0$

$F = 0$

A.P. $\theta = 180^\circ$

$\sin 180^\circ = 0$

$F = 0$

V. imp

3. Charge particle moving perpendicular to magnetic field $(\theta = 90^\circ)$

$$F = qvB\sin\theta$$
$$= qvB\sin 90^\circ$$
$$\boxed{F_{max} = qvB}$$

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

$$\vec{F} \perp \vec{v}$$

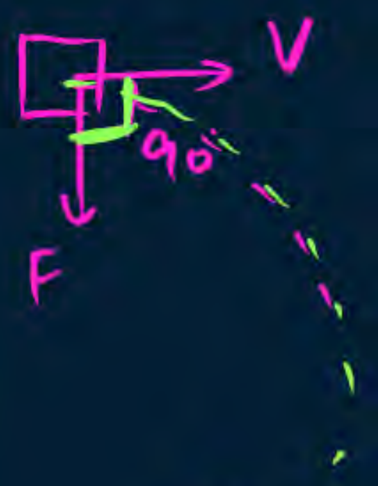
This performs Uniform Circular motion under a centripetal force given by Magnetic Force.

$$F_B = F_c$$

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

$$* \boxed{r = \frac{mv}{qB}}$$

Y.K.B.



$$F_c = \frac{mv^2}{R}$$

1) $$\boxed{r = \frac{mv}{qB}}$$

2) Time Period (T)

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$v = \frac{2\pi r}{T}$$

$$T = \frac{2\pi r}{v}$$

$$T = \frac{2\pi}{\cancel{v}} \frac{m\cancel{v}}{qB}$$

$$\boxed{T = \frac{2\pi m}{qB}}$$

independent of 'r' and 'v'

3. Frequency (ν)

$$\nu = \frac{1}{T}$$

$$\nu = \frac{1}{\frac{2\pi m}{qB}}$$

Hertz (Hz) ← $\boxed{\nu = \frac{qB}{2\pi m}}$

4. Angular frequency (ω)

$$\omega = \frac{2\pi}{T}$$

$$\omega = \frac{\cancel{2\pi}}{\frac{\cancel{2\pi} m}{qB}} = \frac{qB}{m}$$

rad/sec ← $\boxed{\omega = \frac{qB}{m}}$

5. Kinetic Energy $\left(K = \frac{1}{2}mv^2\right)$

$$K = \frac{1}{2}m\left(\frac{qBr}{m}\right)^2$$

$$K = \frac{1}{2}\cancel{m}\frac{q^2B^2r^2}{m^{\cancel{2}}} \Rightarrow \boxed{K = \frac{q^2B^2r^2}{2m}}$$

Other forms to write radius of Circular path

$$r = \frac{(mv)}{qB} = \frac{p}{qB} = \frac{\sqrt{2mK}}{qB} = \frac{\sqrt{2m\cancel{q}V}}{\sqrt{q}\sqrt{q}\;B} = \frac{1}{B}\sqrt{\frac{2mV}{q}}$$

Y.K.B.

$$\boxed{p = mv}$$

1) $\boxed{r = \frac{mv}{qB}}$

2) $\boxed{r = \frac{p}{qB}}$

3) $\boxed{r = \frac{\sqrt{2mK}}{qB}}$

4) $\boxed{r = \frac{1}{B}\sqrt{\frac{2mV}{q}}}$

* Accelerating Voltage

Voltage $V = \frac{U}{q}$

$V = \frac{K}{q}$

$$\boxed{K = qV}$$

$K = \frac{1}{2}mv^2 \times \frac{m}{m}$

$= \frac{m^2v^2}{2m}$

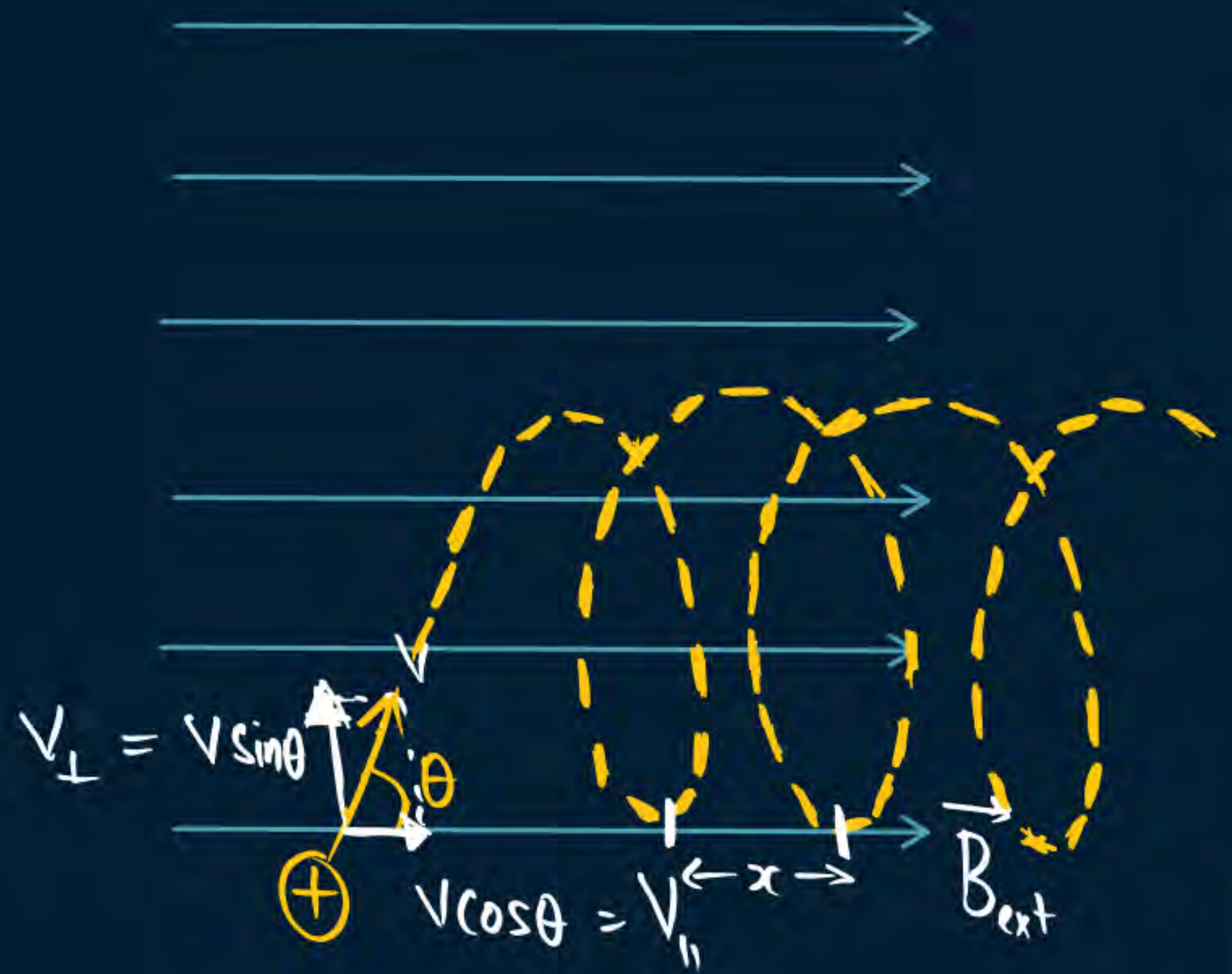
$= \frac{(mv)^2}{2m}$

$$\boxed{K = \frac{p^2}{2m}}$$

$p^2 = 2mK$

$$\boxed{p = \sqrt{2mK}}$$

4. Charge particle moving at some random angle to magnetic field : helical path



1. radius

$$r = \frac{mV_\perp}{qB}$$

$$\boxed{r = \frac{mv\sin\theta}{qB}}$$

2. Time Period

$$T = \frac{2\pi r}{V_\perp} = \frac{2\pi}{v\sin\theta}\frac{mv\sin\theta}{qB}$$

$$\boxed{T = \frac{2\pi m}{qB}}$$

3. pitch (x)

↳ it is horizontal distance covered by the charge after one time Period

$S = \frac{D}{T}$ or $D = S \times T$

$x = V_\parallel \times T$

$$\boxed{x = V\cos\theta \, \frac{2\pi m}{qB}} \longleftarrow x = V\cos\theta \cdot T$$

NOTE :-

$$\boxed{\vec{F} = q(\vec{V} \times \vec{B})}$$

+ve charge

(F ki direction $\vec{V} \times \vec{B}$ ki hi hogi)

-Ve charge

(F ki direction $\vec{V} \times \vec{B}$ ke opp hogi)

Homework

- Notes . . . . . .
- Revision . . . .
- DPP Try

PARISHRAM

2026

Lecture - 05

Moving Charges and Magnetism

PHYSICS Lecture - 5

BY - RAKSHAK SIR

Topics *to be covered*

- **A** Velocity Selector (concept)
- **B** Force on Current Carrying Wire in Magnetic Field ✓
- **C**
- **D**

Charge particle in combined Electric $(\vec{E})$ (q) and Magnetic Fields $(\vec{B})$

$$\vec{F}_{net} = \vec{F}_{elec} + \vec{F}_{mag}$$

$$\vec{F}_{net} = q\vec{E} + q(\vec{V} \times \vec{B})$$

$$\boxed{\vec{F}_{net} = q\left[\vec{E} + (\vec{V} \times \vec{B})\right]}$$

Lorentz Force

QUESTION

A charge q moves in a region where electric field and magnetic field both exist, then force on it is (2002)

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

(A) $q(\vec{v} \times \vec{B})$

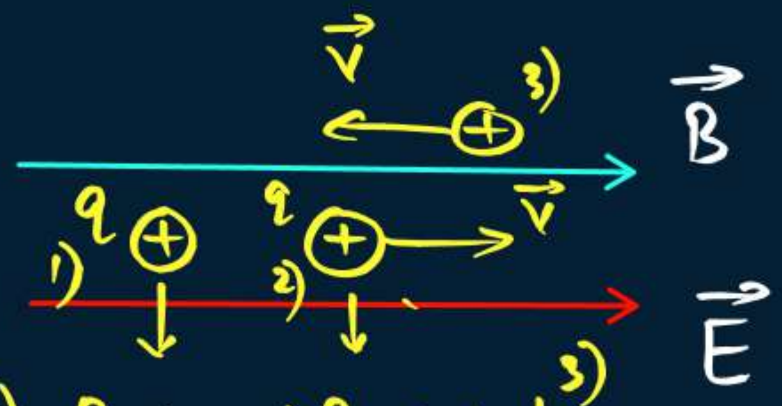
(B) $q\vec{E} + q(\vec{v} \times \vec{B})$

(C) $q\vec{E} + \vec{q}(\vec{B} \times \vec{v})$

(D) $q\vec{E} + q(\vec{E} \times \vec{v})$

$F_B = qvB\sin\theta$, $F_E = qE$

1. Charge particle at rest ormoving parallel or anti-parallel to both fields initially



1) Rest. 2) Parallel / 3) Antiparallel

$F_B = 0$ $\quad$ $F_B = 0 \ (\theta = 0^\circ / 180^\circ)$

$F_e = qE$ $\quad$ $F_e = qE$

$F_{net} = 0 + qE = qE$

$ma = qE$

$$\boxed{a = \frac{qE}{m}}$$

1) $u = 0$

$$a = \frac{qE}{m}$$

$$v = u + at$$

$$v = 0 + \frac{qEt}{m}$$

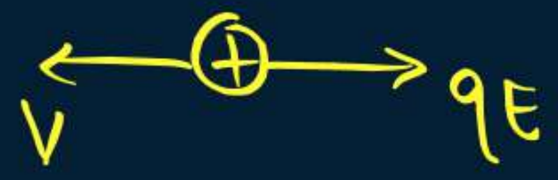
$$\boxed{v = \frac{qEt}{m}}$$

2)

$$v = u + at$$

$$v = u + \frac{qE}{m}t$$

3)



$$v = u - \frac{qE}{m}t$$

QUESTION

A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected in the region such that its velocity is pointed along the direction of fields, then the electron **(2011)**

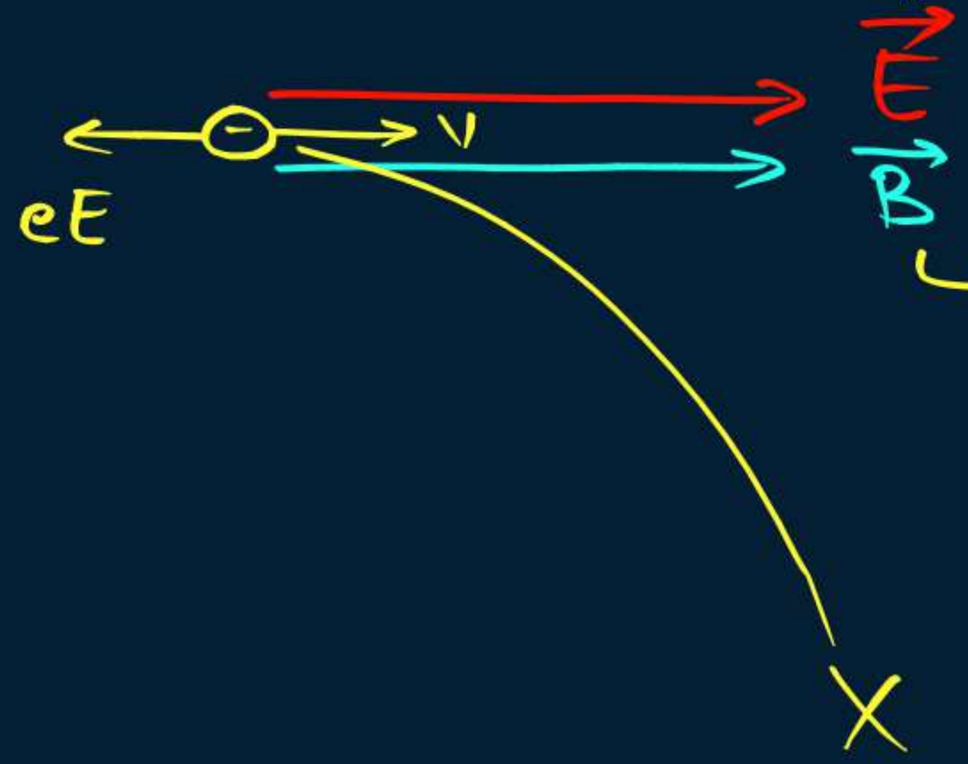
(A) will turn towards right of direction of motion

(B) speed will decrease

(C) speed will increase

(D) will turn towards left of direction of motion.

$F_e = qE$
$= eE$

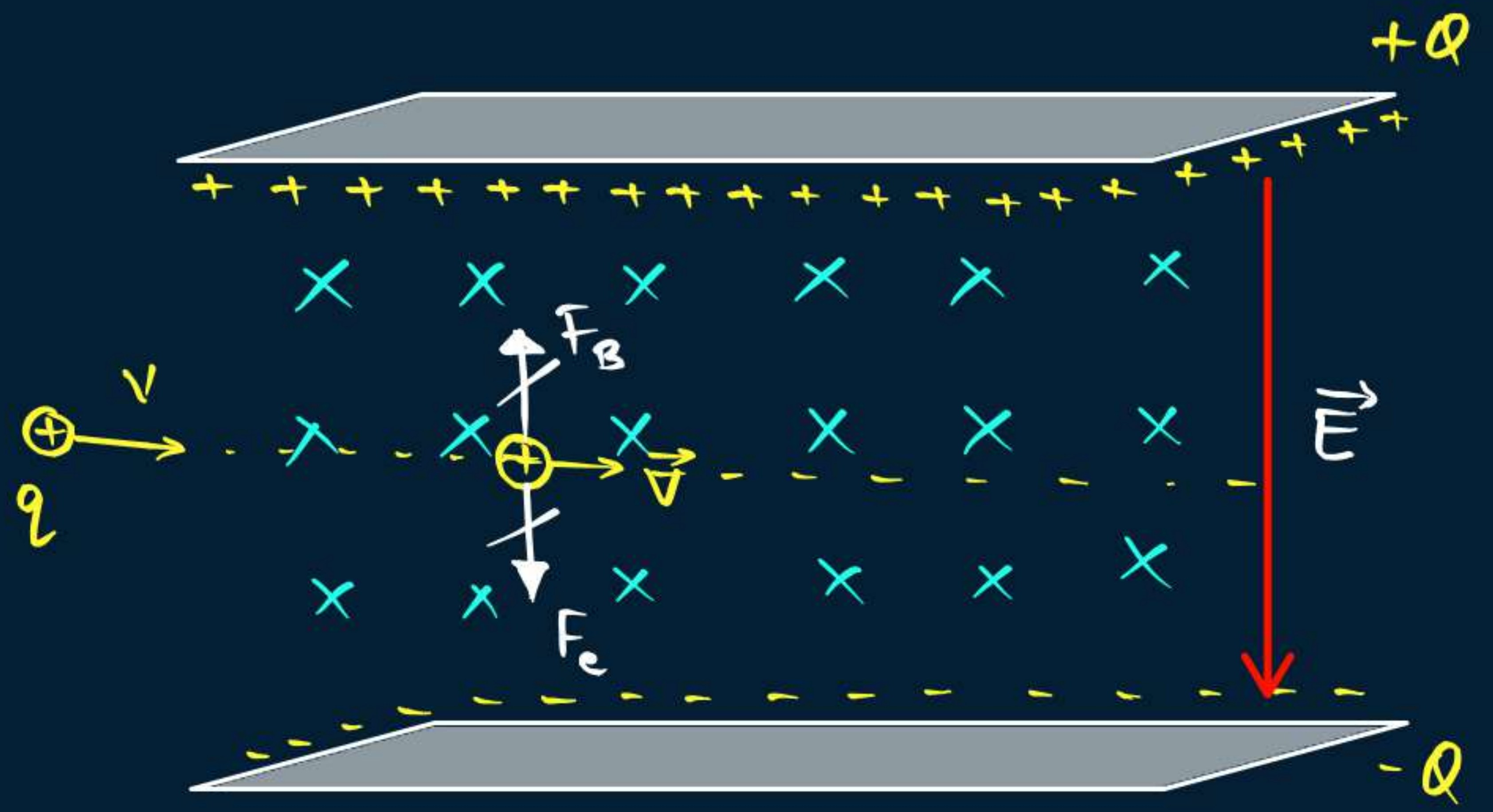


$F_B = 0$

$\vec{V} \perp \vec{E} \perp \vec{B}$

Concept : Velocity Selector

3. Velocity, Electric Field and Magnetic Field are mutually perpendicular



Case i) When $|F_e| = |F_B|$

$$qE = qVB\sin\theta$$

$$\cancel{q}E = \cancel{q}VB\sin 90$$

$$\boxed{V = \frac{E}{B}}$$

ii) $F_e > F_B$

$$\cancel{q}E > \cancel{q}VB$$

$$\frac{E}{B} > V$$

iii) $F_B > F_e$

$$\cancel{q}VB > \cancel{q}E$$

$$V > \frac{E}{B}$$

QUESTION

A beam of electrons is moving with constant velocity in a region having electric and magnetic fields of strength 20 V m^{-1} and 0.5 T at right angles to the direction of motion of the electrons. What is the velocity of the electrons? (1996)

A. 8 m s^{-1}

B. 5.5 m s^{-1}

C. 20 m s^{-1}

D. 40 m s^{-1}

$\boxed{V = \frac{E}{B}}$ → When $V \perp E \perp B$
→ When $|F_e| = |F_B|$

$= \frac{20 \times 10 \cancel{\ } 2}{0.\cancel{5}}$

$= 40$ m/s ✓

QUESTION

H.W.

Assertion (A): If an electron is not deflected while passing through a certain region of space, then only possibility is that there is no magnetic region.

Reason (R): Force is directly proportional to the magnetic field applied.

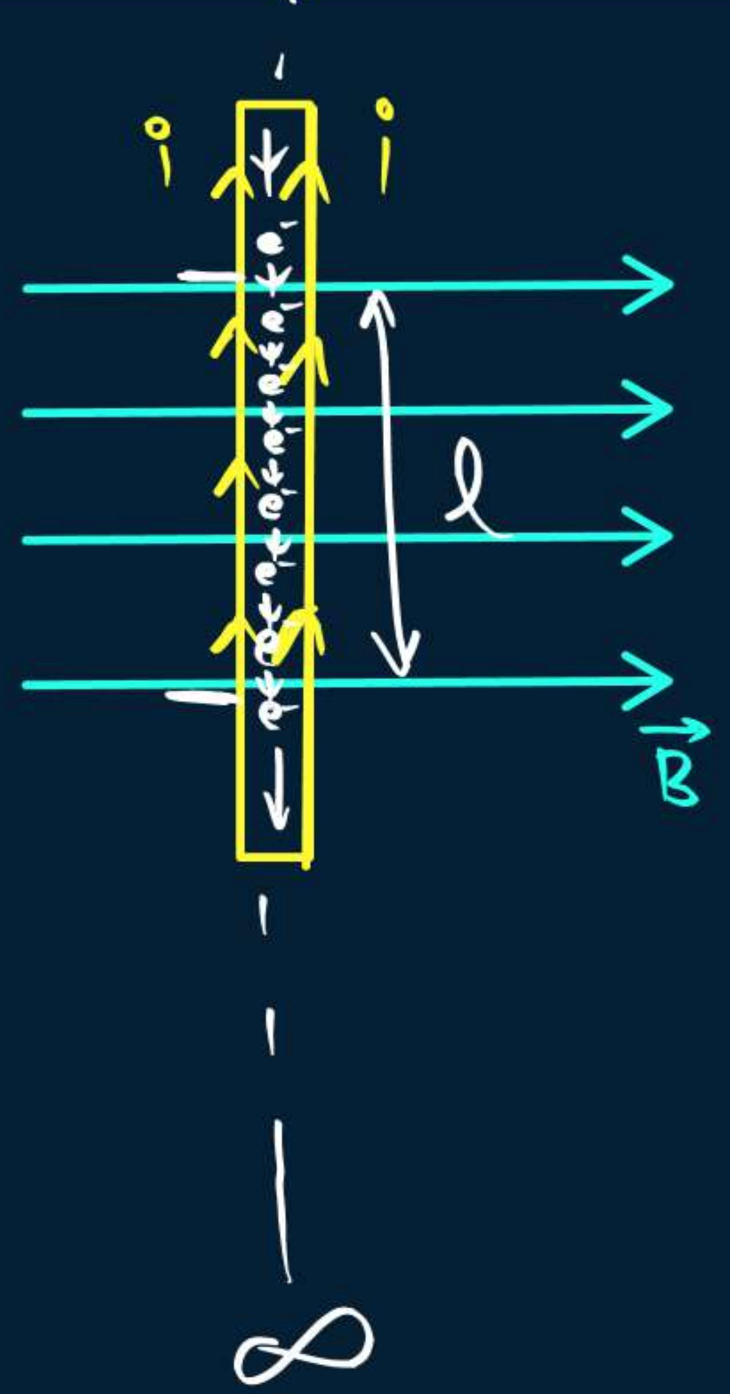
A. If both assertion and reason are true and reason is the correct explanation of the assertion.

B. If both assertion and reason are true but reason is not correct explanation of the assertion.

C. If assertion is true, but reason is false.

D. Assertion is false, reason is true

Force on a current carrying wire in external magnetic field



$$F_B \propto i$$
$$\propto B$$
$$\propto l_{eff}$$
$$\propto \sin\theta$$

$$F \propto B I l \sin\theta$$

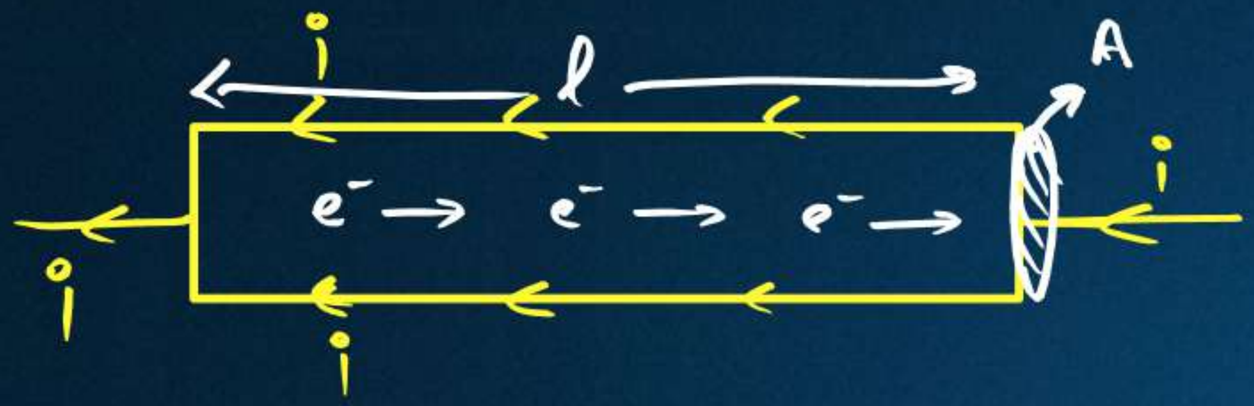
$$\boxed{F = B I l \sin\theta}$$

θ → Angle b/w $\vec{l}$ and $\vec{B}$

$$\boxed{\vec{F} = i(\vec{l} \times \vec{B})}$$

dir of $\vec{l}$ is same as that of 'i'

Derive :-



if force is taken only on 1 e⁻ :-

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

$$\vec{F} = -e(\vec{V_d} \times \vec{B})$$

if 'n' is no. of free electrons per unit volume

$$n = \frac{N}{Vol.}$$

$$n = \frac{N}{A \times l}$$

$$N = nAl$$

Force is now taken on 'N' electrons

$$\vec{F}_{net} = NF$$

$$= -Ne(\vec{V_d} \times \vec{B})$$

$$= -nAle(\vec{V_d} \times \vec{B})$$

$$\vec{F}_{net} = nAe(-l\vec{V_d} \times \vec{B})$$

$$-l\vec{V_d} = V_d\vec{l}$$

e ki dir

i ki Dir

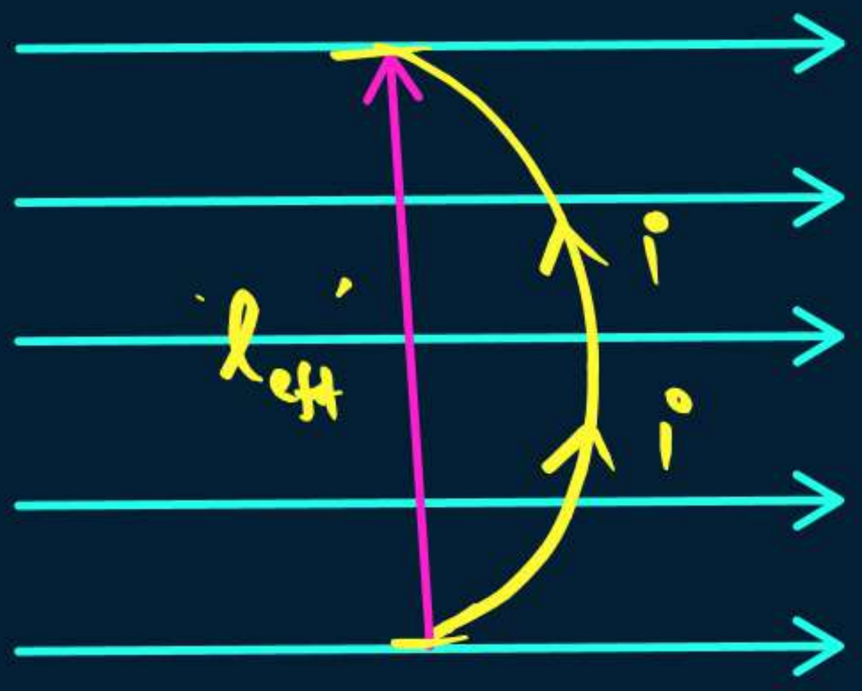
$$\vec{F}_{net} = neA(V_d\vec{l} \times \vec{B})$$

We know,

$$i = neAV_d$$

$$\boxed{\vec{F}_{net} = i(\vec{l} \times \vec{B})}$$

Force on a curved wire in external magnetic field



$F = BIL\sin\theta$

$\downarrow$

l_{eff} (Vector length to be taken)

Force between two parallel current carrying wires

Force on wire 2 by wire 1

$$F_{2,1} = B_1 i_2 l \sin 90^\circ$$

$$F_{2,1} = B_1 i_2 l$$

$$F_{2,1} = \frac{\mu_0 i_1 i_2 l}{2\pi r} \quad \ldots\ldots (1) \qquad \left[B_1 = \frac{\mu_0 i_1}{2\pi r} \right]$$

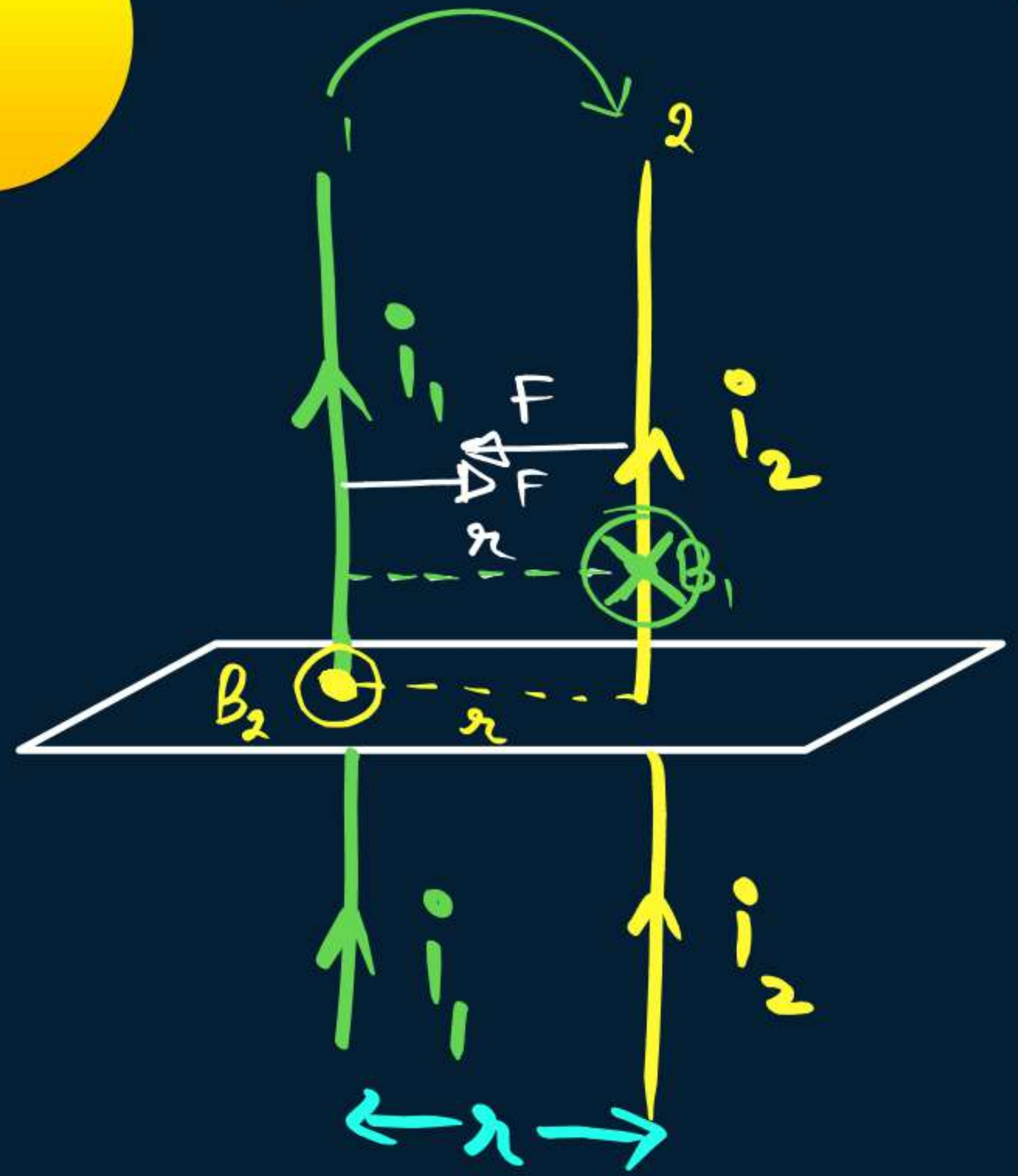
Force on wire 1 due to wire 2

$$F_{1,2} = B_2 i_1 l \sin 90^\circ$$

$$F_{1,2} = B_2 i_1 l$$

$$F_{1,2} = \frac{\mu_0 i_2 i_1 l}{2\pi r} \quad \ldots (2) \qquad \left[B_2 = \frac{\mu_0 i_2}{2\pi r} \right]$$

$$\vec{F} = i(\vec{l} \times \vec{B})$$



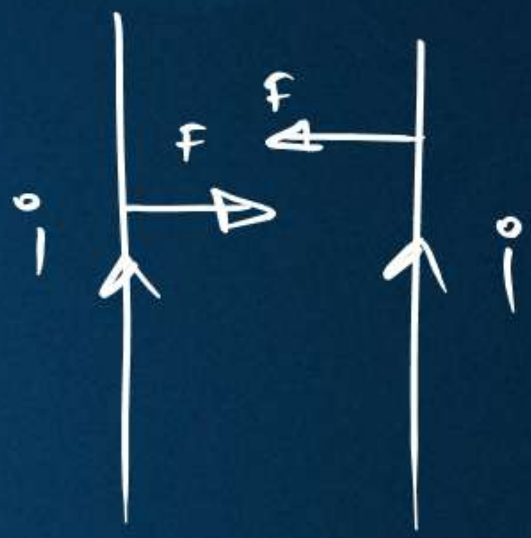
$$F_{2,1} = \frac{\mu_0 i_1 i_2 l}{2\pi r} \longrightarrow \boxed{\frac{F_{2,1}}{l} = \frac{\mu_0 i_1 i_2}{2\pi r}}$$

$$F_{1,2} = \frac{\mu_0 i_1 i_2 l}{2\pi r} \longrightarrow \boxed{\frac{F_{1,2}}{l} = \frac{\mu_0 i_1 i_2}{2\pi r}}$$

$$\boxed{\vec{F}_{1,2} = -\vec{F}_{2,1}}$$

Newton's III law

* RDx



Same direction of i
"Attract"

opp dir i
"Repel"

QUESTION

A very long straight wire carries a current I. At the instant when a charge +Q at point P has velocity $\vec{v}$, as shown, the force on the charge is (2005)

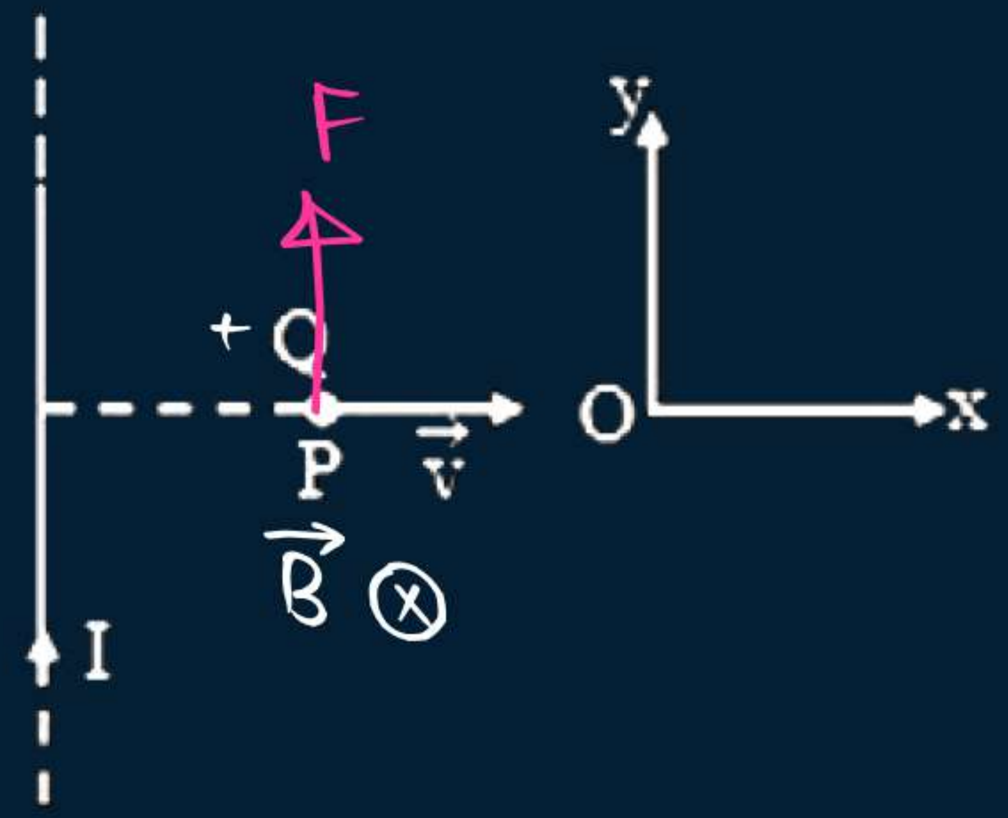
$$\vec{F} = q(\vec{v} \times \vec{B})$$

A Opposite to OX

B Along OX

C Opposite to OY

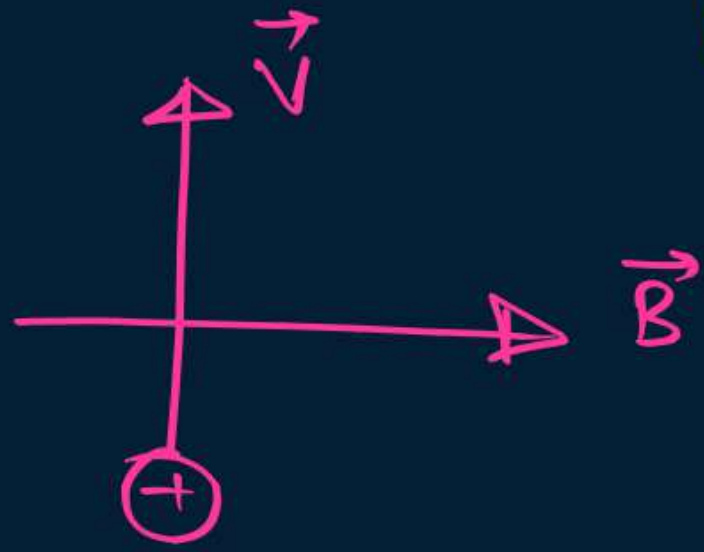
D Along OY



QUESTION

$p = mv$

A charged particle moves through a magnetic field in a direction perpendicular to it. Then the (2003)



A. speed of the particle remains unchanged (Same)

B. direction of the particle remains unchanged X

C. acceleration remains unchanged X

D. velocity remains unchanged X

E. Momentum remains unchanged X

QUESTION

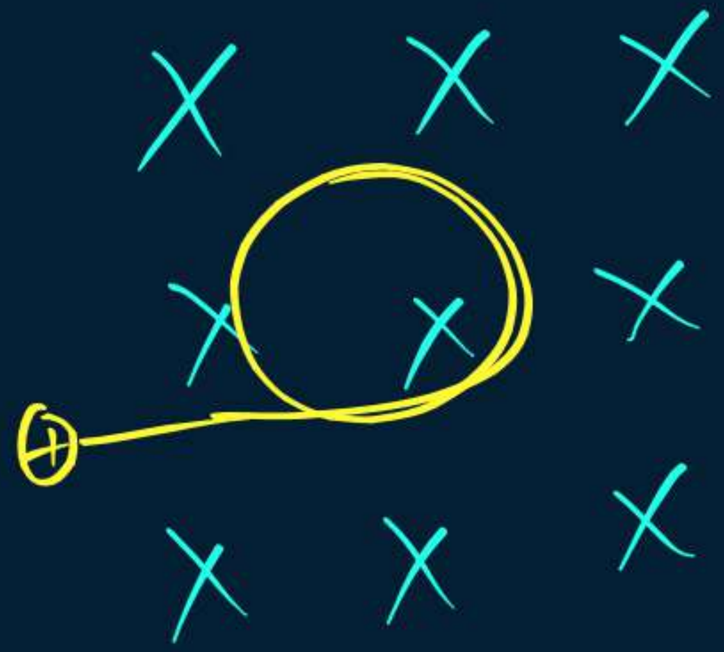
A particle of mass m, charge Q and kinetic energy T enters a transverse uniform magnetic field of indication $\vec{B}$. After 3 seconds the kinetic energy of the particle will be (2008)

A) T

B) 2 T

C) 3 T

D) 4 T



QUESTION

90°

A uniform magnetic field acts right angles to the direction of motion of electrons. As a result, the electron moves in a circular path of radius 2 cm. If the speed of electrons is doubled, then the radius of the circular path will be (1991)

4cm

(A) 2.0 cm

(B) 0.5 cm

(C) 4.0 cm

(D) 1.0 cm

$$r = \frac{mv}{qB}$$

$$r\uparrow \propto v\uparrow$$

r_1

$2v$

QUESTION

$\hat{i} \to \hat{j} \to \hat{k} \to \hat{i}$

$\hat{i} \times \hat{j} = \hat{k}$ $\quad \hat{k} \times \hat{i} = \hat{j}$ $\quad \hat{j} \times \hat{k} = \hat{i}$ $\quad\Big|\quad$ $\hat{i} \times \hat{i} = 0$, $\hat{j} \times \hat{j} = 0$, $\hat{k} \times \hat{k} = 0$

The magnetic force acting on a charged particle of charge $\boxed{-2\ \mu C}$ in a magnetic field of $\boxed{2T}$ acting in y direction, when the particle velocity is $(2\hat{\imath} + 3\hat{\jmath}) \times 10^6\ ms^{-1}$ is (2009)

(A) 4 N in z direction

(B) 8 N in y direction

(C) 8 N in z direction

(D) 8 N in –z direction ✓

Given :-

$q = -2 \times 10^{-6}\ C$

$\vec{B} = 2\hat{j}$

$\vec{V} = (2\hat{i} + 3\hat{j}) \times 10^{6}\ m/s$

$\vec{F} = ?$

$\vec{F} = q(\vec{V} \times \vec{B})$

$\vec{F} = -2 \times \cancel{10^{-6}}\left((2\hat{i} + 3\hat{j}) \times 2\hat{j}\right) \times \cancel{10^{6}}$

$= -2(2\hat{i} \times 2\hat{j} + 3\hat{j} \times 2\hat{j})$

$= -2(4\hat{k} + 0)$

$= -8\hat{k}$

QUESTION

Assertion (A): The energy of a charged particle moving in a uniform magnetic field does not change. T

Reason (R): The work done by the magnetic field on the charged particle is zero. T

A. If both assertion and reason are true and reason is the correct explanation of the assertion.

B. If both assertion and reason are true but reason is not correct explanation of the assertion.

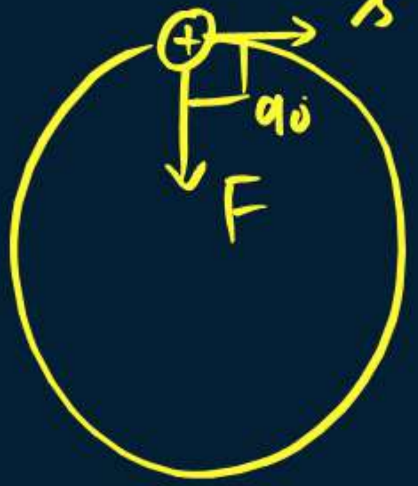
C. If assertion is true, but reason is false.

D. Assertion is false, reason is true

$W_{all} = \Delta K$

$0 = \Delta K$

$K \rightarrow$ Constant



$W = \vec{F} \cdot \vec{s}$

$= Fs\cos\theta$

$= Fs\cos 90$

$W = 0$

QUESTION

H.W.

A proton and an alpha particle both enter a region of uniform magnetic field B, moving at right angles to the field B. If the radius of circular orbits for both the particles is equal and the kinetic energy acquired by proton is 1 MeV the energy acquired by alpha particle will be: (2015)

A. 1 MeV

B. 4 MeV

C. 0.5 MeV

D. 1.5 MeV

QUESTION

H.W.

Statement-I: An e^- moving parallel to the direction of current in a long straight current carrying wire is deflected away from the wire.

Statement-II: e^- is repelled by electrostatic repulsion.

(A) Both statement I and II are correct

(B) Both statement I and II are incorrect

(C) Statement I is correct and statement II is incorrect

(D) Statement I is incorrect and statement II is correct

QUESTION

H.W.

Statement-I: A charge moving along the axis of a current carrying coil will suffer no deflection in its path.

Statement-II: Magnetic force on a charged particle moving parallel to magnetic field is zero.

A. Both statement I and II are correct

B. Both statement I and II are incorrect

C. Statement I is correct and statement II is incorrect

D. Statement I is incorrect and statement II is correct

Homework

- Notes
- Revision
- DPP Try

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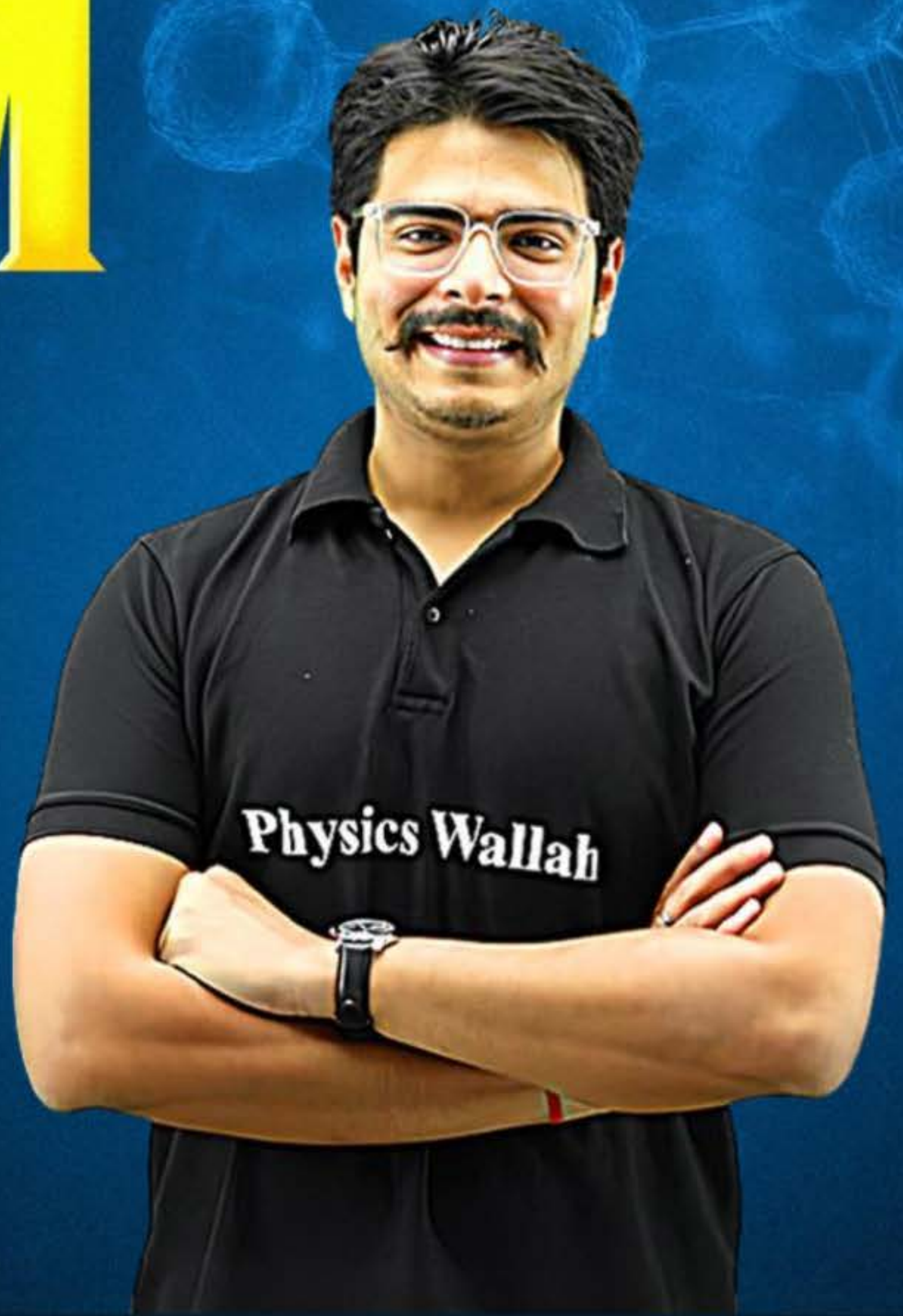
2026

Lecture - 06

Moving Charges and Magnetism

PHYSICS | **Lecture - 6**

BY - RAKSHAK SIR



Topics *to be covered*

- **A** Magnetic Dipole Moment (Majority Ch-5)
- **B** Torque on Current Carrying Loop ✓
- **C**
- **D**

Magnetic Dipole Moment

→ SI unit : $A m^2$

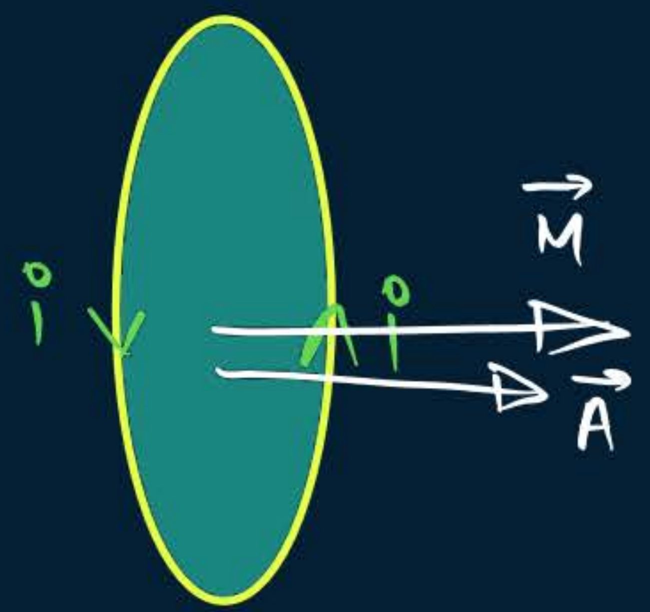
(Ampere-metre^2)

$$\boxed{\vec{M} = N i \vec{A}}$$

N — No. of turns

i — Current

$\vec{A}$ — Area Vector

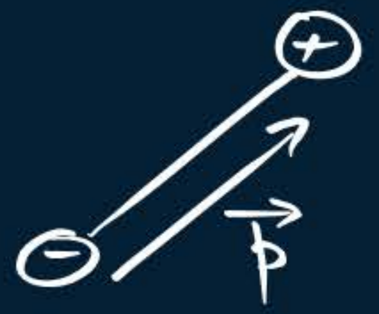


$|M| = NiA$

Direction of M is same as Area Vector

Y.K.B.

Ch-1



QUESTION

Find magnetic moment.

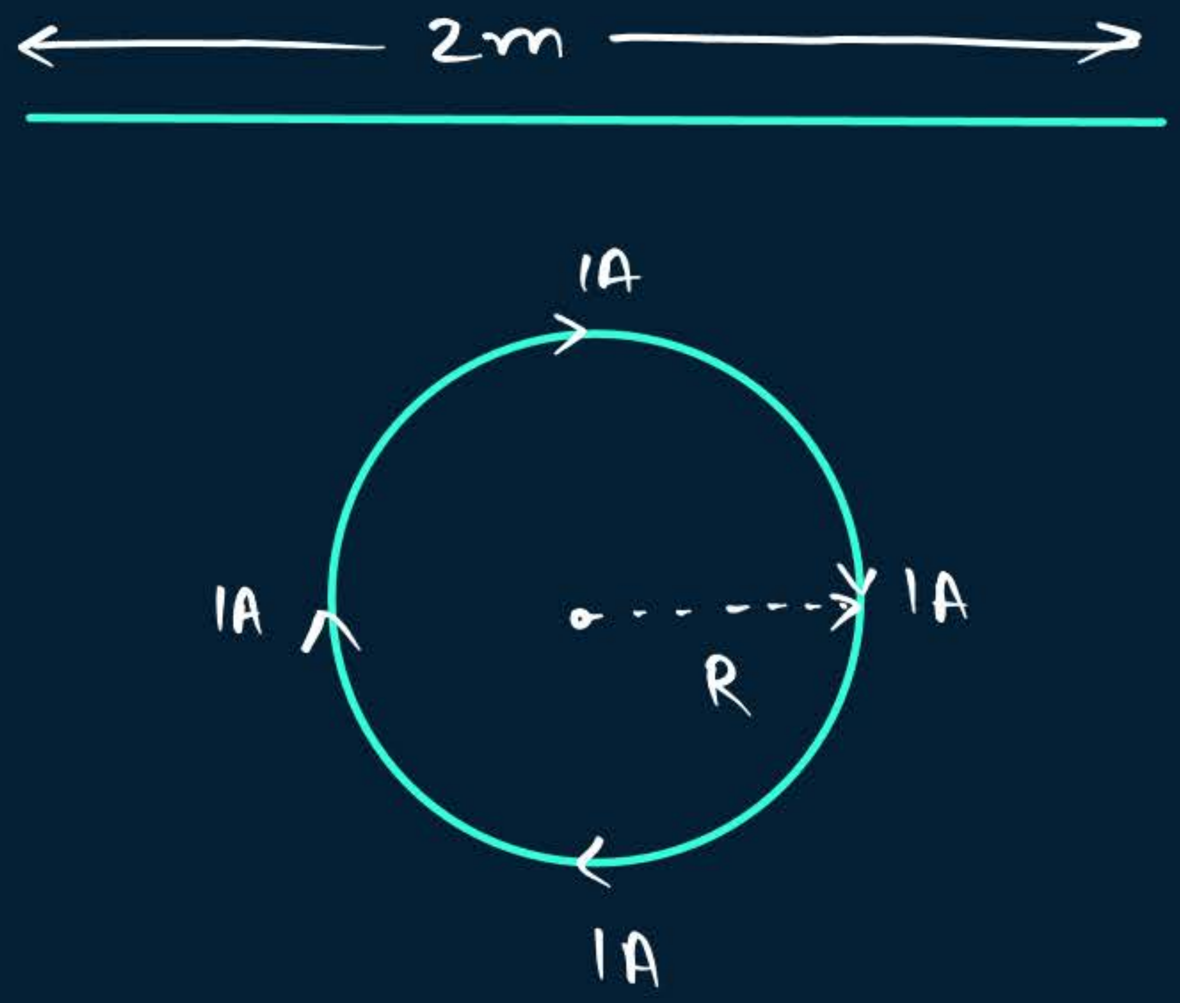
$$M = NiA$$

$$= 1 \times I \times \frac{\pi R^2}{2}$$

$$\boxed{M = \frac{\pi R^2 I}{2}}$$

QUESTION

A wire of length 2 m in bent in the form of a circular loop. When a current of 1 A is passed through a circular loop, then the magnetic moment of the loop is.



(A) π

(B) π^2

(C) $1/\pi$

(D) None

$$\boxed{l = 2\pi r}$$

$$2 = 2\pi r$$

$$r = \frac{\cancel{2}}{\cancel{2}\pi} = \frac{1}{\pi}$$

$$M = NiA$$

$$= 1\times 1\times \pi R^2$$

$$= \cancel{\pi}\times\frac{1}{\pi^{\cancel{2}}} = \frac{1}{\pi}$$

QUESTION

H.W.

If the planes of two identical concentric coils are perpendicular and the magnetic moment of each coil is M, then the resultant magnetic moment of the two coils will be

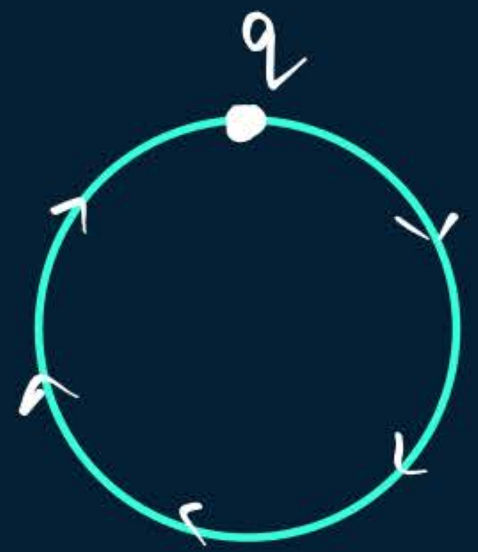
A. M

B. 2M

C. 3M

D. $\sqrt{2}$ M

Magnetic Moment of revolving charge



$S = \frac{D}{T}$

$V = \frac{2\pi R}{T}$

$T = \frac{2\pi R}{V}$

$M = NiA$

$M = \frac{q}{T} \times A$

$M = \frac{q}{\frac{2\pi R}{V}} \cdot A$

$M = \frac{qV}{2\cancel{\pi}\cancel{R}} \times \cancel{\pi} R^{\cancel{2}}$

$$\boxed{M = \frac{qVR}{2}}$$

if $V \rightarrow$ Not given

$V = R\omega$

linear vel ← V, ω → Angular vel

$M = q\frac{R\omega R}{2}$

$$\boxed{M = q\frac{\omega R^2}{2}}$$

Relation between magnetic moment and angular momentum

$$M = \frac{qvR}{2}$$

$$L = mvR$$

$$\frac{M}{L} = \frac{q\cancel{vR}/2}{m\cancel{vR}}$$

$$\boxed{\frac{M}{L} = \frac{q}{2m}}$$

$$\left.\frac{M}{L} = \frac{q}{2m}\right\}$$ independent of 'v' or 'r'

$$\frac{\vec{M}}{\vec{L}} = \frac{q}{2m}$$

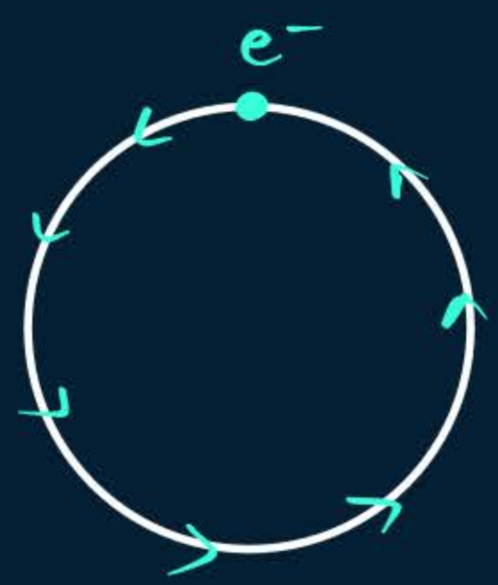
Y.K.B.

(Rotational)

$$L = mvr$$

$$L = \frac{nh}{2\pi}$$

Magnetic moment of revolving electron



$$\frac{\vec{M}}{\vec{L}} = \frac{q}{2m}$$

$$\boxed{\frac{\vec{M}}{\vec{L}} = -\frac{e}{2m}}$$

Vector form

$$\boxed{\frac{M}{L} = \frac{e}{2m} = 8.8 \times 10^{10}\ C/kg}$$

gyro- magnetic Ratio

only magnitude

$$\frac{M}{L} = \frac{e}{2m}$$

$$M = \frac{e}{2m} \times L$$

Acc. to Neils Bohr Saahab,

$$L = \frac{nh}{2\pi}$$ → Plank's constant

$$M = \frac{e}{2m} \frac{nh}{2\pi}$$

if $n = 1$, K-shell

$$\boxed{M = \frac{eh}{4\pi m}} = 9.27 \times 10^{-24} \ Am^2$$

"Bohr's magneton"

QUESTION

H.W.

$MeV = 10^6 eV$

$1 eV = 1.6 \times 10^{-19} J$

A proton and an alpha particle both enter a region of uniform magnetic field B, moving at right angles to the field B. If the radius of circular orbits for both the particles is equal and the kinetic energy acquired by proton is $\boxed{1 \text{ MeV}}$ the energy acquired by alpha particle will be: **(2015)**

(A) 1 MeV

(B) 4 MeV

(C) 0.5 MeV

(D) 1.5 MeV

$r_\alpha = r_p$

$r = \frac{\sqrt{2mK}}{qB}$

$q_\alpha = 2q_p$

$\frac{\sqrt{2m_\alpha K_\alpha}}{q_\alpha B} = \frac{\sqrt{2m_p K_p}}{q_p B}$

$m_\alpha = 4m_p$

$\frac{\sqrt{\cancel{2}\, 4\cancel{m_p} K_\alpha}}{2\cancel{q_p}\cancel{B}} = \frac{\sqrt{\cancel{2}\cancel{m_p} K_p}}{\cancel{q_p}\cancel{B}}$

$\alpha \rightarrow {}^4_2He^{2+} - 4u$

$\beta \rightarrow e^+ - 1u$

$K_\alpha = K_p = 1 MeV$

$\frac{\sqrt{4K_\alpha}}{2} = \sqrt{K_p} \longrightarrow \frac{\cancel{4}K_\alpha}{\cancel{4}} = K_p$

QUESTION

H.W.

Statement-I: An e^- moving parallel to the direction of current in a long straight current carrying wire is deflected away from the wire. T

Statement-II: e^- is repelled by electrostatic repulsion. F

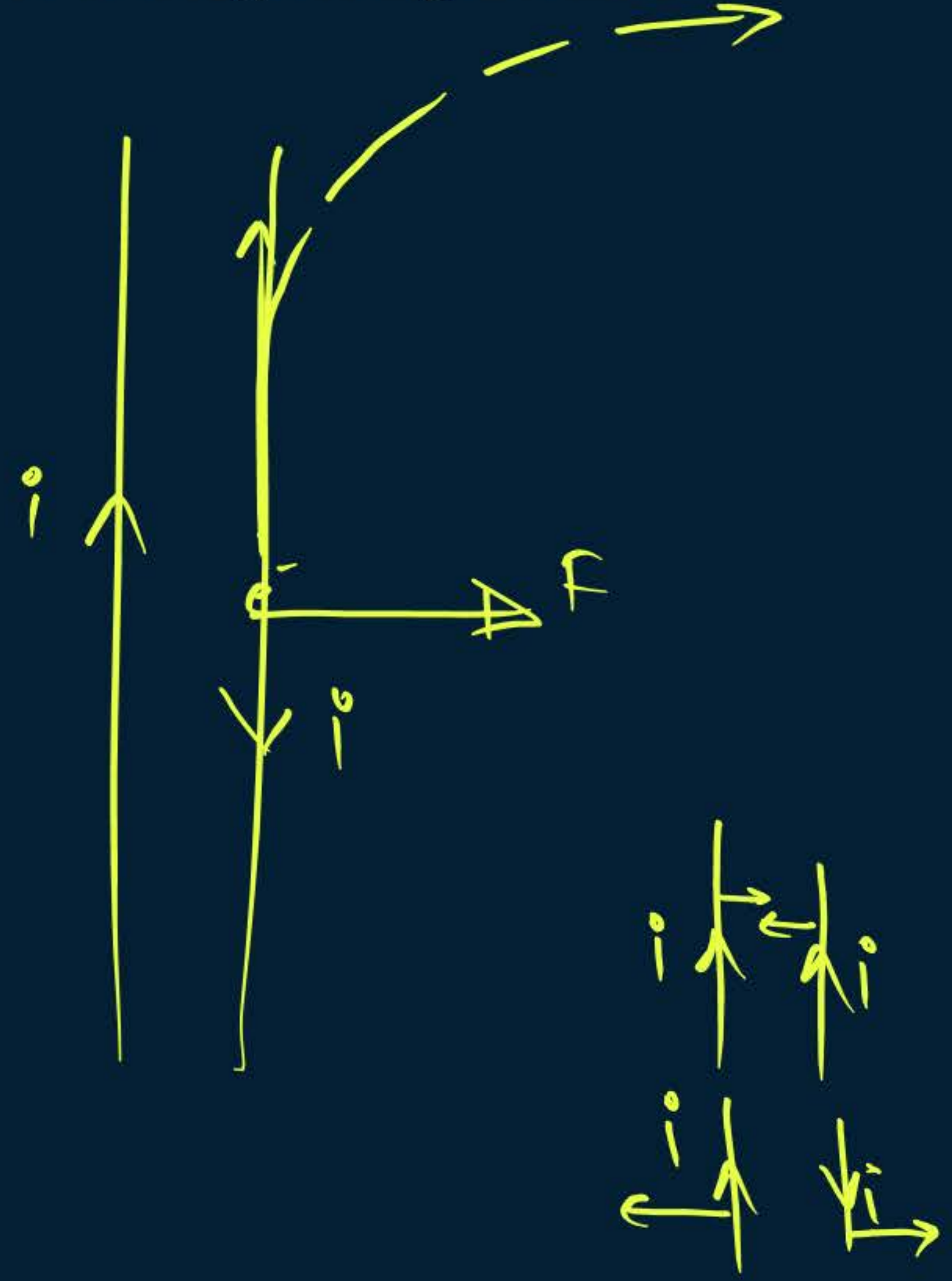
magnetic Force

A Both statement I and II are correct

B Both statement I and II are incorrect

C Statement I is correct and statement II is incorrect

D Statement I is incorrect and statement II is correct



QUESTION

H.W.

Statement-I: A charge moving along the axis of a current carrying coil will suffer no deflection in its path. T

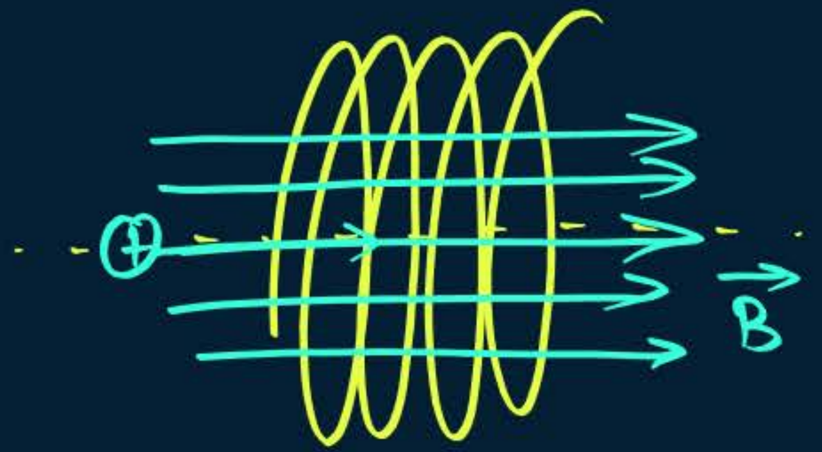
Statement-II: Magnetic force on a charged particle moving parallel to magnetic field is zero. T

(A) Both statement I and II are correct

(B) Both statement I and II are incorrect

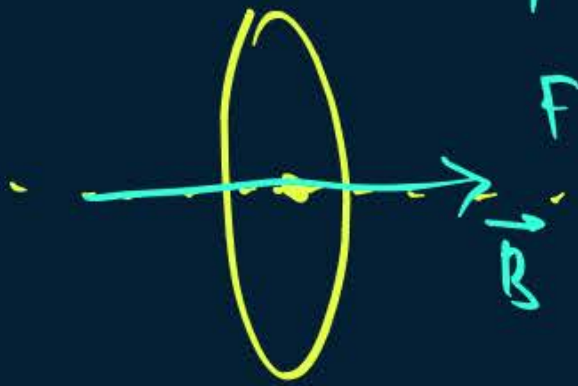
(C) Statement I is correct and statement II is incorrect

(D) Statement I is incorrect and statement II is correct



$F = qvB\sin 0^\circ$

$F = 0$



QUESTION

H.W.

Seedha Pass

Assertion (A): If an electron is not deflected while passing through a certain region of space, then only possibility is that there is no magnetic region. F

Reason (R): Force is directly proportional to the magnetic field applied.

T

$F \propto B$

A If both assertion and reason are true and reason is the correct explanation of the assertion.

B If both assertion and reason are true but reason is not correct explanation of the assertion.

C If assertion is true, but reason is false.

D Assertion is false, reason is true

QUESTION

A straight wire of length 0.5 metre and carrying a current of 1.2 ampere is placed in uniform magnetic field of induction 2 tesla. The magnetic field is perpendicular to the length of the wire. The force on the wire is (1992)

(A) 2.4 N

(B) 1.2 N

(C) 3.0 N

(D) 2.0 N

$F = BIL\sin\theta$

$F = \cancel{2} \times 1.2 \times \frac{1}{\cancel{2}} \times \sin 90$

$= 1.2N$

QUESTION Mashoor

A straight wire of mass 400 g and length 2 m carries a current of 2A. If is suspended in mid air by a uniform horizontal field B. What is the magnitude of the magnetic field?

$$F_B = F_G$$

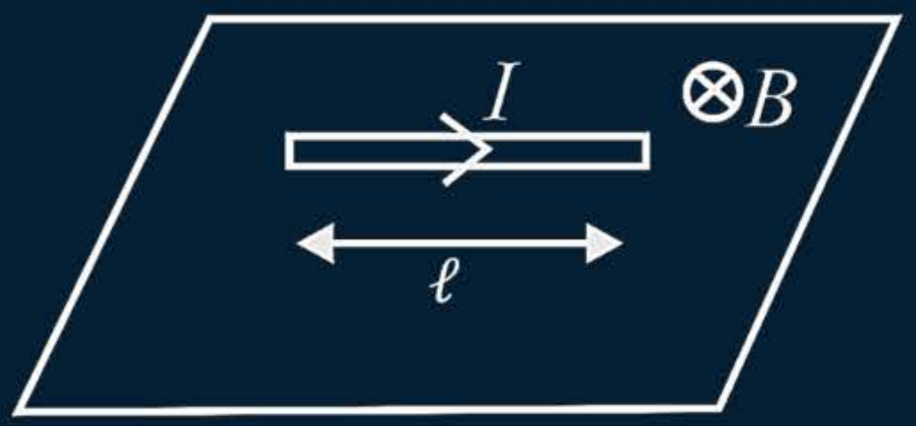
$$BIL\sin\theta = mg$$

$$B \times \cancel{2} \times \cancel{2} \times \sin 90 = \frac{\overset{2}{\cancel{400}}}{1\cancel{000}} \times 1\cancel{0}$$

$$B = 2T$$

$F_B = BIL\sin\theta$

$F_G = mg$



QUESTION

A uniform conducting wire ABC has a mass of 10 g. A current of 2A flows through it. The wire is kept in a uniform magnetic field B = 2T. The acceleration of the wire will be

A Zero

B 12 ms^{-2}

C 1.2×10^{-3} ms^{-2}

D 0.6×10^{-3} ms^{-2}

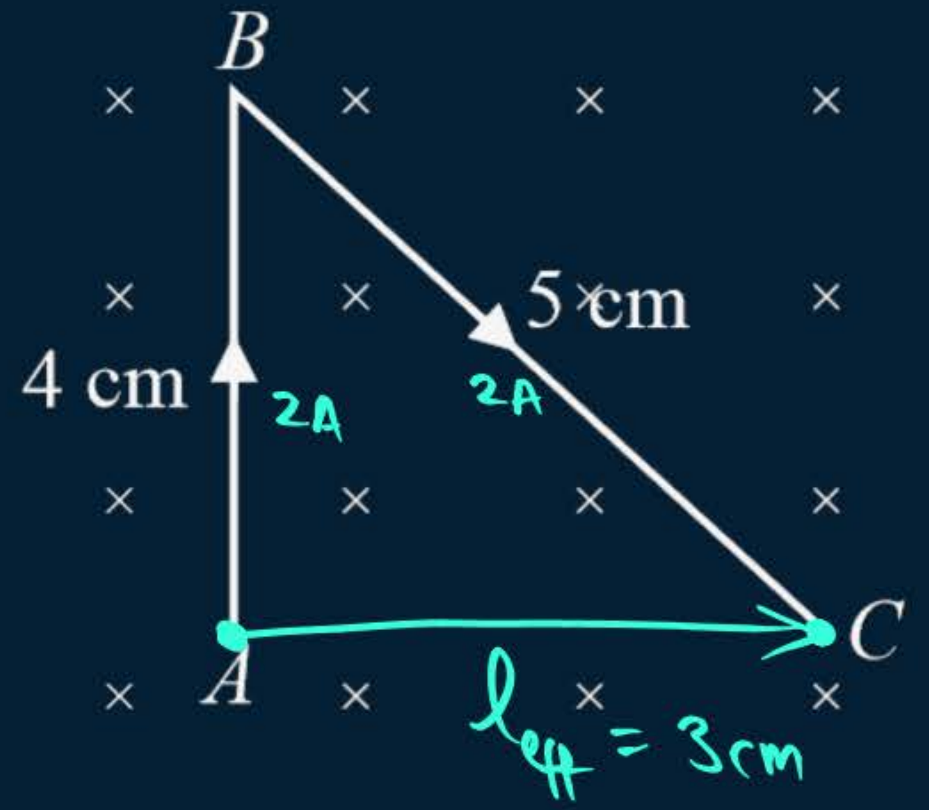
Vector length

$$F = BIL\sin\theta$$

$$ma = 2 \times 2 \times \frac{3}{100} \times \sin 90^\circ$$

$$a = \frac{2 \times 2 \times \frac{3}{1\cancel{00}}}{\frac{1\cancel{0}}{1\cancel{000}}} \times 1$$

$$a = 12\ m/s^2$$

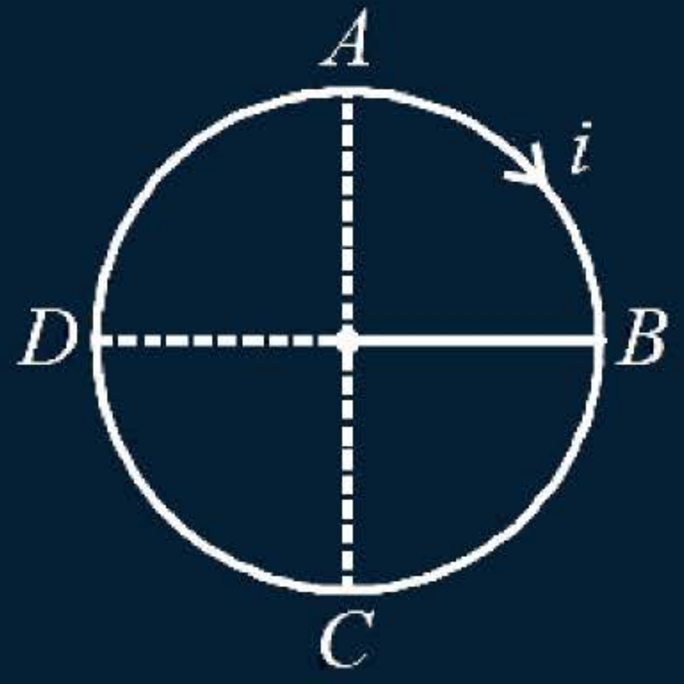


QUESTION

H.W.

A circular coil ABCD carrying a current 'i' is placed in a uniform magnetic field. If the magnetic force on the segment. AB is $\vec{F}$, the force on the remaining segment BCDA is

[Karnataka NEET 2013]



A $-\vec{F}$

B $3\vec{F}$

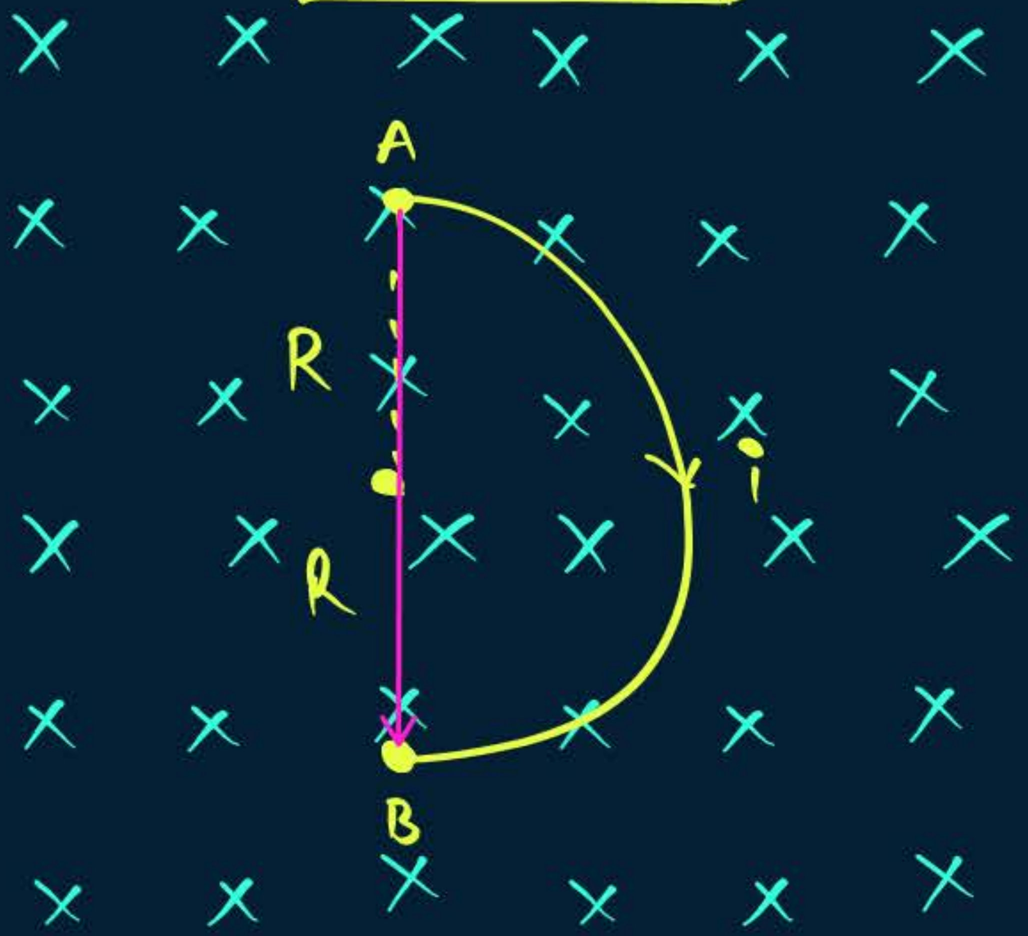
C $-3\vec{F}$

D $\vec{F}$

$F = BIL\sin\theta$

$= Bi2R\sin 90°$

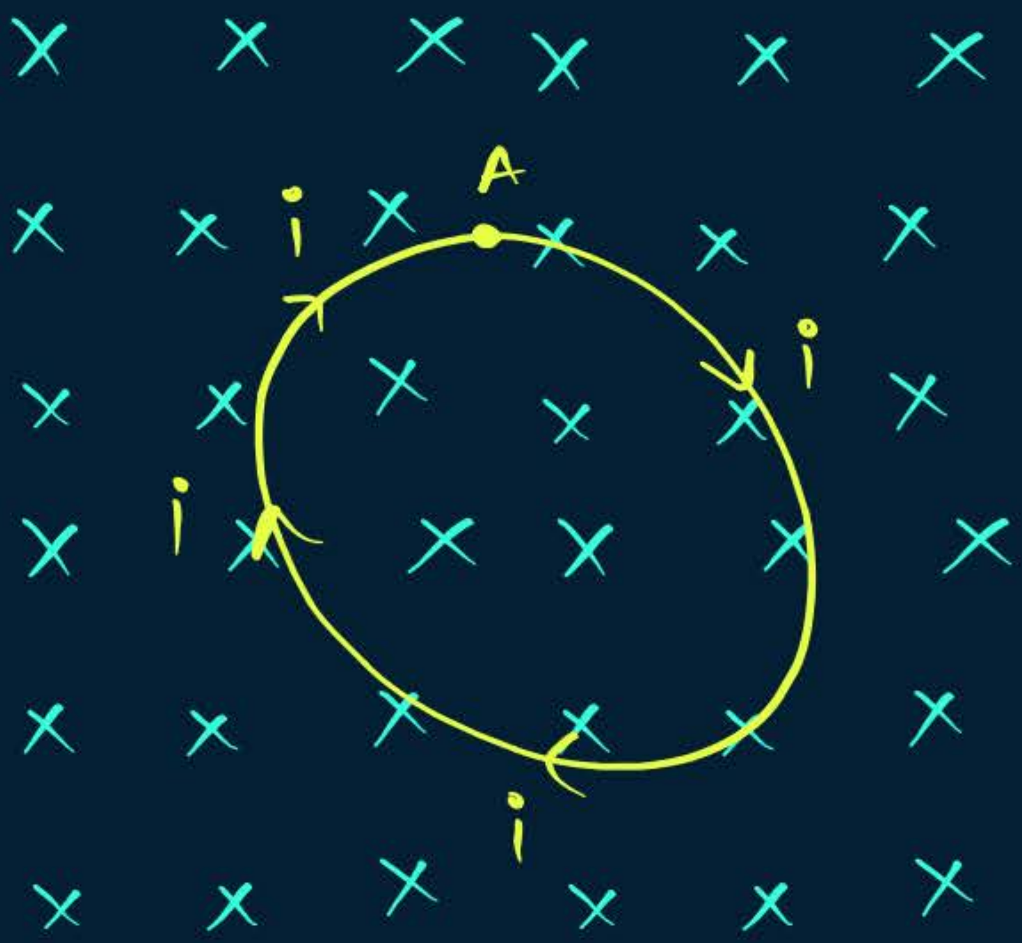
$\boxed{F = 2RBi}$



$F = BIL\sin\theta$

$F = Bi(0) = 0$

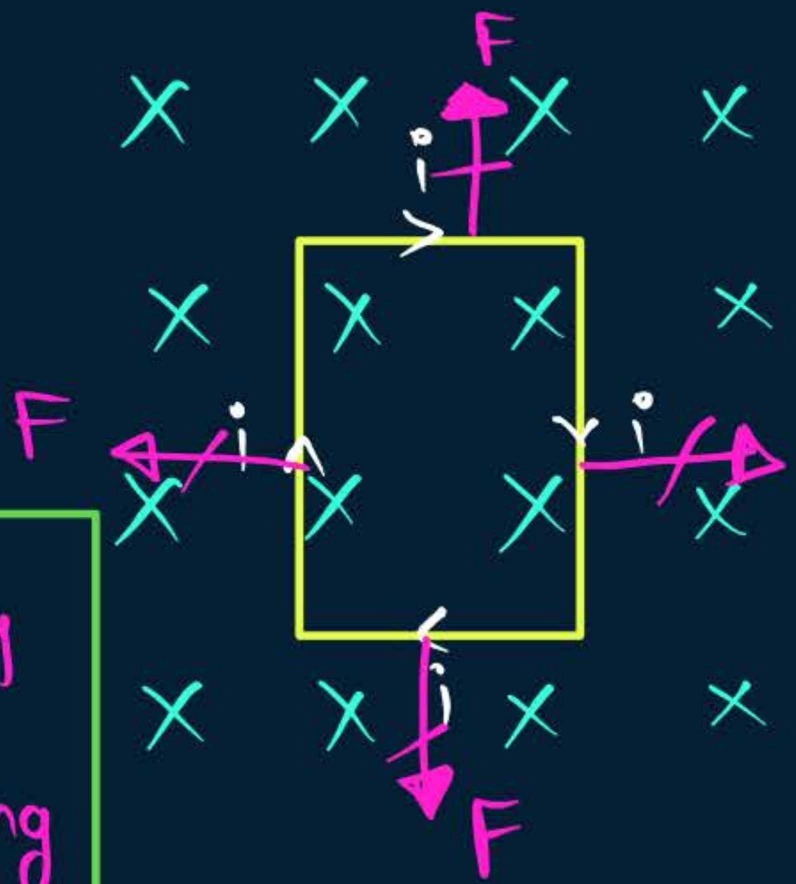
$\boxed{F_{net} = 0}$



$F = BIL\sin\theta \leftarrow \vec{F} = i(\vec{l} \times \vec{B})$

$\boxed{F_{net} = 0}$

RDx Feel



For any shape of loop having $i \perp B$

$F_{net} = 0$

→ $F_{net} = 0$

→ due to individual forces,

Shape changes to circle

QUESTION V. imp.

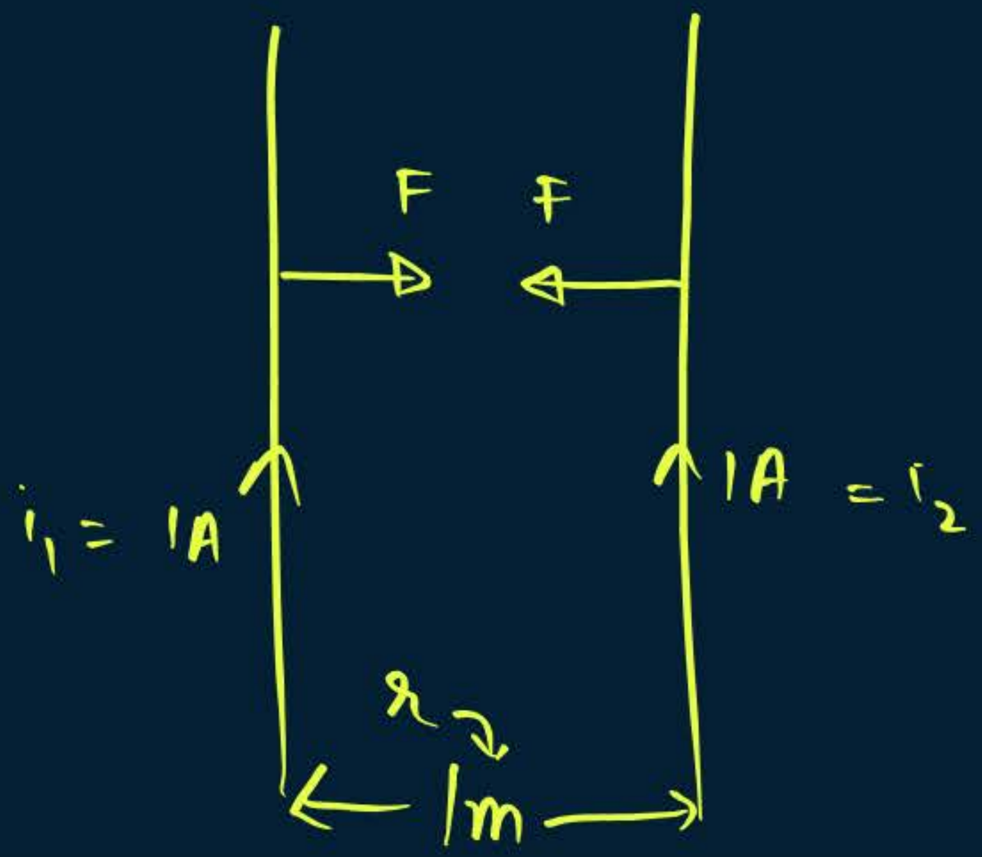
Two long parallel wires are at a distance of 1 metre. Both of them carry one ampere of current. The force of attraction per unit length between the two wires is (1998)

(A) 5×10^{-8} N/m

(B) 2×10^{-8} N/m

(C) 2×10^{-7} N/m

(D) 10^{-7} N/m



$$\boxed{\frac{F}{l} = \frac{\mu_0 i_1 i_2}{2\pi r}}$$

$$= \frac{\cancel{4}^{2}\cancel{\pi} \times 10^{-7} \times 1 \times 1}{\cancel{2}_{1}\cancel{\pi} \times 1}$$

$$\frac{F}{l} = 2 \times 10^{-7} \text{ N/m}$$

* Define 1A : The current of 1A in two parallel wires separated by 1m distance have the value of Force per unit length as 2×10^{-7} N/m.

Homework

- Notes
- Revision
- V. imp. Ques in notes
- Retry All Ques
- DPP Try

PARISHRAM

2026

Lecture - 07

Moving Charges and Magnetism

PHYSICS Lecture - 7

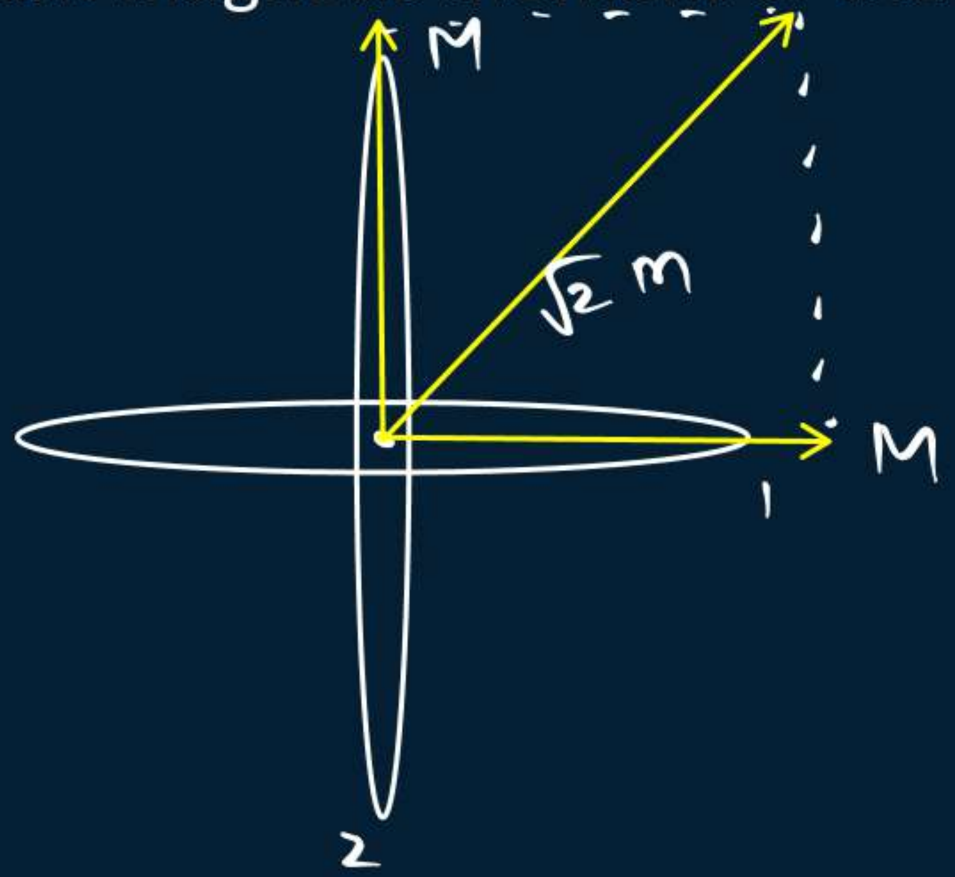
BY - RAKSHAK SIR

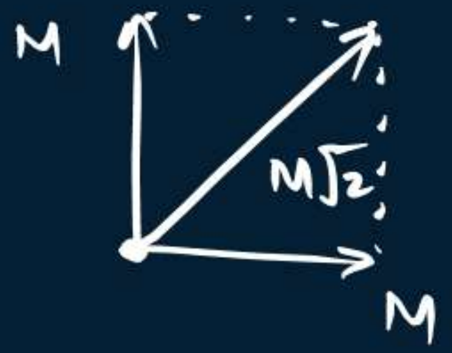
Topics *to be covered*

- **A**
- **B** Torque on Current Carrying Loop ✓
- **C** Moving Coil Galvanometer (MCG) ✓
- **D** **Conversion of Galvanometer**

QUESTION H.W.

If the planes of two identical concentric coils are perpendicular and the magnetic moment of each coil is M, then the resultant magnetic moment of the two coils will be





(A) M

(B) 2M

(C) 3M

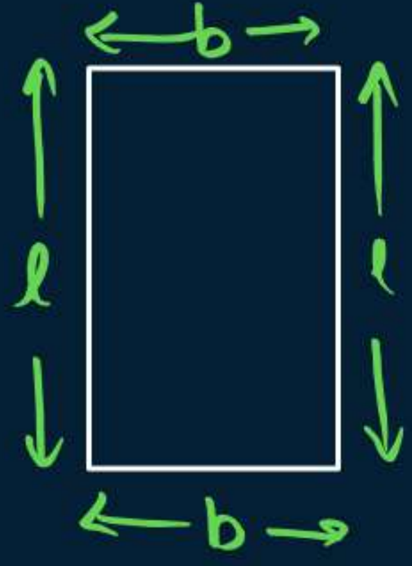
(D) $\sqrt{2}$ M

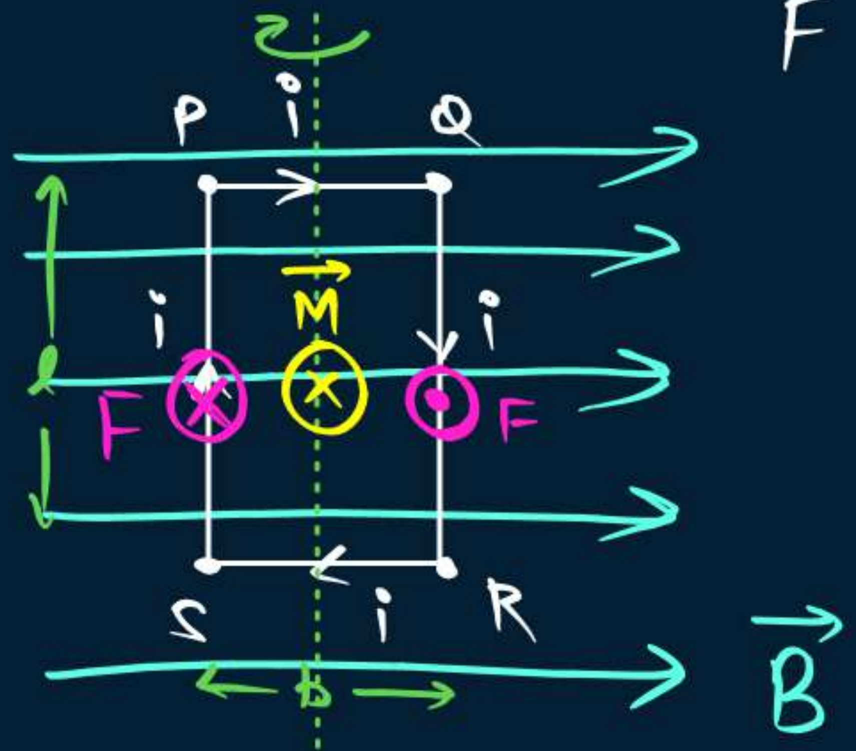
Torque on a current carrying coil in magnetic field

$F_{PQ} = 0$

$\vec{F} = i(\vec{l} \times \vec{B})$

$F = BIL\sin\theta$





$F_{RS} = 0$

$$\boxed{\vec{\tau} = \vec{M} \times \vec{B}}$$

$\tau = MB\sin\alpha$

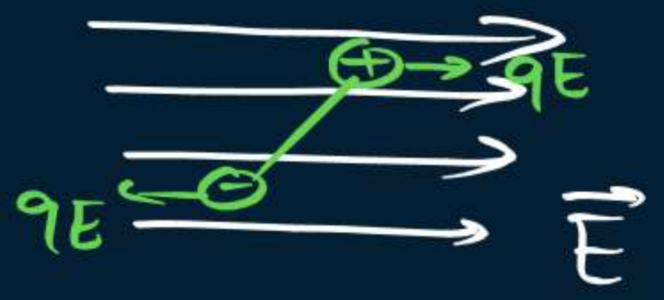
$= NiAB\sin\alpha$

$= BiNA\sin\alpha$

$\tau_{max} = BiNA \quad (\alpha = 90^\circ)$

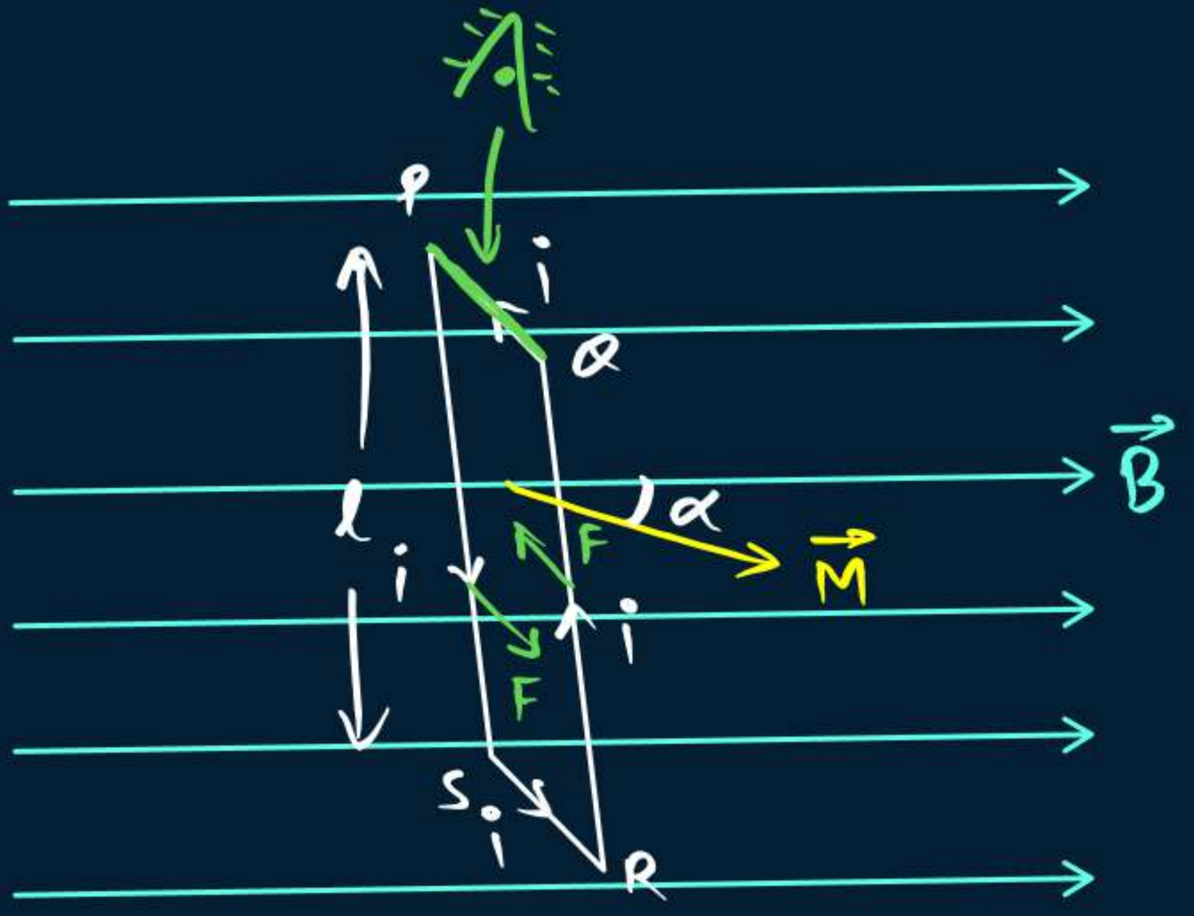
Y.K.B.

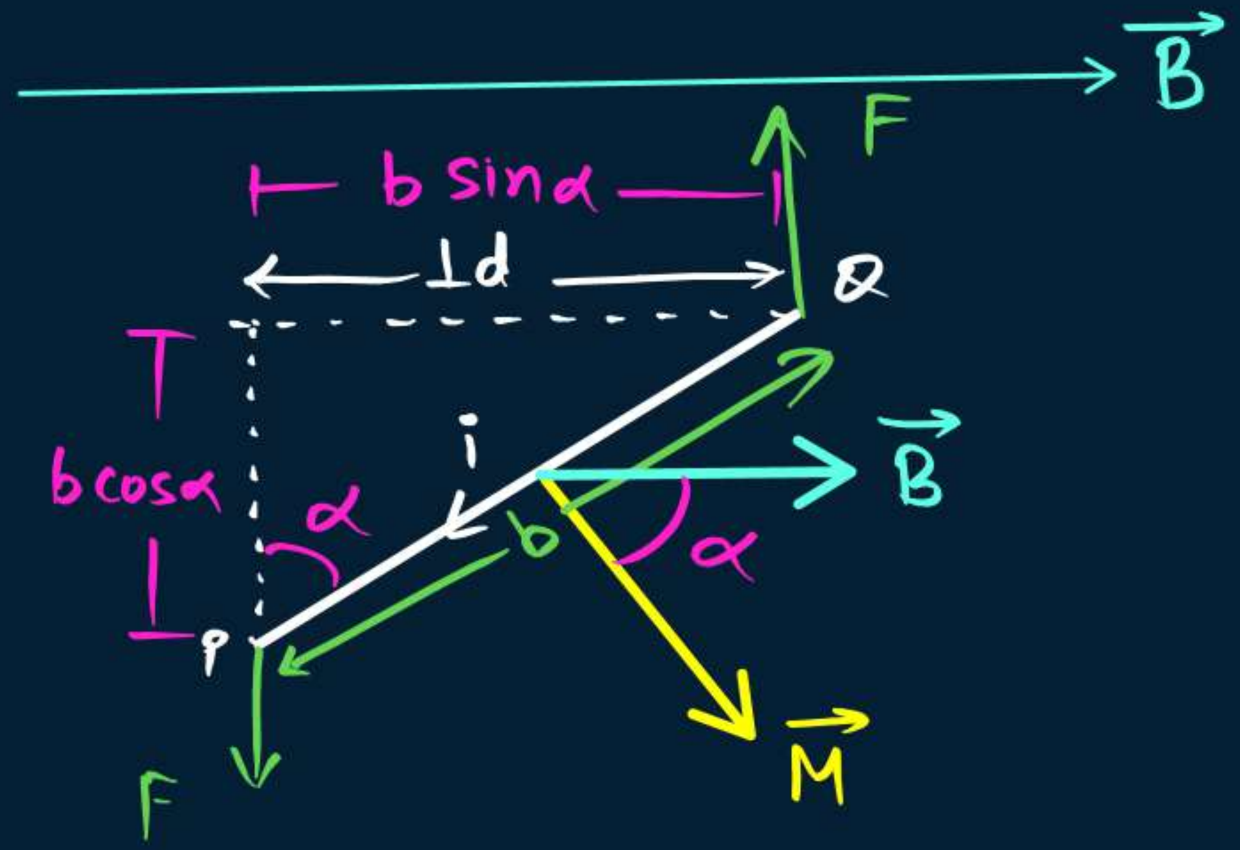
Analogy from ch-1



$\vec{\tau} = \vec{p} \times \vec{E}$

$\tau = pE\sin\theta$





$\vec{\tau} = \vec{r} \times \vec{F}$

$\tau = F . \perp d$

$= F\, b \sin\alpha$

$= BIL\sin\theta . b\sin\alpha$

$= Bil \sin 90 . b\sin\alpha$

$= Bi(lb) \sin\alpha$

for N- Turns

$\tau = NBiA\sin\alpha$

$\boxed{\tau = BiNA\sin\alpha}$

$\tau = MB\sin\alpha$

$\boxed{\vec{\tau} = \vec{M} \times \vec{B}}$

QUESTION

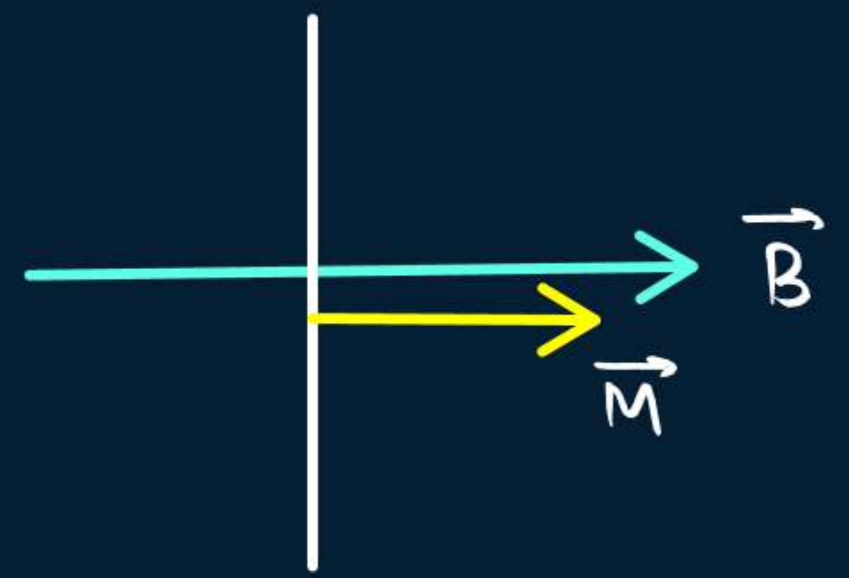
A circular loop of area 0.01 m^2 carrying a current of 10 A, is held perpendicular to a magnetic field of intensity 0.1 T. The torque acting on the loop is [1994]

(A) 0.001 N m

(B) 0.8 N m

(C) zero

(D) 0.01 N m.



$\alpha = 0°$

$\tau = MB\sin\alpha$

$\tau = 0$

Moving Coil Galvanometer (MCG)

It is used to measure small currents.

Principle: The current carrying coil placed in uniform magnetic field experiences a torque.

Moving Coil Galvanometer (MCG)

Principle: A current carrying coil placed in a magnetic field experiences a current dependent torque, which tends to rotate the coil and produces angular deflection.

- Device for detection and measurement of small currents.

$$\alpha = \frac{NBA}{K}I$$

K = Torsion constant (spring constant)

α = angular deflection

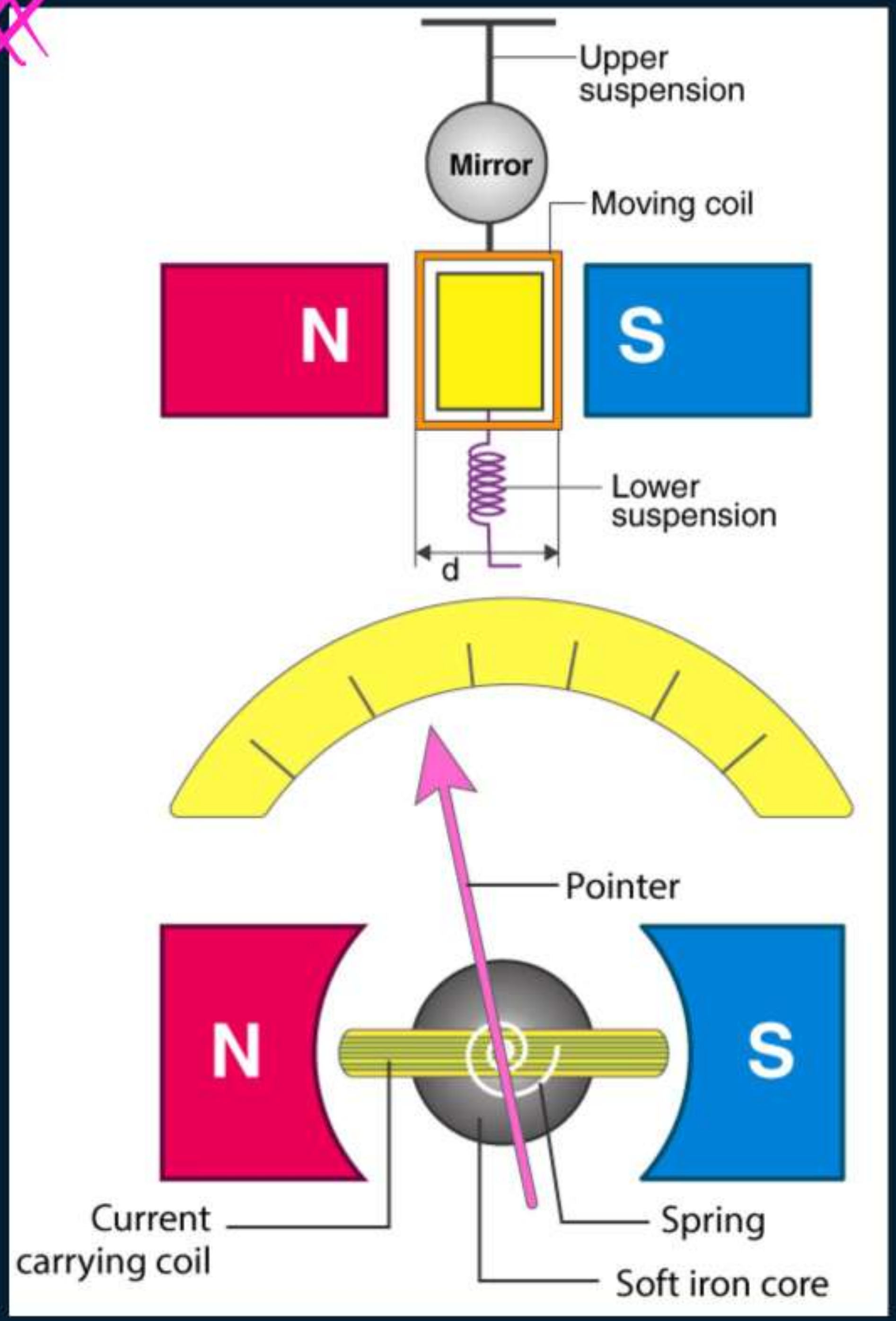
$\vec{\tau} = \vec{M} \times \vec{B}$

$\tau = MB\sin\alpha$

$\alpha = 90^\circ$

$\tau_{max} = MB$

$\boxed{\tau_{Def} = BiNA}$



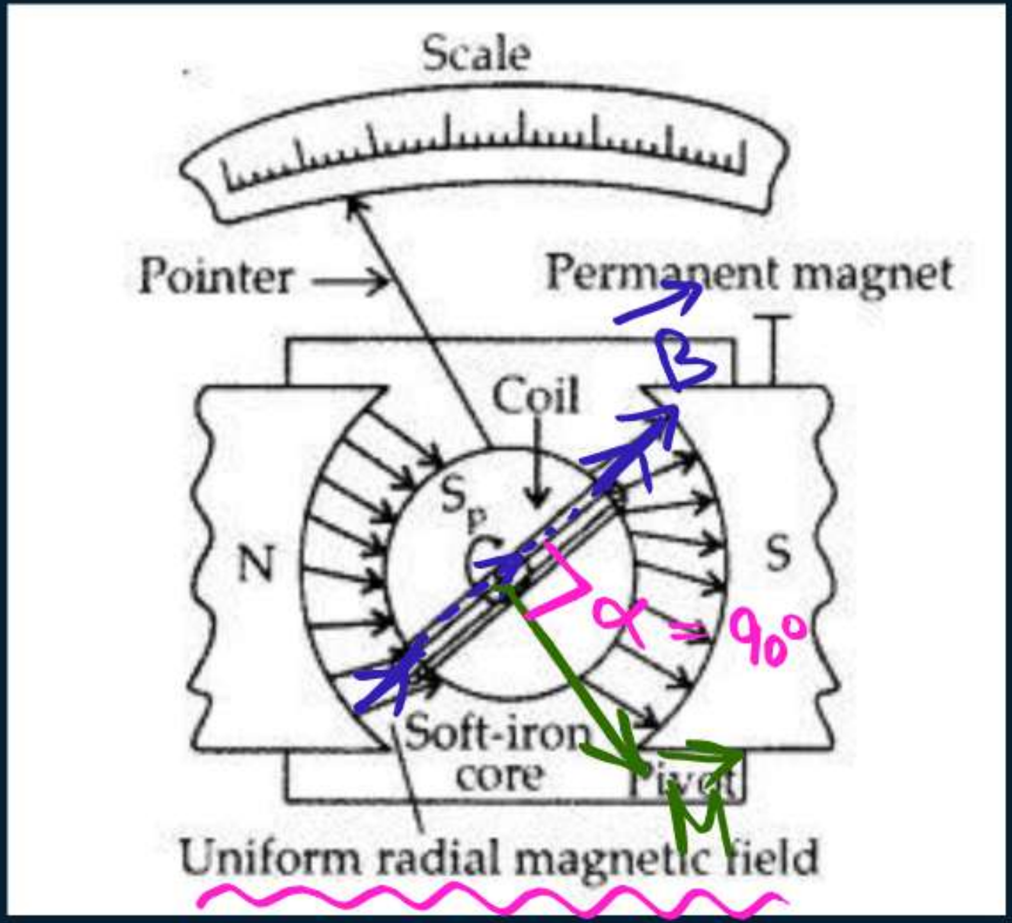
Construction (MCG)

As shown in figure, a moving coil galvanometer consists of a rectangular coil of fine insulated copper wire wound on a light non-magnetic metallic (aluminium) frame.

The two ends of the axle of this frame are pivoted between two bearings. The motion of the coil is controlled by a pair of hair springs of phosphor-bronze.

The inner ends of the springs are soldered to the two ends of the coil and the outer ends are connected to the binding screws. The springs provide the restoring torque and serve and current leads.

A light aluminium pointer attached to the coil measures its deflection on a suitable scale.



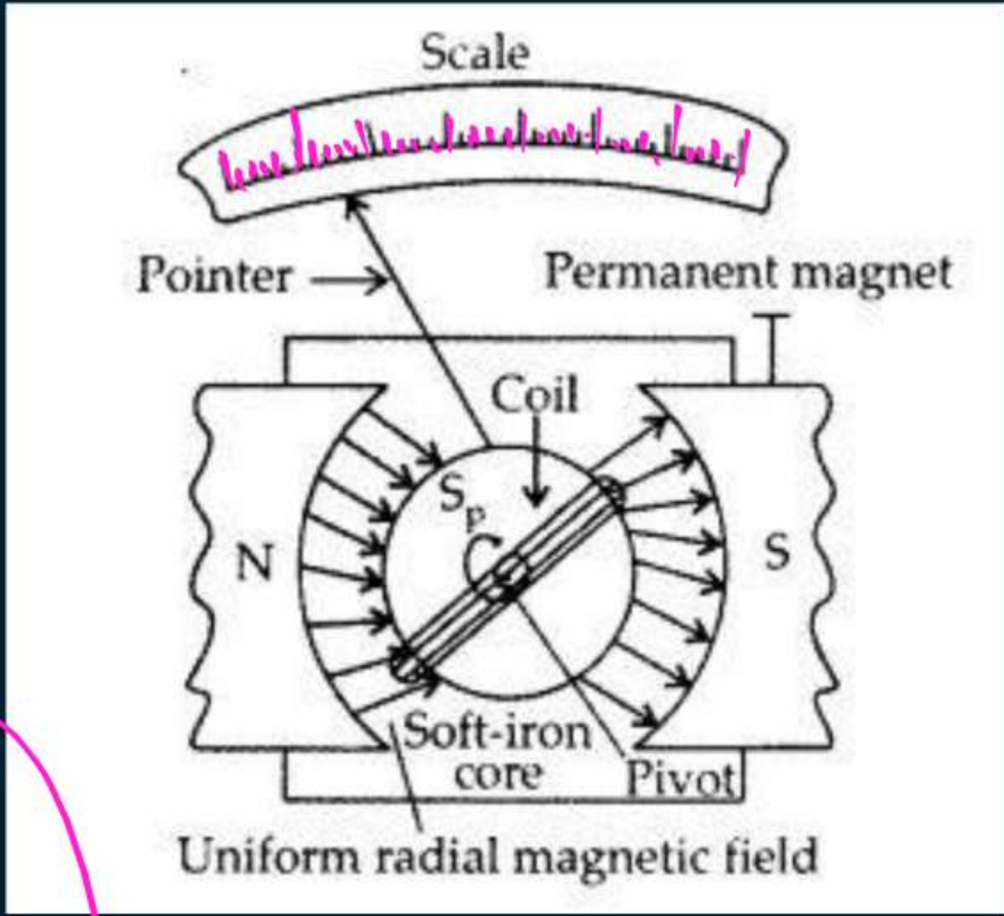
Construction (MCG)

The coil is symmetrically placed between the cylindrical pole pieces of a strong permanent horseshoe magnet.

A cylindrical soft iron core is mounted symmetrically between the concave poles of the horse-shoe magnet. This makes the lines of force pointing along he radii of a circle. Such a field is called a radial field. The plane of a coil rotating in such a field remains parallel to the field in all positions, as shown in fig.

Also, the soft iron cylinder, due to its high permeability, intensifies the magnetic field and hence increases the sensitivity of the galvanometer.

Note: There is a cylindrical soft iron core which not only makes the field radial but also increases the strength of the magnetic field.



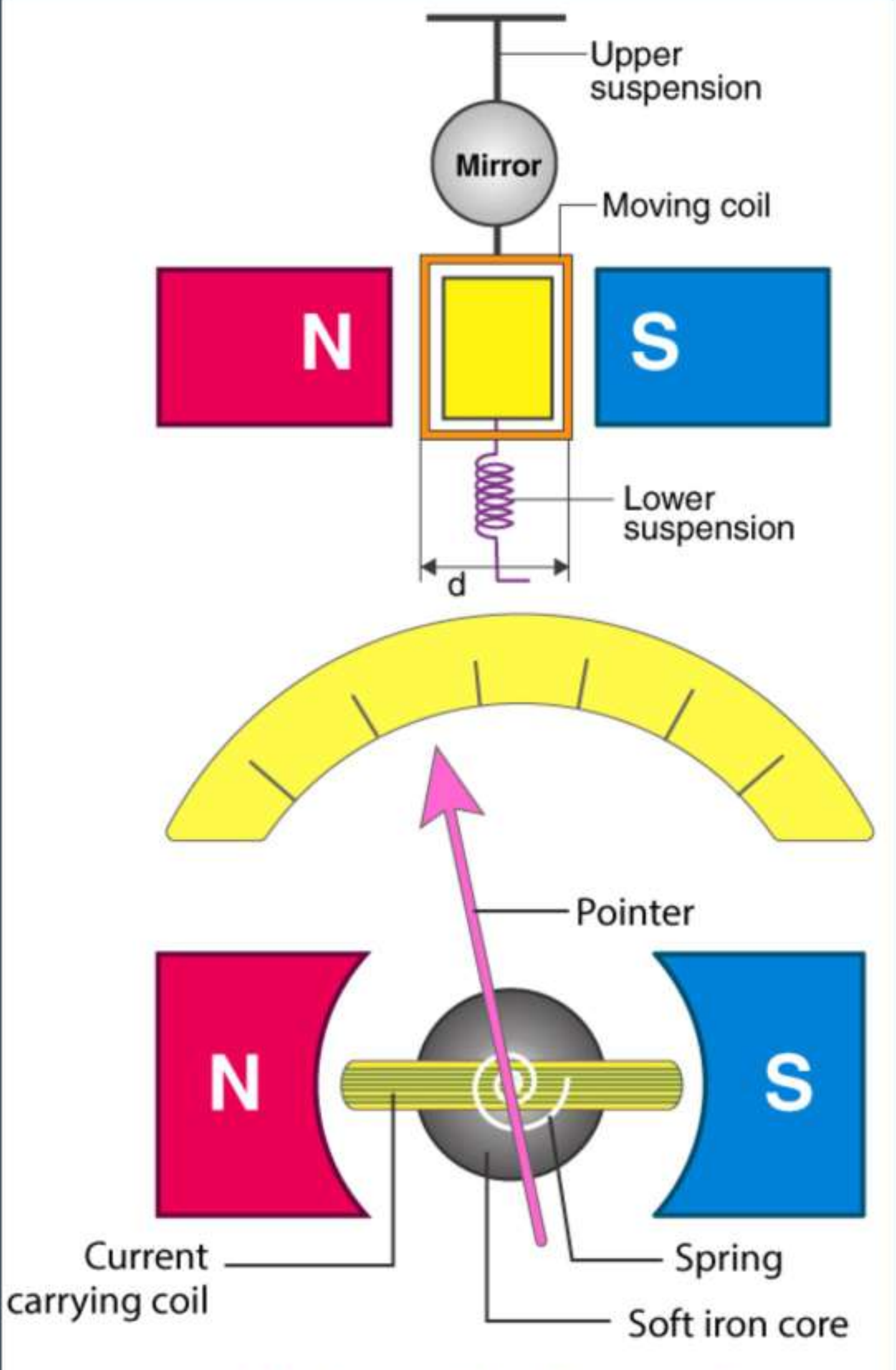
Allow M.F.

WHY?

- **Why aluminium frame (Dead beat):** It provides electro-magnetic damping being a conductor eddy currents generated and does not interact with external magnetic field.

Alloy

- **Why hair springs of phosphor-bronze:** It has small restoring torque per unit twist and high tensile strength.

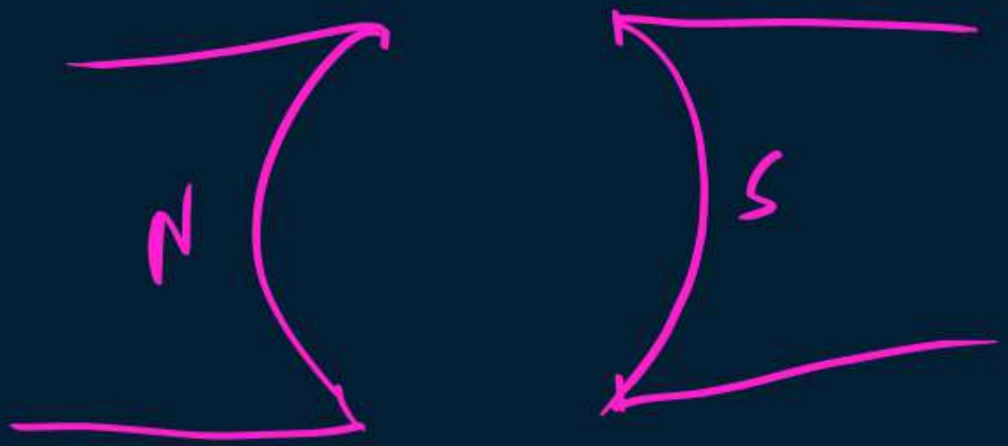


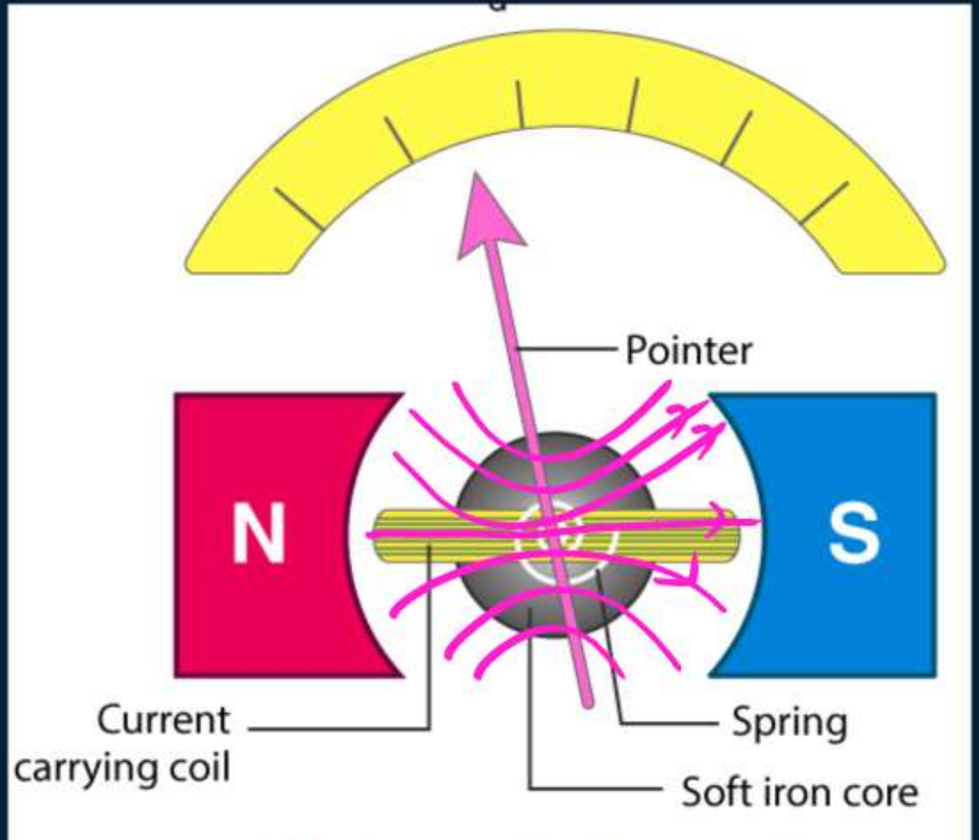
Moving coil galvanometer

WHY?

- **Why radial field in Galvanometer?**
  Because we need max torque and torque is uniform in all positions of MCG.

- **How to make radial field in MCG:** Poles of the magnet cut cylindrical (concave poles) by using soft iron core.



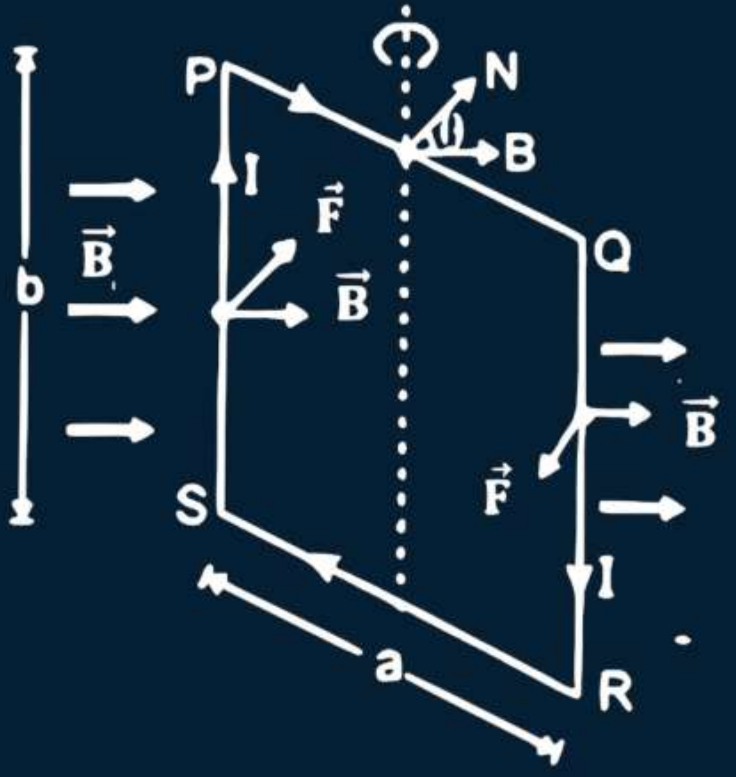


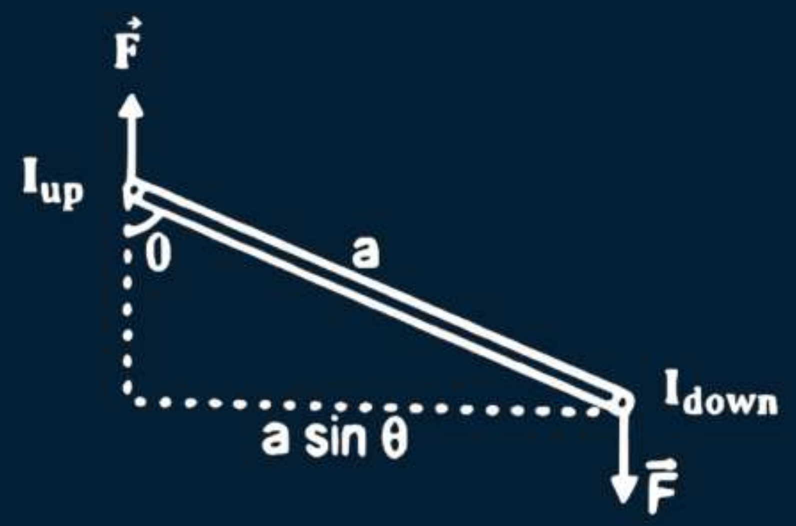
Moving coil galvanometer

Working of MCG

Since the field is radial, the plane of the coil always remains parallel to the field B.
The magnetic forces on sides PQ and SR are equal, opposite and collinear, so their resultant is zero.

According to Fleming's left rule, the side PS experiences a normal inward force equal to NlbB while the side QR experience an equal normal outward force. The two forces on side PS and QR are equal and opposite. They form a couple and exert a torque.





$$\tau = NIBA \sin 90^\circ = NIBA$$

$$\vec{\tau} = \vec{M} \times \vec{B}$$

$$\tau = MB \sin\alpha$$

where $\alpha = 90^\circ$

$$\tau_{max} = MB$$

$$\boxed{\tau_{Def} = BiNA}$$

There is a spring which generates restoring Torque

$$\tau_{res} \propto \theta$$

$$\boxed{\tau_{res} = K\theta}$$

K ↓ Torsional Constant (Material dependent)

At equilibrium,

$$\tau_{def} = \tau_{res}$$

$$BiNA = K\theta$$

$$\frac{BNA}{K} = \frac{\theta}{i}$$

Y.K.B.

Class XI

$$F_s \propto -x$$

$$F_s = -Kx$$

K ↓ Spring Constant

* Current Sensitivity (i_s)

$$i_s = \boxed{\frac{\theta}{i} = \frac{NBA}{K}}$$

$$i_s = \frac{\theta}{i}$$

$$\boxed{i_s = \frac{NBA}{K}}$$

$i_s \uparrow \propto N \uparrow$

$\propto B \uparrow$

$\propto A \uparrow$

$\propto \frac{1}{K \downarrow}$

* Voltage Sensitivity (V_s)

$$V_s = \frac{\theta}{V} = \frac{\theta}{iR}$$

$$= \left(\frac{\theta}{i}\right)_R = \frac{i_s}{R}$$

$$\boxed{V_s = \frac{i_s}{R}}$$

$$\boxed{V_s = \frac{NBA}{KR}}$$

$V_s \propto N \uparrow$

$\propto B \uparrow$

$\propto A \uparrow$

$\propto K \downarrow$

$\propto R \downarrow$

Figure of Merit OR Galvanometer Constant (G)

$$\boxed{G = \frac{1}{i_s} = \frac{K}{NBA}}$$

Factors by which the sensitivity of a moving coil galvanometer can be increased

1. By increasing the number of turns N of the coil. But the value of N cannot be increased beyond a certain limit because that will make the galvanometer bulky and increase its resistance R.
2. By increasing the magnetic field B. This can be done by using a strong horse-shoe magnet and placing a soft iron core within the coil.
3. By increasing the area A of the coil. However, increasing A beyond a certain limit will make the galvanometer bulky and unmanageable.
4. By decreasing the value of torsion constant k. The torsion constant k is made small by using suspension wire and springs of phosphor bronze.

Current Sensitivity: $I_S = \frac{\alpha}{I} = \frac{NBA}{K}$

Voltage Sensitivity: $V_S = \frac{\alpha}{V} = \frac{\alpha}{IR} = \frac{NBA}{KR}$

Advantage of a moving coil galvanometer

$i \propto \theta$

1. As the deflection of the coil is proportional to the current passed through it, so a linear scale can be used to measure the deflection.
2. A moving coil galvanometer can be made highly sensitive by increasing N, B, A and decreasing k.
3. As the coil is placed in a strong magnetic field of a powerful magnet, its deflection is not affected by external magnetic fields. This enables us to use the galvanometer in any position.
4. As the coil is wound over a metallic frame, the eddy currents produced in the frame bring the coil to rest quickly.

$$\alpha \propto I$$

Disadvantages of a moving coil galvanometer

1. The man disadvantage is that its sensitiveness cannot be changed at will.
2. All types of moving coil galvanometers are easily damaged by overloading. A current greater than that which the instrument is intended to measure will burn out its hair-springs or suspension.

$$I_S = \frac{NBA}{K}$$

$$V_S = \frac{NBA}{KR}$$

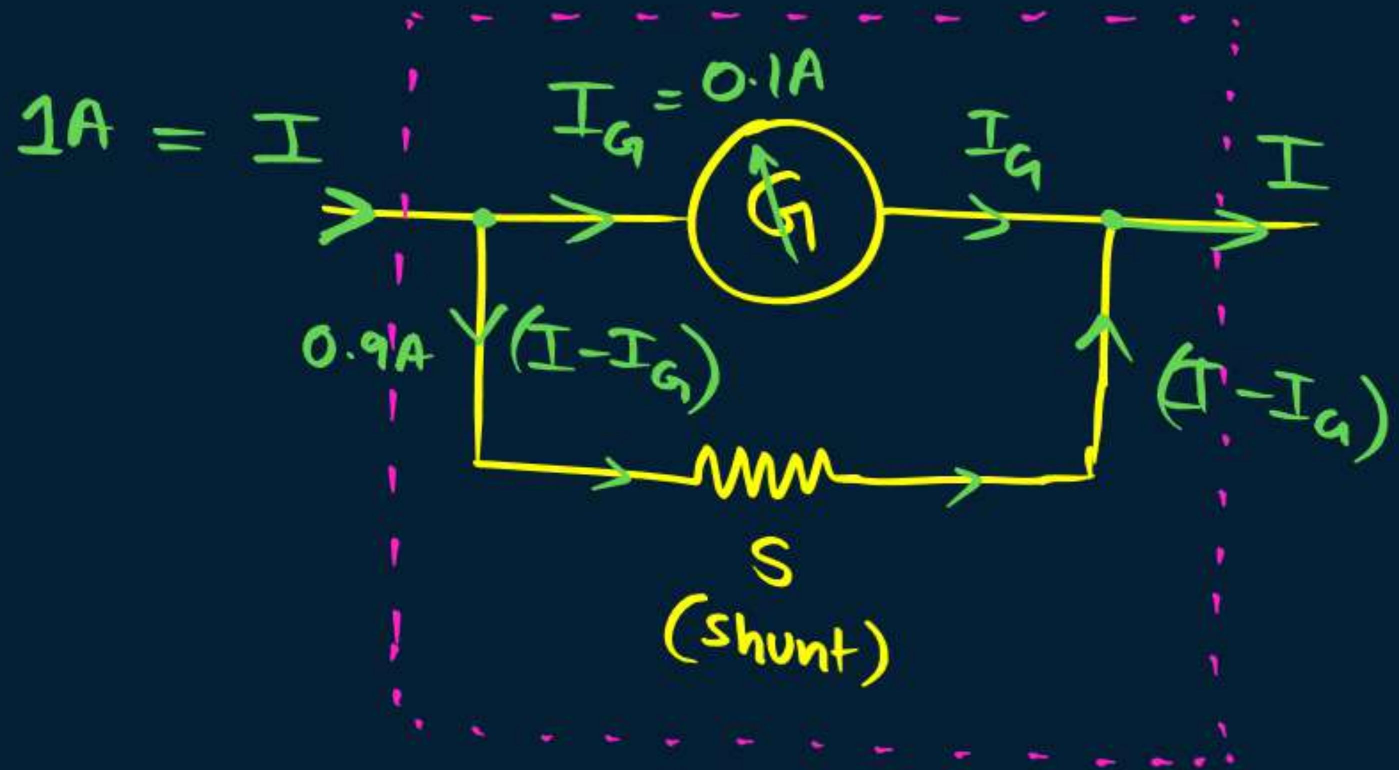
* Conversion of G → A

As both shunt and G are in Parallel, Voltage remains same

$$V_S = V_G$$

$$(I - I_G) S = I_G R_G$$

$$\boxed{S = \frac{I_G R_G}{I - I_G}}$$



R_G → Resistance of Galvanometer

I_G → Full deflection current

S → Shunt Resistance (small)

I → Measurable Current

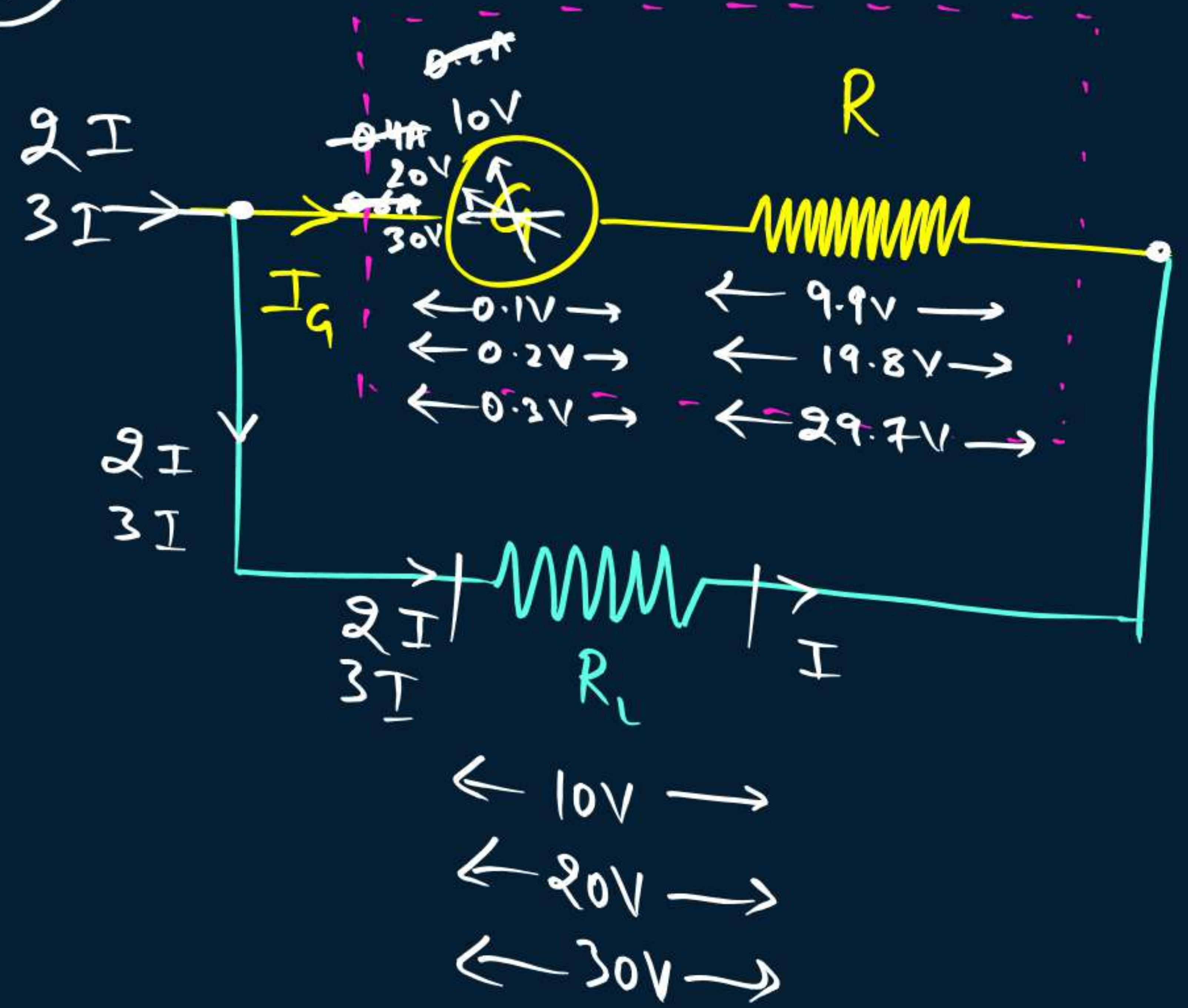
* Conversion of G → V

$$V = I_g R_g + I_g R$$

$$\boxed{V = I_g (R_g + R)}$$

V → Measured Voltage

I_g → full deflection current



PARISHRAM

2026

Lecture - 07

Moving Charges and Magnetism

PHYSICS Lecture - 7

BY - RAKSHAK SIR

Topics *to be covered*

A

B Torque on Current Carrying Loop ✓

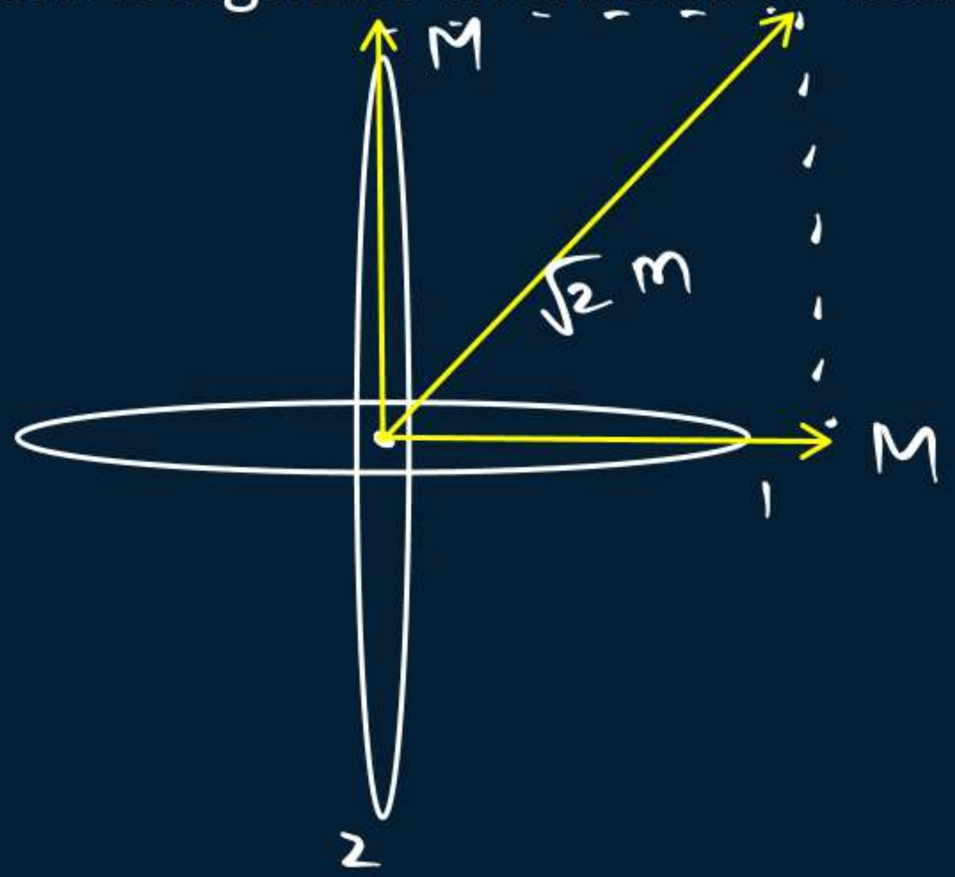
C Moving Coil Galvanometer (MCG) ✓

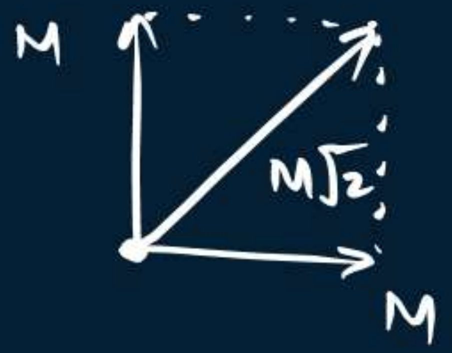
D **Conversion of Galvanometer**

QUESTION

H.W.

If the planes of two identical concentric coils are perpendicular and the magnetic moment of each coil is M, then the resultant magnetic moment of the two coils will be





(A) M

(B) 2M

(C) 3M

(D) $\sqrt{2}$ M

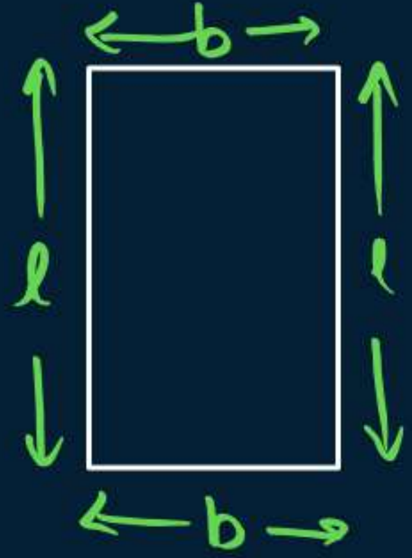
Torque on a current carrying coil in magnetic field

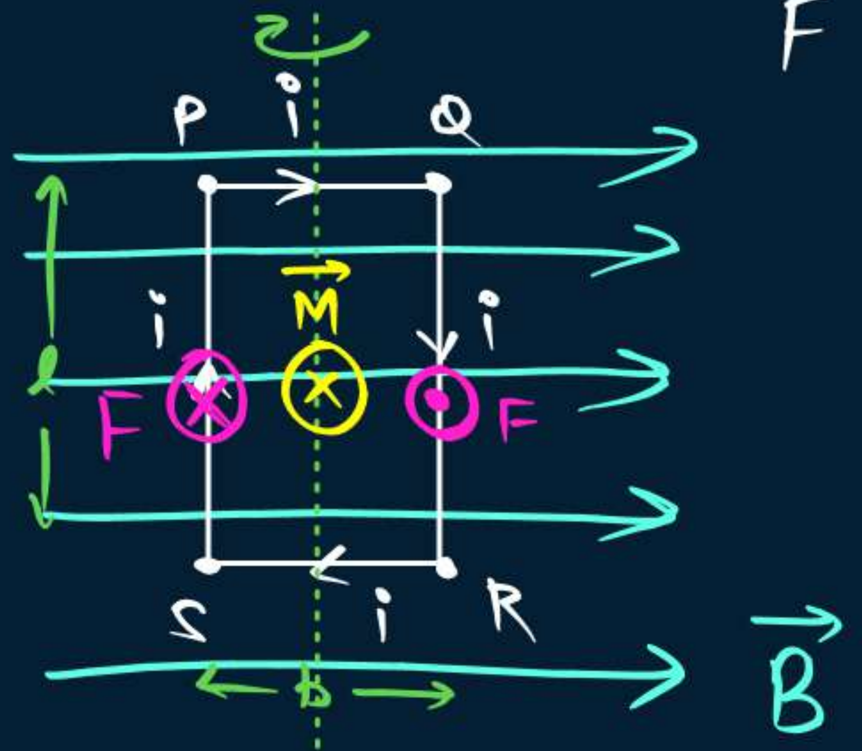
Y.K.B.
Analogy
from ch-1

$F_{PQ} = 0$

$\vec{F} = i(\vec{l} \times \vec{B})$

$F = BIL\sin\theta$





$F_{RS} = 0$

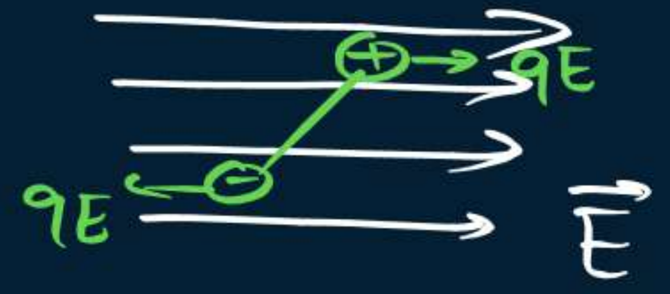
$$\boxed{\vec{\tau} = \vec{M} \times \vec{B}}$$

$\tau = MB\sin\alpha$

$= NiAB\sin\alpha$

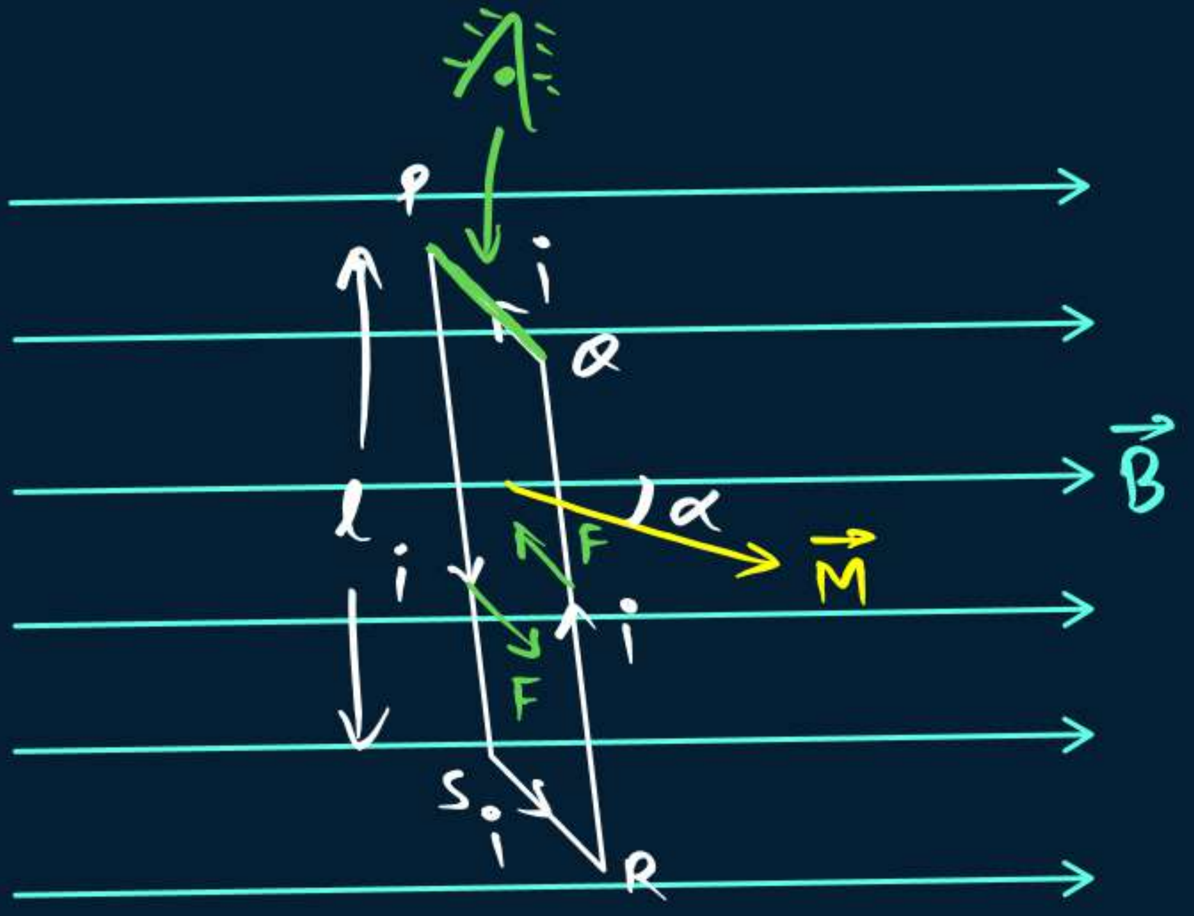
$= BiNA\sin\alpha$

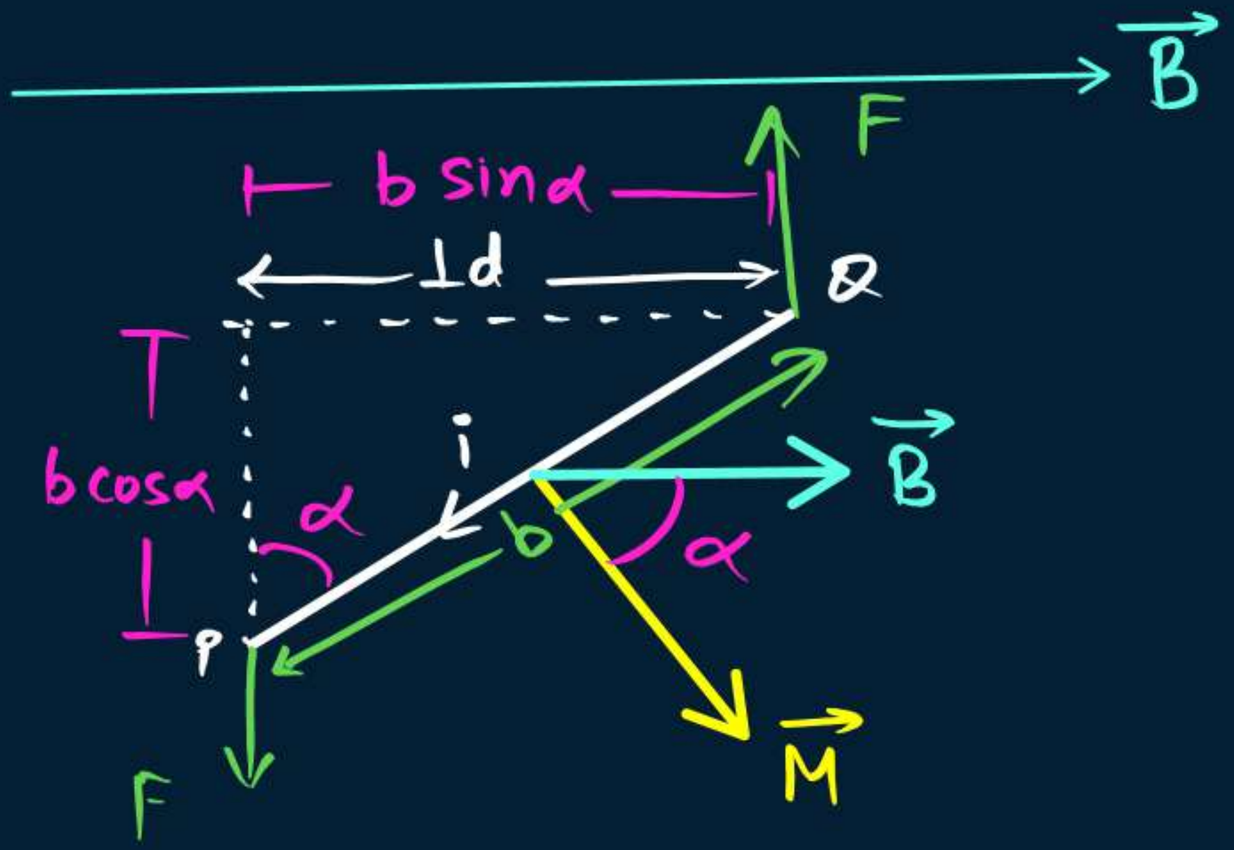
$\tau_{max} = BiNA \quad (\alpha = 90^\circ)$



$\vec{\tau} = \vec{p} \times \vec{E}$

$\tau = pE\sin\theta$





$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$\tau = F . \perp d$$

$$= F\, b\sin\alpha$$

$$= BIL\sin\theta . b\sin\alpha$$

$$= Bil\sin 90 . b\sin\alpha$$

$$= Bi(lb)\sin\alpha$$

for N- Turns

$$\tau = NBiA\sin\alpha$$

$$\boxed{\tau = BiNA\sin\alpha}$$

$$\tau = MB\sin\alpha$$

$$\boxed{\vec{\tau} = \vec{M} \times \vec{B}}$$

QUESTION

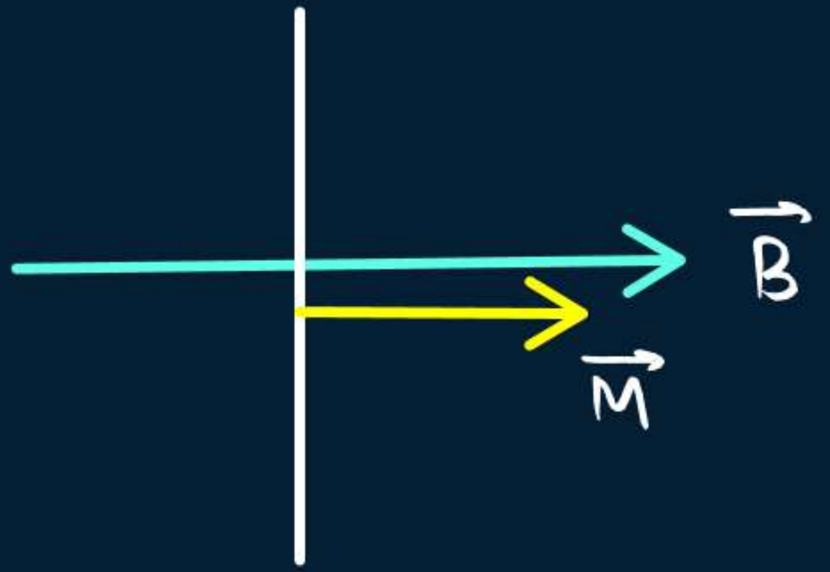
A circular loop of area 0.01 m^2 carrying a current of 10 A, is held perpendicular to a magnetic field of intensity 0.1 T. The torque acting on the loop is [1994]

A 0.001 N m

B 0.8 N m

C zero

D 0.01 N m.



$\alpha = 0°$

$\tau = MB\sin\alpha$

$\tau = 0$

Moving Coil Galvanometer (MCG)

It is used to measure small currents.

Principle: The current carrying coil placed in uniform magnetic field experiences a torque.

Moving Coil Galvanometer (MCG)

Principle: A current carrying coil placed in a magnetic field experiences a current dependent torque, which tends to rotate the coil and produces angular deflection.

- Device for detection and measurement of small currents.

$$\alpha = \frac{NBA}{K} I$$

K = Torsion constant (spring constant)

α = angular deflection

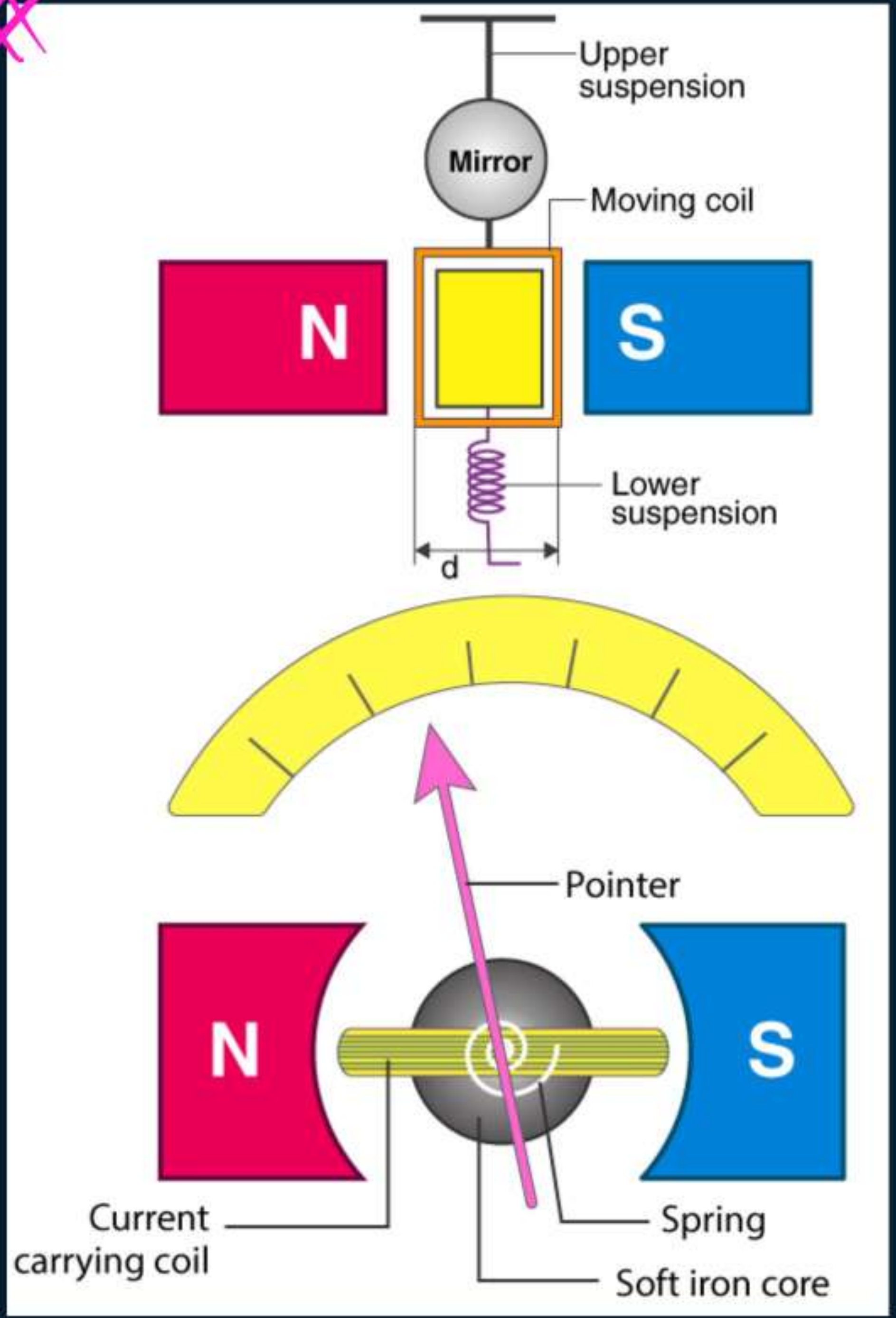
$\vec{\tau} = \vec{M} \times \vec{B}$

$\tau = MB \sin\alpha$

$\alpha = 90^\circ$

$\tau_{max} = MB$

$\boxed{\tau_{Def} = BiNA}$



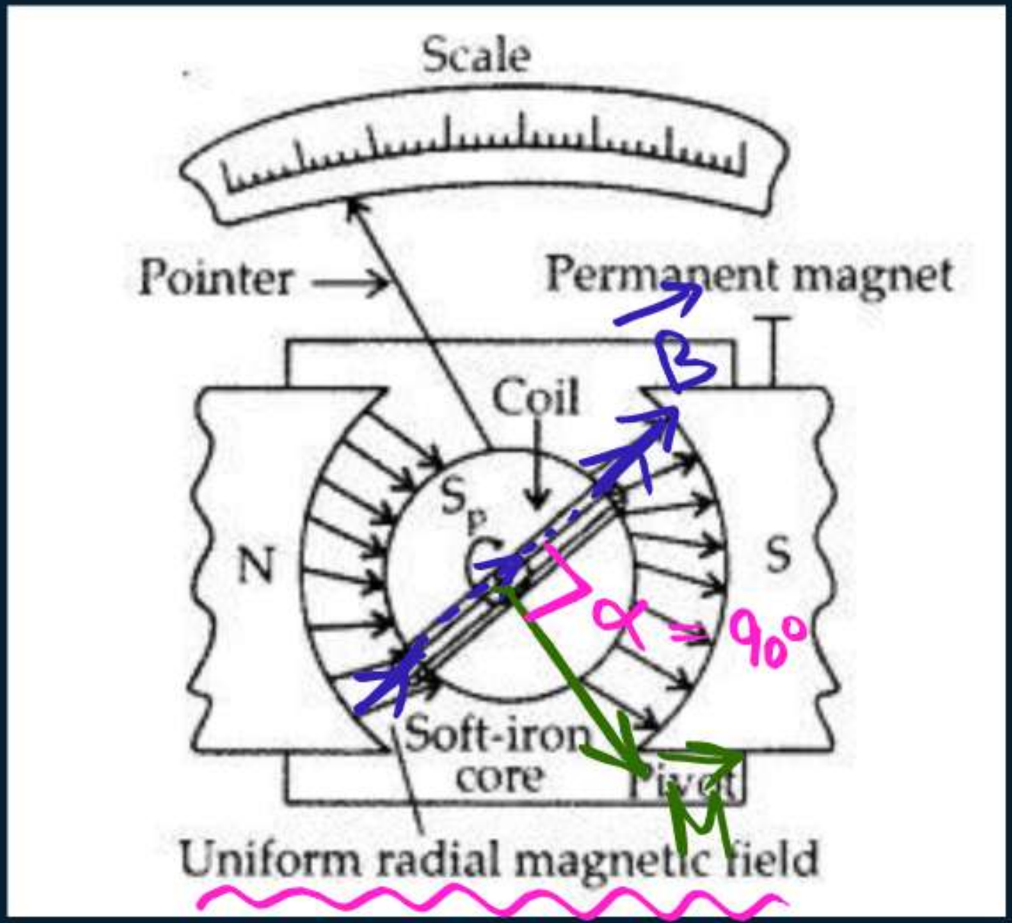
Construction (MCG)

As shown in figure, a moving coil galvanometer consists of a rectangular coil of fine insulated copper wire wound on a light non-magnetic metallic (aluminium) frame.

The two ends of the axle of this frame are pivoted between two bearings. The motion of the coil is controlled by a pair of hair springs of phosphor-bronze.

The inner ends of the springs are soldered to the two ends of the coil and the outer ends are connected to the binding screws. The springs provide the restoring torque and serve and current leads.

A light aluminium pointer attached to the coil measures its deflection on a suitable scale.



Construction (MCG)

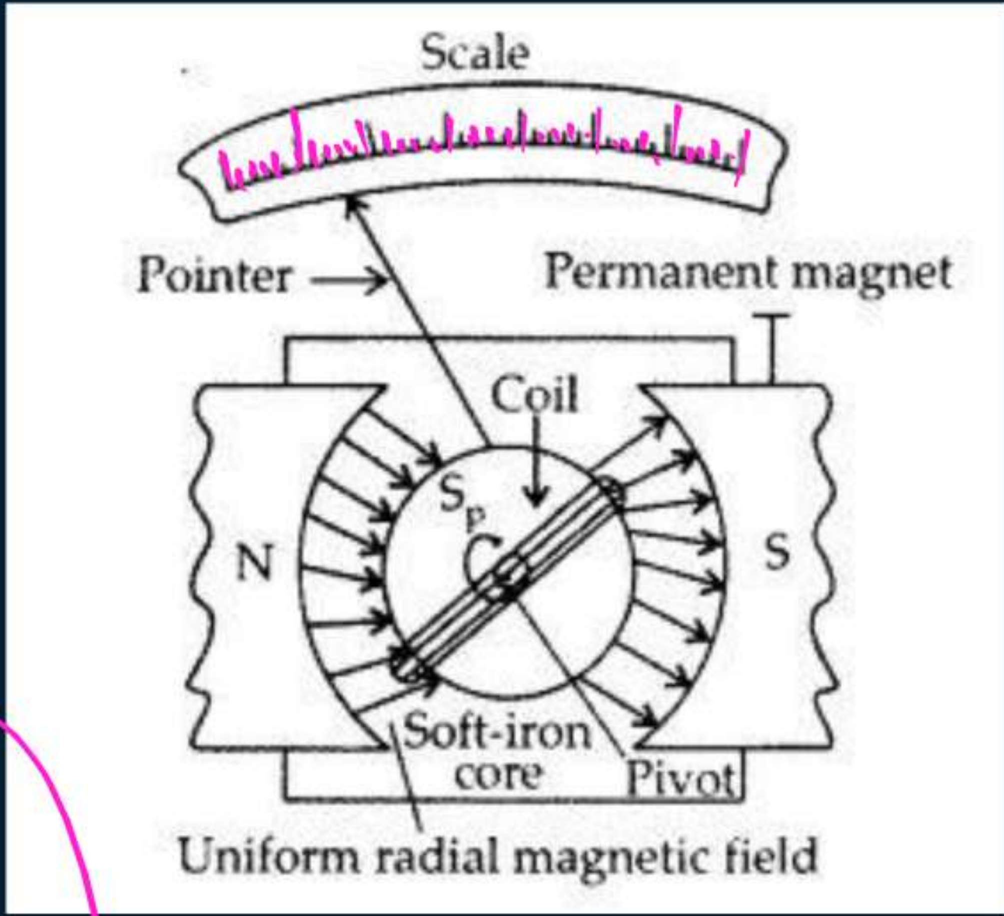
The coil is symmetrically placed between the cylindrical pole pieces of a strong permanent horseshoe magnet.

A cylindrical soft iron core is mounted symmetrically between the concave poles of the horse-shoe magnet. This makes the lines of force pointing along he radii of a circle. Such a field is called a radial field. The plane of a coil rotating in such a field remains parallel to the field in all positions, as shown in fig.

Also, the soft iron cylinder, due to its high permeability, intensifies the magnetic field and hence increases the sensitivity of the galvanometer.

Allow M.F.

Note: There is a cylindrical soft iron core which not only makes the field radial but also increases the strength of the magnetic field.

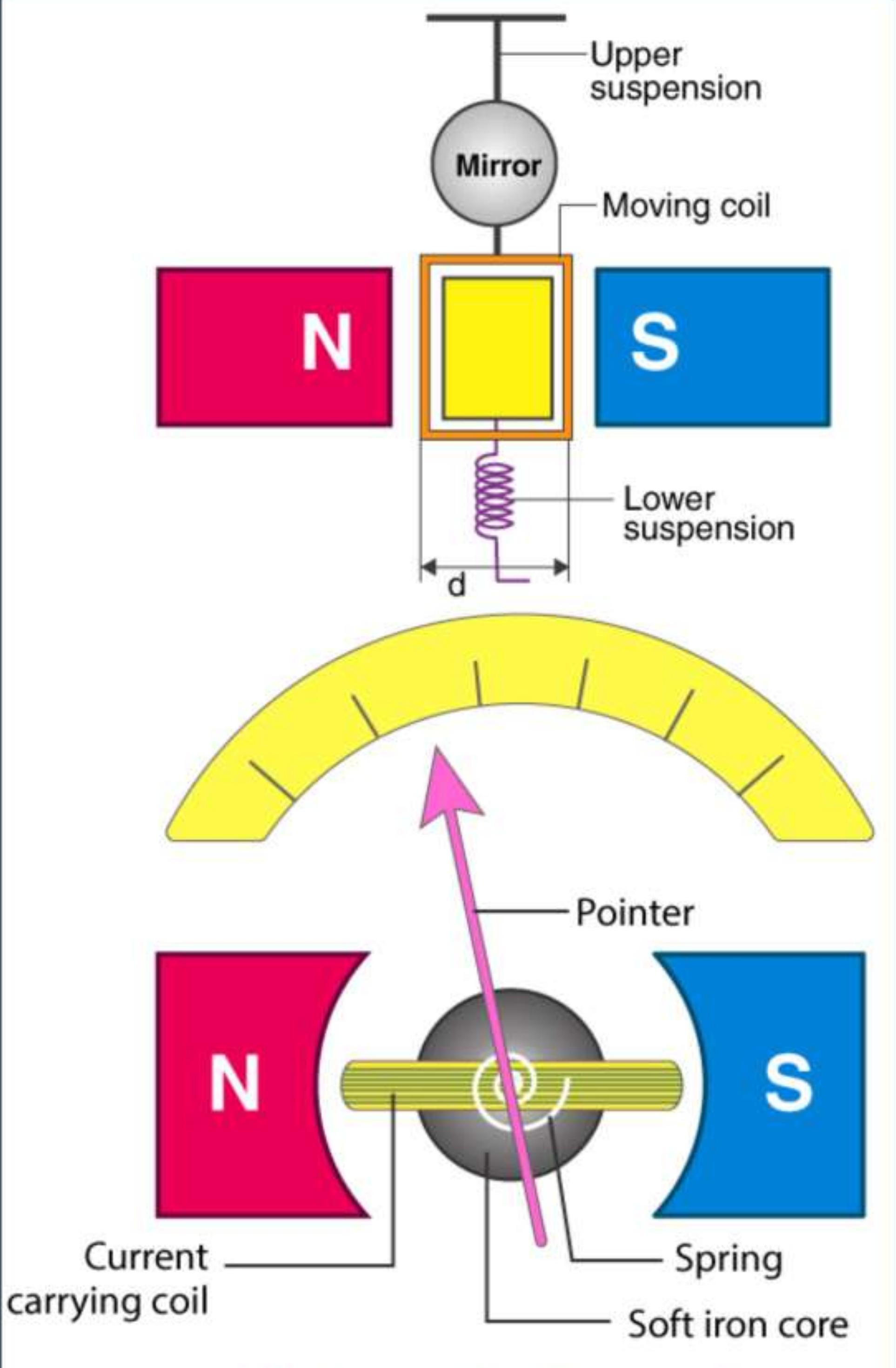


WHY?

- **Why aluminium frame (Dead beat):** It provides electro-magnetic damping being a conductor eddy currents generated and does not interact with external magnetic field.

- **Why hair springs of phosphor-bronze:** It has small restoring torque per unit twist and high tensile strength.

Alloy

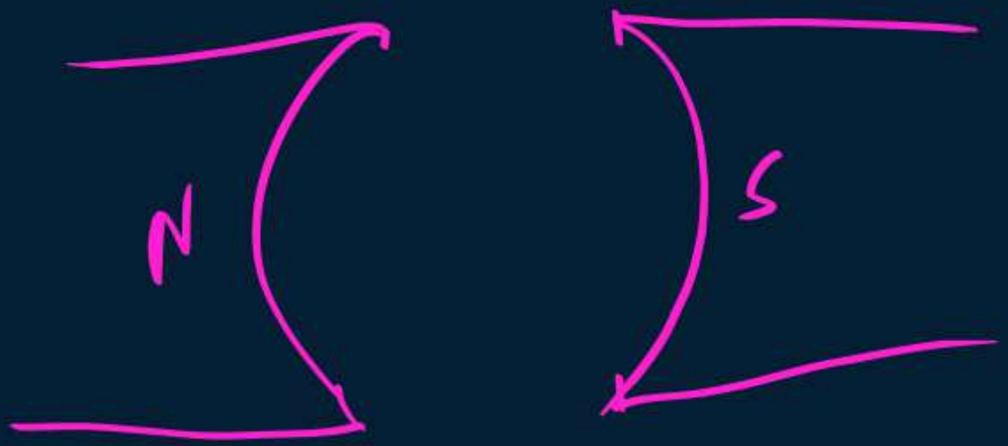


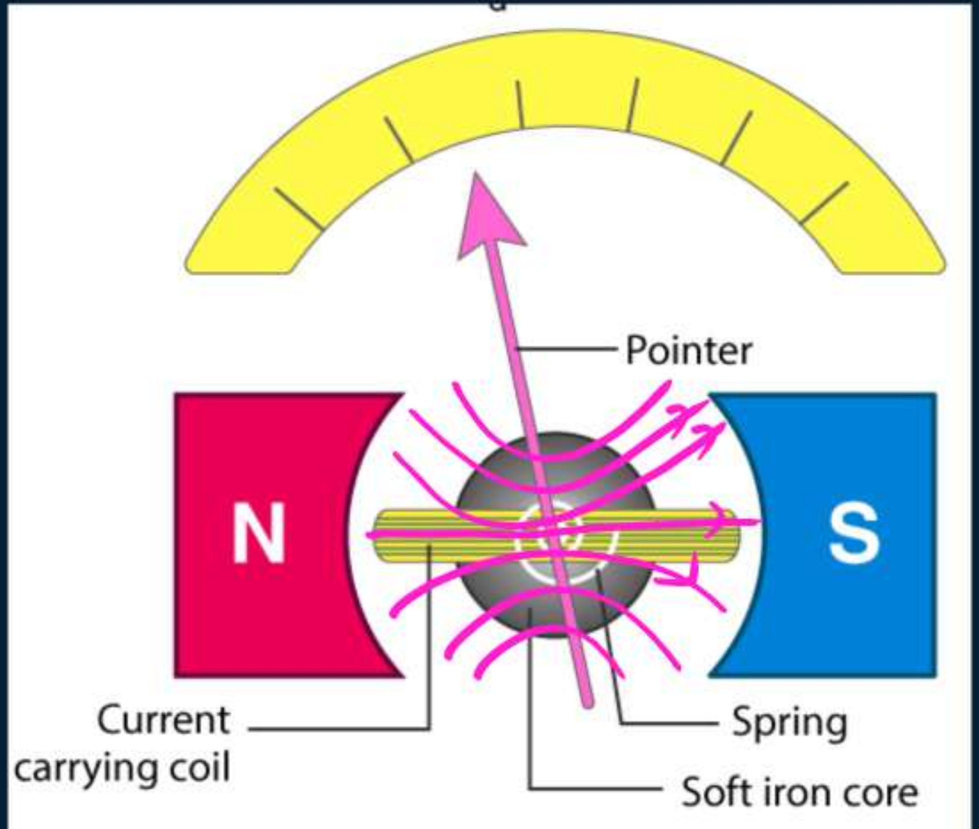
Moving coil galvanometer

WHY?

- **Why radial field in Galvanometer?**
  Because we need max torque and torque is uniform in all positions of MCG.

- **How to make radial field in MCG:** Poles of the magnet cut cylindrical (concave poles) by using soft iron core.



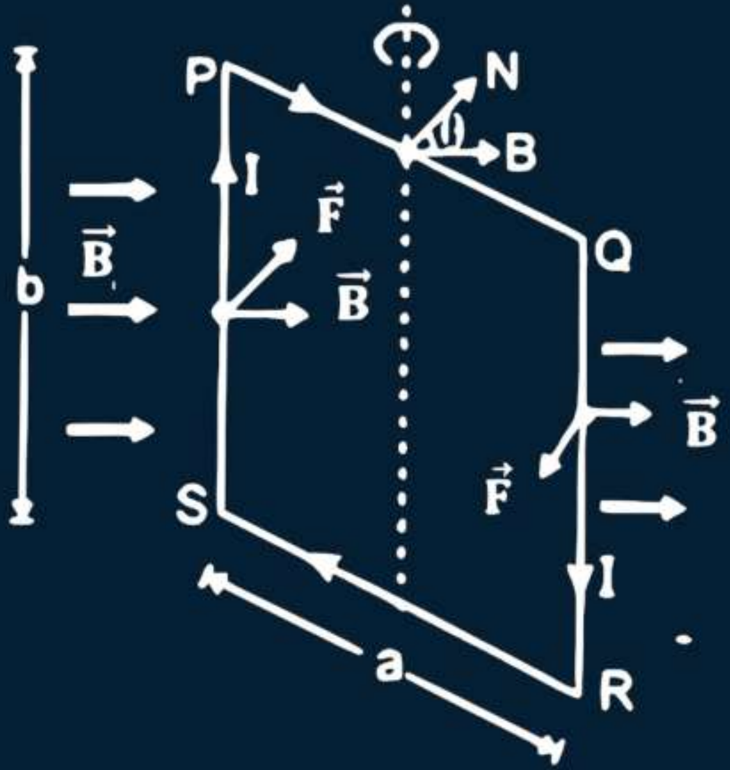


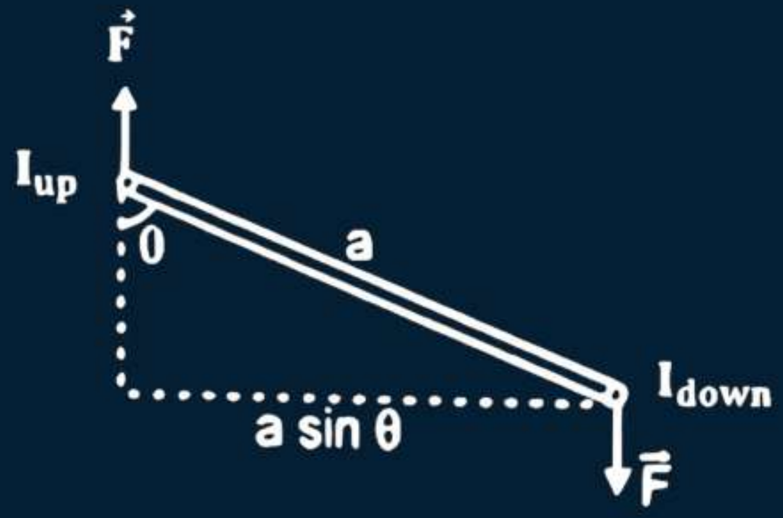
Moving coil galvanometer

Working of MCG

Since the field is radial, the plane of the coil always remains parallel to the field B.
The magnetic forces on sides PQ and SR are equal, opposite and collinear, so their resultant is zero.

According to Fleming's left rule, the side PS experiences a normal inward force equal to NlbB while the side QR experience an equal normal outward force. The two forces on side PS and QR are equal and opposite. They form a couple and exert a torque.





$$\tau = NIBA \sin 90° = NIBA$$

$$\vec{\tau} = \vec{M} \times \vec{B}$$

$$\tau = MB \sin\alpha$$

where $\alpha = 90^\circ$

$$\tau_{max} = MB$$

$$\boxed{\tau_{Def} = BiNA}$$

There is a spring which generates restoring Torque

$$\tau_{res} \propto \theta$$

$$\boxed{\tau_{res} = K\theta}$$

K ↓ Torsional Constant (Material dependent)

Y.K.B. / Class XI

$$F_s \propto -x$$

$$F_s = -Kx$$

K ↓ Spring Constant

At equilibrium,

$$\tau_{def} = \tau_{res}$$

$$BiNA = K\theta$$

$$\frac{BNA}{K} = \frac{\theta}{i}$$

Current Sensitivity (i_s)

$$i_s = \boxed{\frac{\theta}{i} = \frac{NBA}{K}}$$

$$i_s = \frac{\theta}{i}$$

$$\boxed{i_s = \frac{NBA}{K}}$$

$i_s \uparrow \propto N \uparrow$

$\propto B \uparrow$

$\propto A \uparrow$

$\propto \frac{1}{K \downarrow}$

Voltage Sensitivity (V_s)

$$V_s = \frac{\theta}{V} = \frac{\theta}{iR}$$

$$= \left(\frac{\theta}{i}\right)_R = \frac{i_s}{R}$$

$$\boxed{V_s = \frac{i_s}{R}}$$

$$\boxed{V_s = \frac{NBA}{KR}}$$

$V_s \propto N \uparrow$

$\propto B \uparrow$

$\propto A \uparrow$

$\propto K \downarrow$

$\propto R \downarrow$

Figure of Merit OR Galvanometer Constant (G)

$$\boxed{G = \frac{1}{i_s} = \frac{K}{NBA}}$$

Factors by which the sensitivity of a moving coil galvanometer can be increased

1. By $\boxed{\text{increasing the number of turns } N}$ of the coil. But the value of N cannot be increased beyond a certain limit because that will make the galvanometer bulky and increase its resistance R.
2. By $\boxed{\text{increasing the magnetic field } B.}$ This can be done by using a strong horse-shoe magnet and placing a soft iron core within the coil.
3. By $\boxed{\text{increasing the area } A}$ of the coil. However, increasing A beyond a certain limit will make the galvanometer bulky and unmanageable.
4. By $\boxed{\text{decreasing the value of torsion constant } k.}$ The torsion constant k is made small by using suspension wire and springs of phosphor bronze.

Current Sensitivity: $I_S = \frac{\alpha}{I} = \frac{NBA}{K}$

Voltage Sensitivity: $V_S = \frac{\alpha}{V} = \frac{\alpha}{IR} = \frac{NBA}{KR}$

Advantage of a moving coil galvanometer

$i \propto \theta$

1. As the $\boxed{\text{deflection of the coil is proportional to the current}}$ passed through it, so a $\boxed{\text{linear}}$ scale can be used to measure the deflection.
2. A moving coil galvanometer can be made highly sensitive by increasing N, B, A and decreasing k.
3. As the coil is placed in a strong magnetic field of a powerful magnet, its deflection is not affected by external magnetic fields. This enables us to use the galvanometer in any position.
4. As the coil is wound over a metallic frame, the eddy currents produced in the frame bring the coil to rest quickly.

$$\alpha \propto I$$

Disadvantages of a moving coil galvanometer

1. The man disadvantage is that its sensitiveness cannot be changed at will.
2. All types of moving coil galvanometers are easily damaged by overloading. A current greater than that which the instrument is intended to measure will burn out its hair-springs or suspension.

$$I_S = \frac{NBA}{K}$$

$$V_S = \frac{NBA}{KR}$$

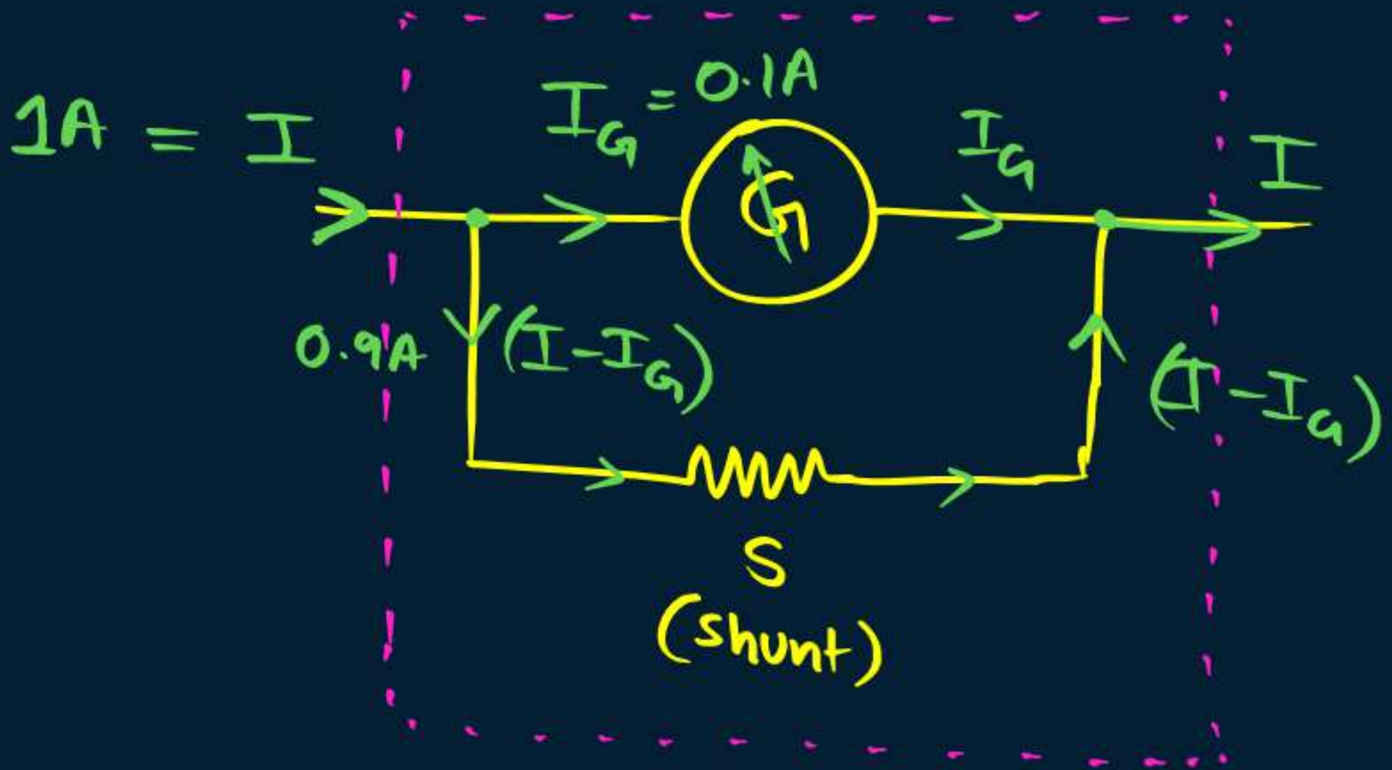
* Conversion of G ⟶ A

As both shunt and G are in Parallel, Voltage remains same

$$V_S = V_G$$

$$(I - I_G) S = I_G R_G$$

$$\boxed{S = \frac{I_G R_G}{I - I_G}}$$



R_G → Resistance of Galvanometer

I_G → Full deflection current

S → Shunt Resistance (small)

I → Measurable Current

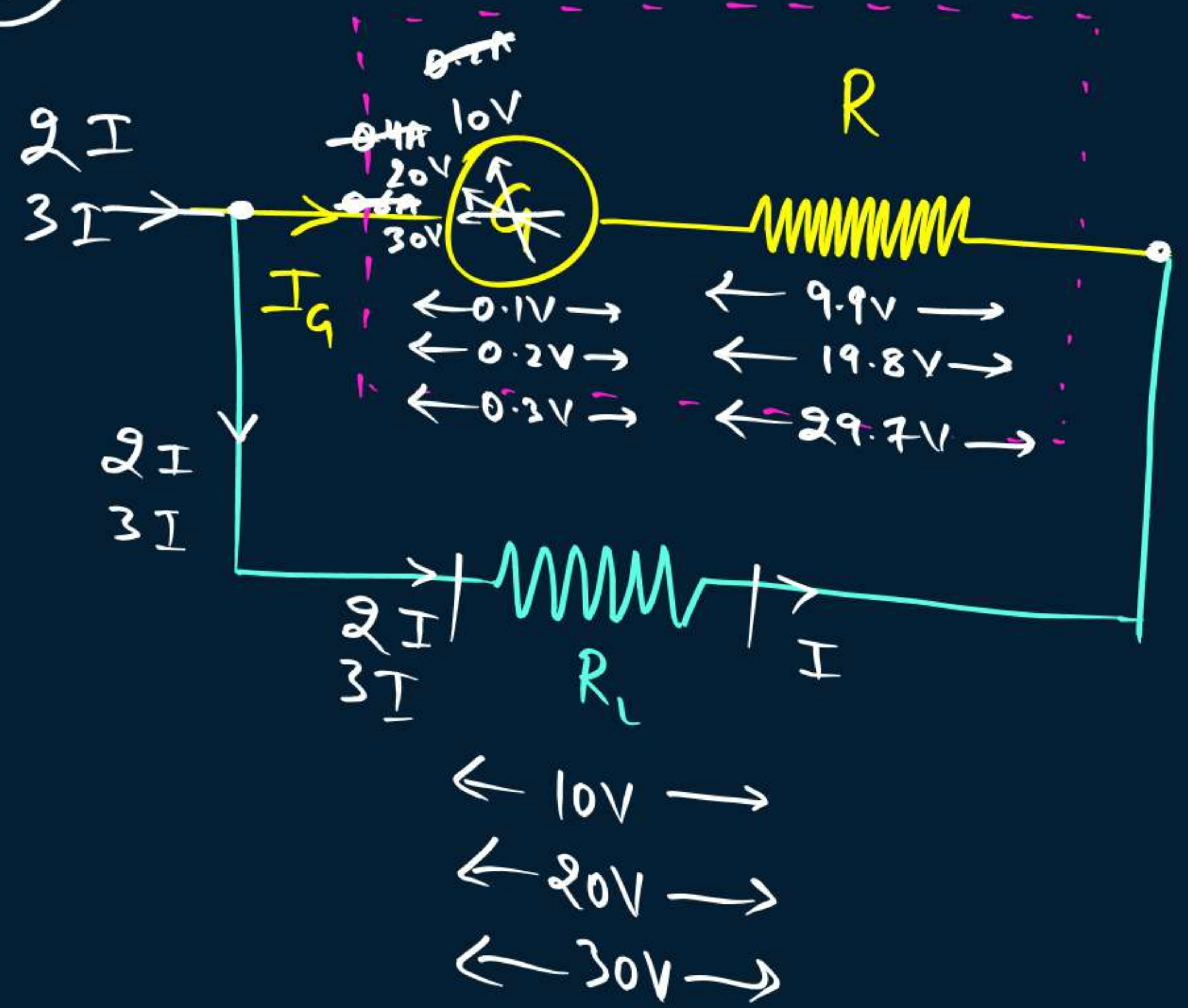
* Conversion of G $\longrightarrow$ V

$$V = I_G R_G + I_G R$$

$$\boxed{V = I_G (R_G + R)}$$

V → Measured Voltage

I_G → full deflection current



PARISHRAM

2026

Lecture - 08

Moving Charges and Magnetism

PHYSICS Lecture - 8

BY - RAKSHAK SIR

Topics *to be covered*

A Practice Session

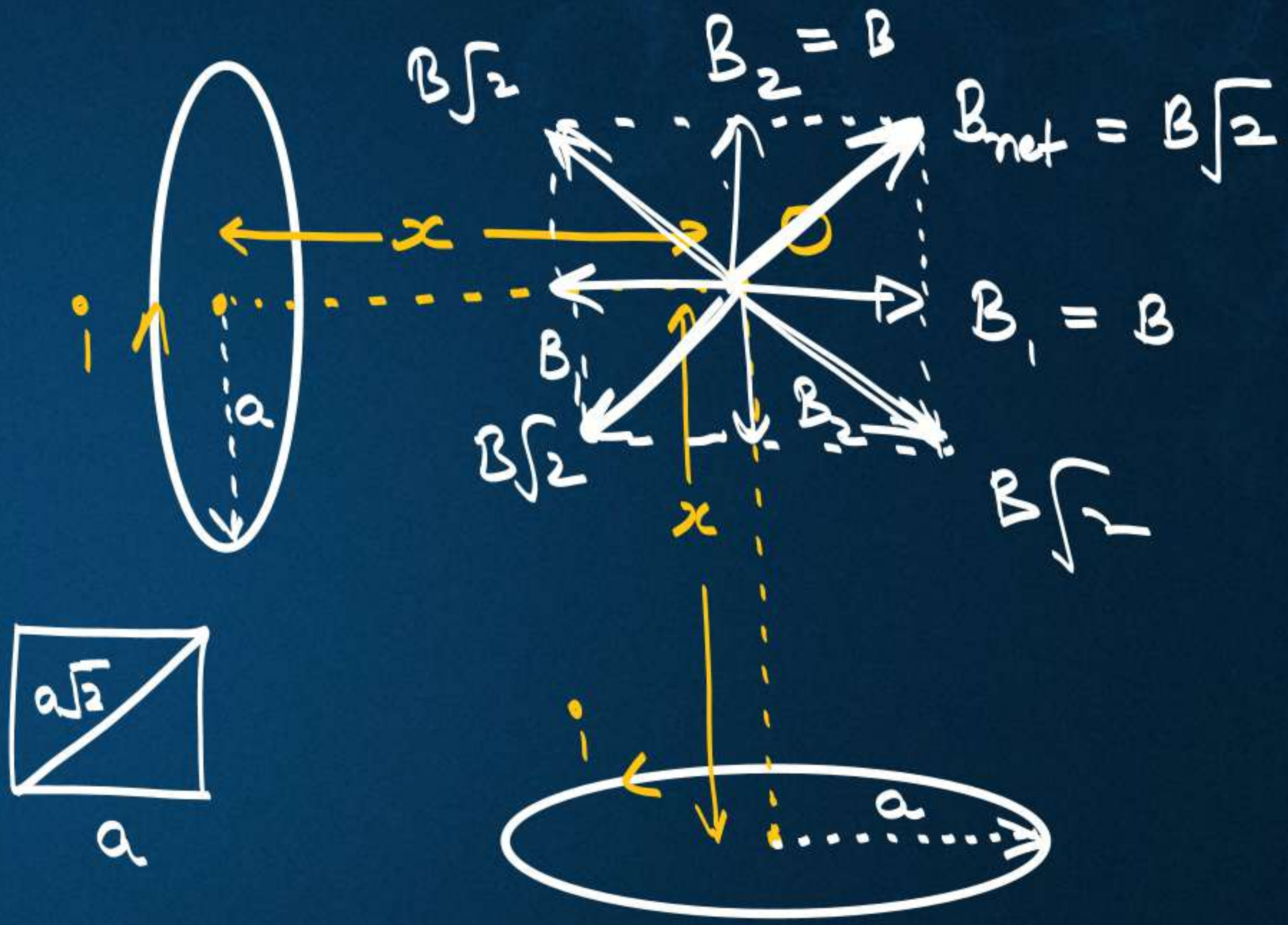
$\boxed{\text{H.W.}}$ Lec-2 Subjective Ques.

$$\boxed{B_{axial} = \frac{\mu_0 i a^2}{2(x^2+a^2)^{3/2}}} \rightarrow \text{O.G.}$$

Spl. case :-

$x >> a$

$$\boxed{B_{axial} = \frac{\mu_0 i a^2}{2x^3}}$$

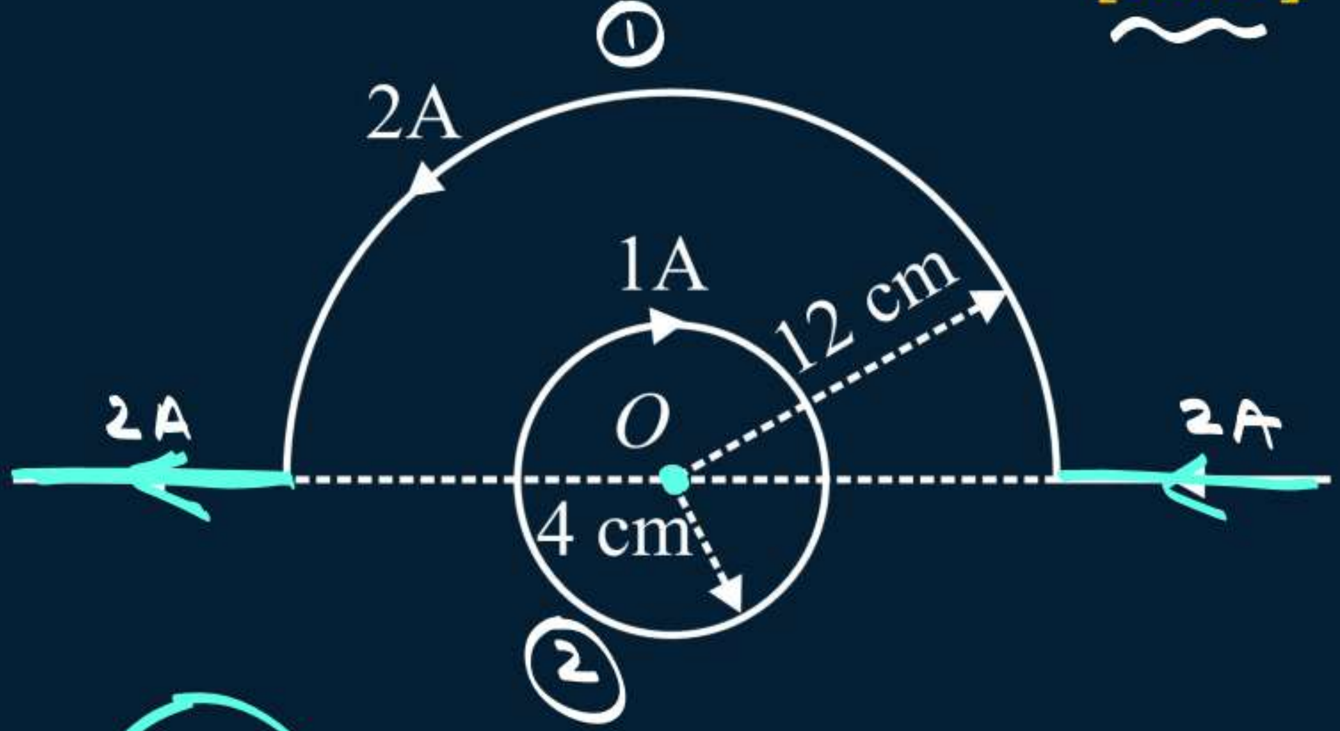


$$\boxed{B_{net} = \sqrt{2}\,\frac{\mu_0 i a^2}{2x^3}}$$

final Ans

QUESTION

A current carrying circular loop and a straight wire bent partly in the form of a semicircle are placed as shown in the figure. Find the magnitude and direction of net magnetic field at point O. **[2023]**



$$\frac{100}{\cancel{4}} \times \cancel{4}\pi \times 10^{-7} \times \frac{1}{3}$$

$$\frac{\cancel{4.19}^{\,1.4}}{\cancel{3}} \times 10^{-5}$$

$$\boxed{1.04 \times 10^{-5}\ \text{T}}$$

$$B_{net} = B_2 - B_1$$

$$= \frac{\mu_0 i_1}{2R_1} - \frac{\mu_0 i_2}{4R_2}$$

$$= \frac{\mu_0 \times 1}{2 \times \frac{4}{100}} - \frac{\mu_0 \times 2}{4 \times \frac{12}{100}}$$

$$= \frac{\mu_0}{\frac{4}{100}}\left[\frac{1}{2} - \frac{\cancel{2}^{\,1}}{\cancel{12}_{\,6}}\right]$$

$$= \frac{100}{4} \times 4\pi \times 10^{-7}\left(\frac{3-1}{6}\right) =$$

$$B_c = \frac{\mu_0 i}{2R} \qquad B_{sc} = \frac{\mu_0 i}{4R}$$

QUESTION

The magnetic field at the centre of a current carrying circular loop of radius R is B_1. The magnetic field at a point on its axis at a distance R from the centre of the loop is B_2. Then the ratio (B_1/B_2) is **[2021-22]**

(A) $2\sqrt{2}$

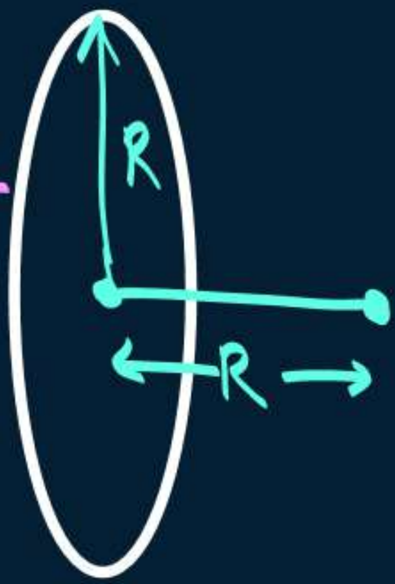
(B) $\frac{1}{\sqrt{2}}$

(C) $\sqrt{2}$

(D) 2

$$B_1 = \frac{\mu_0 i}{2R}$$

$$\frac{B_1}{B_2} = \frac{\cancel{\frac{\mu_0 i}{2R}}}{\cancel{\frac{\mu_0 i}{2\sqrt{2}\, 2R}}} = \frac{\frac{1}{1}}{\frac{1}{2\sqrt{2}}} = 2\sqrt{2}$$



$$B_2 = \frac{\mu_0 i a^2}{2(x^2+a^2)^{3/2}} = \frac{\mu_0 i R^2}{2(R^2+R^2)^{3/2}}$$

$a = R,\ x = R$

$$= \frac{\mu_0 i R^2}{2(2R^2)^{3/2}} = \frac{\mu_0 i \cancel{R^2}}{2 \times 2\sqrt{2}\, R^{\cancel{3}}}$$

QUESTION

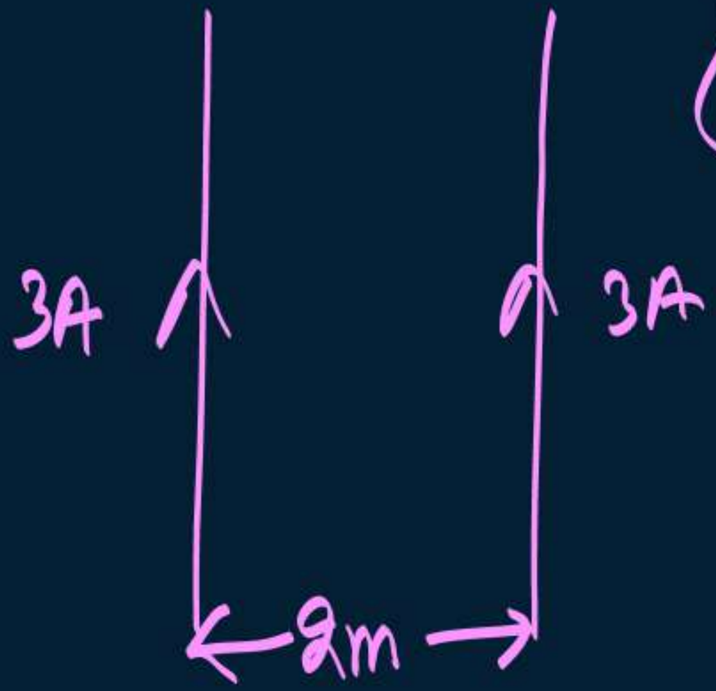
Two long parallel wires kep 2cm apart carry 3A current each, in the same direction. The force per unit length on one wire due to the other is **[2023]**

A $4.5 \times 10^{-5}\ \text{Nm}^{-1}$. attractive

B 4.5×10^{-7} N/m, repulsive

C 9×10^{-7} N/m, repulsive

D 9×10^{-5} N/m, attractive



$$\boxed{\frac{F}{l} = \frac{\mu_0 i_1 i_2}{2\pi r}}$$

$$= \frac{\cancel{4\pi} \times 10^{-7} \times 3 \times 3}{\cancel{2\pi} \times \frac{2}{100}}$$

$$= 9 \times 10^{-7} \times 10^{2}\ \text{N/m}$$

$$= 9 \times 10^{-5}\ \text{N/m}$$

QUESTION

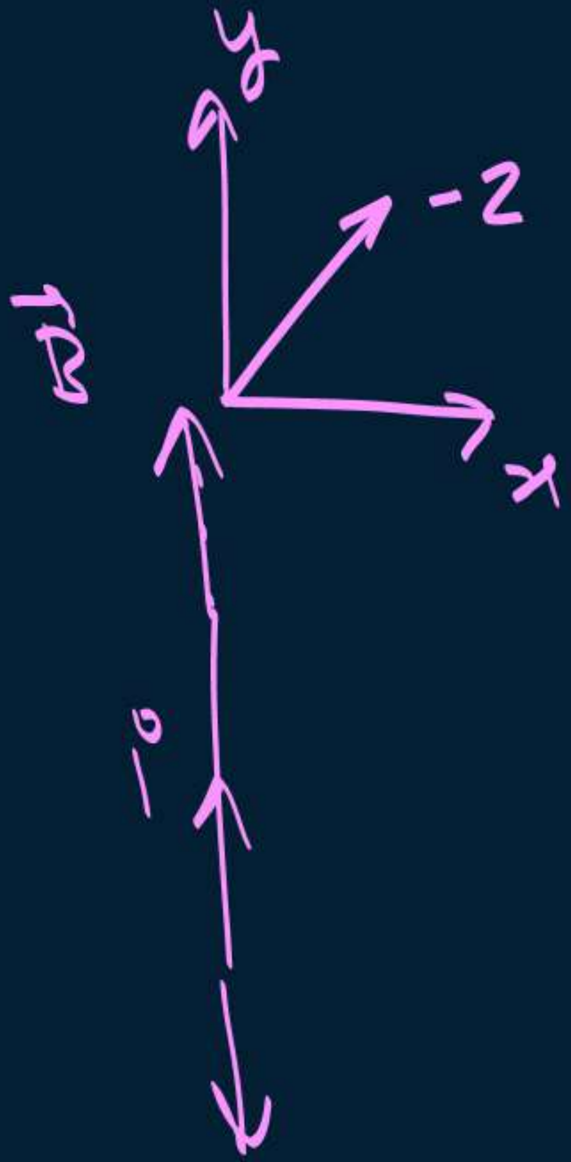
A 2.0 cm segment of wire, carrying 5.0 A current in positive y-direction lies along y-axis, as shown in the figure. The magnetic field at a point (3 m, 4 m, 0) due to this segment (part of a circuit) is **[2024]**

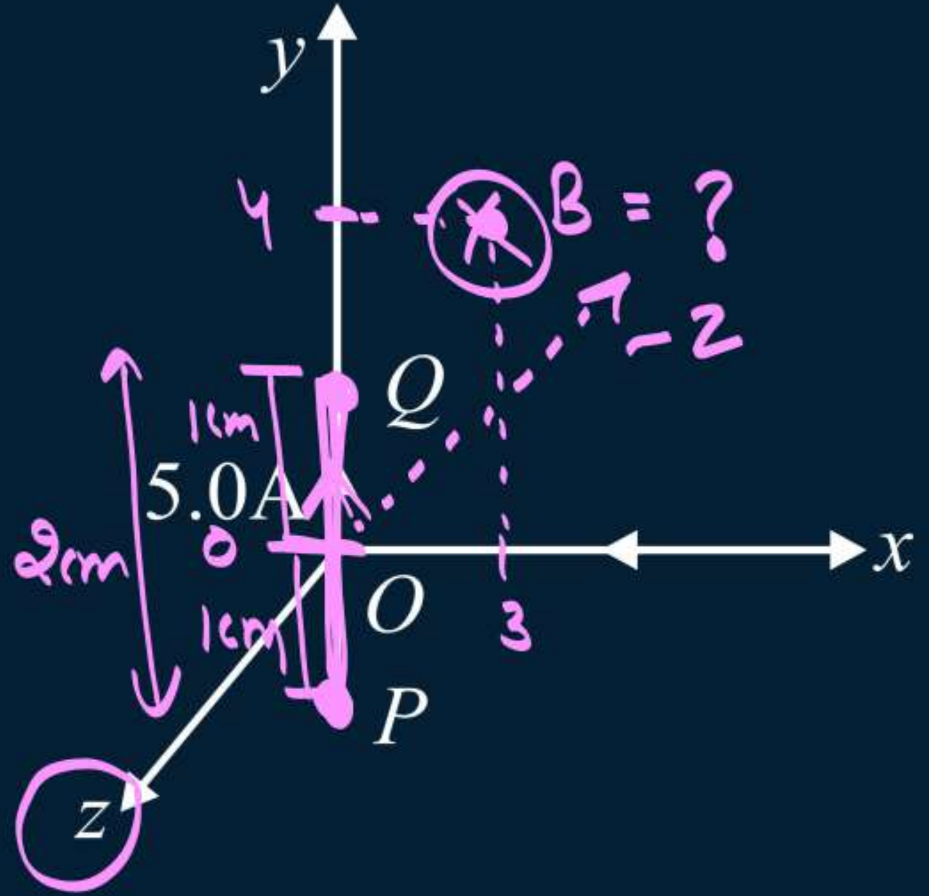
A $(0.12\ \text{nT})\hat{j}$ ×

B $-(0.10\ \text{nT})\hat{j}$ ×

C $-(0.24\ \text{nT})\hat{k}$

D $(0.24\ \text{nT})\hat{k}$





QUESTION

A particle of mass m and charge $-q$ is moving with a uniform speed v in a circle of radius r, with another charge q at the centre of the circle. The value of r is [2023]

(A) $\dfrac{1}{4\pi\varepsilon_0 m}\left(\dfrac{q}{v}\right)$

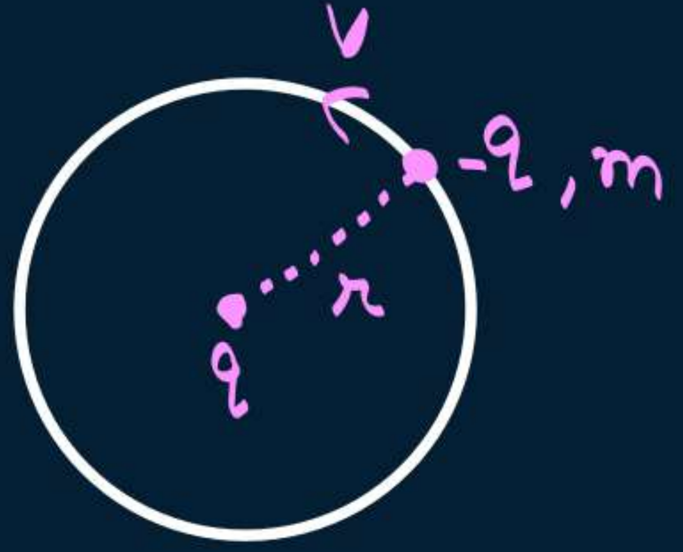
(B) $\dfrac{1}{4\pi\varepsilon_0 m}\left(\dfrac{q}{v}\right)^2$

(C) $\dfrac{m}{4\pi\varepsilon_0}\left(\dfrac{q}{v}\right)$

(D) $\dfrac{m}{4\pi\varepsilon_0}\left(\dfrac{q}{v}\right)^2$

$$F = \frac{k q_1 q_2}{r^2}$$

$$F = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r^2}$$



$$F_{elec} = F_{centri}$$

$$\frac{1}{4\pi\epsilon_0}\frac{q^2}{r^2} = \frac{mv^2}{r}$$

$$r = \frac{1}{4\pi\epsilon_0}\frac{q^2}{mv^2}$$

QUESTION

$\frac{\theta}{i} = i_s \rightarrow$ Deflection per unit current.

(i) What is current sensitivity of a galvanometer? Show how the current sensitivity of a galvanometer may be increased. "Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity". Explain

(ii) A moving coil galvanometer has a resistance 15Ω and takes 20 mA to produce full scale deflection. How can this galvanometer be converted into a voltmeter of range 0 to 100V? [2024]

Given :- $R_g = 15\,\Omega$

$I_g = 20 \times 10^{-3}\,A$

$V = 100\,V$

$R = ?$

$\boxed{V = I_g R_g + I_g R}$

$V = I_g(R_g + R)$

$\boxed{\frac{V}{I_g} - R_g = R}$

$i_s \uparrow = \frac{NBA}{K}$

$V_s = \frac{NBA}{KR\uparrow}$

$N\uparrow \rightarrow$ length $\uparrow \propto R\uparrow$

$$\frac{V}{I_g} - R_g = R$$

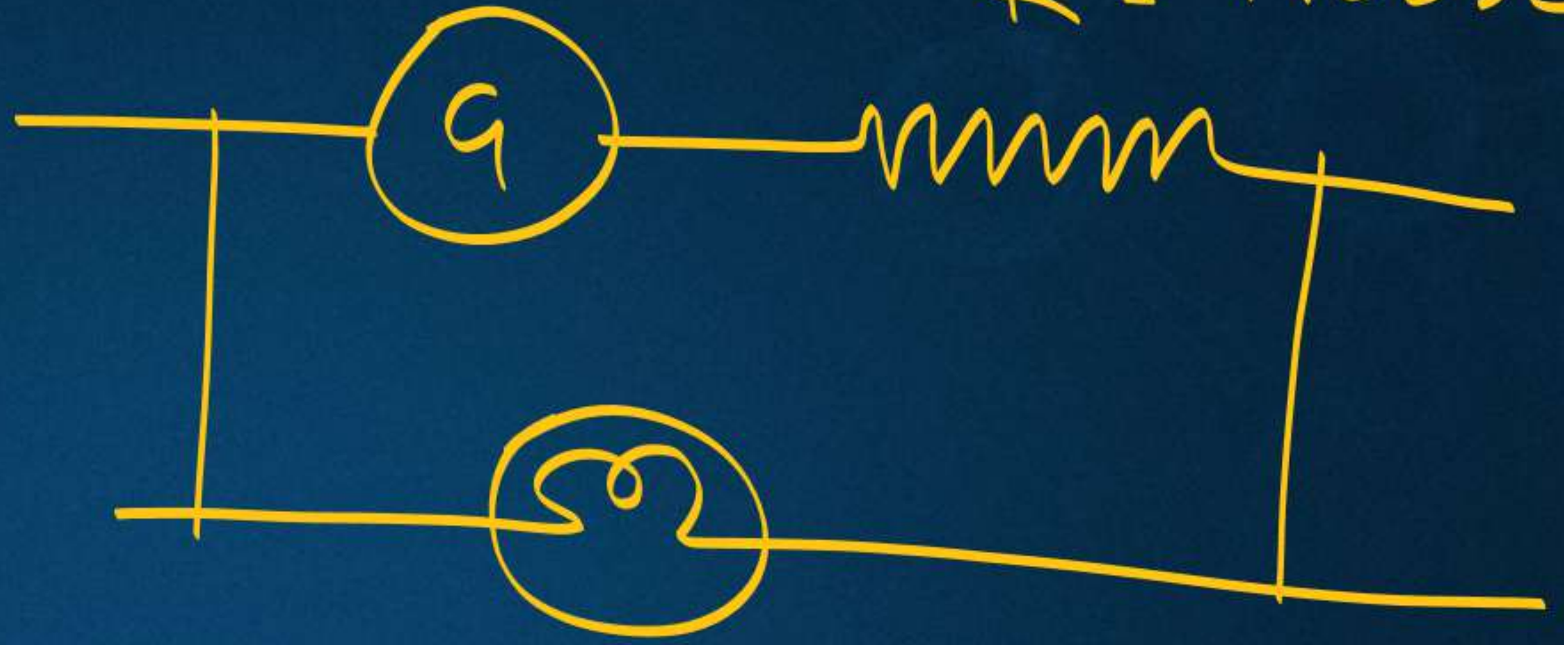
$$\frac{100}{20\times10^{-3}} - 15 = R$$

$$\frac{\overset{5}{\cancel{100}}\times1000}{\underset{1}{\cancel{20}}} - 15 = R$$

$$5000 - 15 = R$$

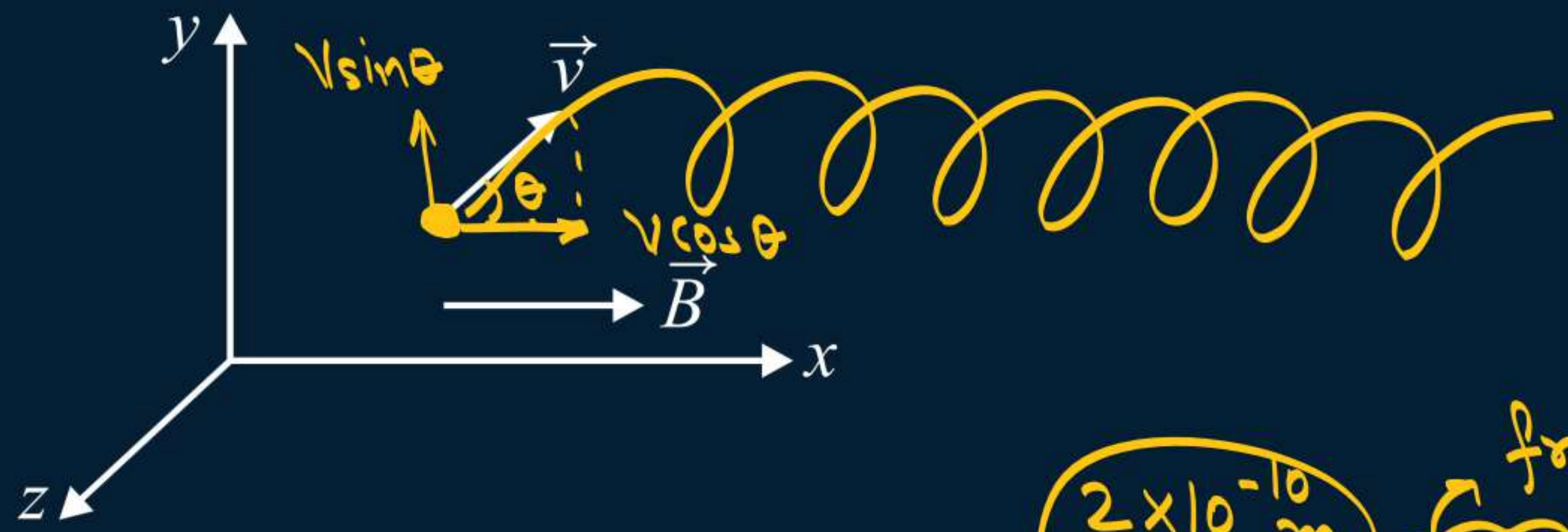
$$4985\,\Omega = R$$

$R = 4985\,\Omega$



QUESTION

(i) A particle of mass m and charge q is moving with a velocity $\vec{v}$ in a magnetic field $\vec{B}$ as shown in the figure. Show that it follows a helical path Hence. Obtain its frequency of revolution.



2×10^{-10} m

freq.

(ii) IN a hydrogen atom, the electron moves in an orbit of radius 2Å making 8×10^{14} revolutions per second. Find the magnetic moment associated with the orbital motion of the electron. [2024]

$M = NiA$

$= 1 \times \frac{q}{t} A$

$M = \frac{q}{T} A$

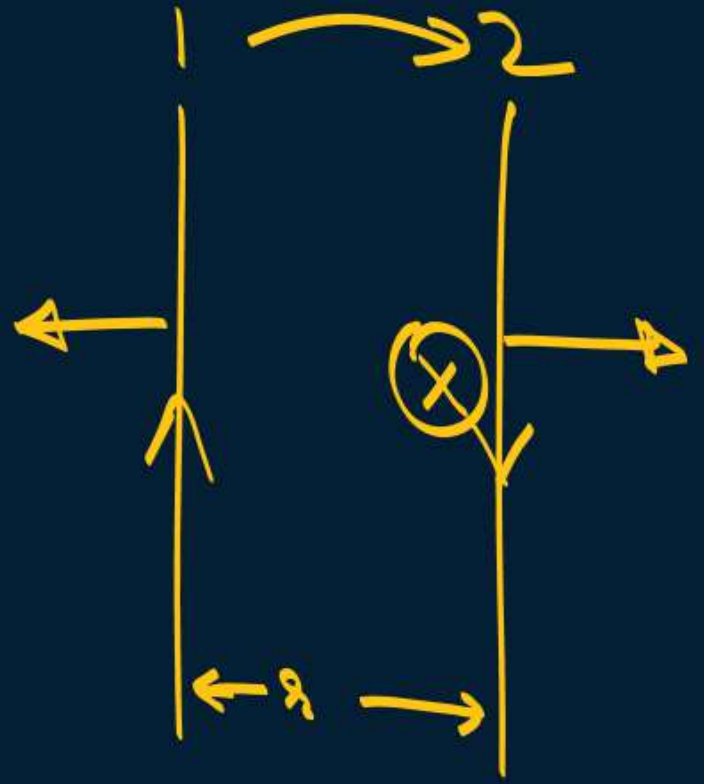
$= q\nu A = 1.6\times10^{-19} \times 8\times10^{14} \times 3.14 \times 4\times10^{-20}$

QUESTION

Repulsive

Two long straight parallel conductors carry steady currents in opposite directions. Explain the nature of the force of interaction between them. Obtain an expression for the magnitude of the force between the two conductors. Hence define one ampere.

[2024]



$$\frac{F}{l} = \frac{\mu_0 i_1 i_2}{2\pi r}$$

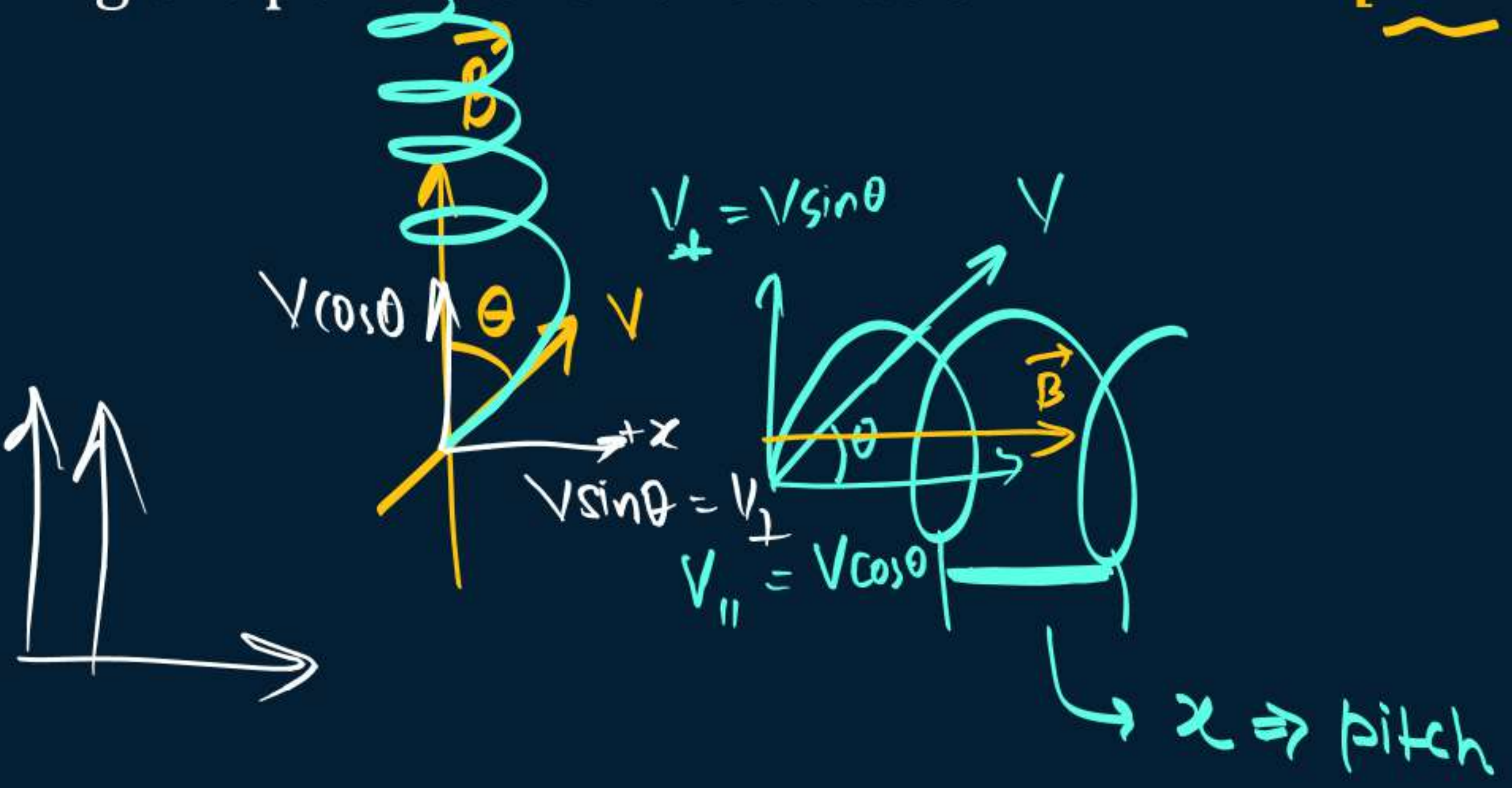
QUESTION

$r = \frac{m(v\sin\theta)}{qB} = \frac{m v_{\perp}}{qB}$

An electron moving with a velocity $\vec{v} = (1.0 \times 10^7 \text{ m/s})\hat{\imath} + (0.5 \times 10^7 \text{ m/s})\hat{\jmath}$ enters a region of uniform magnetic field $\vec{B} = (0.5 \text{ mT})\hat{\jmath}$. Find the radius of the circular path described by it. While rotating does the electron trace a linear path too? If so, calculate the linear distance covered by it during the period of one revolution. [2024]

$\vec{V} = \underbrace{10^7 \hat{i}}_{V_\perp} + \underbrace{0.5 \times 10^7 \hat{j}}_{V_\parallel}$ m/s

$\vec{B} = (0.5 \times 10^{-3} \hat{j})$ T



$r = \frac{m v_\perp}{qB}$

$= \frac{9.1 \times 10^{-31} \times 10^7}{1.6 \times 10^{-19} \times 0.5 \times 10^{-3}}$

QUESTION

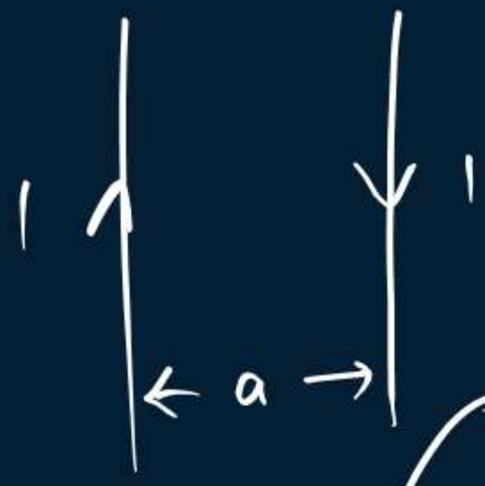
Two thin long parallel wires separated by a distance 'a' carry current 'I' in opposite directions. The wires will **[2024]**

(A) ~~repel each other with a force $\frac{\mu_0 I^2}{2\pi a^2}$, per unit length~~

(B) ~~attract each other with a force $\frac{\mu_0 I^2}{2\pi a^2}$, per unit length~~

(C) ~~attract each other with a force $\frac{\mu_0 I^2}{2\pi a}$, per unit length~~

(D) repel each other with a force $\frac{\mu_0 I^2}{2\pi a}$, per unit length.



$$\frac{F}{l} = \frac{\mu_0 I^2}{2\pi a}$$

QUESTION

$p = mv$

Assertion (A): An electron and a proton enter with the $\boxed{\text{same momentum } \vec{p}}$ in a magnetic field $\vec{B}$ such that $\vec{p} \perp \vec{B}$. Then both describe a circular path of the same radius. T

T

Reason (R): The radius of the circular path described by the charged particle (charge q, mass m) moving in the magnetic field $\vec{B}$ is is given by $r = \frac{(mv)}{qB} = \frac{p}{qB}$ [2024]

(A) If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).

(B) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).

(C) If Assertion (A) is true but Reason (R) is false.

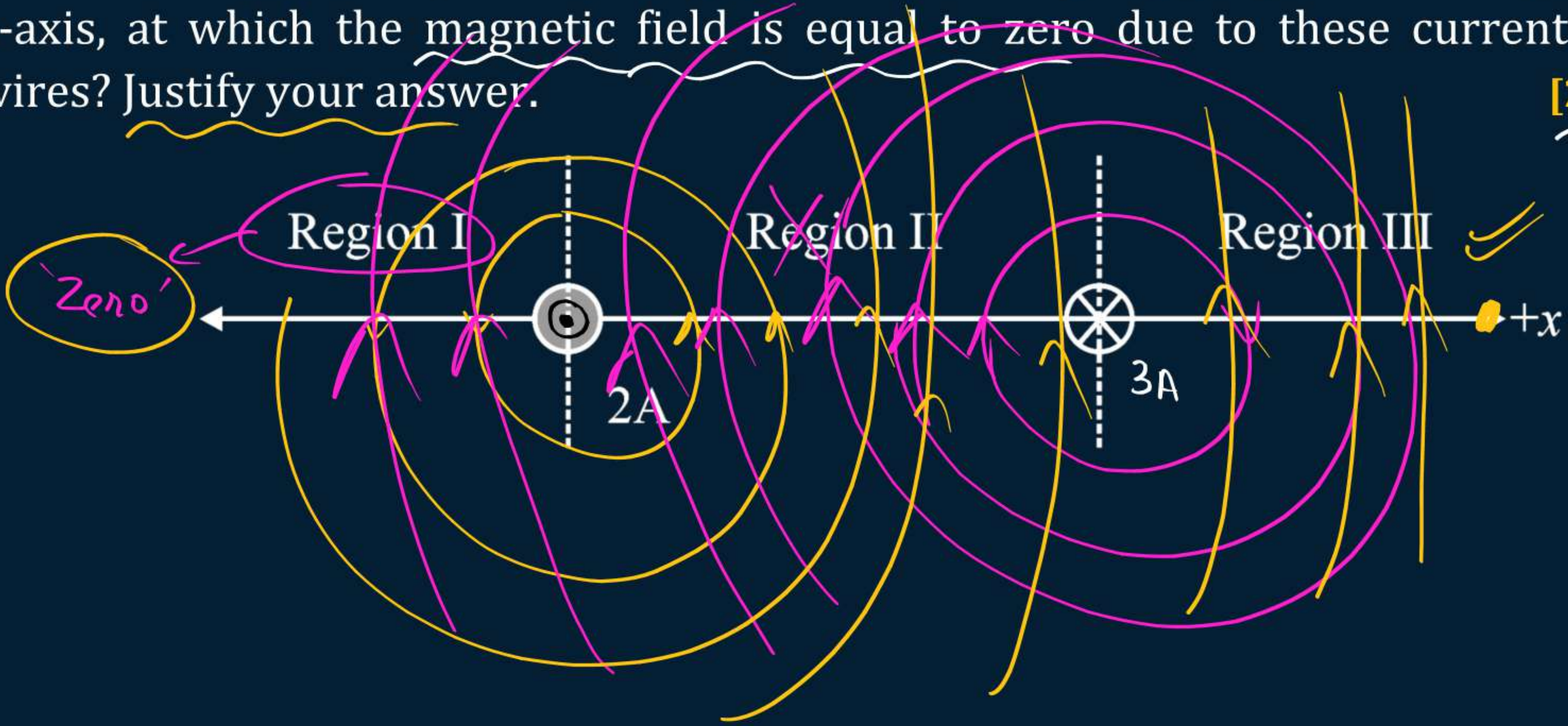
(D) If both Assertion (A) and Reason (R) are false.

$r = \frac{mv}{qB}$

$r = \frac{p}{qB}$ $\rightarrow$ Const.

QUESTION

Two straight infinitely long wires are fixed in space so that the current in the left wire is 2 A and directed out of the plane of the page and the current in the right wire is 3 A and directed into the plane of the page. In which region(s) is/are there a point on the x-axis, at which the magnetic field is equal to zero due to these currents carrying wires? Justify your answer. **[2020-21]**



QUESTION

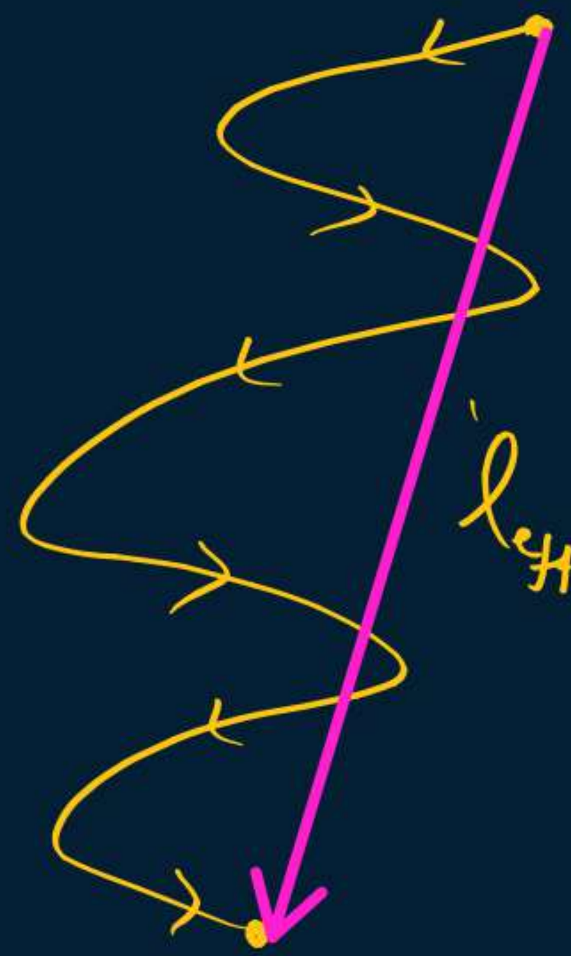
Derive an expression for magnetic force $\vec{F}$ acting on a straight conductor of length L carrying current I in an external magnetic field $\vec{B}$. Is it valid when the conductor is in zig-zag form? Justify

[2024]

$$\boxed{F = BIL\sin\theta}$$

$$\downarrow$$

$$\vec{l}_{eff}$$



'l_{eff}' → Vector Length

QUESTION

Two wires carrying currents I_1 and I_2 lie, one slightly above the other, in a horizontal plane as shown in figure. The region of vertically upward strongest magnetic field is

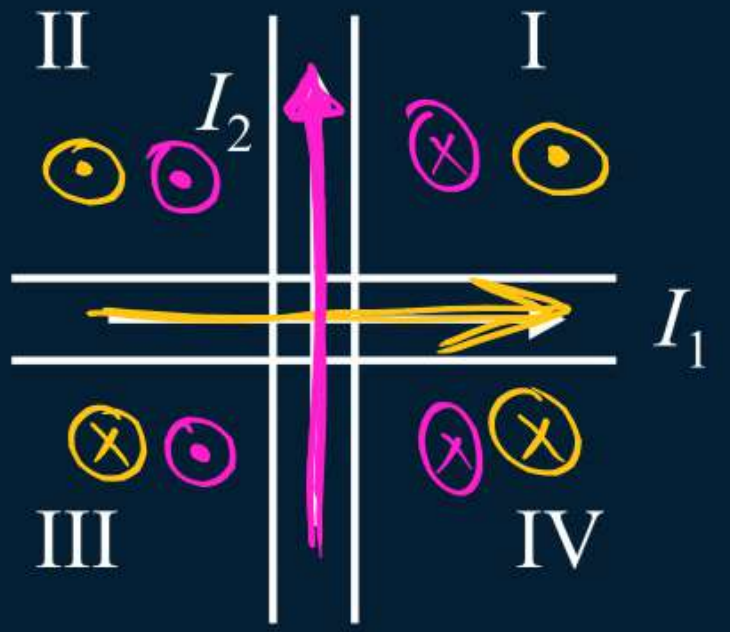
[2021-22]

A I

B II

C III

D IV



QUESTION

Scalar

Assertion (A): The energy of a charged particle moving in a magnetic field does not change. T

Reason (R): It is because the work done by the magnetic force on the charge moving in a magnetic field is zero. T

[2024]

$W = \vec{F} \cdot \vec{s}$

$= Fs\cos 90$

$W = 0$

(A) If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).

(B) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).

(C) If Assertion (A) is true but Reason (R) is false.

(D) If both Assertion (A) and Reason (R) are false

$W = 0$

$\Delta K = 0$

$K_f - K_i = 0$

$K_f = K_i$

QUESTION

$He^{2+} \Rightarrow q = 2 \times 1.6 \times 10^{-19}\,C$

10,000 Volts

An α-particle is accelerated through a potential difference of 10 kV and moves along *x*-axis. It enters in a region of uniform magnetic field $B = 2 \times 10^{-3}$ T acting along y-axis. Find the radius of its path.

(Take mass of α-particle = 6.4×10^{-27} kg) **[2020]**

$$\boxed{r = \frac{1}{B}\sqrt{\frac{2mV}{q}}}$$

$$= \frac{1}{2 \times 10^{-3}}\sqrt{\frac{2 \times 6.4 \times 10^{-27} \times 10000}{2 \times 1.6 \times 10^{-19}}}\ m$$

Homework

'Backlog'

Revision of Ch-1, 2, 3, 4

Checklist

	Lec	DPP + Assign	Test	Rev I	Rev II	Rev III
Ch-1 Electric Charges & field	✓	✓	✓	✓	✓	
Ch2						
Ch3						
Ch4						