

ULTIMATE KCET



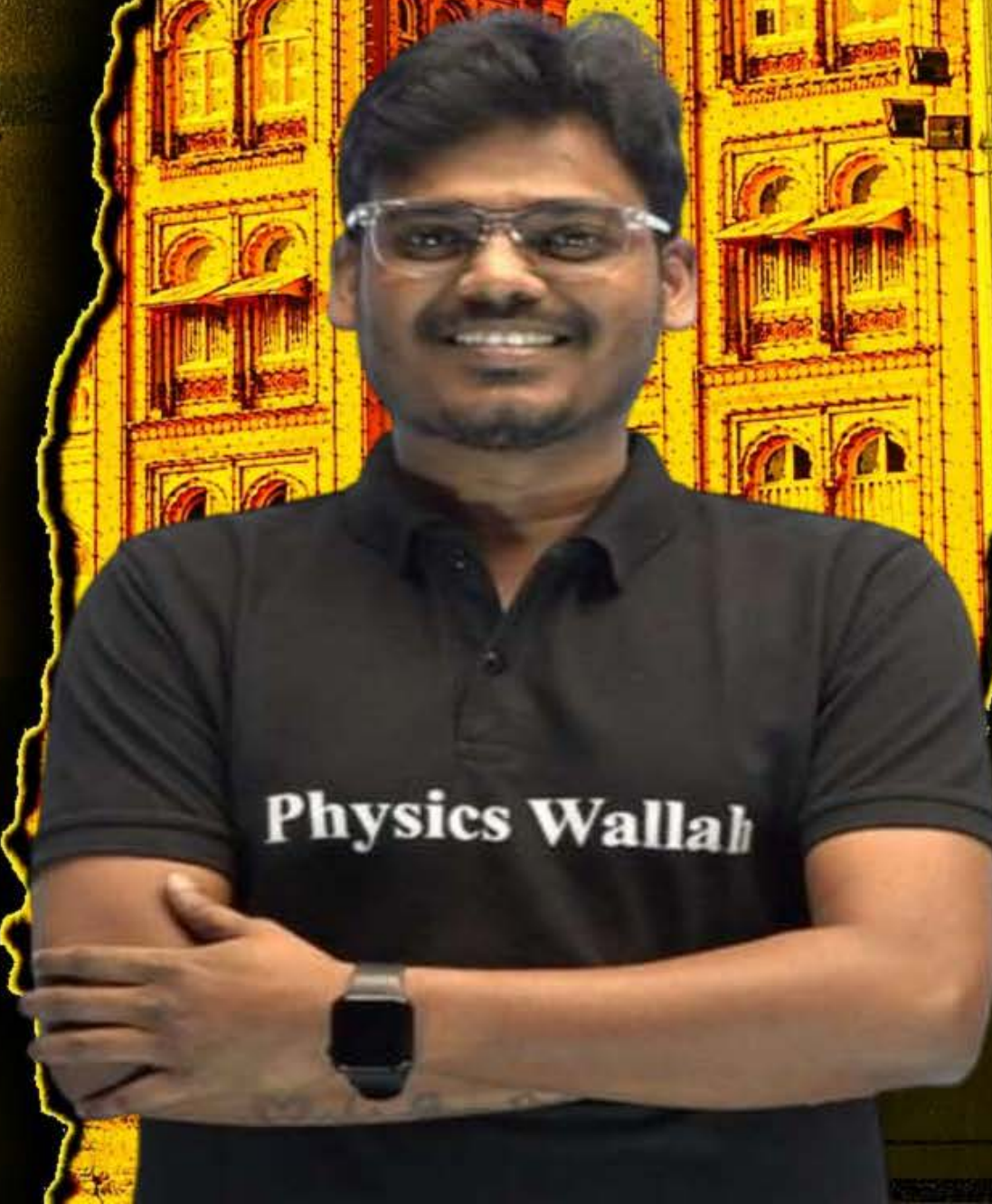
CRASH COURSE 2026

PHYSICS

Lecture - 01

MAGNETISM AND MATTER

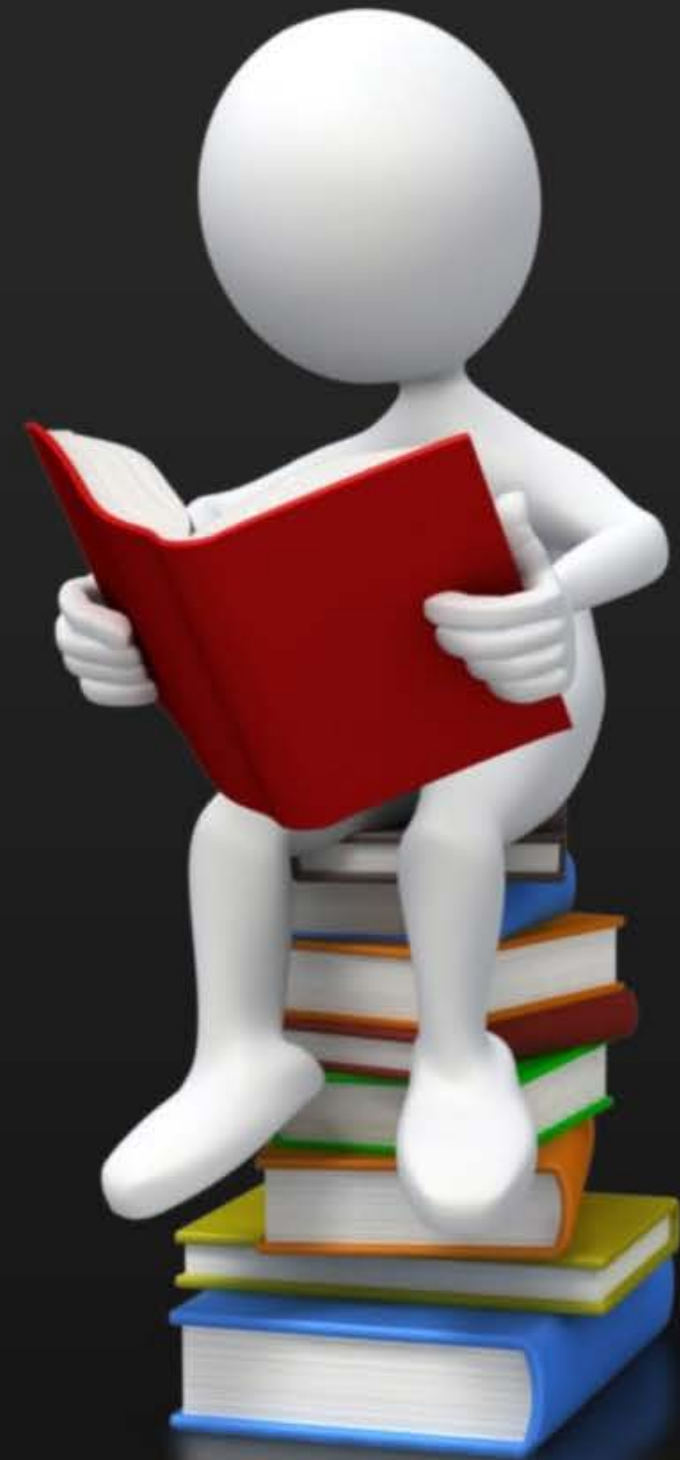
By - AK SIR



Topics *to be covered*



- 1** TORQUE ON A CURRENT CARRYING COIL IN A MAGNETIC FIELD
- 2** CONVERSION OF A GALVANOMETER INTO AMMETER AND VOLTMETER
- 3** BAR MAGNET AND MAGNETIC FIELD LINES
- 4** MAGNETIC MOMENT AND CLASSIFICATIONS OF MAGNETIC MATERIALS





Torque on current carrying loop

When a current carrying loop is placed in an external magnetic field experiences a torque. This torque is the basis of the working of galvanometers as well as of electric motors.

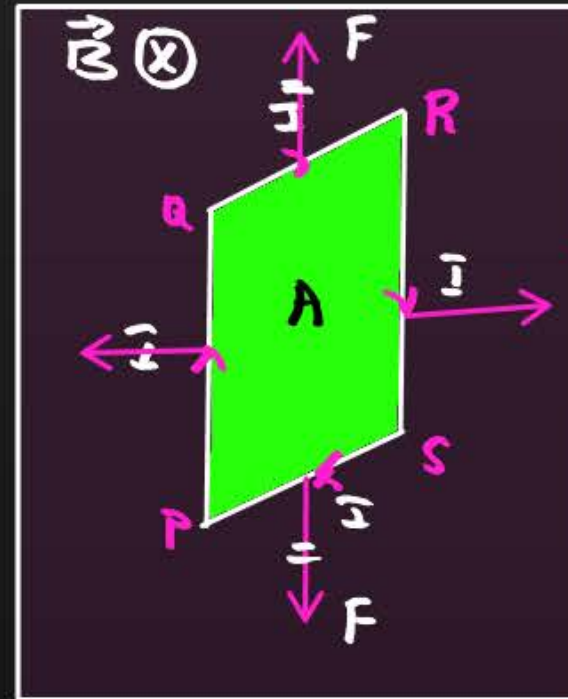
Electric field

$$\tau = PE \sin \theta$$

$$\vec{\tau} = \vec{p} \times \vec{E} \quad p = q \times 2d$$

$$U = -pE \cos \theta = -\vec{p} \cdot \vec{E}$$

$$W = -pE [\cos \theta_2 - \cos \theta_1]$$



Magnetic field

$$\tau = MB \sin \theta$$

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

$$m = NIA$$

$$PE, U = -MB \cos \theta$$

$$\text{Work done, } W = -MB [\cos \theta_2 - \cos \theta_1]$$

Question



A 250 turn rectangular coil of length 2.1 cm and width 1.25 cm carries a current of 85 μA and subjected to the magnetic field of strength 0.85 T. Work done for rotating the coil by 180° against the torque is:

A 4.55 μJ

B 2.3 μJ

C 1.15 μJ

D 9.4 μJ

$$\theta_1 = 0^\circ$$
$$\theta_2 = 180^\circ$$

$$\text{Work done, } W = -mB(\cos\theta_2 - \cos\theta_1)$$

$$W = -NIAB(\cos 180^\circ - \cos 0^\circ)$$

$$W = -NIAB(-1 - 1) = 2NIAB$$

$$W = 2 \times 250 \times 85 \times 10^{-6} \times 2.1 \times 10^{-2} \times 1.25 \times 10^{-2} \times 0.85$$

$$W = 9.4 \times 10^{-6} \text{ J}$$

$$W = 9.4 \mu\text{J}$$

Question



A rectangular coil of length 0.12 m and width 0.1 m having 50 turns of wire is suspended vertically in a uniform magnetic field of strength 0.2 Wb/m^2 . The coil carries a current of 2 A. If the **plane** of the coil is inclined at an angle of 30° with the direction of the field, the torque required to keep the coil in **stable equilibrium** will be:

- A** 0.15 N-m
- B** 0.20 N-m
- C** 0.24 N-m
- D** 0.12 N-m

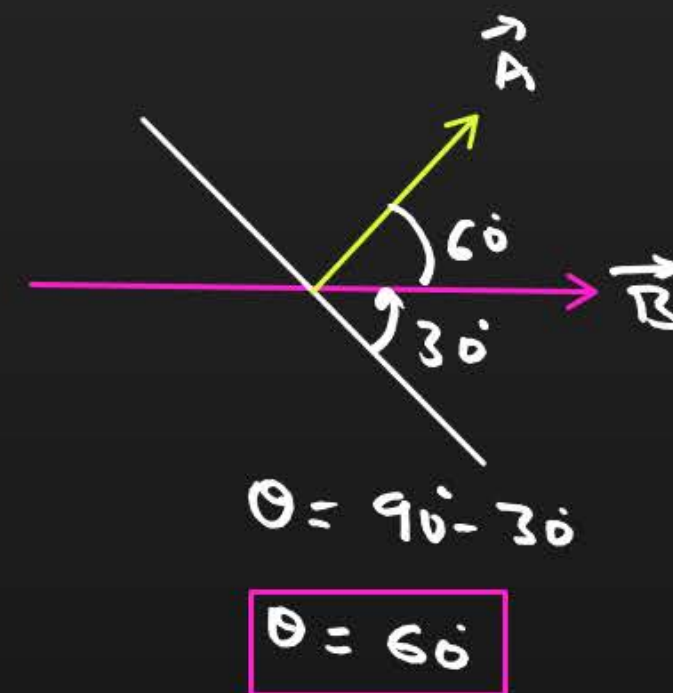
$$\tau = MB \sin \theta$$

$$\tau = NIA B \sin \theta$$

$$\tau = 50 \times 2 \times 0.12 \times 0.1 \times 0.2 \times \sin 60$$

$$\tau = 0.24 \times \frac{\sqrt{3}}{2}$$

$$\tau = 0.20 \text{ N-m}$$



Question



A closely wound solenoid of 2000 turns and area of cross-section $1.5 \times 10^{-4} \text{ m}^2$ carries a current of 2.0 A. It is suspended through its centre and perpendicular to its length, allowing it to turn in a horizontal plane in a uniform magnetic field $5 \times 10^{-2} \text{ T}$ making an angle of 30 deg with the axis of the solenoid. The torque on the solenoid will be [H.W]

- A** $3 \times 10^{-3} \text{ N-m}$
- B** $1.5 \times 10^{-3} \text{ N-m}$
- C** $1.5 \times 10^{-2} \text{ N-m}$
- D** $3 \times 10^{-2} \text{ N-m}$

Question



A current loop in a magnetic field :

$$\tau = MB \sin \theta$$

$$\tau_{\min} = 0 \quad \theta = 0 \rightarrow \text{stable}$$

$$\tau_{\max} = MB \quad \theta = 90^\circ$$

$$\tau_{\min} = 0, \theta = 180^\circ \rightarrow \text{unstable}$$

- A** experiences a torque whether the field is uniform or non-uniform in all orientations
- B** can be in equilibrium in one orientations. ✗
- C** can be equilibrium in two orientations, both the equilibrium states are unstable ✗
- D** can be in equilibrium in two orientations, one stable while the other is unstable ✓



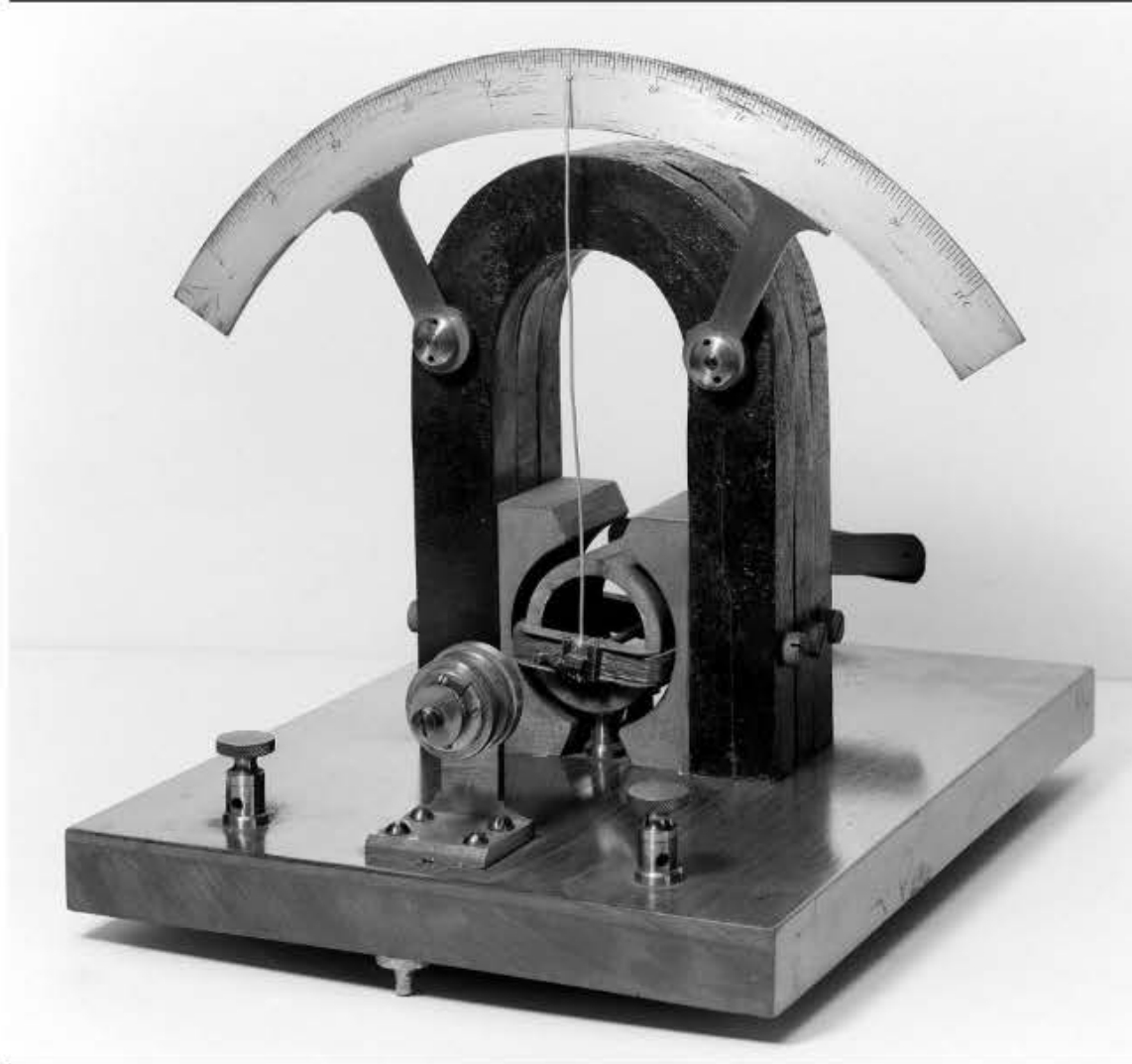
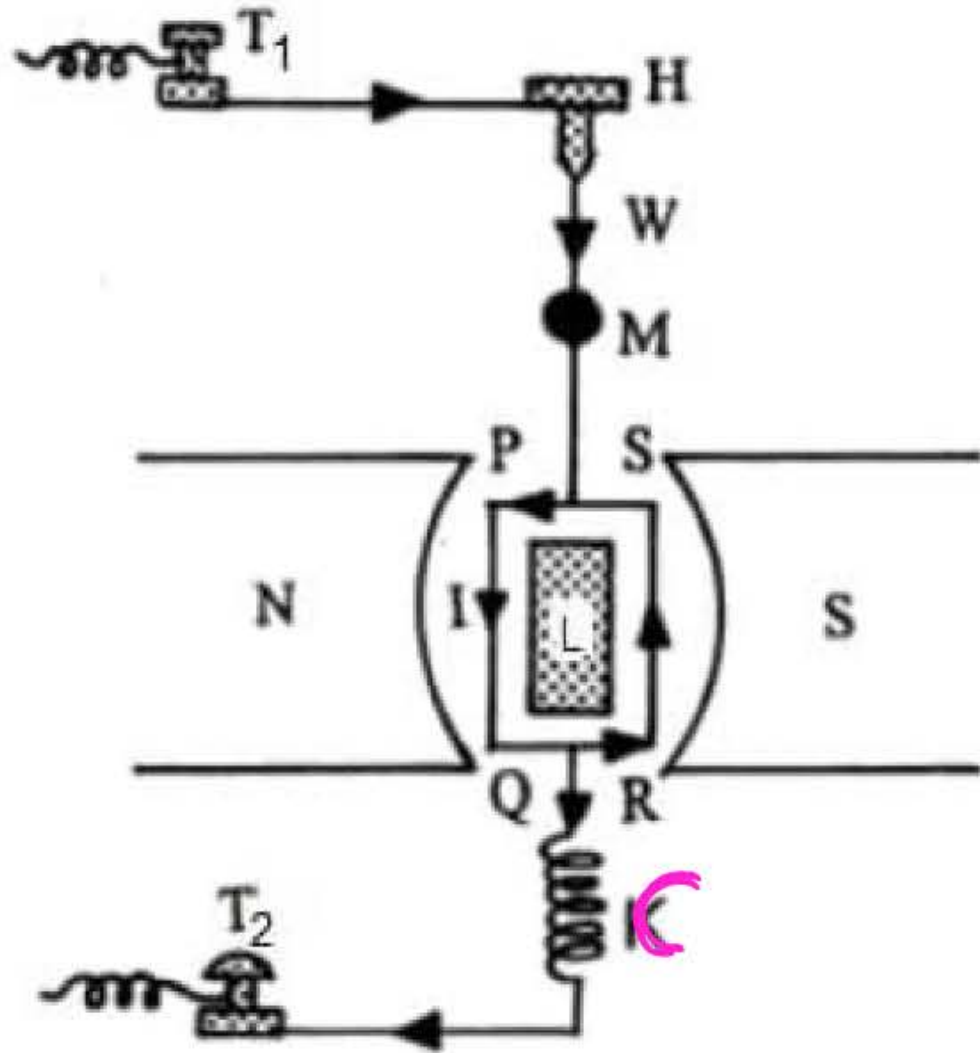
Moving coil galvanometer

$$\tau_{\text{wire}} = \tau_{\text{coil}}$$

$$C\theta = NIAB$$

$$\sin\theta = 1$$

$$\theta = \frac{NIAB}{C}$$

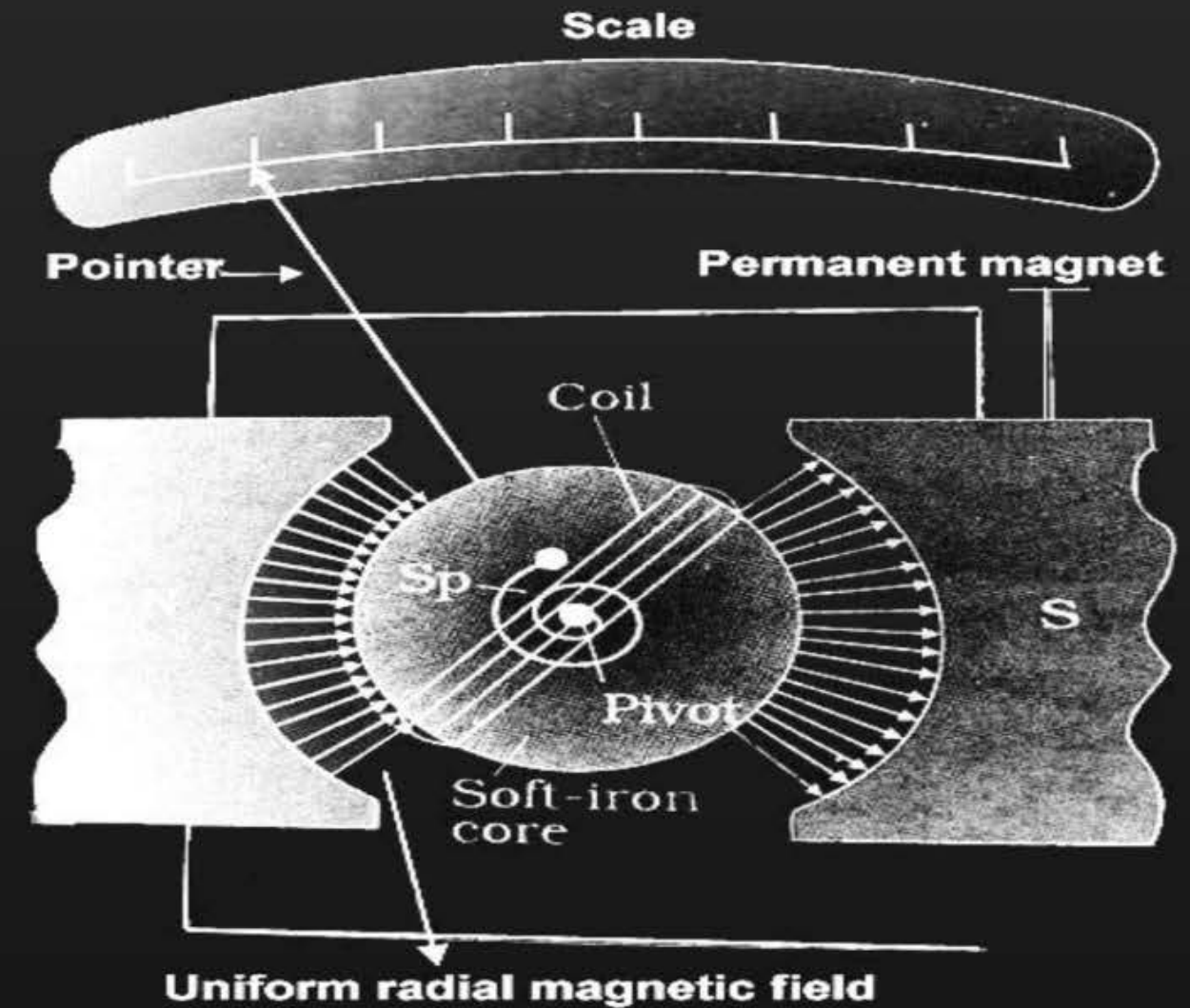




Moving coil galvanometer

It is an instrument used to measure low electric currents.

Principle : It works on the principle that a current carrying coil placed in a magnetic field experiences a torque.





Sensitivity of Galvanometer

Sensitivity: A galvanometer is said to be sensitive if small current passed through it produces a sufficiently large deflection.

Types of sensitivity of Galvanometer :

1. Current sensitivity
2. Voltage sensitivity



Current Sensitivity of Galvanometer

The current sensitivity of a galvanometer is defined as the deflection produced in the galvanometer when a unit current flows through it.

$$I_s = \frac{\phi}{I} = \frac{\phi}{I_g} = \frac{NAB}{C \cdot I}$$

$$I_s = \frac{NAB}{C}$$

$$\phi \propto I$$

$$\text{Unit} \Rightarrow \frac{\text{div}}{A} = \text{div/A}^*$$

$$\frac{\text{rad}}{A} = \text{rad/A}$$



Voltage Sensitivity of Galvanometer

The voltage sensitivity of a galvanometer is defined as the deflection produced in the galvanometer when a unit voltage is applied across its coil.

$$V_s = \frac{\phi}{V_g} = \frac{\phi}{IR} = \frac{NZAB}{IRC}$$

$$V_s = \frac{NAB}{CR}$$

$$\Rightarrow V_s = \frac{1}{R} \left[\frac{NAB}{C} \right]$$

$$V_s = \frac{1}{R} \times I_s$$

*

$$V_s = \frac{I_s}{R}$$

Unit \Rightarrow div/v
rad/v

Question



The number of turns in a coil of galvanometer is **tripled**, then

$$I_s = \frac{NAB}{C}$$

$$I_s' = \frac{3NAB}{C} = \underline{\underline{3I_s}}$$

N

$$N' = 3N$$

$$V_s = \frac{NAB}{CR}$$

$$N' = 3N$$

$$R = \frac{\rho l}{A}$$

$$R \propto l$$

$$l' = 3l$$

$$R' = 3R$$

$$R' = 3R$$

$$V_s' = \frac{(3N)AB}{C(3R)}$$

$$V_s' = \frac{NAB}{CR} = \text{constant}$$

A

voltage sensitivity increases 3 times and current sensitivity remains constant

B

voltage sensitivity remains constant and current sensitivity increases 3 times

C

both voltage and current sensitivity remains constant

D

both voltage and current sensitivity decreases by 33%

Question



The current sensitivity of a moving coil galvanometer is 5 div/mA and its voltage sensitivity (angular deflection per unit voltage applied) is 20 div/V. The resistance of the galvanometer is:

- A** 40 Ω
- B** 25 Ω
- C** 250 Ω
- D** 500 Ω

$$V_s = \frac{I_s}{R}$$

$$R = \frac{I_s}{V_s} = \frac{5 \text{ div/V}}{10^{-3} \text{ A}} \times \frac{1}{20 \frac{\text{div}}{\text{V}}}$$

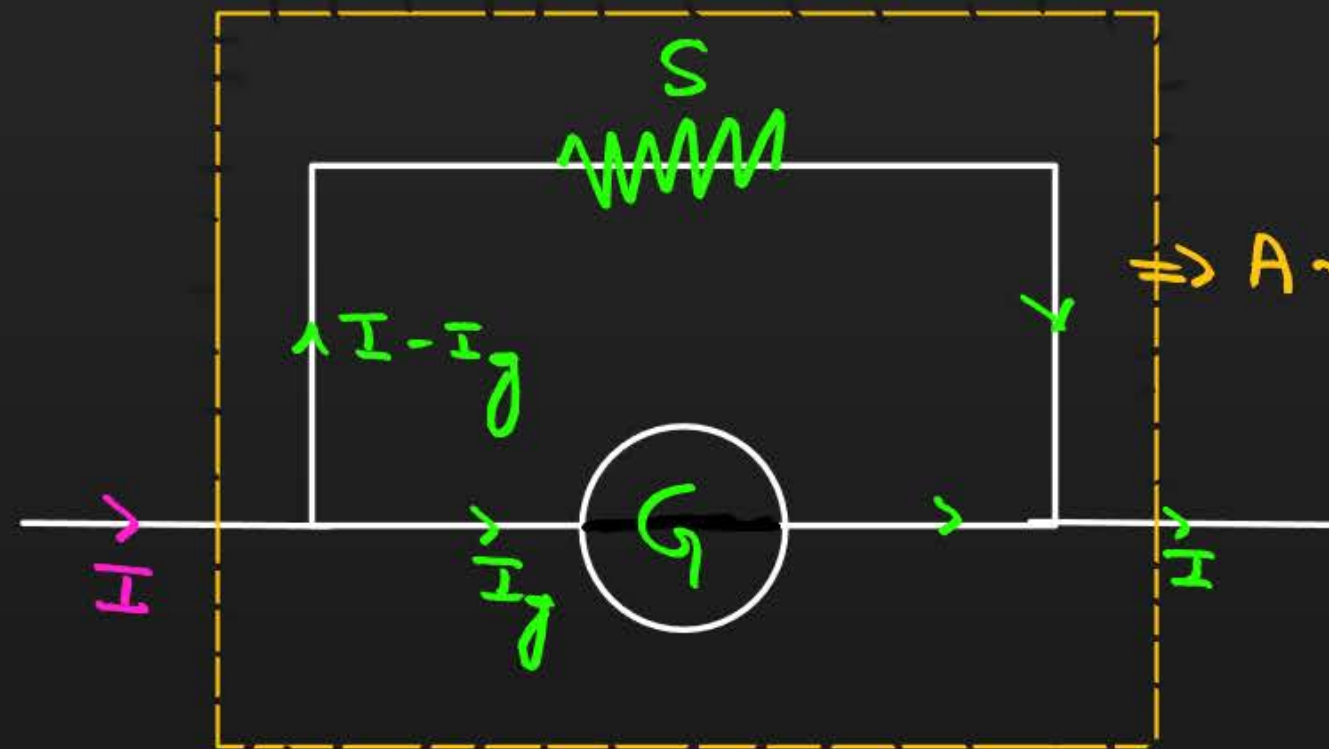
$$R = \frac{5 \times 10^3 \text{ V/A}}{20}$$

$$R = \frac{1}{4} \times 10^3 = 0.25 \times 10^3$$

$$R = 250 \Omega$$



Galvanometer conversion to Ammeter



↳ CKT - SERIES.

Parallel combination

$$V_g = V_s$$

$$I_g G = (I - I_g) S$$

$$S = \left(\frac{I_g}{I - I_g} \right) G$$

→ $G \rightarrow A$

→ connect S-Resistor parallel

↓
Small

$$\overline{I}_g G = (\overline{I} - \overline{I}_g) S$$

$$\overline{I}_g G = \overline{I} S - \overline{I}_g S$$

$$\overline{I}_g G + \overline{I}_g S = \overline{I} S$$

$$\overline{I}_g (S + G) = \overline{I} S$$

$$\overline{I}_g = \left(\frac{S}{S + G} \right) \overline{I}$$

Question



A galvanometer coil has a resistance of 15Ω and gives full scale deflection for a current of 4 mA . To convert it to an ammeter of range 0 to 6 A .

- A** $10\text{m}\Omega$ resistance is to be connected in parallel to the galvanometer
- B** $10\text{m}\Omega$ resistance is to be connected in series with the galvanometer
- C** 0.1Ω resistance is to be connected in parallel to the galvanometer
- D** 0.1Ω resistance is to be connected in series with the galvanometer

$$S = \left(\frac{I}{I_g} \right) G$$

$$S = \left(\frac{4 \times 10^{-3}}{6 - 4 \times 10^{-3}} \right) \times 15$$

$$S = \frac{4 \times 10^{-3} \times 15}{\approx 6}$$

$$S = 10 \times 10^{-3} \Omega$$

$$S = 10\text{m}\Omega$$

Question



Two similar galvanometers are converted into an ammeter and a milli-ammeter. The shunt resistance of ammeter as compared to the shunt resistance of mill-ammeter will be

A Less

B Equal ✗

C Zero ✗

D More

$$V = IR$$

$$V = \text{const}$$

$$I \propto \frac{1}{R}$$

$$I_A > I_{mA}$$

$$R_A < R_{mA}$$

$$R_{mA} > R_A$$

Question



A moving coil galvanometer is converted into an ammeter of range 0 to 5 mA. The galvanometer resistance is 90Ω and the shunt resistance has a value of 10Ω . If there are 50 divisions in the galvanometer-turned-ammeter on either sides of zero, its **current sensitivity is**

- A** 2×10^4 div/A
- B** 1×10^5 A/div
- C** 2×10^4 A/div
- D** 1×10^5 div/A

$$I_s = \frac{50}{5 \times 10^{-4}}$$

$$I_s = 10 \times 10^4$$

$$I_s = 10^5 \text{ div/A}$$

$$I_s = \frac{\Phi}{I} = \frac{\Phi}{I_g}$$

$$I_g = \left(\frac{S}{S+G} \right) I = \left(\frac{10}{10+90} \right) \times 5 \times 10^{-3}$$

$$I_g = \frac{10}{100} \times 5 \times 10^{-3}$$

$$I_g = 5 \times 10^{-4} \text{ A}$$

Question



A certain current on passing through a galvanometer produces a deflection of 100 divisions. When a shunt of 1Ω is connected, the deflection reduces to 1 division. The galvanometer resistance is S

A $100\ \Omega$

B $99\ \Omega$

C $10\ \Omega$

D $9.9\ \Omega$

$$I_g = \left(\frac{S}{S+G} \right) I$$

$$1 = \left(\frac{1}{1+G} \right) 100$$

$$1+G = 100$$

$$G = 100 - 1$$

$$G = 99\ \Omega$$

$$\phi \propto I$$

$$I \propto \phi$$

$$I = 100 \text{ units}$$

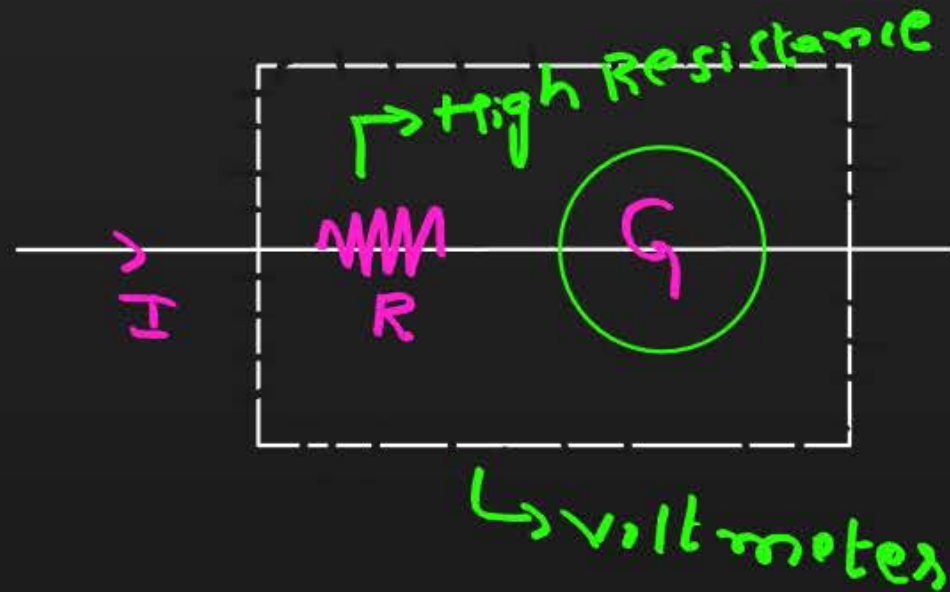
$$S = 1\ \Omega$$

$$I_g = 1 \text{ unit}$$



Galvanometer conversion to Voltmeter

↳ CRT \Rightarrow parallel.



$$\Rightarrow V = IR_T$$

$$V_g = V = I(R + G)$$

$$V = I(R + G)$$

$$V_g = I_g(R + G)$$

$$R = \frac{V_g}{I_g} - G$$

Question



A galvanometer of resistance 50Ω is connected to a battery $3V$ along with a resistance 2950Ω in series. A full scale deflection of 30 divisions is obtained in the galvanometer. In order to reduce this deflection to 20 divisions, the resistance in series should be

A 5550Ω

B 5050Ω

C 4450Ω

D 6050Ω

$$I_g = \frac{V}{R+G}$$

$$I_g = \frac{3}{50+2950}$$

$$I_g = \frac{3}{3000}$$

$$I_g = 10^{-3} A = 1 \text{ mA}$$

$30 \text{ div} \rightarrow 1 \text{ mA}$

$1 \text{ div} \rightarrow \frac{1}{30} \text{ mA}$

$20 \text{ div} \rightarrow \frac{20}{30} \text{ mA} = \frac{2}{3} \text{ mA}$

$$I_g' = \frac{V}{R'+G}$$

$$\frac{2}{3} \times 10^{-3} = \frac{3}{R'+50}$$

$$R'+50 = \frac{9}{2 \times 10^{-3}}$$

$$R'+50 = 4.5 \times 10^3$$

$$R'+50 = 4500$$

$$R' = 4450 \Omega$$

Question



A galvanometer of resistance 50Ω is connected to a battery of 3 V along with a resistance of 2950Ω in series shows full-scale deflection of 30 divisions. The **additional series resistance** required to reduce the deflection to 20 divisions is

A 3950Ω

B 1500Ω

C 4450Ω

D 7500Ω

$$R' = 4450\Omega$$

$$R_{\text{Add}} = R' - R$$

$$= 4450 - 2950$$

$$= 1500\Omega$$

Question



A galvanometer coil has a resistance of 50Ω and the meter shows full scale deflection for a current of 5 mA. This galvanometer is **converted into voltmeter** of range 0-20V by connecting.

- A** 3950Ω in series with galvanometer
- B** 4050Ω in series with galvanometer
- C** 3950Ω in ~~parallel~~ with galvanometer
- D** 4050Ω in ~~parallel~~ with galvanometer

$$R = \frac{V}{I} - G$$

$$R = \frac{20}{5 \times 10^{-3}} - 50 = 4 \times 10^3 - 50 = 4000 - 50$$

$$R = 3950\Omega$$

Question



A galvanometer of resistance 50Ω gives a full scale deflection for a current 5×10^{-4} A. The resistance that should be connected in series with the galvanometer to read 3V is

A 5059Ω

B 595Ω

C 5950Ω

D 5050Ω

$$R = \frac{V_g}{I_g} - G = \frac{3}{5 \times 10^{-4}} - 50$$

$$R = 0.6 \times 10^4 - 50 = 6000 - 50$$

$$R = 5950\Omega$$



MAGNETISM AND MATTER



KCET analysis of chapter – Marks weightage

Year	Topic
2025(1Q)	Diamagnetic substance
2024(2Q)	Magnetic hysteresis and Magnetic susceptibility
2023(3Q)	Curie temperature, Earth's magnetic field and Torque
2022(1Q)	Earth's magnetic field
2021(2Q)	Earth's magnetic field and Electric & magnetic field patter

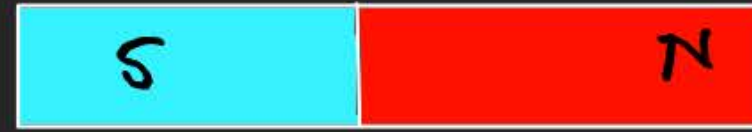


KCET analysis of chapter – Marks weightage

Year	Topic
2020(3Q)	Permanent magnet, Magnetization and Magnetic moment
2019(4Q)	Permanent Magnet, Coersivity, Time period of oscillations and work done on a loop
2018(3Q)	Properties of diamagnet, paramagnet and ferromagnet. Earth's magnet and Angle of dip
2017(4Q)	Susceptibility, properties of bar magnet, dip angle and oscillations
2016(1Q)	Susceptibility
2015(3Q)	Earth's magnet, Time period of magnet and magnetic susceptibilty



Bar Magnet



Magnet : Magnet is an object which attracts pieces of magnetic material.

1. Magnet has two poles. *i.e S & N*
2. Un-Like poles attract and like poles repel.

$N-N \rightarrow \text{Repel}$
 $S-S \rightarrow \text{"}$
 $N-S \rightarrow \text{Attract}$
 $S-N \rightarrow \text{"}$

Magnetic Material: The material/substance which is attracted by magnet.

Examples : Iron, Nickel and Cobalt.

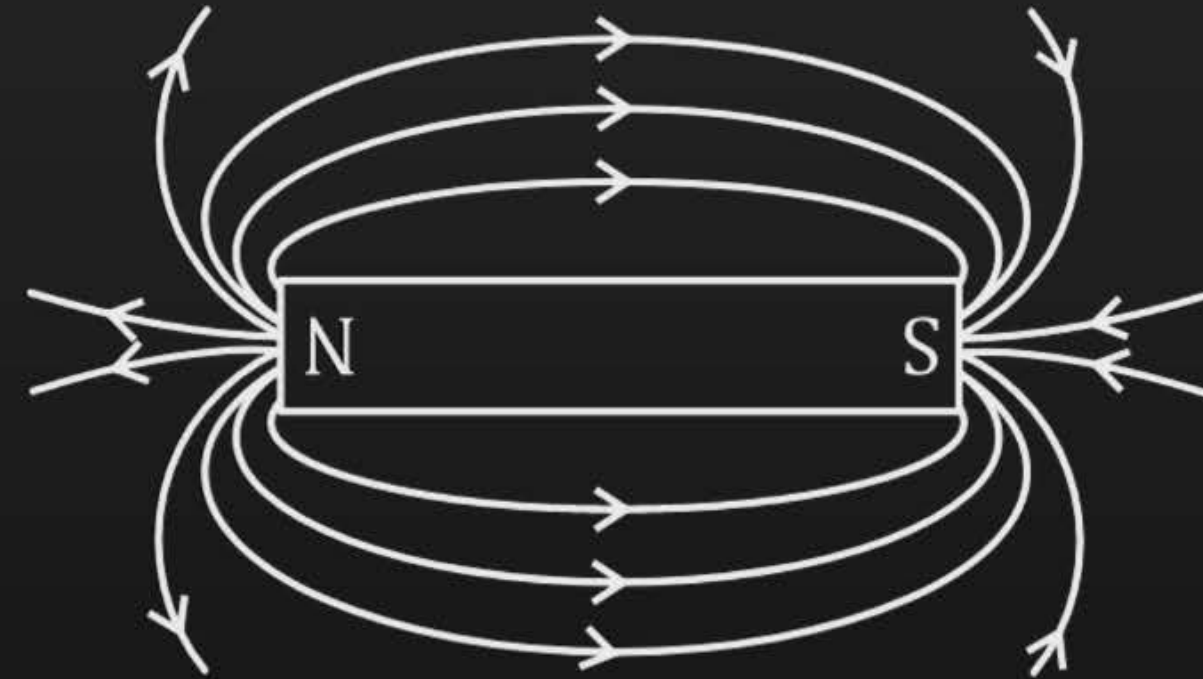
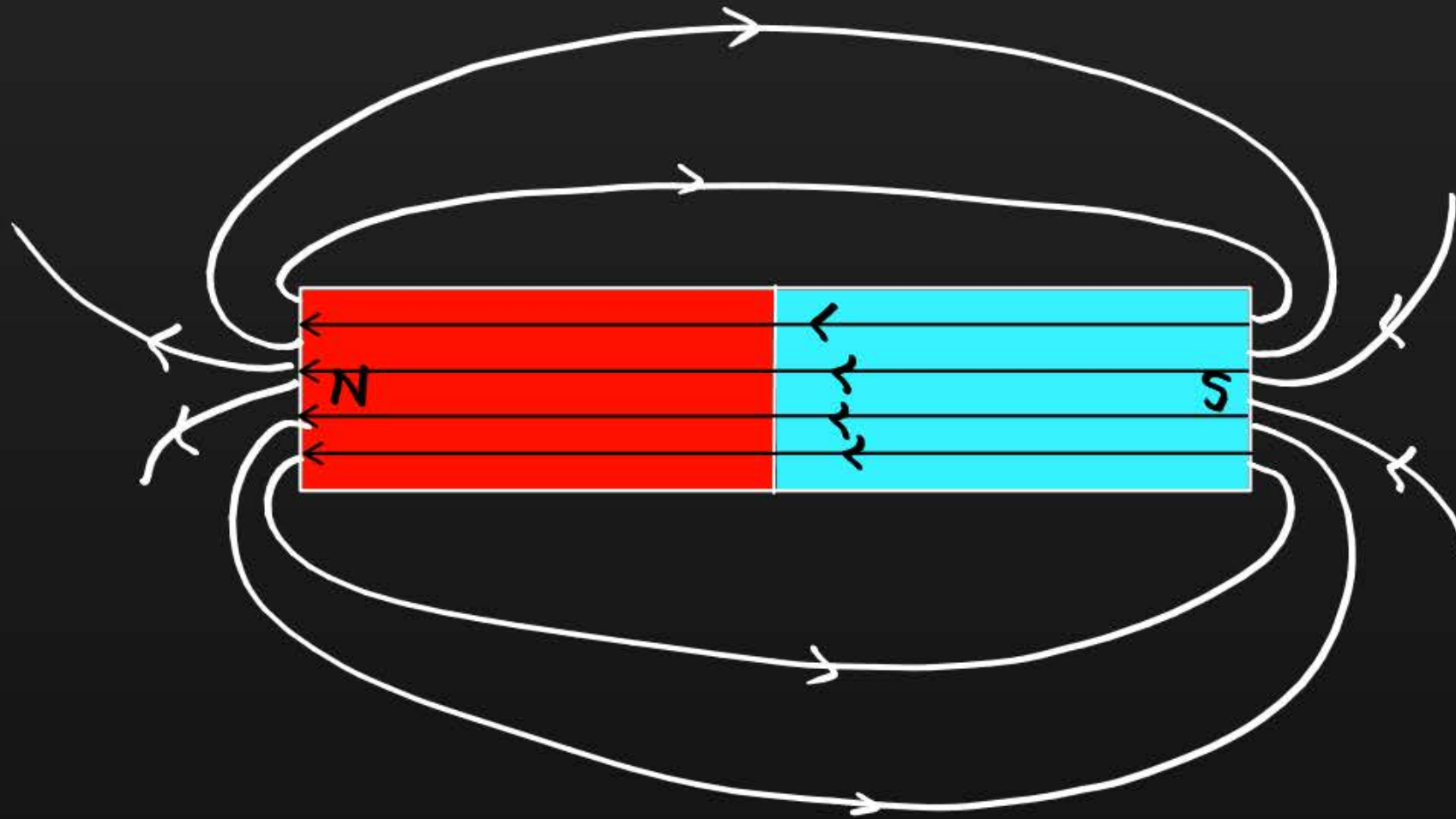
Non-Magnetic : Aluminum, Gold, Silver, Copper, Lead and Brass.

Uses : Magnets are used in Magnetic resonance imaging [MRI], Audio and video cassette, Radio and Television[TV]



Magnetic field lines

The imaginary lines drawn around the magnet to represent the magnetic field is called Magnetic field lines.





Properties of Magnetic field lines

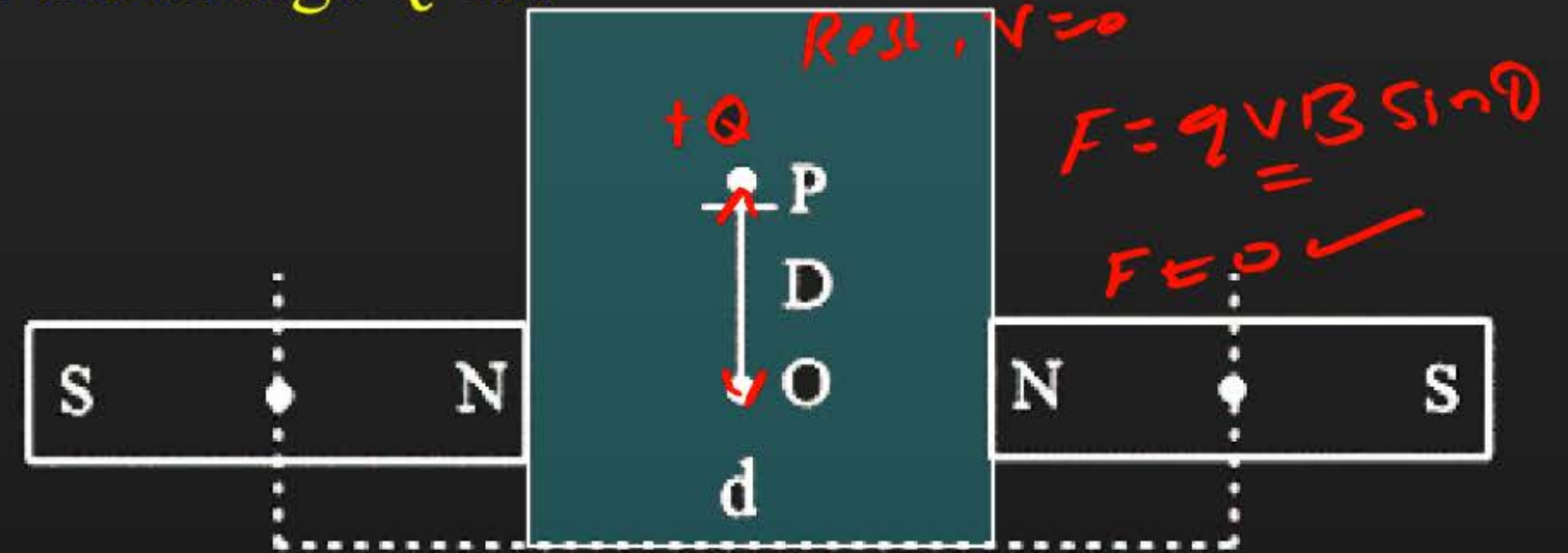
1. Like poles repel each other and unlike poles attract each other and follows inverse square law.
2. The Magnetic field lines originate from the north pole of magnet and moves towards south pole-**Outside Magnet.**
3. The Magnetic field lines move from south pole to north pole-**Inside Magnet**
4. The Field lines cannot cross or intersect each other.
5. The Field lines are continuous & closed loops.
6. They are crowded near the poles which represents the magnetic field is strong.

Question



Two identical bar magnets are fixed with their centers at a distance d apart. A stationary charge Q is placed at P in between the gap of the two magnets at a distance D from the center O as shown in the figure, The force on the charge Q is?

- A** Zero
- B** Directed along OP
- C** Directed along PO
- D** Directed perpendicular to the plane of paper



Question



The magnetic lines of force **inside** a bar magnet

- A** Are from north-pole of the magnet *→ outside*
- B** Do not exist *x*
- C** Depend upon the area of cross-section of the bar magnet *x*
- D** Are from south-pole to north of the magnet

Question



Magnetic field lines produced by a bar magnet, ^{CROSS} cut each other.

- A** At neutral points
- B** Near the poles of the magnets
- C** At equatorial axis
- D** Never intersects to each other

Question



Which of the following properties is 'False' for a bar magnet?

- A** It doesn't produce magnetic field ✗
- B** Its like poles repel and unlike poles attract ✓
- C** Its poles cannot be separated ✓
- D** It points in North-South direction when suspended ✓



Magnetic Moment of bar Magnet (\vec{M})

A magnetic dipole consists of a pair of magnetic poles of equal and opposite strength separated by small distance.

Examples :

1. Magnetic needle
2. Bar Magnet ✖
3. Current carrying coil/solenoid etc.



Magnetic Moment of bar Magnet (\vec{M})

$q \rightarrow m$
 $E \rightarrow B$
 $P \rightarrow N$

For current carrying loop,

The magnetic dipole moment - $M = NIA$



Magnetic dipole moment of bar magnet

Magnetic moment = Pole strength \times separation between poles

$m \rightarrow$ pole strength
 $(A \cdot m)$

$$\vec{M} = m \times L \Rightarrow M = mL \Rightarrow A \cdot m \cdot m = A \cdot m^2$$

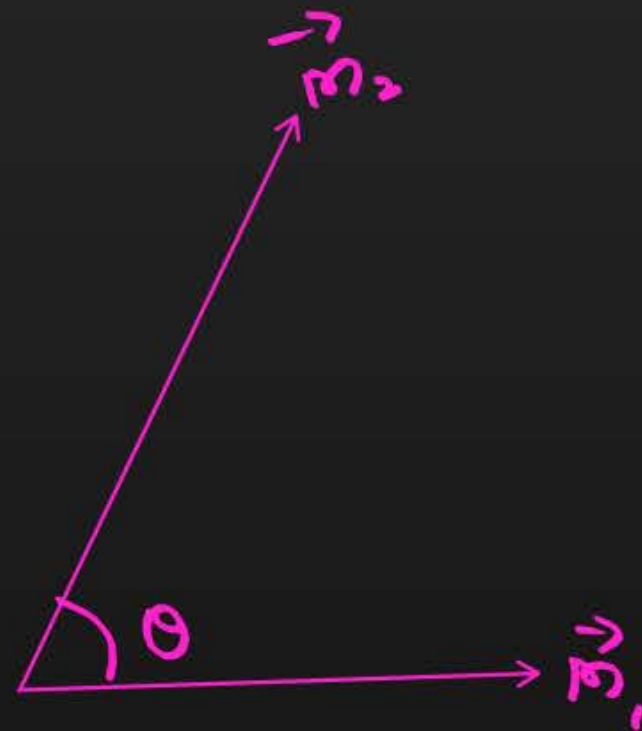
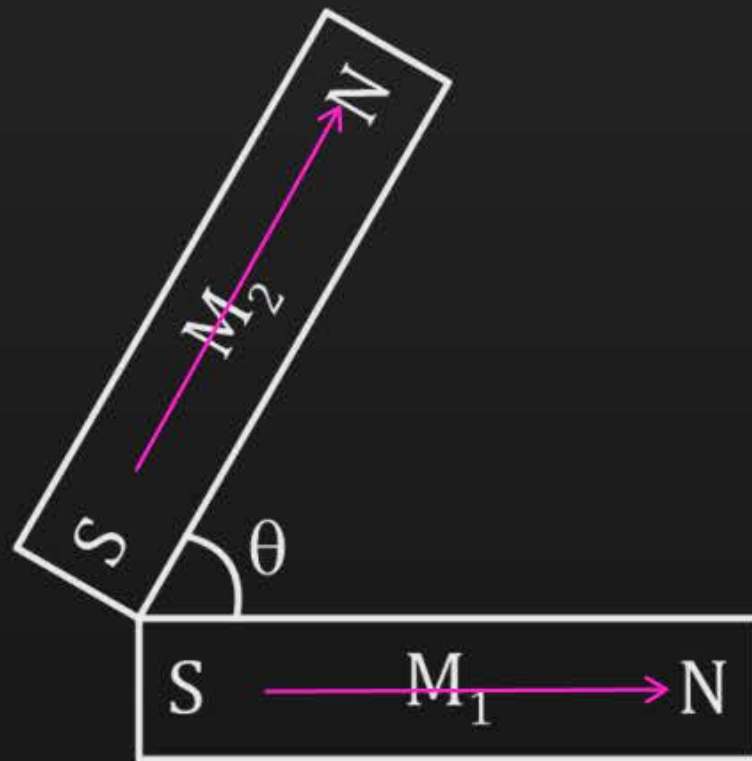
- Vector quantity which directed from south pole to north pole.
- It follows vector law of addition

IF $A = B$
 $R = 2A \cos\left(\frac{\theta}{2}\right)$

$$R = \sqrt{A^2 + B^2 + 2AB \cos \theta}, A \neq B$$



Equivalent Magnetic Moment



$$R = \sqrt{m_1^2 + m_2^2 + 2m_1m_2 \cos\theta}$$

$$\hookrightarrow m_1 \neq m_2$$

$$\hookrightarrow \text{If } m_1 = m_2 = m$$

$$R = 2m \cos\left(\frac{\theta}{2}\right)$$



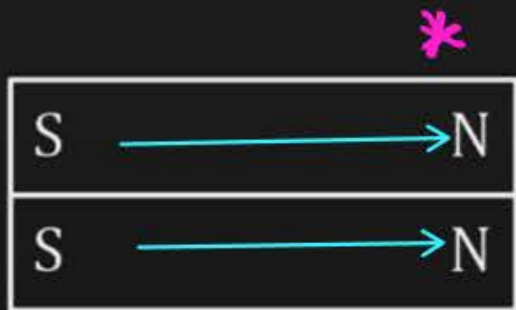
Equivalent Magnetic Moment

Every magnet have magnetic moment (\vec{M}). Find equivalent magnetic moment in following cases.

(i) $R = 2m \cos\left(\frac{\theta}{2}\right)$

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

$R = 2m$

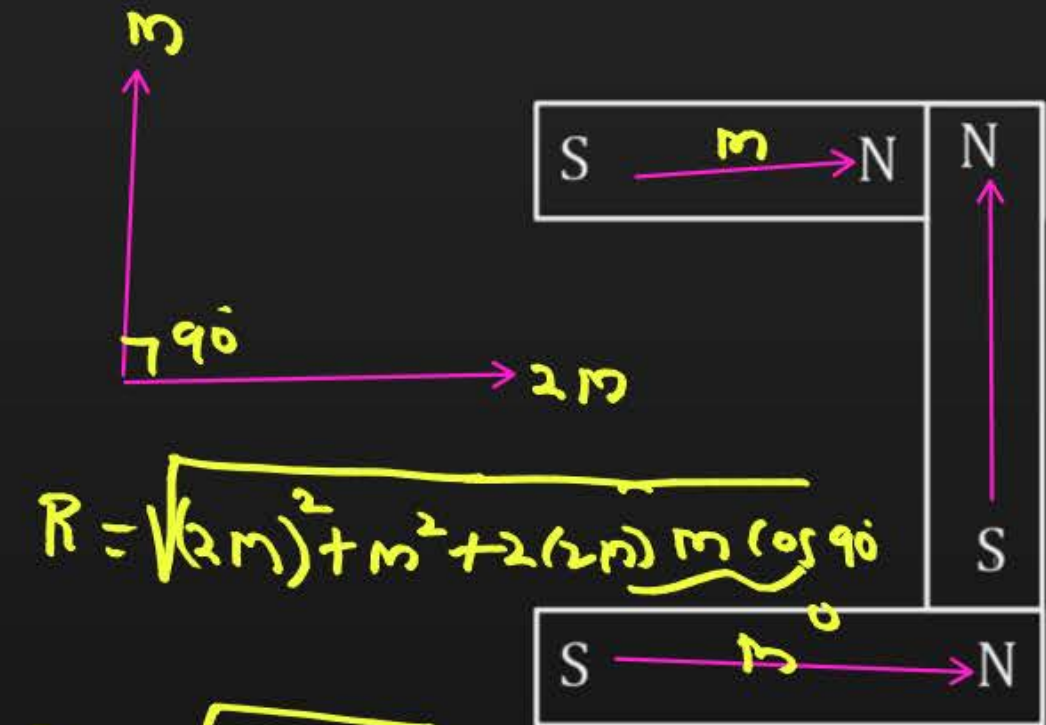
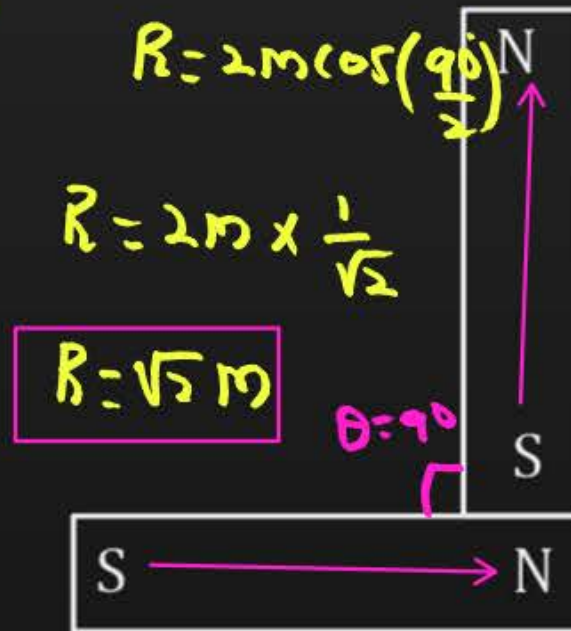


$\theta = 180^\circ$

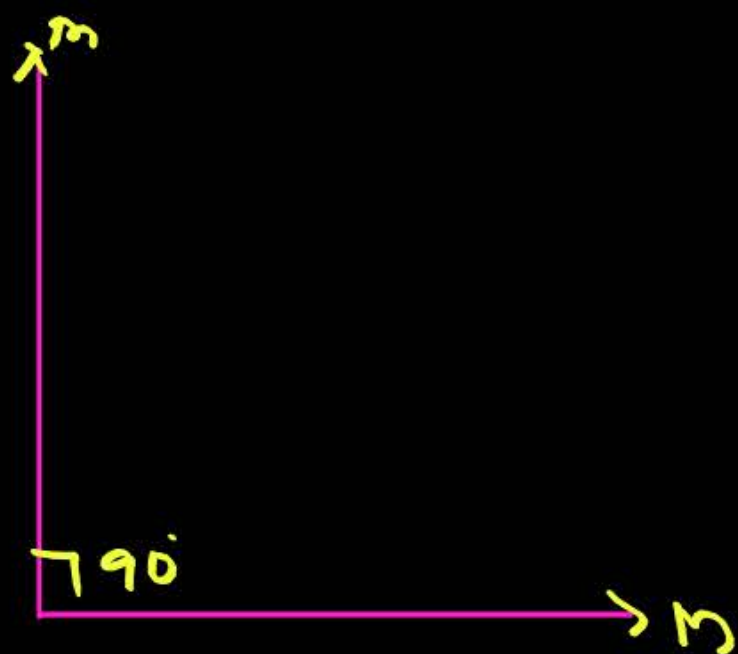
$R = 2m \cos\left(\frac{\theta}{2}\right)$

$R = 2m(0)$

$R = 0$



(3)



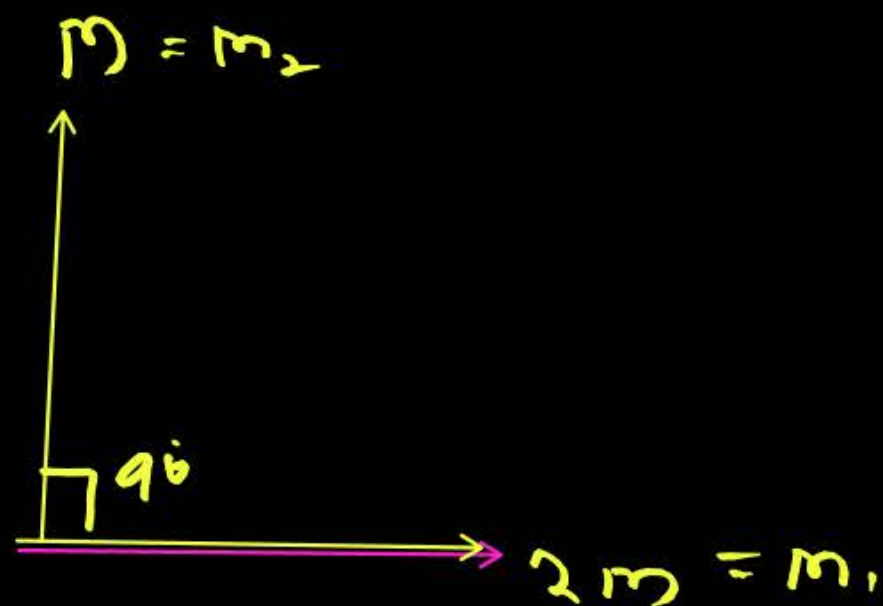
$$R = 2m \cos\left(\frac{0}{2}\right)$$

$$R = 2m \cos\left(\frac{90}{2}\right)$$

$$R = 2m \times \frac{1}{\sqrt{2}} = m \times \sqrt{\frac{4}{2}}$$

$$R = \sqrt{2} m$$

(4)



$$R = \sqrt{(2m)^2 + (m)^2 + \underbrace{2 \times 2m \times m \times \cos 90}_0}$$

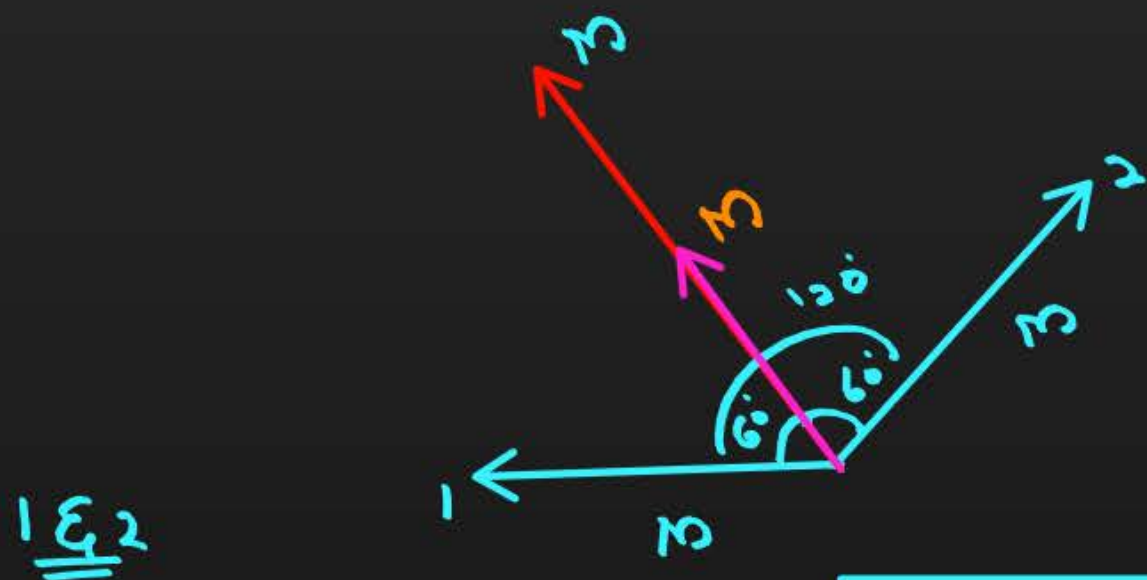
$$R = \sqrt{4m^2 + m^2} = \sqrt{5m^2}$$

$$R = \sqrt{5} m$$

Question

Three identical bar magnets each of magnetic moment M are placed in the form of an equilateral triangle as shown. The **net magnetic moment** of the system is

- A** Zero
- B** $2M$
- C** $M\sqrt{3}$
- D** $3M/2$



1 & 2

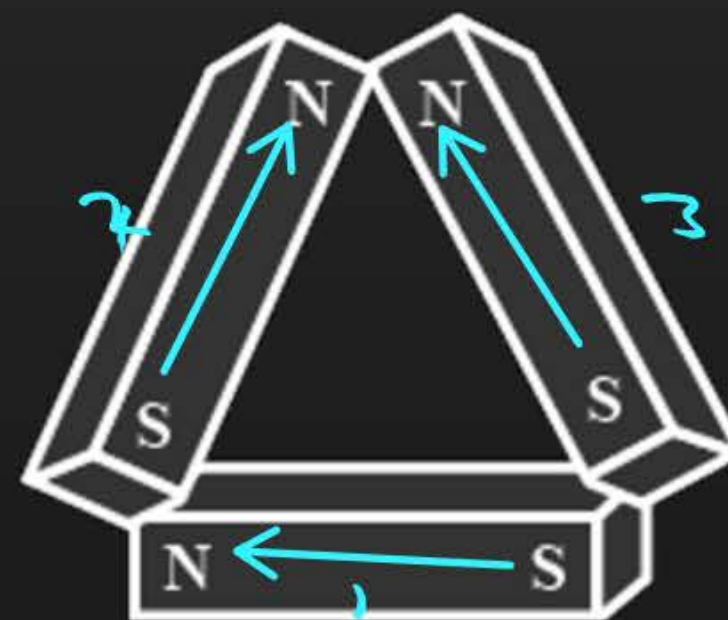
$$R = 2m \cos\left(\frac{0}{2}\right)$$

$$R = 2m \cos\left(\frac{120}{2}\right)$$

$$R = 2m \cos 60^\circ$$

$$R = 2m \times \frac{1}{2} = m$$

$$m_{\text{net}} = m + m = 2m$$

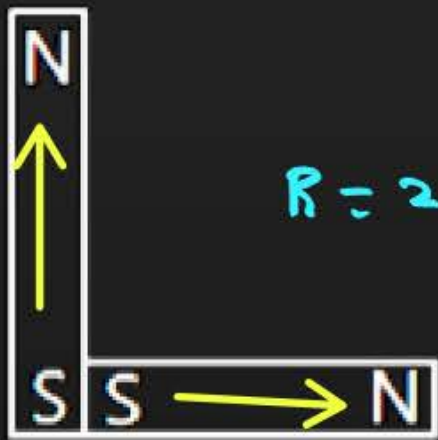


Question



The following figures show the arrangement of bar magnets in different configurations. Each magnet has magnetic dipole. Which configuration has the highest net magnetic dipole moment?

A



$$R = 2m \cos\left(\frac{\theta}{2}\right)$$

$$R = 2m \times \frac{1}{\sqrt{2}} = \sqrt{2} m$$

B

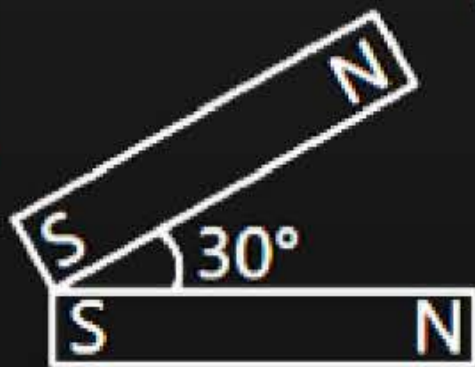


$$R = 0$$

$\theta = 180^\circ$

$$\sqrt{3} = 1.73$$

C



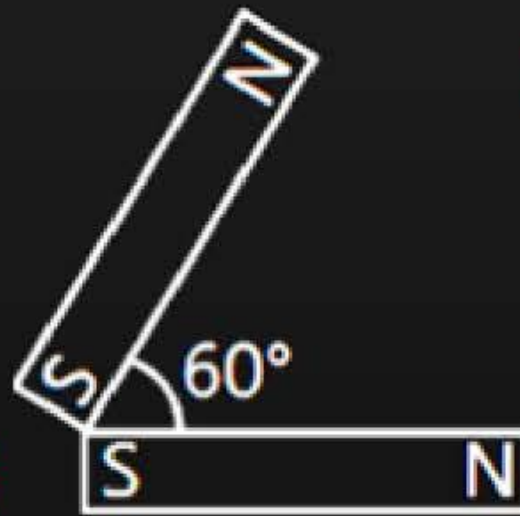
$$R = \sqrt{m^2 + m^2 + 2m^2 \cos 60^\circ}$$

$$R = \sqrt{2m^2 + 2m^2 \times \frac{1}{2}}$$

$$R = m\sqrt{2 + 1} = m\sqrt{3}$$

$$R = \sqrt{3} m$$

D



$$R = 2m \cos\left(\frac{60^\circ}{2}\right)$$

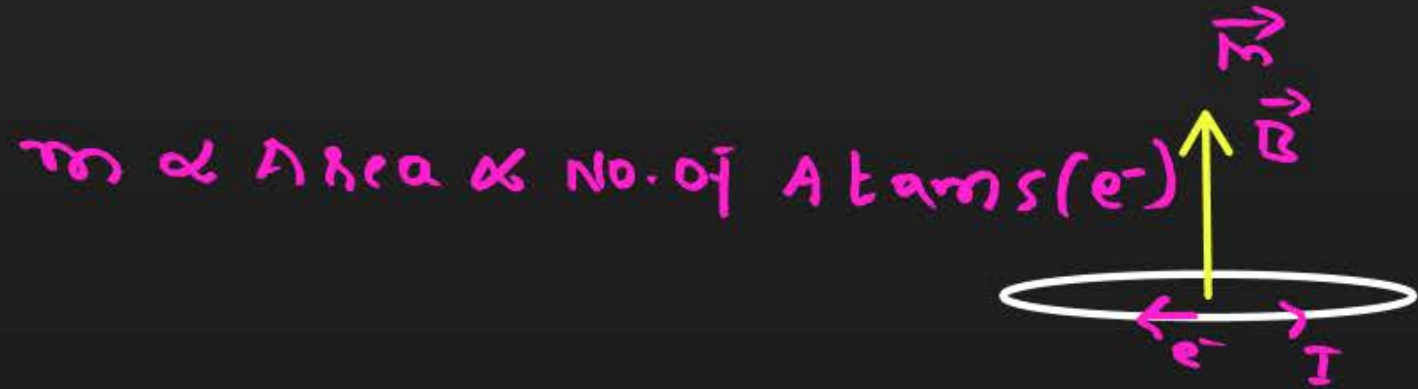
$$R = 2m \times \frac{\sqrt{3}}{2}$$

$$R = \sqrt{3} m$$



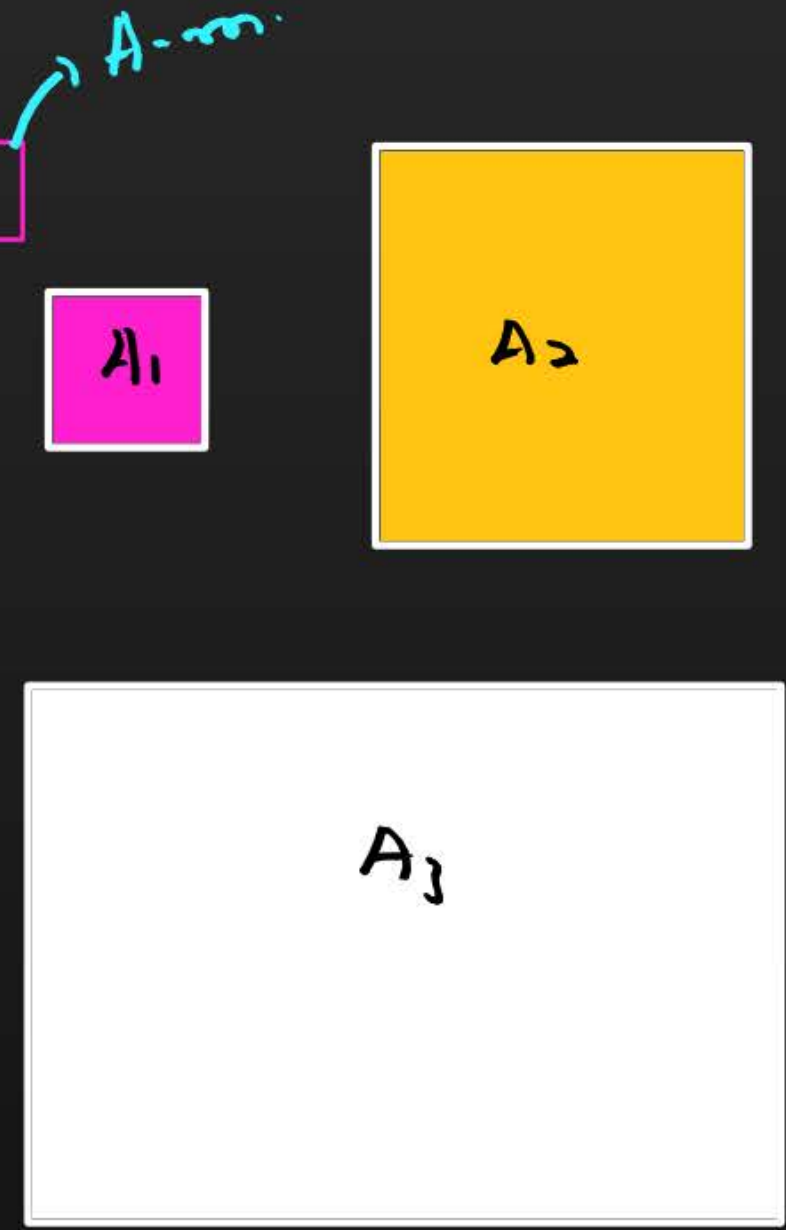
Cutting of a bar magnet

Pole strength is directly proportional to Area of cross-section.



$$A_3 > A_2 > A_1$$

$$m_3 > m_2 > m_1$$

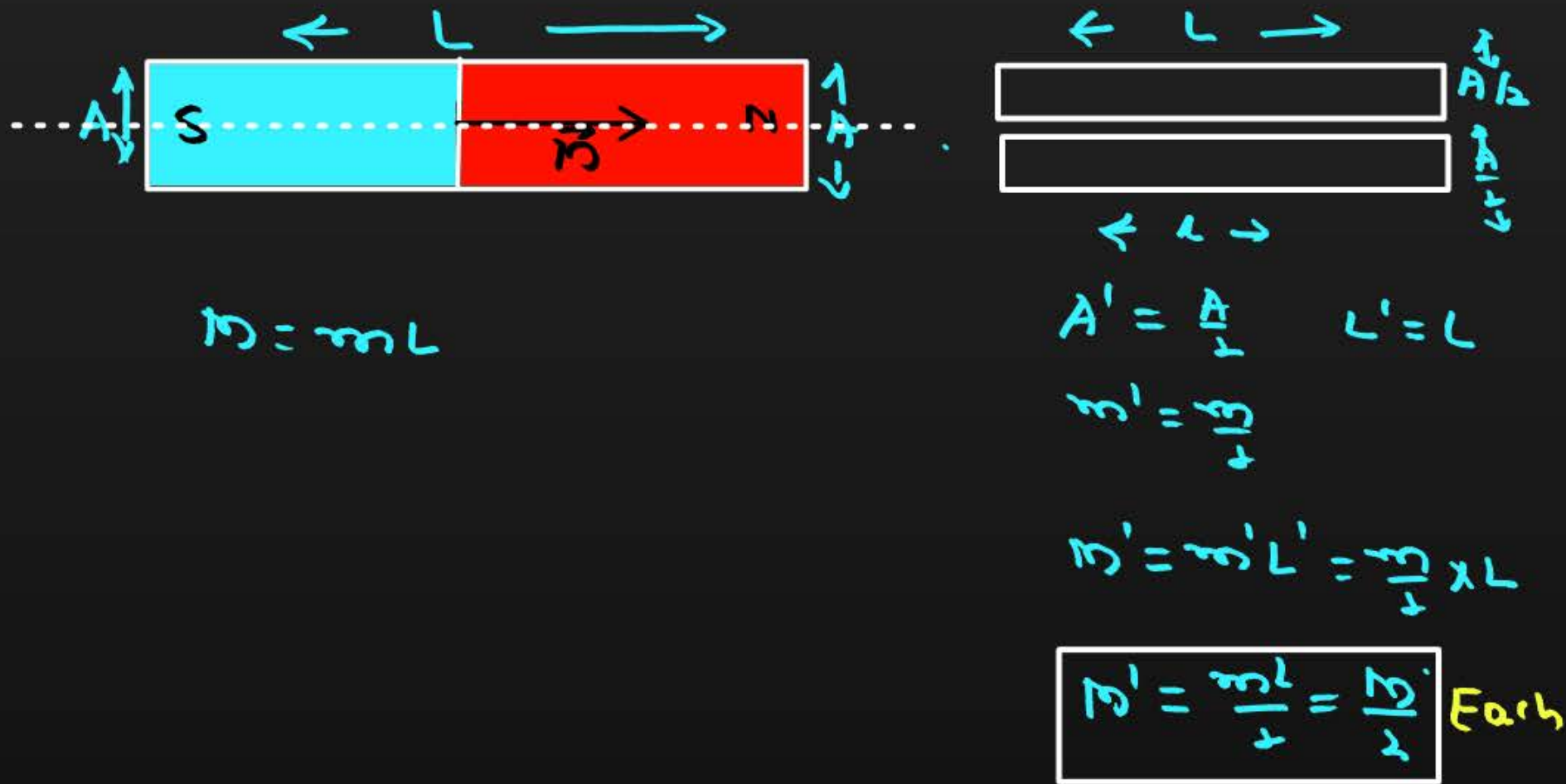




Cutting of a bar magnet

m - pole strength
 M - magnetic Dipole.

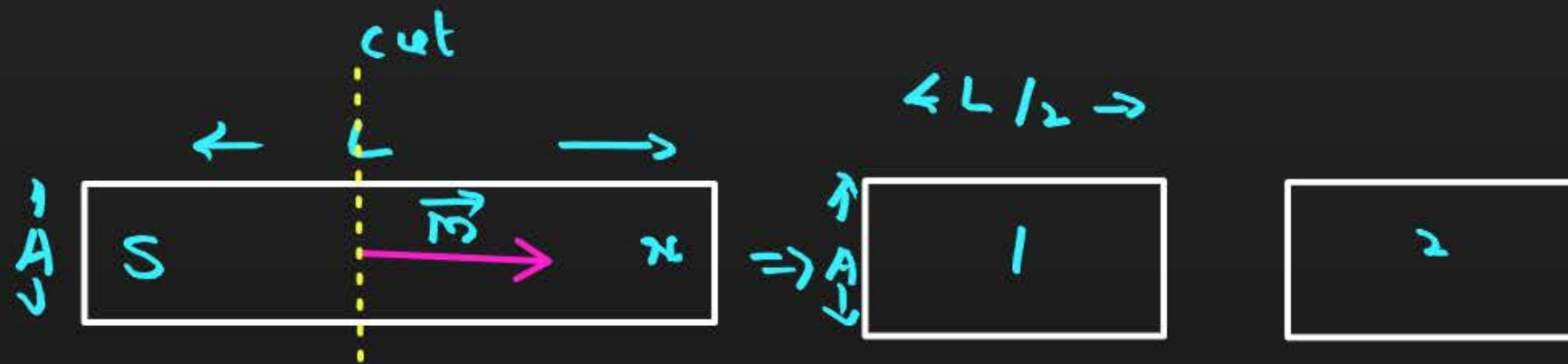
Case (1) : Cut the magnetic dipole along length in half





Cutting of a bar magnet

Case (2) : Cut the magnetic dipole perpendicular to length in half



$$A' = A$$

$$m' = m$$

$$L' = L/2$$

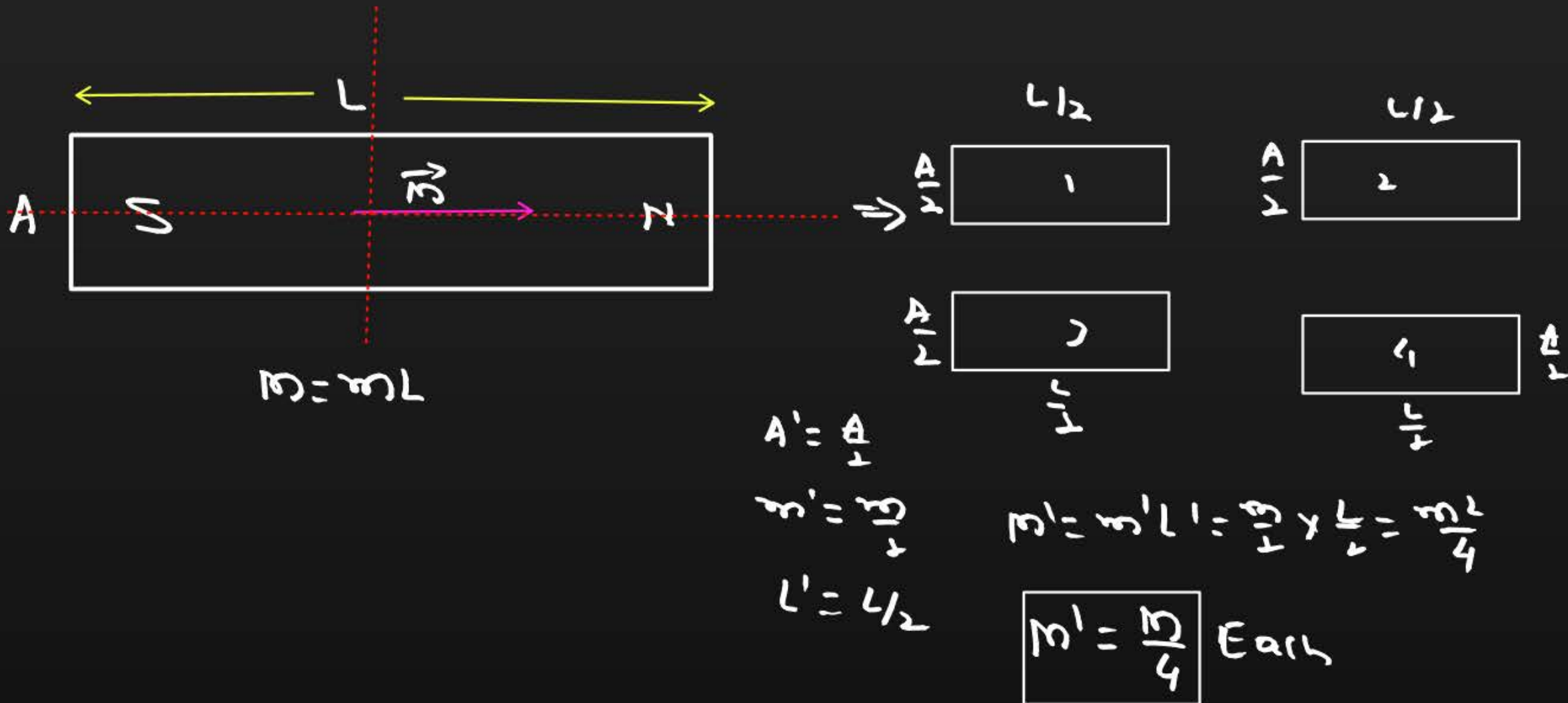
$$M' = m' L' = m \times \frac{L}{2}$$

$$M' = \frac{mL}{2} = \frac{M}{2} \text{ Each}$$



Cutting of a bar magnet

Case (3) : Cut the magnetic dipole along the length and perpendicular to length in half each



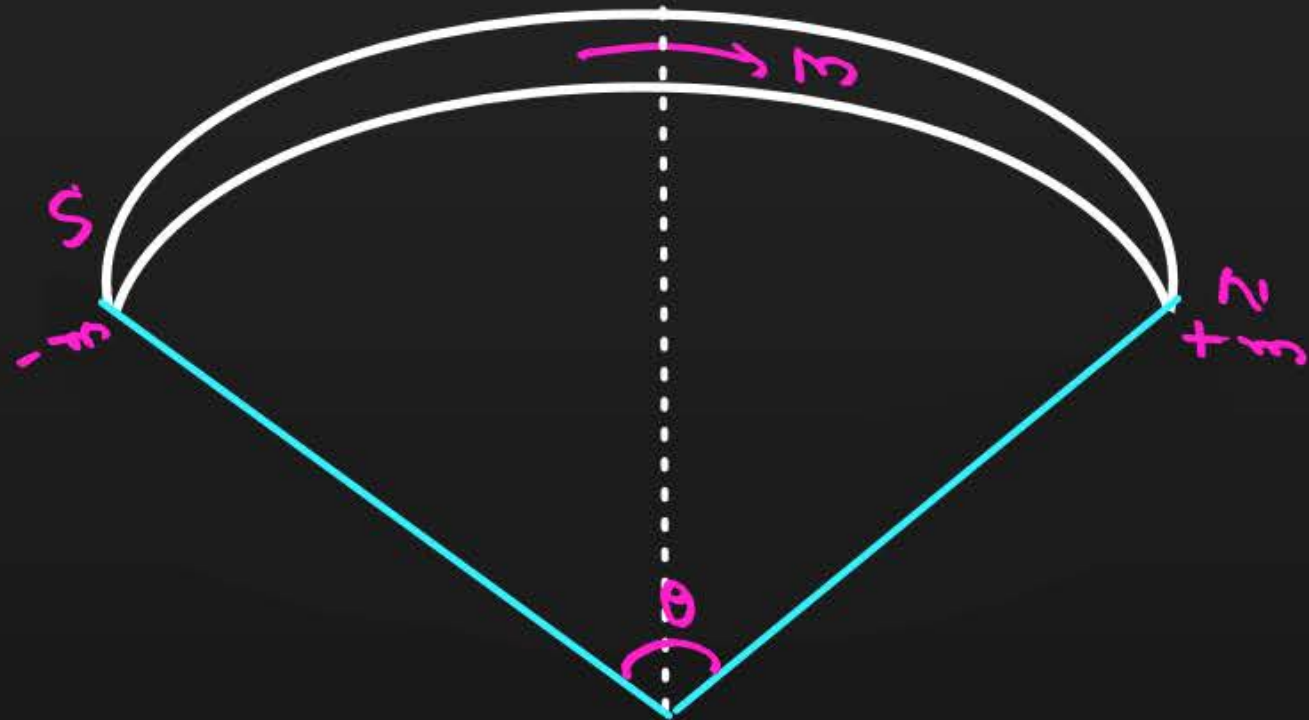


Cutting of a bar magnet

Case (4) : When a magnet is bent .

$$R = \frac{2M}{\theta} \sin\left(\frac{\theta}{2}\right)$$

↳ Radius



Question



If a magnet of pole strength m is divided into **four parts** such that the length and width of each part is half that of initial one, then the **pole strength** of each part will be

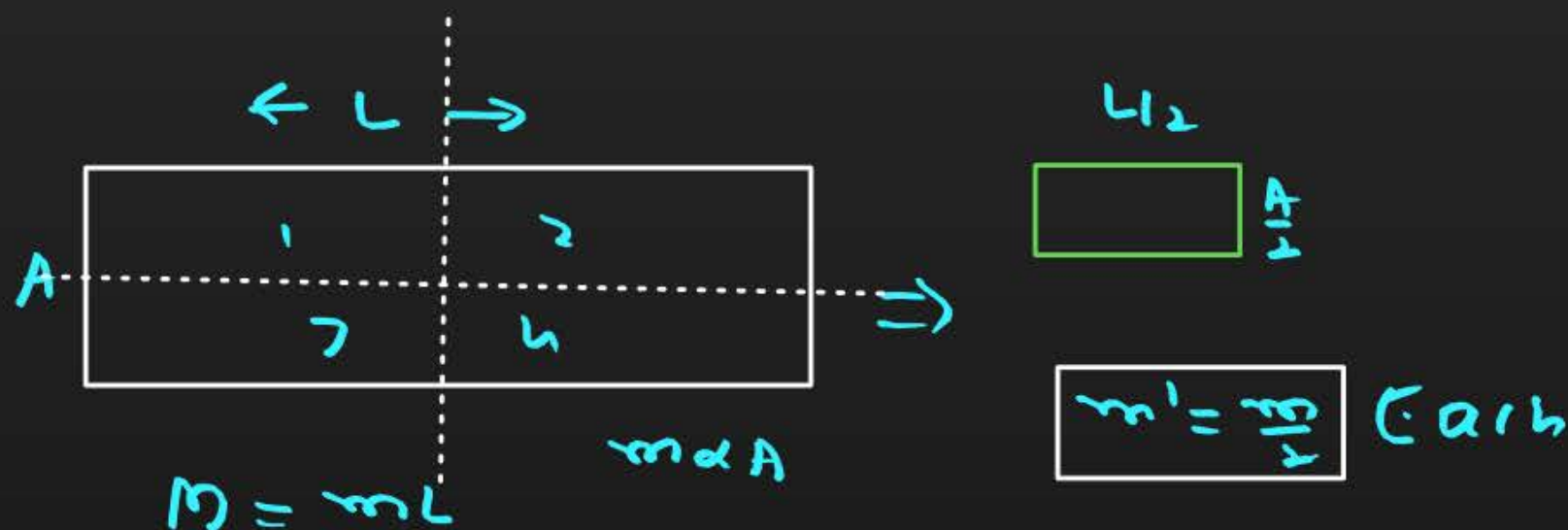
$$\Rightarrow M' = \frac{m}{4}$$

A $m / 4$

B $m / 2$

C $m / 8$

D $4 m$



Question



An iron bar of length L has a magnetic moment M . It is bent at the middle of its length such that the two arms make an angle 60° with each other. The magnetic moment of this new magnet is

A $M/2$

B $2M$

C $M/\sqrt{3}$

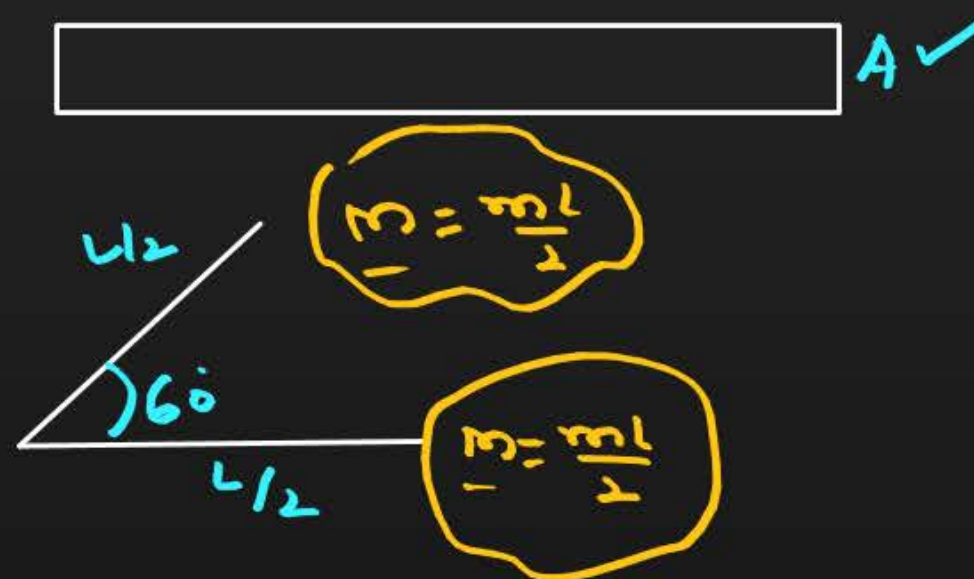
D M

$$\hookrightarrow \theta = 60^\circ = \frac{\pi}{3}$$

$$L \Rightarrow L' = \frac{L}{2}$$

$$R = \frac{2M}{\theta} \sin\left(\frac{\theta}{2}\right)$$

$$R = \frac{2M}{\frac{\pi}{3}} \times \frac{1}{2} = \frac{3M}{\pi}$$



Question



The length of a magnetized iron bar is L and its magnetic moment is M . When this bar is bent to form a **semicircle** its magnetic moment is:

$$\hookrightarrow \theta = 180^\circ = \pi$$

A M

$$R = \frac{2M}{\theta} \sin\left(\frac{\theta}{2}\right)$$

B $M\pi/2$

$$R = \frac{2M}{\pi} \sin\left(\frac{\pi}{2}\right)$$

C $M/M\pi$

$$R = \frac{2M}{\pi}$$

D $2M/\pi$

Question



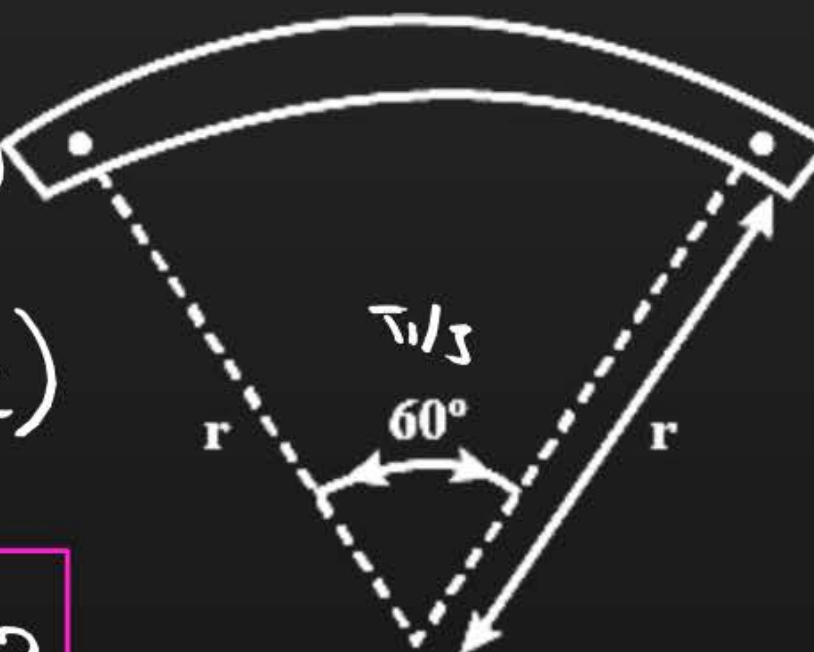
A bar magnet of length L and magnetic dipole moment M is bent in the form of an arc as shown in figure. The new magnetic dipole moment will be

- A** M
- B** $3M/\pi$
- C** $2/\pi M$
- D** $M/2$

$$R = \frac{2M}{\theta} \sin\left(\frac{\theta}{2}\right)$$

$$R = \frac{2M}{\frac{\pi}{3 \times 2}} \sin\left(\frac{\pi}{3 \times 2}\right)$$

$$R = \frac{2M}{\frac{\pi}{6}} \times \frac{1}{2} = \frac{3M}{\pi}$$



Question



A bar magnet of magnetic moment M is cut into **two parts** of equal length. The magnetic moment of each part will be

- A** M
- B** $2M$
- C** Zero
- D** $0.5M$

$$M = m \cdot l$$
$$M' = \frac{M}{2} = \frac{m \cdot l}{2} = 0.5M$$

Question

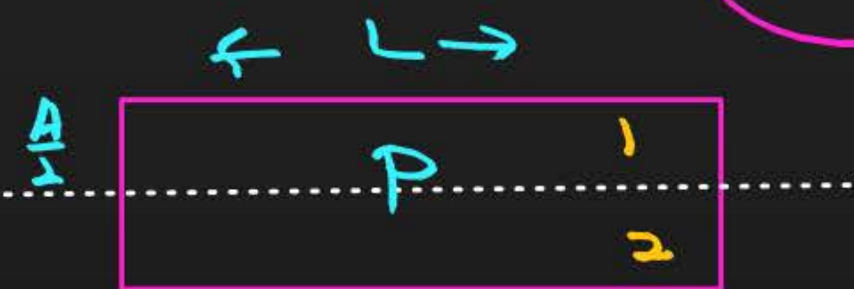


Two similar bar magnets P and Q, each of magnetic moment M , are taken. If P is cut along its axial line and Q is cut along its equatorial line, all the four pieces obtained have

- A** Equal pole strength ✗
- B** Magnetic moment $M/4$ ✗
- C** Magnetic moment $M/2$ ✓
- D** Magnetic moment M ✗

$L' = L$
 $A' = \frac{A}{2}$
 $m' = \frac{M}{2}$
 $m' = \frac{M}{2}$

$L' = \frac{L}{2}$
 $A' = A$
 $m' = m$
 $m' = \frac{M}{2}$



$L' = L$
 $A' = \frac{A}{2}$
 $m' = \frac{M}{2}$
 $m' = \frac{M}{2}$

$L' = \frac{L}{2}$
 $A' = A$
 $m' = m$
 $m' = \frac{M}{2}$

Question



A long magnetic needle of length $2L$, magnetic moment M and pole strength m units is broken into two pieces at the middle. The magnetic moment and pole strength of each piece will be

A $M/2, m/2$

B $M, m/2$

C $M/2, m$

D M, m



$$M = m(2L) = 2mL$$

$$L' = L$$

$$A' = A$$

$$m' = m$$

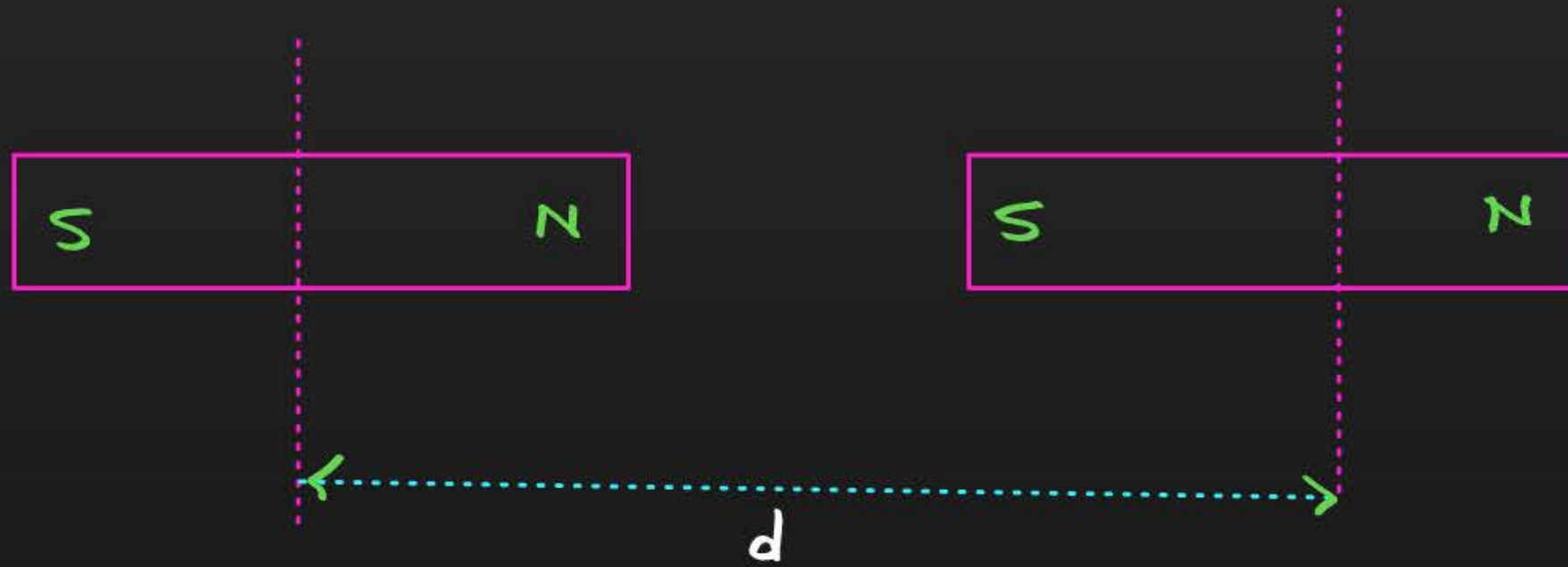
$$M' = mL \times 2 = \frac{(2mL)}{2} = \frac{M}{2}$$

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



Force Between 2 Bar-Magnet

$$F = \frac{\mu_0 m_1 m_2}{4\pi d^2}$$



$$F = \frac{\mu_0}{4\pi} \frac{6m_1 m_2}{d^4} \quad F \propto \frac{1}{d^4}$$

Question



Force between two identical bar magnets whose centres are r metre apart is 4.8 N, when their axes are in the same line. If separation is increased to $2r$, the force between them is reduced to

A 2.4 N

B 1.2 N

C 0.6 N

D 0.3 N

$$F \propto \frac{1}{d^4}$$
$$\frac{F'}{F} = \frac{d^4}{d'^4} = \left(\frac{r}{2r}\right)^4 = \frac{r^4}{16r^4} = \frac{1}{16}$$

$$F' = \frac{F}{16} = \frac{4.8}{16}$$

$$F' = 0.3 \text{ N}$$



Magnetic Moment of Current Carrying Coil

Current carrying coil (or loop) behaves like magnetic dipole. The face of coil in which current appears to flow anticlockwise acts as north pole while face of coil in which current appears to flow clock wise acts as south pole.

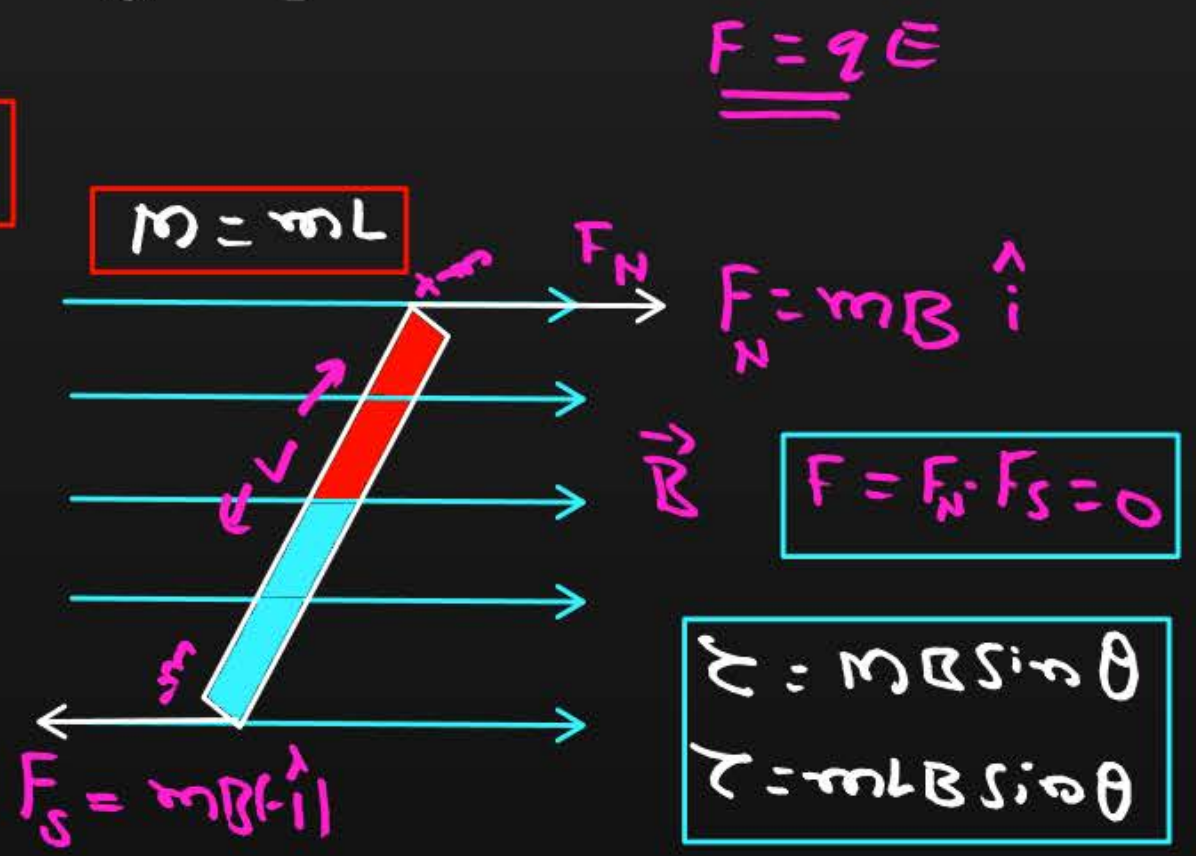
A current carrying coil acts as a Magnetic Dipole \Rightarrow $\boxed{M = NIA}$
 \hookrightarrow unit $A \cdot m^2$



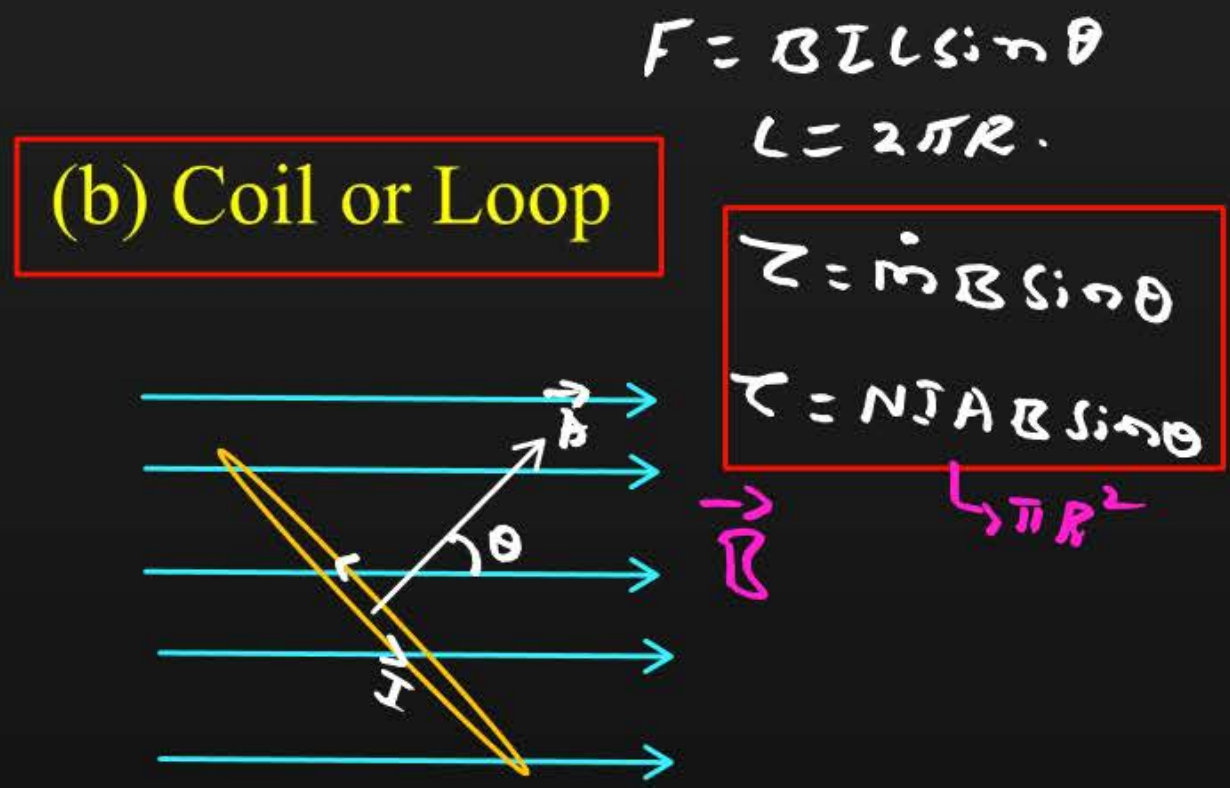
Magnetic Moment of Current Carrying Coil

When a bar magnet is placed in a uniform magnetic field the two poles experience a force. They are equal in magnitude and opposite in direction and do not have same line of action. They constitute a couple of forces which produces a torque. The torque tries to rotate the magnet so as to align it parallel to direction of field

(a) Bar magnet



(b) Coil or Loop





The electrostatic analog

$$\begin{array}{l} q \rightarrow \phi \\ E \rightarrow B \\ p \rightarrow \vec{m} \end{array}$$

Parameters	Electrostatics	Magnetism, $K = \frac{\mu_0}{4\pi}$
Dipole moment	$p = q \times 2d$	$m = m_L$
Equatorial field for a short dipole	$E_{\perp} = \frac{Kp}{r^3}$	$B_{\perp} = \frac{Km}{r^3}$
Axial field for a short dipole	$E_{\parallel} = \frac{2Kp}{r^3}$	$B_{\parallel} = \frac{2Km}{r^3}$
External field - Torque	$\tau = pE \sin\theta$	$\tau = mB \sin\theta$
External field – Potential Energy	$U = -pE \cos\theta$	$U = -mB \cos\theta$

Question



The torque acting on a magnetic dipole placed in uniform magnetic field is zero, when the angle between the dipole axis and the magnetic field is _____

- A** Zero
- B** 45°
- C** 60°
- D** 90°

$$\tau = MB \sin \theta$$

$$0 = MB \sin \theta$$

$$\sin \theta = 0$$

$$\sin \theta = \sin 0^\circ$$

$$\theta = 0^\circ$$

Question



A bar magnet when placed at an angle of 30° to the direction of magnetic field induction of 5×10^{-2} T, experiences a moment of couple 25×10^{-6} N-m. If the length of the magnet is 5 cm its pole strength is

plane \Rightarrow 90° - angle = θ

A 2×10^{-2} A-m

B 5×10^{-2} A-m

C 2 A-m

D 5 A-m

$$\tau = mB \sin \theta$$

$$\tau = mL \cdot B \sin \theta$$

$$25 \times 10^{-6} = m \times 5 \times 10^{-2} \times 5 \times 10^{-2} \times \sin 30^\circ$$

$$\cancel{25} \times 10^{-6} = m \times \cancel{25} \times 10^{-4} \times \frac{1}{2}$$

$$m = 2 \times 10^{-2} \text{ A-m}$$

Thank

You