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BY

Asst. Prof. Tarun Kumar Gautam

(B.Tech, M.Tech, PhD (P))

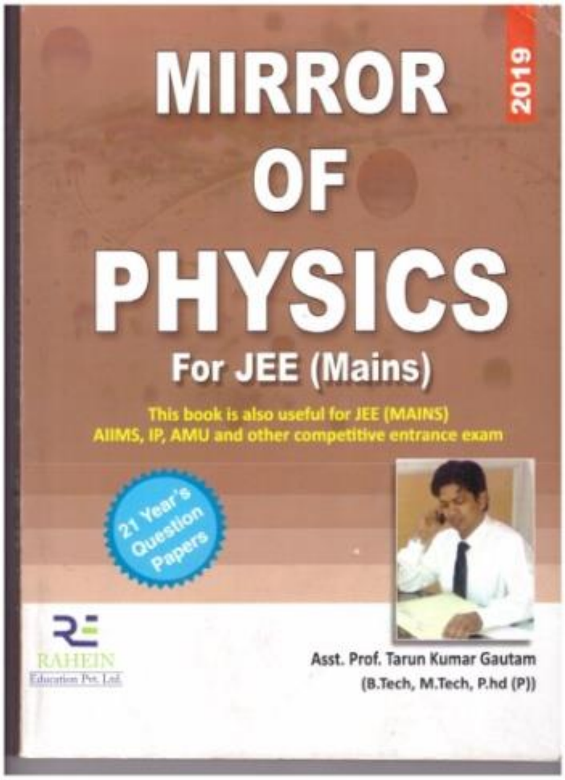
Currently working in Jamia Hamdard, (HSC), Delhi

Working on Nano Technology with Rise University, USA

Author of 8 books regarding Physics and Engineering Subject.

Ex-Faculty of Rajshree Institute of Management & Technology (RMIT), Braeilly, Uttar Prdesh

Ex-Faculty of Assistant professor in Krishna Engineering Collage (KEC), Ghaziabad, Uttar Prdesh
Member of Educational Project in University of Petroleum and Energy Studies (UPES), UK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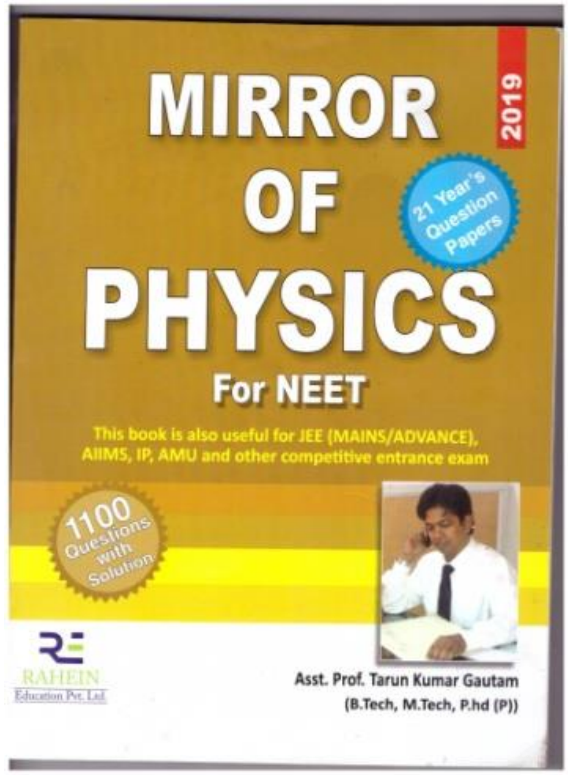
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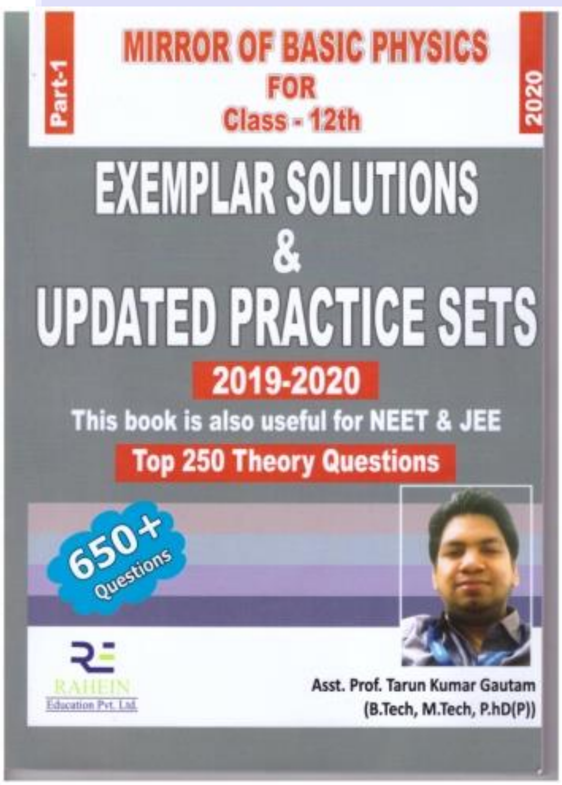
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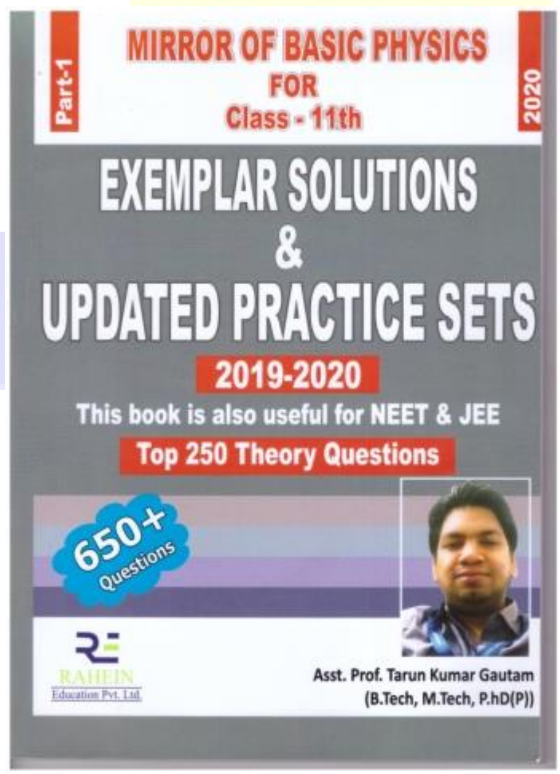
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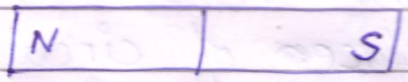
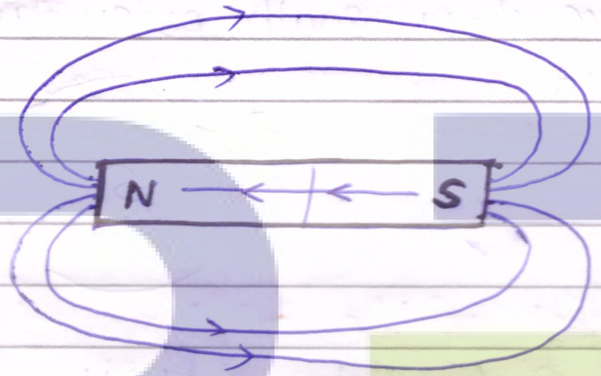
Chapter-5

(Magnetism)

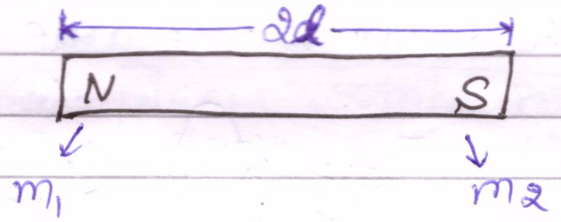
① Magnetic Field of Magnet





[Magnetic Field Lines move from (N) to (S) &
Magnetic field lines inside magnetic field move (S) to (N)

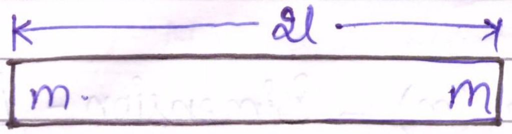
Magnetic Pole Strength



m_1 & m_2 be the magnetic strength of pole of magnet. They are separated by small distance (2d)

Let (M) be the Magnetic dipole moment.

Magnetic Pole Strength

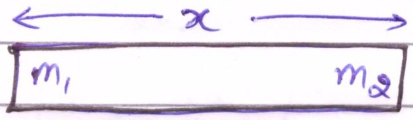


Pole strength of (N) & (S)

C-1

$$M = m \times 2l$$

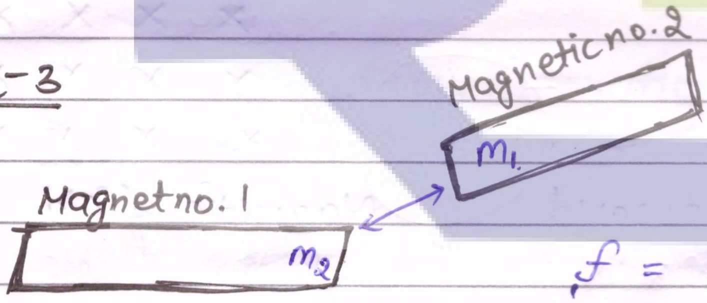
C-2



$$f = \frac{k m_1 m_2}{x^2}, \quad \left[k = \frac{\mu_0}{4\pi}\right]$$

$$f = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{x^2}$$

C-3



$$f = \frac{k m_1 m_2}{x^2}$$

$$f = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{x^2}$$

Note -

M = magnetic dipole moment = NIA

$M = m \times 2l$

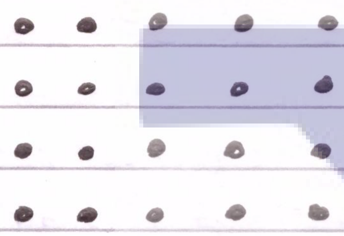
Note -

1) Magnetic Pole Strength (m) → Dimension - [AL]
   Unit - Am

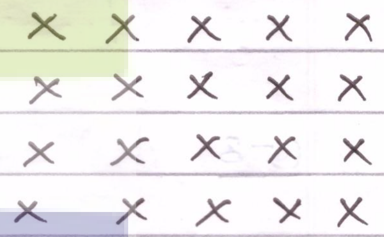
2) Magnetic dipole Moment (M) → Dimension - $[AL^2]$
   Unit - Am^2

$$\left[\frac{\mu_0}{4\pi} = 10^{-7}\right]$$

Types of Magnetic Field



Magnetic Field Upward



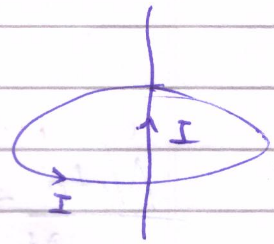
Magnetic field downward

Ques Explain Magnetic dipole moment of revolving electron?

Ans

$$I = \frac{\text{charge}}{\text{time}}$$

$$I = \frac{q}{t} = \frac{ne}{t} = \frac{e}{t} \quad [n=1]$$



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

$$\boxed{t = \frac{2\pi r}{v}}$$

$$I = \frac{e}{2\pi r/v} = \frac{ev}{2\pi r}$$

Orbital Magnetic Moment of electron (μ)

$\Rightarrow$ $\mu = NIA$ $\quad [\because N = 1]$

$$\mu = 1 \times \frac{ev}{2\pi r} \times A$$

$$\mu = \frac{ev}{2\pi r} \times \pi r^2$$

$$\boxed{\mu = \frac{evr}{2}}$$

Angular Momentum [L] $\quad \boxed{L = mvr} \Rightarrow \boxed{L = \frac{nh}{2\pi}}$

v = velocity
r = radius

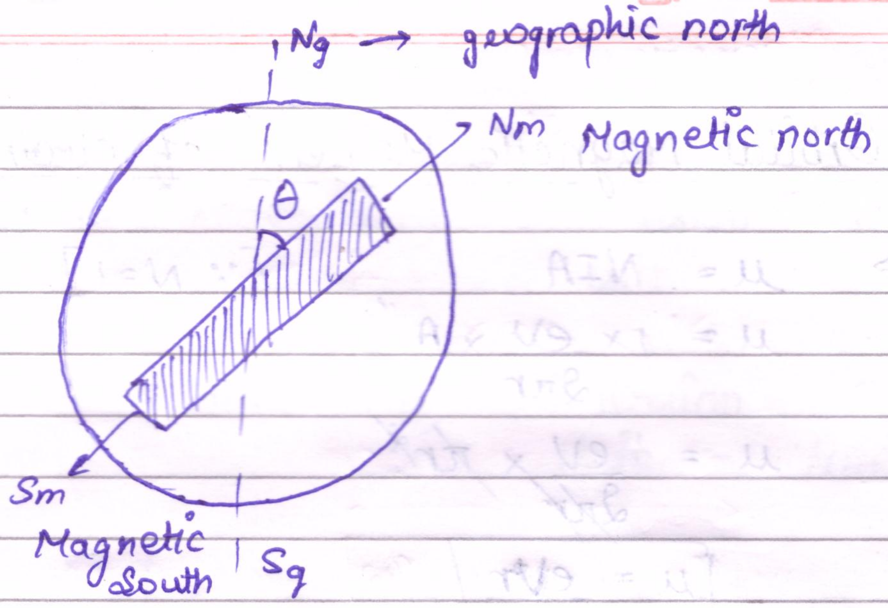
$\frac{\mu}{L}$ = gyromagnetic ratio $\rightarrow$ It is ratio of magnetic moment to angular momentum.

$$\frac{\mu}{L} = \frac{\frac{evr}{2}}{\frac{nh}{2\pi}} = \frac{evr}{2} \times \frac{2\pi}{nh}$$

$$\boxed{\frac{\mu}{L} = \frac{evr\pi}{nh}}$$

Gauss Law in Magnetism : This law state that the net magnetic flux through any closed surface is zero.

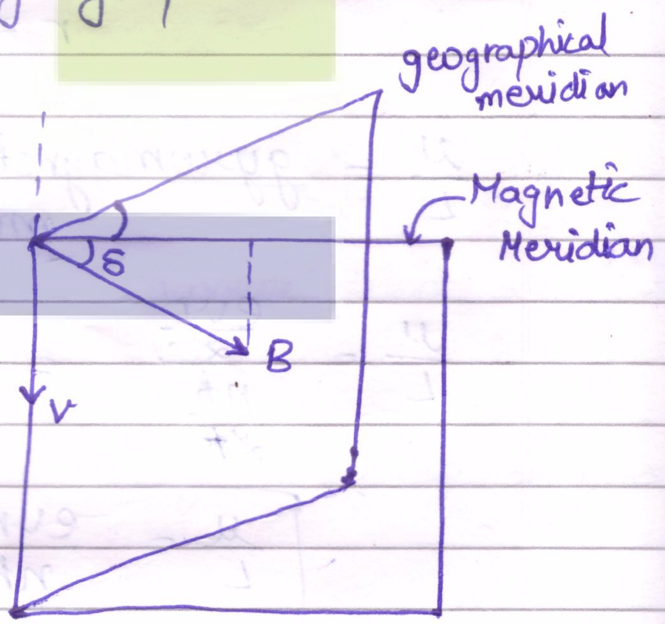
$$\boxed{\oint \vec{B} \cdot \vec{dl} = 0}$$



Magnetic element of earth

① **Declination** (θ) - It angle geographical meridian & magnetic meridian geographical meridian.

② **Angle of dip** (δ)
Angle of Inclination (δ)



Let B = Total Magnetic field of earth

V → vertical component of B

$V = B \sin \delta$

$H = B \cos \delta$

$\tan \delta = \frac{B_V}{B_H}$

It is angle b/w Total magnetic field (B) & its horizontal component.

③ **Horizontal Component** — Its horizontal component of total magnetic field of earth.

$$\boxed{H = B\cos\delta} \quad \text{--- --- ①}$$

$$\boxed{V = B\sin\delta}$$

$$\Rightarrow \frac{V}{H} = \frac{B\sin\delta}{B\cos\delta} = \tan\delta \qquad \boxed{\frac{V}{H} = \tan\delta}$$

$$\Rightarrow H^2 + V^2 = B^2\cos^2\delta + B^2\sin^2\delta$$

$$H^2 + V^2 = B^2(\cos^2\delta + \sin^2\delta)$$

$$H^2 + V^2 = B^2$$

$$\boxed{B = \sqrt{H^2 + V^2}}$$

Ques: $V = \frac{1}{\sqrt{3}}$, $H = \sqrt{3}$, find angle of dip

Ans $\frac{V}{H} = \tan\delta$

$$\frac{1}{\sqrt{3}\times\sqrt{3}} = \tan\delta$$

$$\frac{1}{3} = \tan\delta \Rightarrow \boxed{\delta = \tan^{-1}\left(\frac{1}{3}\right)}$$

Ques: $V = 5$, $H = 6$ find total Magnetic field.

Ans $B = \sqrt{H^2 + V^2}$

$$B = \sqrt{25 + 36}$$

$$B = \sqrt{61}$$

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at pole

$\boxed{\delta = 90}$

$H = B\cos\delta = B \times 0 = 0$

$\boxed{H = 0}$

$V = B\sin\delta = B$

$\boxed{V = B}$

at equator

$\boxed{\delta = 0}$

$H = B\cos\delta = B$

$\boxed{H = B}$

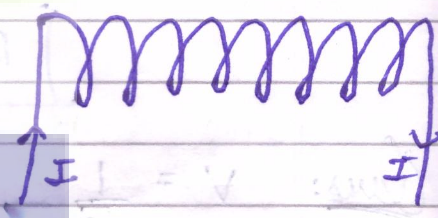
$V = B\sin\delta = 0$

$\boxed{V = 0}$

Q. Explain terms

① **Magnetising field** – The magnetic field that exists in vaccum & induce magnetism is called "Magnetising field"

Magnetic field set up in solenoid



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

unit of Magnetic field is Tesla (T)

② **Magnetising field Intermity or magnetic Intensity (H)**

It is number of ampere turns (nI) flowing round the unit length of solenoid required to produce a given magnetising field.

$B = \mu_0 n I$ $\qquad [\because H = nI]$

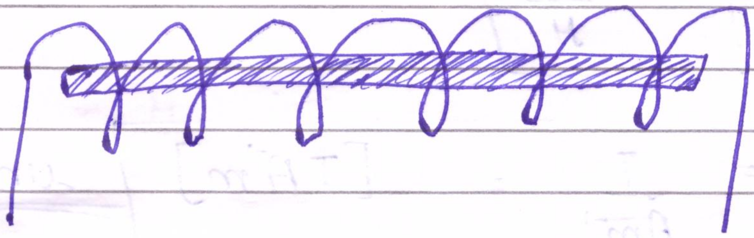
$\boxed{B = \mu_0 H}$ $\qquad \left[n = \frac{H}{l}\right]$

$\boxed{H = \frac{B}{\mu_0}}$ $\qquad$ unit of 'H' ⇒ $[Am^{-1}]$

GOOD WRITE

(3) Magnetic Induction

When the interior of solenoid is filled with magnetic material, field inside the solenoid becomes greater than B_0.



$B_0 \rightarrow$ Magnetic field
$B_m \rightarrow$ magnetising field

$$\boxed{B = B_0 + B_m}$$

$B_0 = \mu_0 H \longrightarrow$ vaccum

[$\because$ $\mu_0 \rightarrow$ vaccum
$\mu \rightarrow$ material]

$B_H = \mu H$

$B = \mu_0 H + \mu_r H$

$$\boxed{B = (\mu_0 + \mu_r) H}$$

μ_r = Relative magnetic permeability

$$\boxed{\mu = \mu_0 \times \mu_r}$$

$\mu_0 \rightarrow$ vaccum
$\mu \rightarrow$ material

$$\boxed{\mu = \mu_0 \times \mu_r}$$

Note

$B = \mu \times H$ $\mu \rightarrow$ magnetic permeability
It's ratio of magnetic field to magnetising field Intensity

$$\mu = \frac{B}{H}$$

$$\mu = \frac{T}{Am^{-1}} = [T A^{-1} m]$$ unit

* Permanent magnets -
The material used for making permanent magnets must be characteristics.

Reason -
(i) high resistivity - which produce strong magnetic field.
(ii) high coercivity - that its magnetisation is not destroyed by strong magnetic field, Temp.
(iii) high Permeability

* Electromagnets -
(i) high initial Permeability
(ii) Low retentivity

* Transfer cores - characterics of material used for tranform coil.
(i) high initial permeability
(ii) Low resistivity to reduce losses due to eddy current.
(iii) Low hysteresis Loss

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Ques In the magnetic meridian of a certain place, horizontal component of earth's magnetic field is 0.26 G & dip angle is 60°. What is magnetic field of earth in this location?

Ans $H = 0.26 \qquad \delta = 60^\circ$

$H = B\cos\delta$

$B = \dfrac{H}{\cos\delta}$

$B = \dfrac{0.26}{\cos 60^\circ} = \dfrac{0.26}{1/2} = 0.26 \times 2$

$\boxed{B = 0.52\ T}$

Ques The electron in hydrogen atom is moving with a speed of $2.3 \times 10^6\ ms^{-1}$ in an orbit of radius 0.53 Å. Calculate the magnetic moment of revolving electron.

Ans $\mu = \dfrac{evr}{2}$

$e = 1.6 \times 10^{-19}, \quad v = 2.3 \times 10^6, \quad r = 0.53 \times 10^{-10}\ m$

$\mu = \dfrac{1.6 \times 10^{-19} \times 2.3 \times 10^6 \times 0.53 \times 10^{-10}}{2}$

$\mu = \dfrac{1.9504 \times 10^{-23}}{2}$

$\boxed{\mu = 0.9752 \times 10^{-23}}$

Ques A magnetised needle of magnetic moment $4.8 \times 10^{-2}\ JT^{-1}$ is placed at 30°. with direction

of uniform magnetic field of magnitude 3×10^{-2} T
What is Torque acting on needle?

Ans

$M = 4.8\times10^{-2}\ JT^{-1}$

$\theta = 30^\circ$

$B = 3\times10^{-2}$

$[\because M = NIA]$

$\tau = MB\sin\theta$

$\tau = (4.8\times10^{-2})(3\times10^{-2})\sin30^\circ$

$$\boxed{\tau = 7.2\times10^{-4}}$$

Note

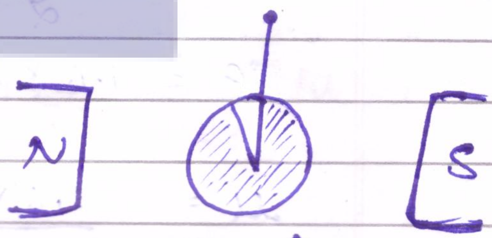
$\tau = NIBA\sin\theta \quad , \quad \theta = 90^\circ$

$$\boxed{\tau = NIBA}$$

① Restoring Torque = Deflection Torque

$K\theta = NIBA$

$\tau = NIBA \quad \text{—} ①$



$$\boxed{\tau = K\theta}$$

K = Moment of restoring couple per unit angular twist or Torsional Constant

θ = angular twist.

$\tau = K\theta \quad \text{- - - -} ②$

from eq^n ① & ②

$K\theta = NIBA$

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

(i) Current Senstivity (I_s) - deflection per unit current

$$I_s = \frac{\theta}{I} = \frac{\theta}{\frac{K\theta}{NBA}} = \frac{NBA}{K}$$

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

(ii) Voltage senstivity (V_s) - deflection per unit voltage.

$$V_s = \frac{\theta}{V} = \frac{\theta}{RI} = \frac{\theta}{R \times \frac{K\theta}{NBA}} = \frac{NBA}{RK}$$

$$V_s = \frac{NBA}{RK}$$

$$V_s = \frac{I_s}{R}$$ (It not follow ohm law)

unit of I_s → $I_s = \frac{\theta}{I} = \frac{rad.}{A} = [rad.A^{-1}]$

unit of V_s → $V_s = \frac{\theta}{V} = \frac{rad.}{volt} = [rad.volt^{-1}]$

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Ques A rectangular coil of Area $5 \times 10^{-4} m^2$ & 60 turns is pivoted about one of its vertical sides. The coil is in radial horizontal field of 90G. What is the Torsional constant of hair spring constant connected to coil. If current is 0.20mA produce an angular deflection of 180°.

Ans $A = 5 \times 10^{-4} m^2$

$N = 60$ $\quad [\because 1G = 10^{-4} T]$

$B = 90G = 90 \times 10^{-4} T$

$K = ?$, $I = 0.20 \times 10^{-3} A$, $\theta = 180°$

$$K\theta = NIBA$$

$$K = \frac{NIBA}{\theta}$$

$$K = \frac{60 \times 0.2 \times 10^{-3} \times 90 \times 10^{-4} \times 5 \times 10^{-4}}{180}$$

Ques To increase the current senstivity of MCG By 50% Its resistance so that new resistance become twice its initial resistance By what factor due voltage senstitity change?

Ans $V_s = ?$, $I_s' = I_s + \frac{I_s \times 50}{100} = \frac{3}{2} V_s$

$$R' = 2R$$

$$V_s' = \frac{I_s'}{R'} = \frac{3/2 \, I_s}{2R} = \frac{3}{4} \times \left[\frac{I_s}{R}\right]$$

$$V_s' = \frac{3}{4} V_s$$

75%

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Ques Compare the current sensitivity and voltage sensitivity of MCG

Meter A $N = 30$, $A = 1.5 \times 10^{-3} m^2$
$B = 0.25T$, $R = 20\Omega$

Meter B $N = 35$, $A = 2.0 \times 10^{-3} m^2$
$B = 0.25T$, $R = 30\Omega$

$[K_1 = K_2]$

Ans Current Sensitivity

$$\frac{(I_s)_A}{(I_s)_B} = \frac{\frac{N_1 B_1 A_1}{K_1}}{\frac{N_2 B_2 A_2}{K_2}} = \frac{N_1 B_1 A_1}{N_2 B_2 A_2} \quad \text{---} (1)$$

$$= \frac{30 \times 0.25 \times 1.5 \times 10^{-3}}{35 \times 0.25 \times 2.0 \times 10^{-3}} = \boxed{\frac{9}{14}}$$

Voltage Sensitivity

$$\frac{(V_s)_A}{(V_s)_B} = \frac{\frac{N_1 B_1 A_1}{K_1 R_1}}{\frac{N_2 B_2 A_2}{K_2 R_2}} = \frac{N_1 B_1 A_1}{N_2 B_2 A_2} \times \frac{R_2}{R_1}$$

By eq^n (1)

$$= \frac{9}{14} \times \frac{20}{30} = \boxed{\frac{3}{7}}$$

NCERT

Ques A moving coil meter has following particular
$N = 24$, Area of coil $= 20 \times 10^{-3} m^2$
magnetic field, $B = 0.02T$, Resistor of coil, $R = 14\Omega$
If in doings the resistance of coil increased to

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Q. Is the voltage sensitivity of coil modified meter greater or less than original meter?

Ans $V_{s_1} = \frac{NBA}{KR_1} = \frac{24 \times 0.02 \times 20 \times 10^{-3}}{K \times 14}$ — (1)

$V_{s_2} = \frac{NBA}{KR_2} = \left[\frac{24 \times 0.02 \times 20 \times 10^{-3}}{K \times 21 \times 14}\right] \times 14$

$V_{s_2} = \frac{V_{s_1}}{21} \times 14$

$V_{s_2} = \frac{14}{21} V_{s_1} = 66\% \, V_s$

Factors on which Current Sensitivity of M.C.G depend

1. No. of turns (N)
2. Magnetic Field (B)
3. Area (A)
4. Torsion constant (K)

for Increasing (↑) I_s

as, $I_s = \frac{NBA}{K}$

N(↑), B(↑), A(↑), K(↓)

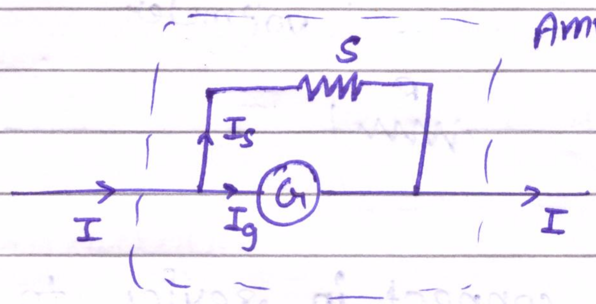
For Increasing V_s

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

N(↑), B(↑), A(↑), K(↓), R(↓)

★ Moving coil Galvanometer $\xrightarrow{\text{convert}}$ (1) Ammeter
(2) Voltmeter

Moving Coil Galvanometer convert into a Ammeter.



$$I = I_g + I_s$$

$$I_s = I - I_g$$

S → Shunt → Low Resistance

Shunt connect in parallel to galvanometer then galvanometer behaves as Ammeter.

Let I_g is current in galvanometer
I_s is current in Shunt

Voltage same

$$S \times I_s = I_g \times G$$

$$S = \frac{I_g \times G}{I_s} \Rightarrow \frac{I_g \times G}{I - I_g}$$

Net Resistance

$$\frac{1}{R_N} = \frac{1}{S} + \frac{1}{G}$$

$$R_N = \frac{S \times G}{(S+G)}$$

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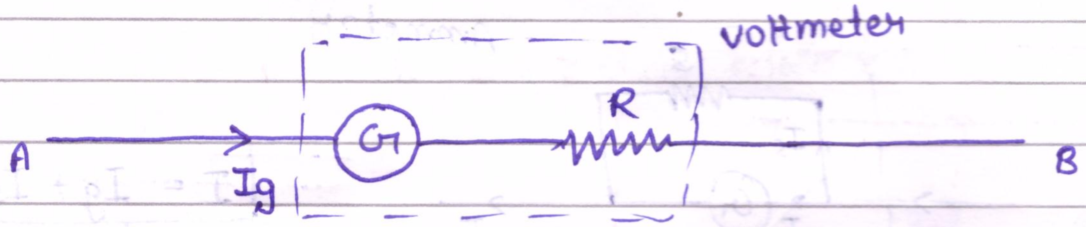
Moving coil galvanometer into Voltmeter



A high resistance connect in series to galvanometer to convert galvanometer into voltmeter

$$V = IR$$

$$I_g = \frac{\text{Potential difference}}{\text{Total Resistance}}$$

$I_s \rightarrow$ current in galvanometer

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

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

Use of Shunt

(i) To prevent a galvanometer from being damaged due to large current.

(ii) To convert galvanometer into voltmeter.

(iii) To increase the range of voltmeter.