# Magnetism & Matter

04 September 2020 17:00

$i_g = \frac{C \cdot \theta}{NAB}$ — ①

$i_A = i_g \cdot \frac{(R_G + r_s)}{r_s} \approx i_g \cdot \frac{R_G}{r_s}$ — ②

$V = i_g \cdot R_V = i_g (R_G + R)$ — ③

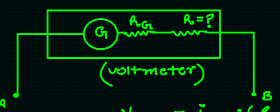
imp: $V \propto i_g$

$i_A \propto i_g$

**Q:** A galvanometer coil has a resistance of $12\,\Omega$ its display shows full scale deflection for a current of 3mA. How it can be converted into a voltmeter of range 0 to 18 V ?

**Sol$^n$:→** $i_{g_{Max}} = 3 \times 10^{-3}$ A : $V_{Max} = 18$ volt

$0 \le V \le 18$ volt




∵ reading of Ⓥ : $V = i_g \cdot (R_G + R)$

⇒ $\uparrow V \propto i_g \uparrow$

⇒ $V_{Max} \to i_{g\,Max}$

$V_{Max} = i_{g_{Max}} \cdot (R_G + R)$

⇒ $18 = 3 \times 10^{-3} \times (12 + R)$

$6000 = 12 + R$ ⇒ $R = 5988\,\Omega$ (in series with G.)

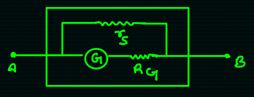
**Q:→** A galvanometer coil has a resistance of $15\,\Omega$. It shows a full scale deflection for a current of 4mA. How it can be converted into an Ammeter of range 0 to 6A ?

**Sol$^n$:→** $i_{g_{Max}} = 4 \times 10^{-3}$ A ; $R_G = 15\,\Omega$ : $0 \le i \le 6$ A

$i_{A\,Max} = 6$ A

reading of Ⓐ : $i_A = i_g \cdot \frac{(R_G + r_s)}{r_s}$

$\uparrow i_A \propto i_g \uparrow$




⇒ $i_{A\,Max} = i_{g_{Max}} \cdot \left(\frac{15 + r_s}{r_s}\right)$

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

$1500 = \frac{15 + r_s}{r_s}$

$1499\, r_s = 15$

⇒ $r_s = \frac{15}{1499} = 0.01\,\Omega$

(in parallel with G.)

**Q:→** A MCG of resistance $100\,\Omega$ is used as an ammeter using a resistance $0.1\,\Omega$. The maximum deflection current in the Ⓖ is $100\,\mu A$. Find the circuit current for which the Ⓐ shows maximum deflection.

**Sol$^n$:→** $R_G = 100\,\Omega$ : $r_s = 0.1\,\Omega$ ; $i_{g_{Max}} = 100\,\mu A = 10^{-4}$ A

circuit current or reading of Ⓐ $i_A = i_g \cdot \frac{(R_G + r_s)}{r_s}$

⇒ $i_{A\,Max} = i_{g_{Max}} \cdot \left(\frac{R_G + r_s}{r_s}\right)$

$= 10^{-4} \times \left(\frac{100 + 0.1}{0.1}\right)$

$= 10^{-3} \times 100.1$

⇒ $i_{A_{Max}} = 0.1$ A.

<u>current sensitivity of a Ⓖ</u> :→ $(S_c)$ : "it is the deflection of the Ⓖ coil per unit value of current"

$\boxed{S_c = \frac{\theta}{i_g}}$ rad/Amp

G1 $\xleftarrow{}$ 1mA $\xrightarrow{}$ G2

× 5°     10° ✓

as; $\theta = \frac{N i_g AB}{K}$

⇒ $S_c = \frac{N \cdot i_g \cdot A \cdot B}{K \cdot i_g}$

$\boxed{S_c = \frac{NAB}{K}}$

⇒ $\uparrow S_c \propto N \uparrow$ & $\uparrow S_c \propto \frac{1}{K \downarrow}$

<u>Voltage Sensitivity of a Galvanometer;</u> $(S_V)$ it is the deflection of the Ⓖ coil for unit value of P.D.

$\boxed{S_V = \frac{\theta}{V}}$ rad/volt

× G1 $\xleftarrow{}$ 1V $\xrightarrow{}$ G2 ✓

10°     20°

∵ $\theta = \frac{N i_g \cdot A \cdot B}{K}$

⇒ $S_V = \frac{N \cdot i_g \cdot A \cdot B}{K \cdot V}$

∵ $\frac{V}{i_g} = R_G$

⇒ $\boxed{S_V = \frac{NAB}{K \cdot R_G}}$ — ④

as $\frac{N}{R_G} = $ const $\left\{ \uparrow R_G = \frac{\rho\, l \uparrow}{A} \right\}$

"increasing the no. of turns will not increase the voltage sensitivity."

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

"increasing the no. of turns will not increase the voltage sensitivity"

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

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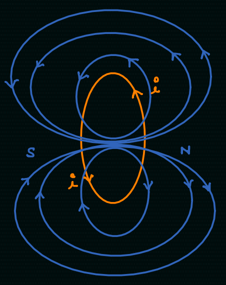
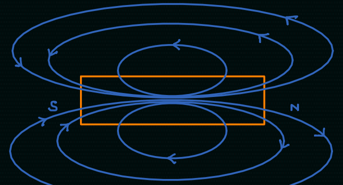
**Magnetism & Matter** : In this chapter we study the magnetism as a property itself and about magnetic properties of matter.

there are two magnets ( Magnetic Dipoles) which we study.

i) **Electro-Magnets** :→ Any current carrying coil is called an electromagnet. In an electromagnet the magnetism arises due to electric current (Biot-Savart's Law & ACL).
Eg: Solenoid & toroid.




ii) **Natural or Permanent Magnets** :→ These are the magnets which posses magnetism due to natural reasons like magnetite (an ore of iron), AlNiCo (an ore of aluminium, nickel & cobalt)
Eg:→ Bar magnet, horse-shoe magnet etc.




imp points :→ i) when a Bar magnet is freely suspended from its center of mass it always stops in North-South direction. The tip which points to the geographic north is called the north pole & the tip which points the geographical south of earth is called South pole.

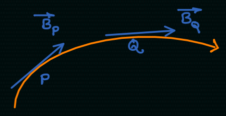
ii) we cannot separate both the N & S poles. If we break a magnet into two pieces, we get 2 separate magnets, although the magnetic strength decrease.

iii) like poles repel & opposite poles attract each other.

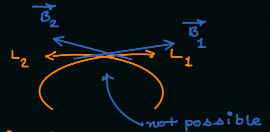
**Magnetic field lines** :→ These are the imaginary lines which describe the strength & direction of magnetic field in the space.

properties :→ 1) MFLs. form close continuous curves, the move from N to S outside the magnet & from S to N inside the magnet.

2) Tangent drawn at any point on the MFL gives the direction of magnetic field at that point.

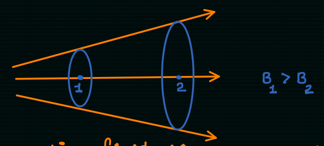



3) Magnetic field lines do not intersect as more than one directions of magnetic induction is not possible at a point.




4) Less spacing b/w the field lines indicates stronger field & vice-versa.

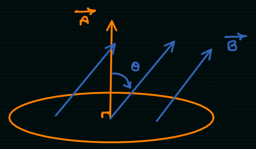
& vice – versa.




5) Magnetic field lines can penetrate through conductors

6) Magnetic field lines must not be called magnetic lines of force as the moving charge experience force perpendicular to the field.

Magnetic flux ($\phi_B$) :→ it is the no. of magnetic field lines passing perpendicularly to any surface inside magnetic field.




$\phi_B \propto \vec{B}$ —①

$\phi_B \propto \vec{A}$ —②

$\Rightarrow \phi_B \propto \vec{B}\cdot\vec{A}$ ; $\phi_B = K\cdot\vec{B}\cdot\vec{A}$

here ; $K = 1$

$\therefore \boxed{\phi_B = B\cdot A\cdot\cos\theta = B_\perp\cdot A}$ —⊛

unit is weber

D.F. is $[ML^2T^{-2}A^{-1}]$

*) if $\theta = 0°$ ; ie; $\vec{B}$ is along $\vec{A}$

$\phi_B = B\cdot A\cdot\cos 0° = B\cdot A$ = positive (outgoing & maximum)

*) if $\theta = 180°$ ; $\vec{B}$ is along $\vec{A}$

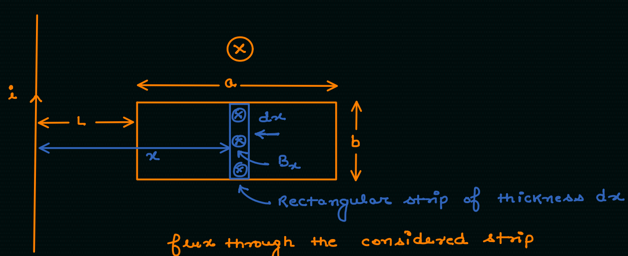
$\phi_B = B\cdot A\cdot\cos 180° = -B\cdot A$ = negative (incoming & max.)

*) if $\theta = 90°$ ; $\vec{B}$ is $\perp$ $\vec{A}$

$\phi_B = B\cdot A\cdot\cos 90° = 0$ = no. flux is linked.

eg:→ find the magnetic flux passing through the rectangular frame.

Sol$^n$:→




flux through the considered strip

$d\phi_B = \vec{B}\cdot d\vec{A}$

$= B\cdot dA\cdot\cos 180°$

$= \frac{\mu_0}{2\pi}\cdot\frac{i}{x}\cdot b\cdot dx \times -1$

$$\int_0^{\phi_B} d\phi_B = -\frac{\mu_0}{2\pi}\cdot i\cdot b\cdot\int_L^{(L+a)}\frac{dx}{x}$$

$$\Rightarrow \phi_B = -\frac{\mu_0}{2\pi}\cdot i\cdot b\cdot\left(\log_e x\right)_L^{L+a}$$

$$\therefore \phi_B = -\frac{\mu_0}{2\pi}\cdot i\cdot b\cdot\log_e\left\{\frac{L+a}{L}\right\} \text{ wb}$$

or

$$\frac{\mu_0}{2\pi}\cdot i\cdot b\cdot\log_e\left\{\frac{L+a}{L}\right\} \text{ wb (incoming)}$$