"CHAPTER # 12" "ELECTRO - MAGNETISM"

non - contact force.
↑
Magnetic field → Permenant (N → S)
Magnetic field → temporary (Charges ka flow)

•=> So Basically, Electromagnetism charges k flow ki wajah se produce hone wali magnetic field ko kahen ge.

•=> Mutual Relationship between electric current and magnetic field.

Q Direction of Magnetic lines outside magnet

Ans:- North pole ⟶ South pole
(origination) (absorption)

Q Inside :- S. pole ⟶ N. Pole.

Ferro Magnetic Materials ⟶ Iron, Steel etc.

MICHAEL FARADAY

→ According to M.F ① har magnet ki apni field hoti he. ② Magnetic field, magnetic force apply kerti he.

(agr magnetic field mein iron fillings ko rkhien ge tou wo automatically khud ko field lines k hissab se arrange ker lien gi.)

→ magnetic field lines alway form Complete Loops

→ No monopoles (North Pole & South Pole donot exist independently.

SQ Properties of magnetic fields

→ Vectors

→ never cross each other.

→ density $\propto$ Strength

→ Closed loops

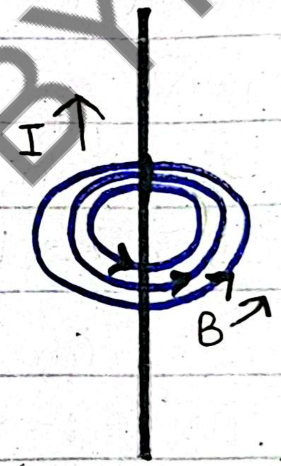
→ N. pole ⟶ S. pole.

→ Like → repel, unlike → attract.

Magnetic field Due to Current in a Long Straight Wire.

Prof. Hans Oersted ⟶ 1820

⇒ In order to find the Direction of magnetic field we can use right hand rule.



Right hand rule States that :-

If the wire is grasped in the fist of right hand with the thumb pointing in the direction of conventional current, then the curled fingers indicate the direction of magnetic field.

Q How Can U find Direction of Magnetic field in current carrying wire.

(conventional current ⇒ +ve → -ve)

(electronic current ⇒ -ve → +ve)

V.V.V. IMPORTANT FOR LQ

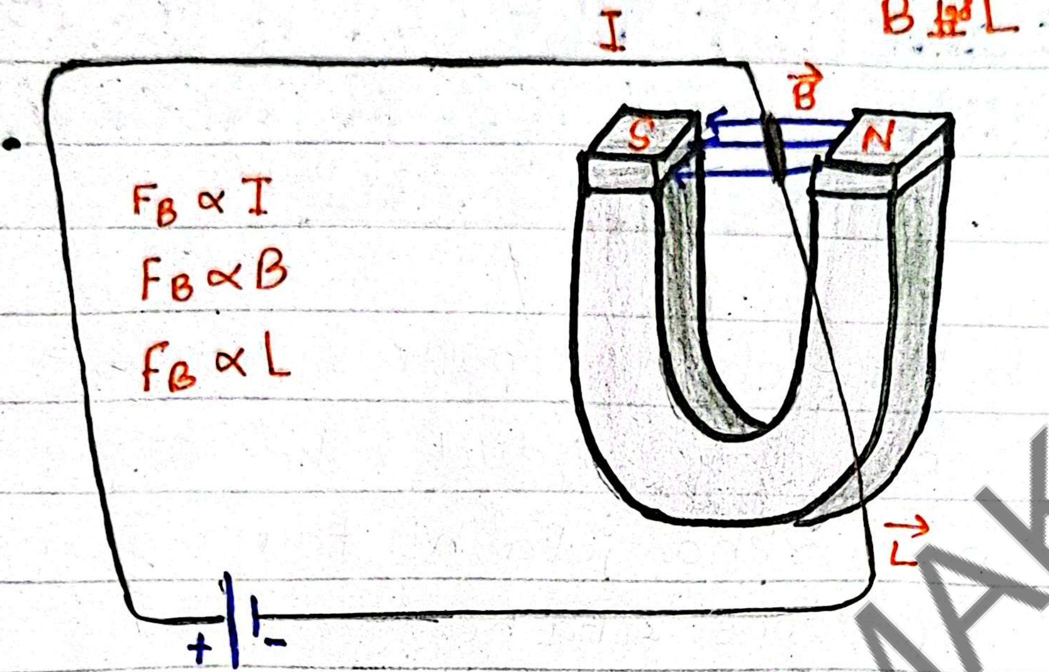
"MAGNETIC FORCE ON A CURRENT CARRYING CONDUCTOR IN UNIFORM" "MAGNETIC FIELD"

⇒ jab kissi charged particle ko ya current carrying conductor ko magnetic field mein rkha jata he tou wo magnetic force experiance krta he.

"Phenomenon"

Ab scene ye ho ga k, jab current carrying conductor ko magnet k dono poles k darmian place kia jai ga, tou permenant magnet samjhe ga k jo current carrying wala he, wo b magnet he and phir us per force lagai ga.
tou is scene ko hum keh sakte hen magnetic force on current carrying conductor.

Q Catapult field → Wo magnetic field jo wire ko move krwati he wo Catapult field kehlati he.



⟹ Jab Zyada Current How ho ga tou F_B bhi ziyada ho gi and Electro-magnet b zyada strong ho ga

MATHEMATICALLY!

$F_B \propto I$ — i

$F_B \propto B$ — ii

$F_B \propto L$ — iii

∴, $F_B \propto BIL$

$F_B = k(BIL)$

$F_B = BIL$ (Experimentally $k = 1$)

As, magnetic force is a vector Quantity So, it also depends on the direction

$$\vec{F_B} = I\cdot(\vec{L} \times \vec{B})$$

$$\vec{F_B} = BIL\sin\theta$$

SQ Max. force? Min. force?

"**MAXIMUM FORCE**"

when the angle b/w $\vec{L}$ and $\vec{B}$ is 90° (Perpendicular)

$F = BIL \sin(90)$

$F_{max} = BIL$ $\because \sin(90) = 1$

"**MINIMUM FORCE**"

when the angle b/w $\vec{L}$ and $\vec{B}$ is 0° (Parallel),

$F = BIL \sin(0)$

$F = BIL\ (0)$ $\because \sin(0) = 0$

$F_{min} = 0$

when the angle b/w $\vec{L}$ and $\vec{B}$ is 180° (Antiparallel),

$F = BIL \sin(180)$

$F_{min} = 0$ $\because \sin(180) = 0$

"**CONCLUSION**"

Thus we conclude that (1) If L and B are mutually Perp. the current carrying wire experiance max force (2) If L and B are mutually Parallel. the current carrying wire experiance min force (no force).

FLEMING'S LEFT HAND RULE

Below Stated flemings left hand rule helps to solve problems-

If we arrange thumb, fore finger and middle finger of left hand mutually perp. they points towards direction of magnetic force, magnetic field and direction of current respectively.

"MAGNETIC FLUX DENSITY"

Flux $\longrightarrow$ Measurement of no. of lines / Area

As we know that,

$$F = BIL$$

$$B = \frac{F}{IL}$$

where B is magnetic flux density or magnetic field intensity.

$$B = \frac{F}{IL} \Rightarrow 1T = \frac{1N}{A.m}$$

$$\boxed{1 \text{ Telsa} = 1 N.A^{-1}.m^{-1}}$$

→ Very Imp. topic for MCQs.

→ Magnetic field is a vector Quantity.

→ Tesla ⟶ S.I unit

Gauss ⟶ CGS unit

$$1T = 10000 G$$

Eik hota he Magnetic flux and eik hota he flux density, above mentioned wala is flux density

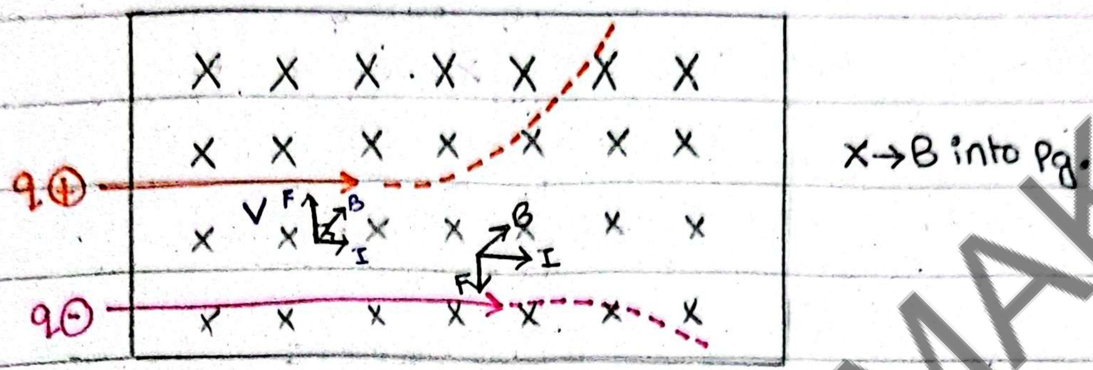
Magnetic flux ⟶ SI unit = Weber (Wb)

$$1 Wb = 1T \times m^2$$

Formula: $\Phi = B \times A$

MAGNETIC FORCE ON A MOVING CHARGE IN A UNIFORM MAGNETIC FIELD

PKMZ



Story:-

charge (q) magnetic field mein enter hota he tou us k movement ki wajah se us ki apni bhi eik magnetic field produce hoti he. Jab permenent magnet ki magnetic field ko yeh sab kuch pata lagta he tou wo us charge per force lagati and us ko deflect ker deti he.

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

$$\vec{F}_B = qVB\sin\theta\,\hat{n} \quad -\text{i}$$

equation (i) can help to find the magnetic force on a unit positive charge.

Incase of -ve charge (q⊖)

↳ $\vec{F}_B = qVB\sin\theta\,\hat{n}$

↳ In this case, we'll apply the same left hand rule but from right hand

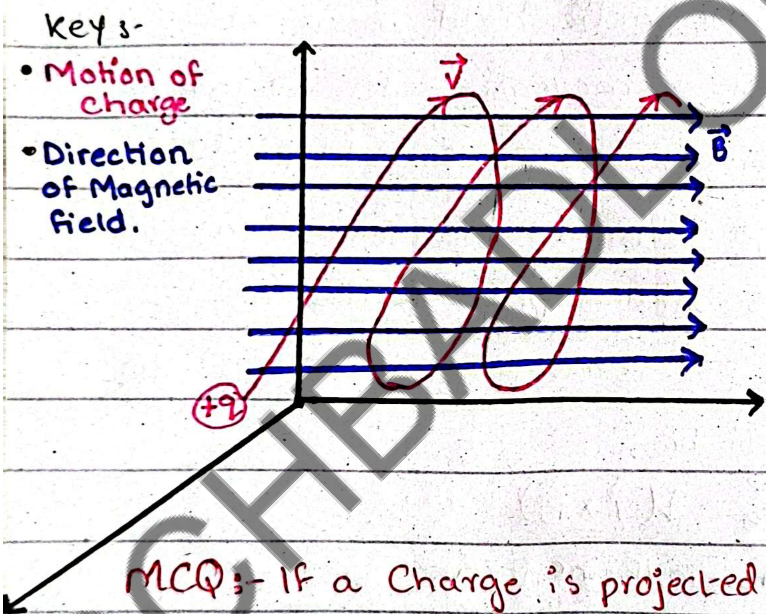
Q Max Magnetic Force on Charge?

$$F_B = qVB\sin\theta$$
$$= qVB\sin(90)$$
$$F_{B(max)} = qVB \qquad \because \sin 90 = 1$$

Q Min Magnetic Force on Charge?

$$F_B = qVB\sin\theta$$
$$= qVB\sin(0^\circ)$$
$$F_{B\,min} = 0 \qquad \because \sin 0 = 0$$

Q If the angle is b/w 0° and 90°?



MCQ:- If a Charge is projected other than angle 0°/ 90°/180° then it follows "helical" path.

Special Tip:-

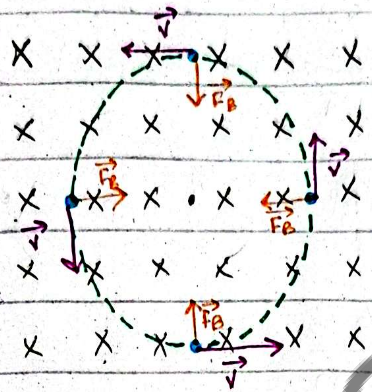
90° → Circular

0°/180° → Straigth path

other than 0°/90°/180° → helical.

"MOTION OF A CHARGED PARTICLE MOVING IN A UNIFORM" "MAGNETIC FIELD"

V.V.V. Imp. ⟶ [LQ, SQ, Numerical, Derivation]



$$F_B = qVB\sin\theta \qquad \because \theta = 90^\circ$$

$$F_B = qVB$$

$$F_c = mv^2/r$$

As in the Current Situation,

$$F_B = F_c$$

$$q\cancel{V}B = mv^{\cancel{2}}/r$$

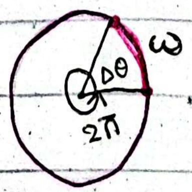
$$qB = mv/r$$

$$qB = m(\cancel{r}\omega)/\cancel{r} \qquad \because v = r\omega$$

$$\omega = \frac{qB}{m}$$

where 'ω' shows Angular frequency.

Yahan 'ω' angular frequency aaise he k agr poora cycle complete ho jai tou frequency ban jai gi



Q Derive Cyclotron frequency:

$$\omega = \theta / t$$

as $\Rightarrow \theta = \omega \times t$

$\Rightarrow 2\pi = \omega \times t \Rightarrow \omega = \frac{2\pi}{t}$

$$\omega = 2\pi \times \frac{1}{T} \Rightarrow \omega = 2\pi f$$

Putting the value of ω in equation i

$$\omega = \frac{qB}{m}$$

$$2\pi f = \frac{qB}{m}$$

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

Q Time Period.

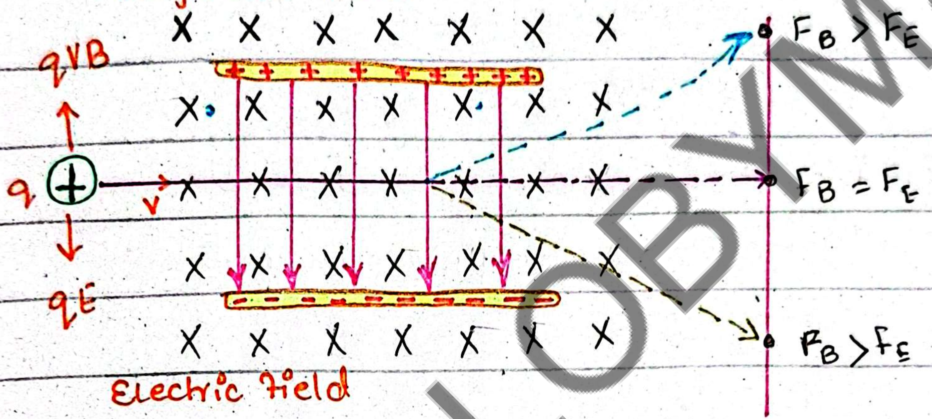
$$f = \frac{qB}{2\pi m}$$

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

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

"Velocity Selector"

→ In this Case Electric field is held Perpendicular to magnetic field.



Since, F_B and F_E are in Balanced condition,

$$F_B = F_E$$

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

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

Q Lorentz force.

total force acting on a Charged particle in both electric and magnetic fields.

$$\vec{F} = \vec{F_E} + \vec{F_B}$$

$$\vec{F} = q\vec{E} + q\vec{V}\times\vec{B}$$

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

"MAGNETIC FIELD PATTERN"

Electric Current jab b magnetic field produce krta he tou wo in the form of loop hi hota he.

Strength depends on
→ ① no. of turns
→ ② Current passing

① 'B' due to 'I' in straight Conductor :

Q Derivation of Ampheres circuit law.

$B \propto I$

$B \propto 1/r$

$B = (\text{constant})(I/r)$

$B = \frac{\mu_0}{2\pi}\left(\frac{I}{r}\right)$ ∵ constant $= \frac{\mu_0}{2\pi}$

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

where value of $\mu_0 = 4\pi \times 10^{-7}$ Wb/Am

② 'B' due to 'I' in flat circular coil

As, Yahan Sirf Single Circular Loop he.

$$B = \frac{\mu_0 I}{2r}$$

③ 'B' due to 'I' in Solenoid.

→ Solenoid k andar field uniform and strong hoti he. as compared to outside.

$B = \mu_0 n I$ ∵ $n = \frac{N}{L}$ (no. of turns) / (Length of solenoid)

Q Right hand rule 3 of Solenoid.

Ye kehta he ki right hand ki fingers agr solenoid per jo magnetic field he us ki direction mein curl keien ge tou thumb north pole ki traf point kre ga.

"MAGNETIC FIELD DUE TO CURRENT IN SOLENOID (INC. BY A FERROUS CORE)"

Common ferrous materials :-

1. Iron (Fe)
2. Silicon steel
3. Iron alloys.

[Sab ki apni alag Permeability he]

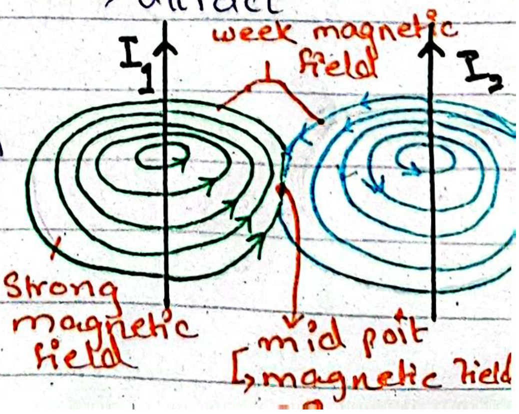
jab ferrous rod solenoid k andar place hota he tou magnetic field intensity inc hoti he.

This combination of ferrous core and solenoid is known as Electromagnet

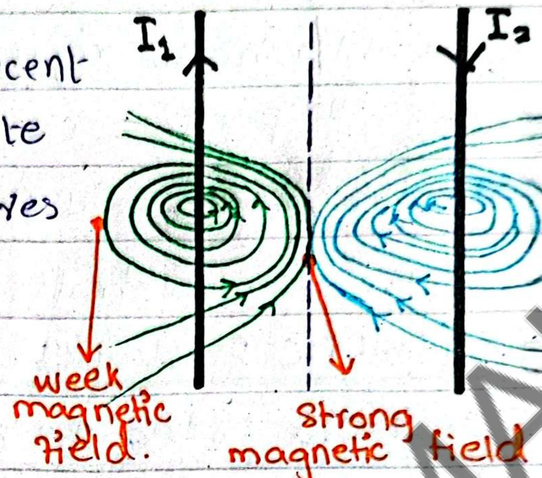
"MAGNETIC FORCES B/W CURRENT CARRYING CONDUCTORS"

1. Same direction ⟶ attract

according to right hand rule if direction of current moving in 2 adjesent wires is same then, they'll attract each other. at mid point, $B=0$ cause opp. direction cancels ...'s effect.



(2) Different direction → repel



If the current in 2 adjecent wires is moving in opposite direction, then both wires will oppose each other.

'B' will be strongest in the centre and weekest at ~~the~~ open ends.

LQ Derive the relation for finding force/Length exerted by 1 wire on another.

Magnetic field of first wire is given by :-

$$B_1 = \frac{\mu_0 I_1}{2\pi r}$$

$$F_{12} = B_1 I_2 L$$

$$F_{12} = \frac{\mu_0 I_1 I_2 L}{2\pi r} \Rightarrow \boxed{\frac{F_{12}}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}} \text{ — i}$$

Magnetic field of 2nd wire is given by :-

$$B_2 = \frac{\mu_0 I_2}{2\pi r}$$

$$F_{21} = B_2 I_1 L$$

$$F_{21} = \frac{\mu_0 I_2 \times I_1 \times L}{2\pi r} \Rightarrow \boxed{\frac{F_{21}}{L} = \frac{\mu_0 I_2 I_1}{2\pi r}} \text{ — ii}$$

So these forces make action and rxn Pair

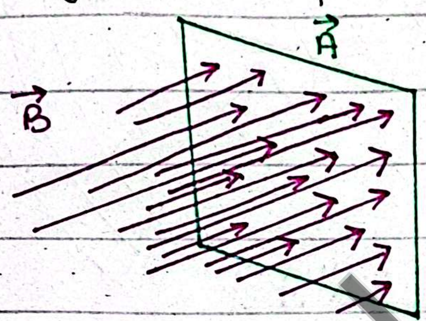
"MAGNETIC FLUX"

The number of magnetic lines of force passing through certain element of Area is called Magnet flux.

Mathematically:-

$$\Phi = \vec{B} \times \vec{A} = BA\cos\theta$$

Diagramatically:-



Dot/Scalar product of magnetic field and Vector area.

Point to Ponder

vector area ($\vec{A}$)

- when we multiply a unit normal vector with area then, we get vector area.

$A \times \hat{n} = \vec{A}$

MAGNETIC FLUX At different ANGLES

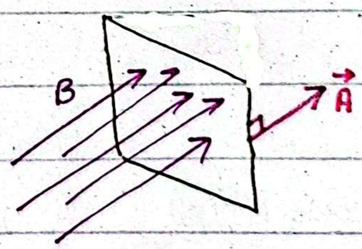
① When the angle b/w $\vec{B}$ and $\vec{A}$ is "0"

- When magnetic field 'B' and Area 'A' are parallel then $\theta = 0°$

$\Phi = BA\cos\theta$

$\Phi = BA\cos 0°$ $(\cos 0° = 1)$

$\Phi = BA$



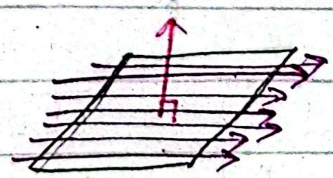
When the angle b/w $\vec{B}$ and $\vec{A}$ is "90°"

- when $\vec{B}$ and $\vec{A}$ are perpendicular, $\theta = 90°$

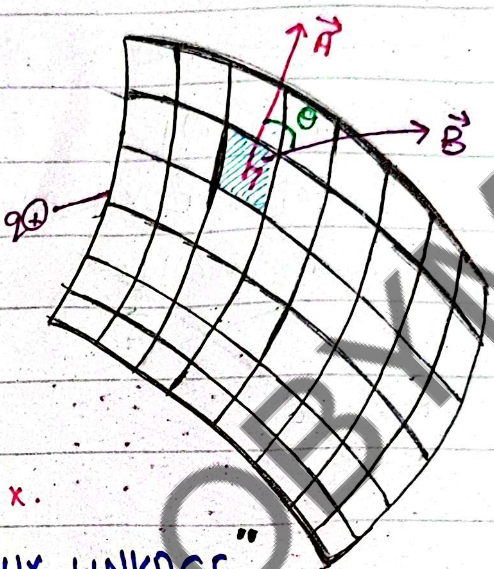
$\Phi = BA\cos\theta$

$\Phi = BA\cos(90°)$

$\Phi = 0$ $(\cos 90 = 0)$



"MAGNETIC FLUX THROUGH CURVED/NON UNIFORM "MAGNETIC FIELD"



Formula:-

$\Phi = \Sigma \vec{B} \cdot \Delta\vec{A}$

Unit:-

$1\,Wb = 1T \cdot 1m^2$

Weber (Wb) is the unit of magnetic flux.

"MAGNETIC FLUX LINKAGE"

- magnetic flux and magnetic field density mein ye farq he k magnetic flux, area involve krta he and density wala sirf field lines ko

Magnetic flux linkage is basically;

The product of magnetic flux and the no. of turns of the coil.

→ Involves wire jin mein N turns of wire hote hen.

Mathematically;

If $\vec{B}$ and $\vec{A}$ are perpendicular

$N\Phi = NBA$

Magnetic flux $(\vec{B})$ and $\vec{A}$ are not perpendicular

MAGNETIC FLUX LINKAGE $= BAN\cos\theta$

Unit :-

$N\Phi$ = Wb . turns.

— x — x — x — x — x —

Important MCQs for Board Exams :-

① Unit of Magnetic flux density (B).

from, $F = BIL \Rightarrow B = F/IL$

$\Rightarrow \boxed{T = N.A^{-1}.m^{-1}}$ — i

from, $\Phi_B = BA \Rightarrow B = \Phi_B / A$

$\Rightarrow \boxed{T = Wb.m^{-2}}$ — ii

② Unit of magnetic flux (Φ)

from ii $\longrightarrow \boxed{1\,Wb = 1\,T.m^2}$

from i $\longrightarrow 1\,Wb = (N.A^{-1}.m^{-1})(m^2)$

$\boxed{1\,Wb = N.m.A^{-1}}$

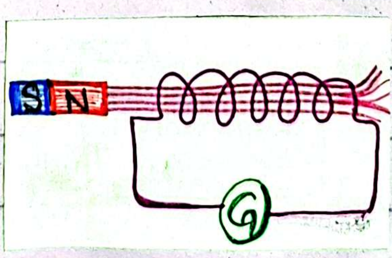
— x — x — x — x — x —

FARADAY'S LAW

The phenomenon in which the change in magnetic flux causes an induced emf in a conductor is called electromagnetic induction.

PKMZ Story.

hum jab magnet ko agay peechay kereinge tou no. of



jab tak emf induce hoga tab tk coil will act as battery.

lines passing through the coil change hongi, jis ki wajah se emf induce ho ga, and isko hum electromagnetic induction kehte hen.

Mathematically:-

$$\mathcal{E}_{induced} \propto \frac{N \Delta \Phi}{\Delta t}$$

$$\mathcal{E}_{ind} = kN \frac{\Delta \Phi}{\Delta t}$$

Experimentally $k = 1$

$$\mathcal{E}_{ind} = -\frac{N \Delta \Phi}{\Delta t}$$

here the -ve sign shows that induced emf has opp. direction. and it opposes the change in flux.

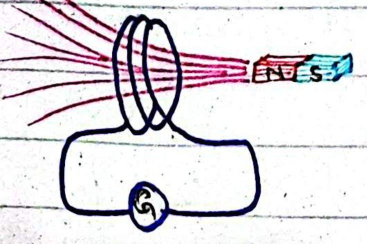
Experiments

① BAR MAGNET AND COIL CONNECTED TO SENSITIVE GALVANOMETER.

Case 1:- Na coil move ker rha and na hi magnet, so no deflection on Galvanometer

Case 2 and 3:-

jab Bar magnet ko coil k paas le ker gai, emf induce hoa current flow hoa. phir jab bar magnet ko coil se door le kr gai tou b emf induce hoa but current opposite direction mein move ker rha.



② Generator Effect

Is experiment mien simple yeh hota he k, jo coil he wo magnetic field mein rotate hoti he and area and magnetic field mein θ b change hota he, jis ki wajah se magnetic flux change ho ga, emf induce ho ga, aur current flow kre ga. and ELECTRIC GENERATOR ka Yahi Basic Principal he.

③ Transformer Effect

Simple 2 coils hen primary and secondary, Primary k saath hum series mein battery and rheostat attatch krte hen. ad sec. k saath sirf galvanometer attatch krte.

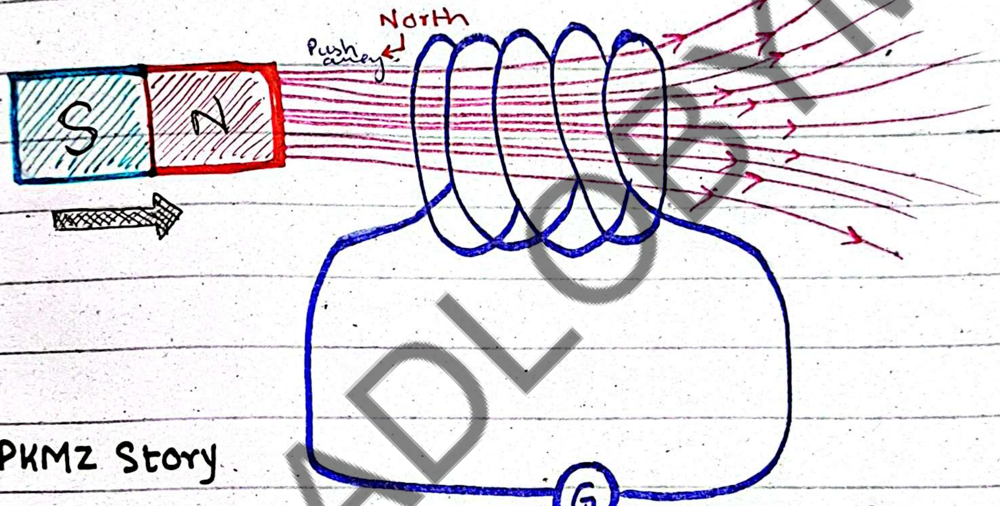
jab switch of primary coil closed hota jab emf sec coil mein b induce hota and us ki reading b aati.

rheostat wo device he jo k ~~[illegible]~~ resistance ko vary krwati he.

"LENZ'S LAW" → PARASITE

Lenz's law states that:-

The direction of the induced current is always such that it opposes the change that causes the current



PKMZ Story

jab hum bar magnet ko Solenoid k Qareeb le kr jaate tou us mein emf induce hota jis ki wajah se charge induce hota and us charge ki wajah se 'B' induce hoti.

Example le lein k hamare koi parasite dost hein jo hum se faida b lete and ulta humein nuqsan b dete, bilkul usi trah jab hum (bar magnet) apne us parasite dost (Solenoid) k Qareeb jaate to wo humein khud se door kr deta (jab bar magnet solenoid k paas le k jaate tou wo current induce hone ki wajah se, bar magnet k Qareeb wale pole ko

Fleming right hand rule
fore finger → magnetic field
middle " → induced current
Thumb → motion of Conductor

Used to find direction of induced current.

apna north pole bana leta. (jis k wjah se repulsion hoti).

ab jab hum apne dost se khafa ho kr door jaa rhe hon tou phir wo kehta 'nai yr mera wo matlab nai tha' (Qareeb wale pole ko South pole bana leta) and attract krta

So acc. to Lenz law, Faradays law ki mathematical representation mein jo -ve sign aata he wo issi induced emf ki wjah se aata he.

$$\mathcal{E}_{ind} = -\frac{N\Delta\Phi_B}{\Delta t}$$

Q Show that Lenz's law is menifestation of law of cons. of energy.

hum mechanical energy de kr move kr rhe hen magnet ko jis se k electrical energy produce hoti he, energy mechanical ⟶ electrical mein convert hoti he. jitni M.E, utni E.E

SEISMOMETER

ye eik aaisi device he jo seismic wave ko record krti (ground movement → Electrical Signals)

tarika is ka ye he k jab ground movement hoti tou magnet aur coil mein relative motion hota he jis ki wajah se current induce hota and external circuit mein values record hoti.