Electromagnetism

Magnet & Magnetism

The substance which has property to attract small pieces of Iron and steel is called Magnet. This property of a material is called magnetism.

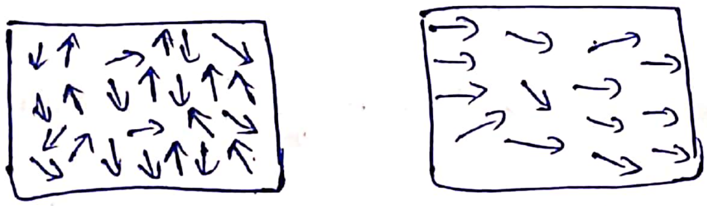
Magnetic Materials

The substances which are attracted by magnets are called magnetic materials.

Magnetic field

The field in which material is exposed to get magnetised.

Magnetization & Intensity of Magnetization



Non magnetised. Magnetised.

when magnetic material is exposed to magnetic field

↓

random oriented loops ⟶ Magnetic moments get alligned in one direction

↓

It gets magnetised

Intensity of magnetization

$$I = \frac{M \text{ (Magnetic Moment)}}{V \text{ (vol)}}$$

Magnetic flux density ($\vec{B}$)

No. of magnetic lines pass through a certain pt. on the surface is called Magnetic flux density.
Unit → tesla (T).

Magnetic susceptibility (χ_m)

Since,
Intensity of Magnetization ∝ Magnetic field Intensity

$$\vec{I} \propto \vec{H}$$

$$\vec{I} = \chi_m H.$$

χ_m → Magnetic Susceptibility.

χ → +ve → Paramagnetic Material

χ → −ve → Diamagnetic Material.

χ → +ve & large → ferromagnetic Material.

Magnetic permeability (μ).

The degree to which magnetic field can penetrate a medium is called relative permeability of a material

Diamagnetic Materials

The substances which are repelled by magnets are called diamagnetic materials

for example, copper, zinc, gold

$\mu < 1$, $\chi \rightarrow$ small & -ve

Paramagnetic Materials

The substances which are ~~strongly~~ weakly attracted by magnets. are called ~~diamagnetic~~ paramagnetic materials.

e.g aluminium, platinum

$\mu > 1$, $\chi \rightarrow$ small & +ve

Ferromagnetic Materials.

The substances which are strongly. attracted by magnets. are called ~~ferro~~ ferromagnetic Materials

e.g cobalt, Iron, Nickel.

$\mu >> 1$, χ = large & +ve.

Magnetic field & its Intensity

The space around the magnet, over which magnetic force is felt

Magnetic force $\vec{F_m} = q(\vec{V} \times \vec{B})$

$q \rightarrow$ charge
$V \rightarrow$ velocity of charge
$\vec{B} \rightarrow$ Magnetic field

$$\boxed{\vec{F_m} = q\vec{V}B \sin\theta}$$

if $q = 1C$
$V = 1m/s$
$\theta = 90° \Rightarrow \sin 90 = 1$

$\therefore F_m = B.$

$\therefore$ Magnetic field ~~insity~~ Intensity at a pt. is defined as magnetic force experienced by 1 C charge, moving with velocity $1m/s^2$ at right angle to the direction of magnetic field

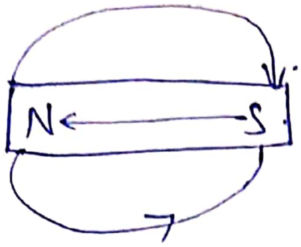
Units. $F_m = qVB\sin\theta$

$$B = \frac{F_m}{qV\sin\theta} = \frac{N}{C\frac{m}{s}} = NsC^{-1}m^{-1} = \boxed{NA^{-1}m^{-1}}$$

$\because \frac{C}{s} = A$

Magnetic Lines & its properties.

The tangent at any pt. of magnetic lines of forces represent the direction of magnetic field.



Properties.

1> Magnetic lines of forces start from North pole & End at south pole outside the magnet.

But, Inside the magnet, they move from south pole to north pole

2> Tangent at every pt of magnetic lines of forces gives the direction of mag. field at that pt.

3> Two magnetic lines of forces never cross each other.

4> Magnetic lines of forces expands laterally & contract longitudinally.

5> Magnetic lines of forces crowded at a pt.

↓ means

strong magnetic field at that pt.

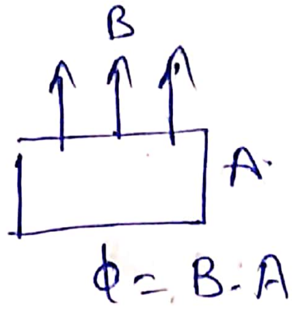
5> Magnetic lines of forces can pass through Iron more easily than air.

7> Magnetic lines of forces don't exist inside a superconductor.

Magnetic Flux

The no. of magnetic lines of force crossing through a given surface area in perpendicular direction is called magnetic flux.

$$\phi_m = \vec{B} \cdot \vec{A}$$



$$\phi_m = B A \cos\theta$$

$$\phi_m = \oint \vec{B} \cdot ds$$

Unit of Magnetic flux

S.I → weber

CGS → maxwell.

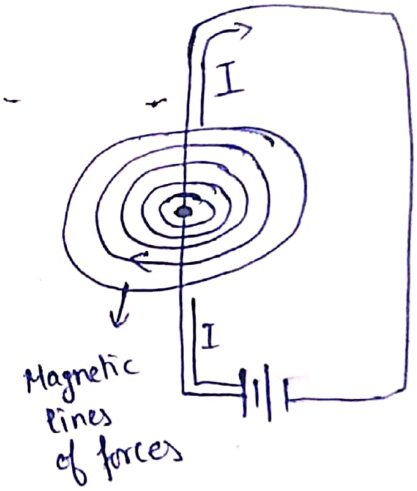
$$1 \text{weber} = 10^8 \text{ maxwell}$$

Magnetic field Pattern due to straight conductor, coil circular coil and solenoid.

When electric current is passed through a conductor
↓
Magnetic field is set up along the length of the conductor
└ depends upon → shape of the conductor

1) The straight conductor

When straigh conductor carries current
↓
Magnetic lines of forces will be in circular direction



&

⇒ Magnetic lines of forces will be in perpendicular direction to the flow of current.

⇒ Magnetic field would be strong at the centre & becomes weak as we go away from the centre.

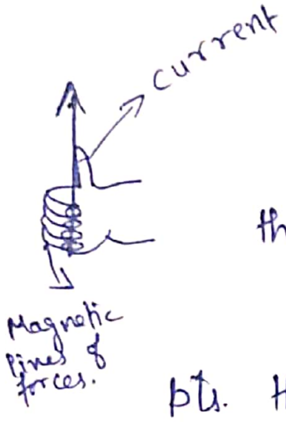
⇒ If current is reversed, direction of field also reverses.

⇒ Magnetic field become stronger, If the current is increased.

Direction of Magnetic lines of forces

Right Hand rule

Hold the conductor with right hand.



thumb ↓. pts. the current

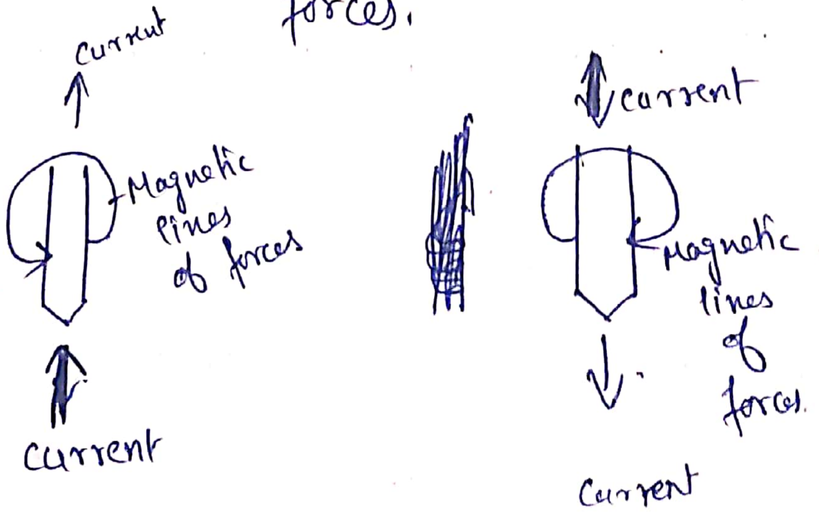
encirculing fingers ↓.. give the direction of magnetic lines of forces

Right Hand Cork Screw Rule

Hold the conductor with right hand

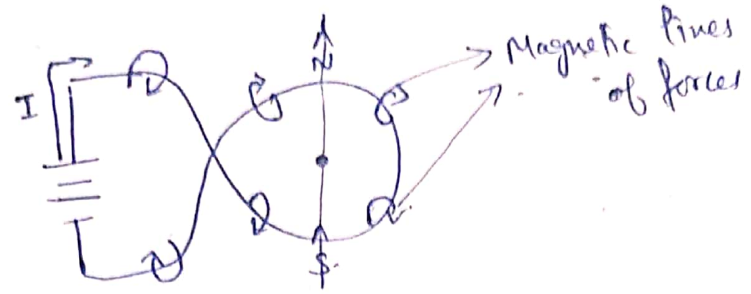
It advances in the direction of Current

fingers give the direction of magnetic lines of forces.



2) Circular Coil

The conductor bend in this shape is called circular coil.



when current is passed through the circular coil.

↓

→ Magnetic lines of forces will be circular near the edges of the coil.

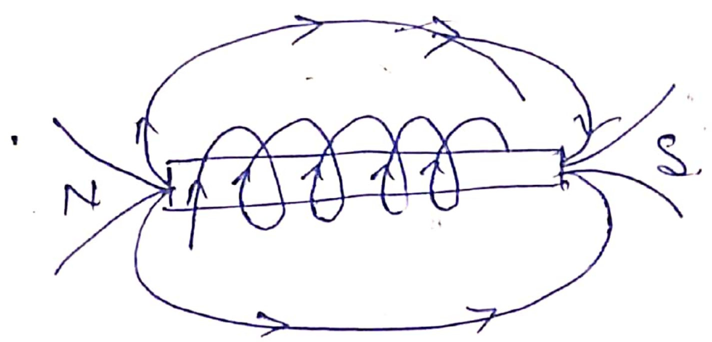
→ Straight & parallel in the centre

⇒ Direction of Magnetic lines of forces can be find out by Right hand rule or Right hand screw rule.

Solenoid

When a number of circular coils are arranged co-axially, such that same current flows in same direction in the coil.

This arrangement is called solenoid.



When current is passed thorough a solenoid

↓

It behaves like magnet

Right Hand rule

Hold the solenoid in Right hand

Direction of fingers —gives→ Direction of current

Thumb —gives→ Direction of North pole

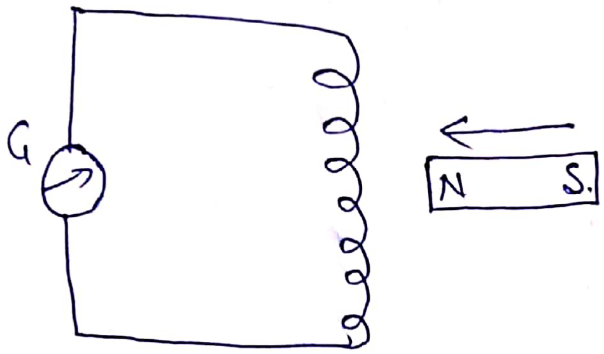
OR

 → Represent North pole

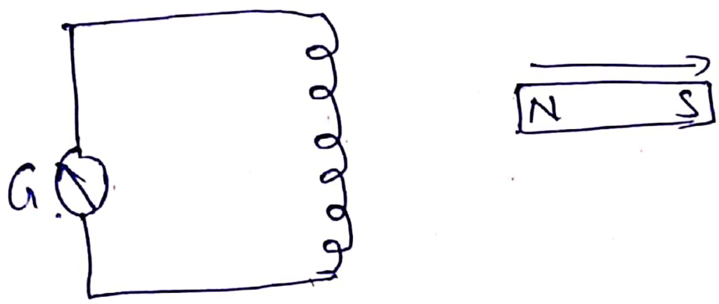
 → Represent South pole

Electromagnetic Induction

Oersted ~~perm~~ performed an experiment
↓
He connected a galvanometer with Induction coil and He observed



Deflection in Galvanometer when magnet is moved towards the coil.



- Delfection was also absorbed in Galvanometer when magnet is moved away from the coil, but deflection was in opp. direction.
- That means current move in opp direction

And, No current (or deflection in galvanometer) was observed when there was no motion in magnet

Conclusion.

when magnetic flux linked with closed circuit changes
↓
Induced emf, is produces as long as change take place
(Induced current)
↓
This phenomenon is called electromagnetic Induction.

Faraday's Law of Electromagnetic Induction

Faraday's Ist Law

It states that whenever magnetic flux linked with close circuit changes, Induced emf and hence Induced Current is produced. This phenomenon lasts as long as magnetic flux changes.

Faraday's IInd Law

The magnitude of Induced emf is directly proportional to the change in magnetic flux.

$$E \propto \frac{d\phi}{dt}$$

(E → Induced emf
φ → mag. flux)

$$\boxed{E = -N\frac{d\phi}{dt}}$$

(−ve sign shows the opp. nature of Induced emf)

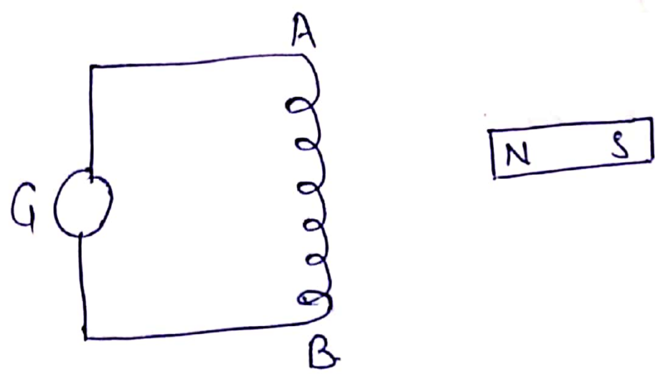
(N → If coil has N no. of turns)

Lenz's law

Lenz give the statement for the direction of Induced em.f.

Lenz's law

It states that Induced current flows in a direction such that current opposes the change that produced it.



When magnet is held stationary Near A end of coil.

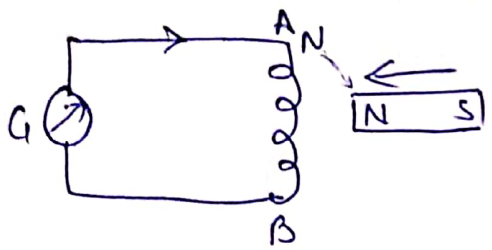
↓

No change in magnetic flux

↓

No emf is produced &

Galvanometer shows No deflection



As magnet was moved towards coil

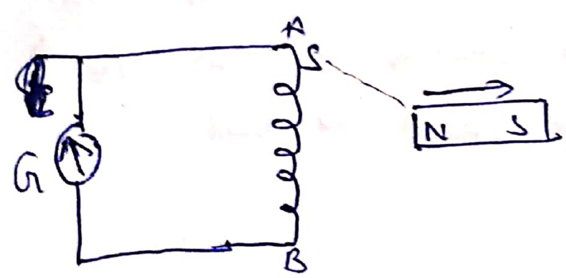
↓

Magnetic flux Increases

↓

Induced current starts flowing

Induced current gave north polarity to A end of coil, this north end of coil A side repell the North end of magnet



As the magnet was moved away from coil

↓

Magnetic flux decreases

↓

Induced emf starts flowing in opp. direction

Induced current give south polarity to A end of coil, this south end of coil A side attract the South end of magnet

Thus in both cases

Induced current opposes the direction of magnet.

Method to induce e.m.f by changing flux linked with coil.

Magnetic flux.

$$\phi = B \cdot S$$

$$\phi = B S \cos\theta$$

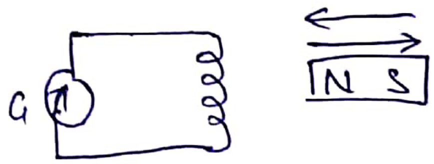
Induced e.m.f is produced by changing

(a) B with time

(b) S with time

(c) θ with time

(a) Induced emf by changing B with time,

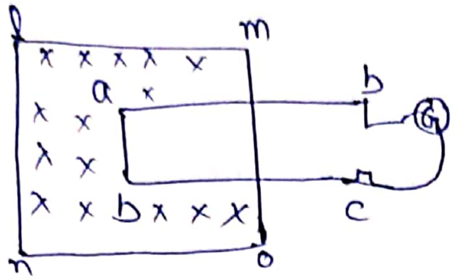


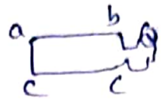
Induced e.m.f is produced $\xrightarrow{\text{when}}$ Magnetic flux changes.

↓

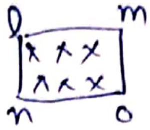
This can be done by moving magnet towads the coil and away from the coil.

(b) Induced e.m.f by changing S with time.





→ coil.



→ magnetic field,

If the coil 'abcd' is pulled out of the magnetic field 'lmno'

↓.

magnetic field experienced by coil decreases.

↓.

Magnetic flux decreases.

↓

Induced e.m.f is produced,

(C) Induced e.m.f. by changing θ with time

we know $\phi = BS\cos\theta$

If the coil is rotated in uniform magnetic field.

↓.

θ changes.

↓.

Magnetic field & Magnetic flux changes

↓.

Induced e.m.f is produced.