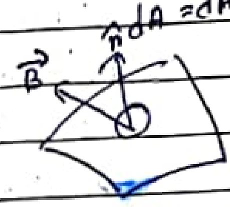
ELECTROMAGNETIC INDUCTION

Magnetic flux:

No of magnetic field lines crossing an area is called magnetic flux. It is represented by ϕ and its SI unit is Weber. For a constant area and magnetic field we can write, θ is the angle b/w $\vec{A}$ and $\vec{B}$

$$\phi = BA\cos\theta$$

(B → uniform, A → constant)



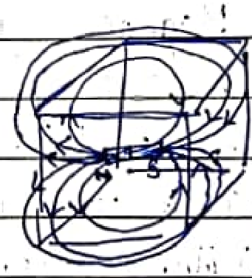
For variable ~~electric~~ magnetic field (elemental area is taken)

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

$$\phi = \int \vec{B}\cdot d\vec{A}$$

NOTE:-

1. Area vector is $\perp^r$ to the surface.
2. For open surface choose one direction as the area vector direction and stick to it for the whole numerical.
3. For closed surface outward normal is taken as the area vector direction.
4. $$\oint B\cdot dA = 0$$



because magnetic field lines exist in a closed loop.
No of field line coming out = no of field lines going inside.

{Clock wise current → South pole}
{Anti clockwise " → North pole}

Faraday's Law of Electromagnetic Induction :-

Whenever the flux of magnetic field through the area bounded by a closed conducting loop changes, an emf is produced in the loop which is given as

$$\varepsilon = -\frac{d\phi}{dt}$$ = rate of change of flux with time

Negative sign indicates that emf is induced in such a way that it opposes the cause which has produced it
→ Given by Lenz's law.

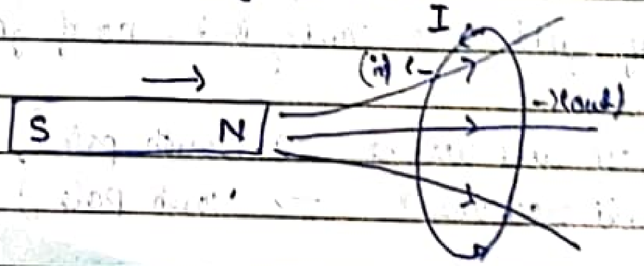
If $R \rightarrow$ is resistance of loop then current in loop is $\frac{\varepsilon}{R}$

$$I = \frac{1}{R}\left(-\frac{d\phi}{dt}\right)$$

Hence, we conclude that emf is induced when,

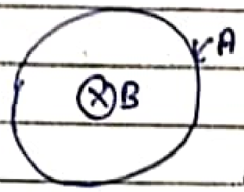
1.) Magnetic field changes
2.) Area of loop changes
3.) Angle b/w the magnetic field and area vector changes.
↳ Application – Generator

eg.



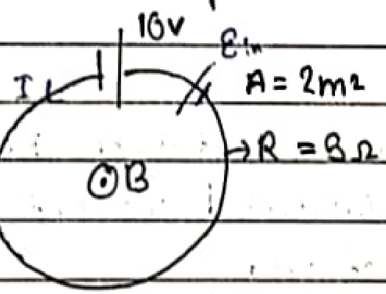
As we move magnet towards stationary loop, emf and hence current is induced in the loop ~~is~~ → because flux through the loop is increasing → Induced current in the loop must be anticlock wise to oppose the cause which has produced the change in flux.

i.e. if flux is increasing then it will try to decrease the flux and
if flux is decreasing it will try to increase the flux.



If B is decreasing then induced emf will be in clockwise so as to support the decreasing magnetic field lines.

Q. If $\frac{dB}{dt} = 10\ T/s$ and decreasing with respect to time. Find the net current in the loop & its direction.



~~Current~~ emf induced produces will be in anticlock wise direction.

$$|\varepsilon| = \frac{d\phi}{dt} = A\frac{dB}{dt} = 2\times10 = 20\ V = \text{Induced emf}$$

Net current, $I = \frac{20-10}{5} = 2A$