B-section

4. state and explain Faradays low of induction Deduce its differential form.

or Deduce Faradays low of electromagnitude induction in from -

Faradays low of induction :

If the magnetic flux ϕ_B through on area bounded by a closed conducting loop changes with time a current an emf are produced in the loop, this Process is called induction the induced emf is $\Sigma = \frac{d\phi_B}{dt}$

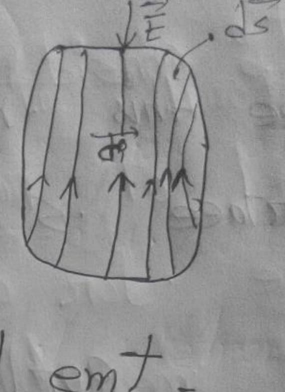
which is Faradays low of induction if the loop is replaced by a closely packed coil of N torn the induced emf is $\Sigma = -N \frac{d\phi_B}{dt}$

let c is a closed circuit and s any surface with c as its boundary let $\vec{B}$ the magnetic flux density in the neighbourhood the circuit, the megnetic flux through a small area

$$\vec{ds} \text{ is } \vec{B} \cdot \vec{d}$$

$$\therefore \phi_B = \int_s \vec{B} \cdot \vec{ds}$$

The line integral of the electric field round the circuit field round the circuit gives the induced emf.



$$\mathcal{E} = \oint \vec{E} \cdot \vec{ds} \quad \text{——— (ii)}$$

According to faradays law induced emf

$$\mathcal{E} = -\frac{d\phi_B}{dt}$$

$$\mathcal{E} = -\frac{d}{dt} \int_s \vec{B} \cdot \vec{ds} \quad \text{——— (iii)}$$

From equation (ii) and (iii)

$$\oint \vec{E} \cdot \vec{ds} = -\frac{d}{dt} \int_s \vec{B} \cdot \vec{ds} \quad \text{——— (iv)}$$

or $$\oint \vec{E} \cdot d\vec{s} = -\int_s \frac{d\vec{B}}{dt} \cdot d\vec{s} \quad \text{——— (v)}$$

From stokes theorem,

$$\oint \vec{E} \cdot \vec{ds} = \int_s \text{curl} \cdot \vec{E} \, d\vec{s} \quad \text{——— (vi)}$$

$$\int_s \text{curl}\, \vec{E} \cdot \vec{ds} = -\int \frac{d\vec{B}}{dt} \cdot \vec{ds}$$

Since this must be true for all surface s it follows that,

$$\text{curl } \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \quad \text{——} (vii)$$

equation (vii) is the differentiation of faradays law.

[1] state and explain Amperes low

<u>statement</u>: The line integral of $\oint \vec{B} \cdot \vec{dl}$ of closed curve is equal to μ_0 times the net current i through the area bounded by the curve. that is

$$\oint \vec{B} \, d\vec{l} = \mu_0 i$$

Here,

$\vec{B} \Rightarrow$ magnetic induction

$dl \Rightarrow$ current electron vector.

$\mu_0 \Rightarrow$ Permitivity constant

$i \Rightarrow$ current

Proof: consider a path consisting a circel of radius "r" centered on the wire for any point of the circele the megnetude of the d magnetic field B is same $\vec{B}$ and $\vec{dl}$ which is always tangential to the integrat of the path,

$$\oint \vec{B} \cdot d\vec{l} = \oint B dl$$

$$\text{or } \vec{B} \cdot d\vec{l} = B \oint dt$$

$$\text{or } \oint \vec{B} \cdot d\vec{l} = B \times 2\pi r \quad \text{——} \quad (1)$$

Now megnetude of the electric field is proportional to the folowing corren and inversely propotional to the distance r,

$$B \propto \frac{i}{r}$$

$$B = \frac{\mu_0}{2\pi} \cdot \frac{i}{r}$$ where $\frac{\mu_0}{2\pi}$ is the propationaty constant

$$B = \frac{\mu_0 i}{2\pi r} \text{ ——— (II)}$$

Put the in equation (1) then we get

$$\oint \vec{B} \cdot d\vec{l} = \frac{\mu_0 i}{2\pi r} \times 2\pi r$$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 i$$

$$\oint B \cdot dl = \mu_0 i$$

(Proved)

Motional emf : Prove that $P = \frac{B^2 l^2 v^2}{R}$

Soln : Consider a rectangular loop at wire of with l one end of which is in unit or field $\vec{B}$ pointing at right angels to the plane of the loop. The experiment consist in Polling the loop to the right at speed v the flux ϕ. by the loop is

$$\phi_B = BA = Blx$$

where lx is the even of the loop which immersed in B. According to

Faraday low

$$\mathcal{E} = -\frac{d\phi_B}{dt}$$

or $\mathcal{E} = -\frac{d}{dt}(Blx)$

or $\mathcal{E} = -Bl \cdot \frac{dx}{dt}$

or $\mathcal{E} = Blv$ ——— ①

where $v = -\frac{dx}{dt}$, the indueed emf is called notional emf. The emf $\mathcal{E} = -Bl$ sets up a eurrent i the loop is given by $i = \frac{\mathcal{E}}{R} = \frac{Blv}{R}$

where r is the resistence of the loop. the eurrent in the loop will eauses foree F_1, F_2 and F_3 ets on the eonduetors.

Those $\vec{F} = i\vec{l} \times \vec{B}$

Here, $\vec{F_2} = -\vec{F_3}$

$\vec{F_2} + \vec{F_3} = 0$ they conneet eaeh other

F_1 which is the force that opposites our effort,

to move the loop is given in magnitude of $F_1 = i l \, B \sin B$

$$\text{or } F_1 = ilB$$

$$\text{or } F_1 = \frac{Bl^2}{R} \times lB$$

$$\text{or } F_1 = \frac{B^2 l^2 v}{R}$$

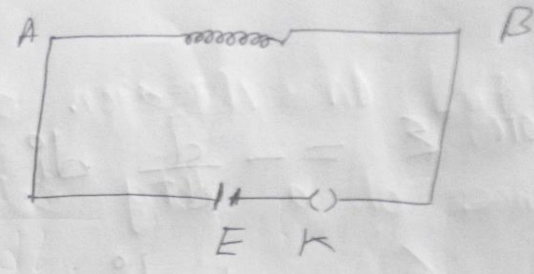
The agent that polls the loop.

Must be work at the steady rate of

$$P = F_1 V = \frac{B^2 l^2 v^2}{R}$$

$$P = \frac{B^2 l^2 v^2}{R}$$

selt indoetenee :



A indoetonee emt appears in a eoil it the eurrent in the same eoil is changed this is called selt indoetion and emt is produeed its called selt indoetanee.

$$\phi \propto i$$

$$\text{or } N\phi \propto i$$

where N is the Nomber ot terms

$$\text{or } N\phi = Li$$

where L is the proportional eonstant, it is ealled selt indoetanee ot the eoil,

From Faraday's low.

$$\varepsilon = -\frac{d}{dt}(N\phi)$$

or, $\mathcal{E} = -\frac{d}{dt}\, di$

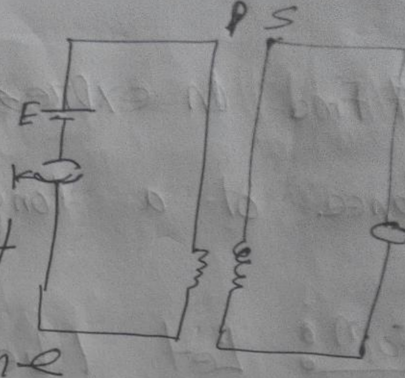
$$\mathcal{E} = -L\frac{di}{dt}$$

$$\therefore L = -\frac{\mathcal{E}}{\frac{di}{dt}}$$

$\frac{di}{dt} = 1$ then $|\mathcal{E}| = L$

Unit of the self inductance is Henry (H)

Mutual inductance :



Mutual inductance may be defind as the amount of emf induced in one coil per unit rate of change of current in another coil adjust to the first coil we can write,

$$\phi_2 \propto i_1$$

$$\text{or } N\phi_2 \propto i_1$$

$$\text{or } N\phi_2 = M i_1$$

where m i, proportionlity constant its called mutual inductence,

from faraday's low,

$$\varepsilon_2 = -N \frac{d\phi_2}{dt}$$

$$\varepsilon_2 = -\frac{d}{dt}(N\phi_2)$$

$$\varepsilon_2 = -\frac{d}{dt} M i_1$$

$$\varepsilon_2 = -M \frac{di_1}{dt}$$

$$M = -\frac{\varepsilon_2}{\frac{di_1}{dt}}$$

Find an expression for the self-inductance of a long solenoid.

Soln: Let l be the length of a long solenoid with an ean and total number of turns are N. When a current i is flows through it the magnetic field inside, it is given by

$$B = \frac{\mu_0 N i}{L}$$

Total flux through the solenoid

$$\phi_B = \frac{\mu_0 N i A}{L} N$$

$$\Rightarrow \phi_B = \frac{\mu_0 N^2 i}{L}$$

when the current i varies the flux ϕ_B changes giving rise to the induced emf

$$\epsilon = -\frac{d}{dt}\left(\frac{\mu_0 N^2 A i}{L}\right)$$

$$\Rightarrow \epsilon = -\frac{\mu_0 N^2 A}{L} \cdot \frac{di}{dt}$$

$$\Rightarrow \epsilon = -L \cdot \frac{di}{dt} \quad \text{[From definition of L]}$$

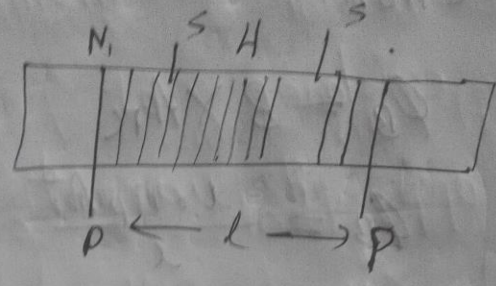
There for

$$L = \frac{\mu_0 N^2 A}{L}$$

$$\Rightarrow L = \mu_0 n^2 l A \quad [N = nl]$$

where n are the number of turns per unit length. If the solenoid is wound a can of constant permeability μ then $L = \frac{\mu N^2 A}{L}$ [when $\mu = \mu_0$]

Q. Find the mutual inductance of two co-axial coil.



Solⁿ: let us consider a long solenoid of area of cross-section A_p and length l which is called the primary and n_p are the number of turn per unit length of coil. Another see coil of N_s turns is woned inside the primary coil. The magnitie indoetance due to the current in primary is obtained be amper low.

$$B = \frac{\mu n_p i}{l}$$

And the megnitie flux $= B \times$ area of cross-section.

$$\phi_B = B \times A_R$$

$$\phi_B = \frac{\mu_0 n_p A i}{l}$$

the flux is linked with each turns of the secondary soppose there is no leakage of flux therefore. the total flux linked with N_s. of the secondary is given by

$$\phi_B' = n_s \cdot \phi_B$$

$$\phi_B' = n_s \frac{\mu_0 n_p A i}{l}$$

$$= \frac{\mu_0 n_p n_s A p i}{l}$$

Then the induced emf in secondary coil.

$$E_2 = -\frac{d\phi_B}{dt}$$

$$E_2 = -\frac{\mu_0 n_s n_p A_p}{l} \cdot \frac{di}{dt}$$

$$E_2 = -M \cdot \frac{di}{dt}$$

therefore $M = \frac{\mu_0 n_s n_p A_p}{l}$

if the primary and secondary are worked over a . of meterial heaving permeatility and there.

$$M = \mu n_p n_s A_p$$

12-11

Galvanometer : The instrument by which the existance of current in a conductor and its amount can be determined is called a galvanometer. The working principle of galvanometer depends on the effect of magnetic field on the flow of current or effect of current of a magnet.

3 type of glavanometer :

(i) moving coil glavanometer.

(ii) Blalastic glavanometer

(iii) Dead - beat glavanometer.

Moving coil glavanometer : A glavanometer by which current can be measured from the deflaction of the coil that can be rotated when placed in the magnetic field of a magnet is called moving coil galvanometer. Example. D ansonval galvanometer.

Balastic galvanometer : An instroment designed to measure quantity of charge through it in torns to momentary current i is called balastic Galvanometer.

Dead-best galvanometer: An instrument designed to measured quantity of current through it in terms of deflation of coil of N turns due to extenden or continoously coorrent i is called dead best galvanometer.

* Differene between Dead-beat and Ballastic galvanometer.

Deadbeat	Ballastic
① It measures steady current	① It measure charge
② The steady deflection measures the current	② The throw measure the charge
③ The coil is wound a metal frame to increase electromagnetic damping	③ The coil is wound on a non-metalic frame to reduce electromagnetic damping
④ The coil is non-oscillatory due to large damping	④ The coil is oscillatory due to small damping
⑤ The coil rotates due to constant torqe	⑤ The momentary passage of charge causes impulse on the coil the torque is zero when the coil rotate

*** A solenoid leving on aircore and 10 cm long has 100 turn's and its area of cross-section is 5 sqcm Find the co-efficient of self inductance of the solenoid!

Sol^n :

We know,

$$L = \frac{U_0 N^2 A}{l}$$

$$= \frac{4\pi \times 10^{-7} \times 10^{4} \times 5 \times 10^{-4}}{0.1}$$

$$= 62.8 \times 10^{-6}\ m$$

Here,

$l = 10\ cm$
$= 0.1\ m$

$N = 100$

$A = 5\ sq.cm$
$= 5 \times 10^{-4}\ m^2$

A solenoid of length 30 cm and area of cross-section 10 sq-cm has 1000 turns wound over a core of constant permeability 600. another coil of 500 turns is wound over same coil at its middle calculate the mutual inductance of the coil.

Solⁿ:

Here,

$l = 30\,cm$

$= 30 \times 10^{-2}\,m$

$A = 10\,sq\text{-}cm$

$N_1 = 1000$

$N_2 = 500$

$U_r = 600$

$$M = \frac{U_0 U_r N_1 N_2 A}{l}$$

$$= \frac{4\pi \times 10^{-7} \times 600 \times 1000 \times 500 \times 10 \times 10^{-4}}{0.3}$$

$= 1.257$