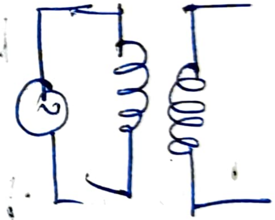
Mutual Inductance:

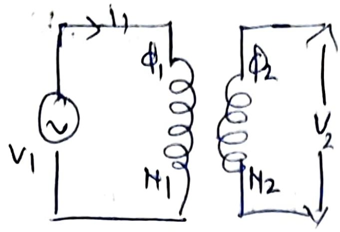


→ Defn:

Mutual inductance between two coils is defined as the ratio of induced magnetic flux linkage in one coil to the current through the other coil.

$$\boxed{M = \frac{N_1 \Phi_{21}}{i_2}} \text{ Henry.}$$

Proof:



→ Consider two coils magnetically coupled together.

→ ϕ_{12} is produced by the current i_1,

→ The induced emf 'v' in coil 2 is proportional to the rate of change of 'i'

$$V_2 \propto \frac{di_1}{dt}$$

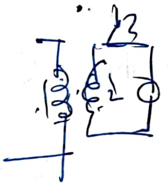
$$\boxed{V_2 = M\frac{di}{dt}} \rightarrow (1)$$

~~From~~ ~~From~~ From Faraday's law, the induced emf in coil 2 is.

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

$$\boxed{V_2 = N_2 \frac{d\phi_{12}}{dt}} \rightarrow (2)$$

equating (1) + (2)



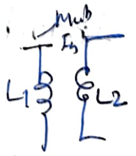
$$M\frac{di_1}{dt} = N_2 \frac{d\phi_{12}}{dt}.$$

$$M = N_2 \frac{d\phi_{12}}{di}$$

$$\boxed{M = N_2 \frac{\phi_{12}}{i_1}} \quad \text{or} \quad \boxed{\frac{N_1 \phi_{21}}{i_2}}$$

* Coupling coefficient:

$$k = \frac{\phi_{12}}{\phi_1} = \frac{\phi_{21}}{\phi_2}$$



$M \Rightarrow K\sqrt{L_1L_2}$

Relation between M + k.

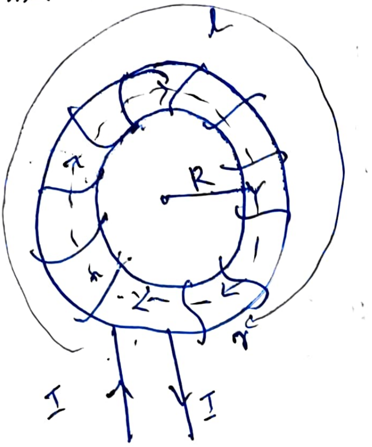
$$M = k\sqrt{L_1L_2}.$$

$$k = \frac{M}{\sqrt{L_1L_2}}$$

$$\boxed{k < 1}$$

Inductane of Toroid :

→ It is a hollow circular ring on which a large number of turns of a wire are closely wound.



→ A toroid is a coil wound in the shape of torus 

→ It is used as an inductor in electric circuits where large inductance are needed.

Inductane of a Toroid :

Consider a toroid of 'N' Number of turns carrying current 'I' with radius 'R'

$$L = \frac{N\phi}{I} \rightarrow (1)$$

The magnetic flux is given as

$$\phi = B.A \rightarrow (2)$$

where $B \rightarrow$ flux density

$A \rightarrow$ cross sectional area.

The flux density of toroid is.

$$B = \frac{\mu_0 N I}{l}$$

where $l \rightarrow$ means length of the coil.

$l \rightarrow 2\pi R$.

$$B = \frac{\mu_0 N I}{2\pi R} \rightarrow (3)$$

If the radius of the coil is 'r' then the cross - sectional area A is given as $A = \pi r^2 \rightarrow (4)$

Sub 3 + 4 in 2

$$\phi = B \cdot A$$

$$= \frac{\mu_0 N I}{2\cancel{\pi} R} \cdot \cancel{\pi} r^2$$

$$\boxed{\phi = \frac{\mu_0 N I r^2}{2R}} \rightarrow 5$$

Sub 5 in 1.

$$L = \frac{N \phi}{I} = \frac{N}{\cancel{I}} \cdot \frac{\mu_0 N \cancel{I} r^2}{2R}$$

$$\boxed{L = \frac{\mu_0 N^2 r^2}{2R}} \text{ Henry.}$$