Paper 1, TDC Part-1
Chapter– 1, Introduction to Passive Elements
Mutual Inductance Lecture 1

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Coefficient of self-induction (L)

Self-induction L is the property of the coil due to which it opposes any increase or decrease or current of flux through it.

It may be defined in any of the three ways as discussed below:→

~~The~~ 1st Way for L :→

L of a coil is defined as "Weber-turns per ampere in the coil. i.e.

$$L = \frac{N\Phi}{I} \text{ henry}$$

Unit of L is henry (After the American Scientist Joseph Henry)

A coil is said to have a self-inductance of 1 H if a current of 1 ampere when flowing through it

a current of 1 ampere ... it.

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A coil is said to have a self-inductance of 1 H if a current of 1 ampere when flowing through it produced flux-linkages of 1 Wb-turn in it.

2nd Way for L:→

Flux produced in a solenoid is

$$\Phi = \frac{NI}{l/\mu_0\mu_r A}$$

where l = length of solenoid

A = Cross-Sectional Area

N = Number of turns

$\mu_0\mu_r$ = Permeability of material

$$\Rightarrow \frac{\Phi}{I} = \frac{N}{l/\mu_0\mu_r A}$$

and,

$$L = \frac{N\Phi}{I}$$

$$L = N \cdot \frac{N}{l/\mu_0\mu_r A} = \frac{N^2}{l/\mu_0\mu_r A} = \frac{\mu_0\mu_r A N^2}{l}$$

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Third Method for L :→

$$L = \frac{N\phi}{I} \Rightarrow N\phi = LI$$

or, $-N\phi = -LI$

differentiating both sides ~~by~~ w.r.t. 't' (time) we get,

$$-\frac{d}{dt}(N\phi) = -L\frac{dI}{dt} \quad \text{(assuming L to be const)}$$

$$-N\frac{d\phi}{dt} = -L\frac{dI}{dt}$$

$$-N\frac{d\phi}{dt} = \text{self induced emf } (e_L) = -L\frac{dI}{dt}$$

Hence a coil has a self-inductance of one henry if one volt is induced in it when current through it changes at the rate of one ampere/second.

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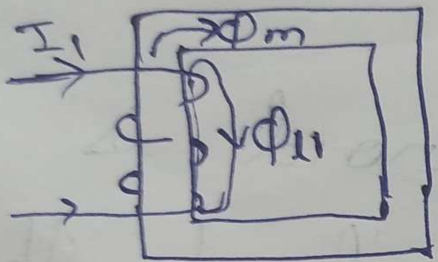
Mutual Inductances :→



Φ_{t1} = Total flux created by coil 1 when it carry current I_1

No. of turns = N_1

$$\Phi_{t1} = \Phi_{m1} + \Phi_{l1} \quad \text{—— (i)}$$

Φ_{m1} ↓ Mutual flux in the core

Φ_{l1} → Leakage flux

$$\Phi_{m1} >> \Phi_{l1}$$

Self inductance of coil 1 is

$$L_1 = \frac{N_1 \Phi_{t1}}{I_1} = \frac{N_1(\Phi_{m1} + \Phi_{l1})}{I_1} \approx \frac{N_1 \Phi_{m1}}{I_1} + \frac{N_1 \Phi_{l1}}{I_1}$$

$= L_{m1}$ (magnitising inductance) + L_{l1} → leakage Inductance

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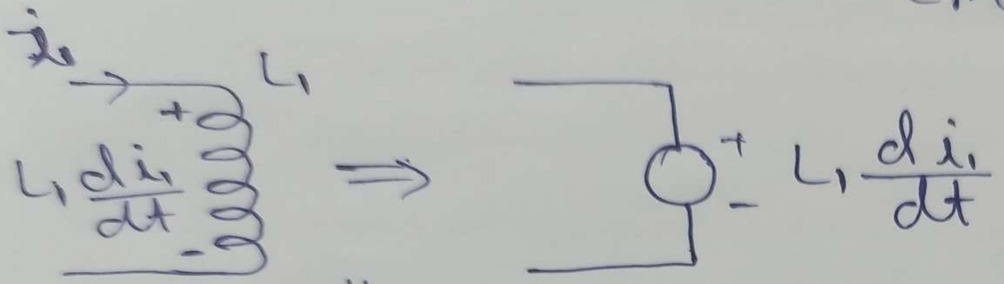
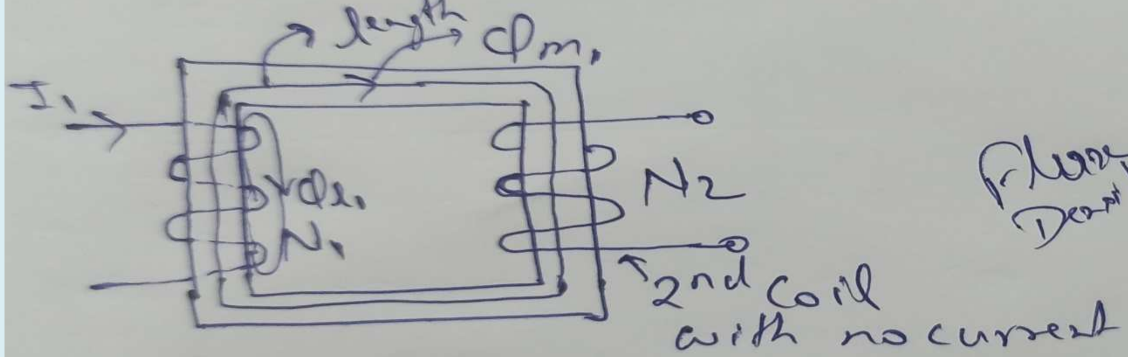
$L_1 \approx L_{m1}$ $\qquad$ $L_{m1} >> L_{l1}$





Note :- Field Strength N/Wb

$H_1 = \frac{N_1 I_1}{l}$

Flux Density

$B_{m1} = \mu_0 \mu_r \frac{N_1 I_1}{l}$

$\Phi_{m1} = B_{m1} A$

$= \frac{N_1 I_1}{\frac{l}{\mu_0 \mu_r A}}$

<u>Mutual Inductance (M21).</u>

M_{21} = Flux linkage with the 2nd coil due to current in 1st coil.

$\Phi_{m1} = \frac{N_1 I_1}{R}$

$M_{21} = \frac{N_2 \Phi_{m1}}{I_1} = \frac{N_2}{I_1} \frac{N_1 I_1}{R}$

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$$M_{21} = \frac{N_2 \Phi_{m1}}{I_1} = \frac{N_2}{I_1} \frac{N_1 I_1}{R}$$

$$M_{21} = \frac{N_2 N_1}{R}.$$

Ilarly,

M_{12} = Flux linkage with the 1st coil due to current in 2nd coil.

$$M_{12} = \frac{N_1 \Phi_{m2}}{I_2}$$

$$\Phi_{m2} = B_{m2} A = \frac{\mu_0 \mu_r N_2 I_2}{l}$$

$$M_{12} = \frac{N_1}{I_2} \frac{N_2 I_2}{R}$$

$$\Phi_{m2} = \frac{N_2 I_2}{\frac{l}{\mu_0 \mu_r A}} = \frac{N_2 I_2}{R}$$

$$M_{12} = \frac{N_1 N_2}{R}$$

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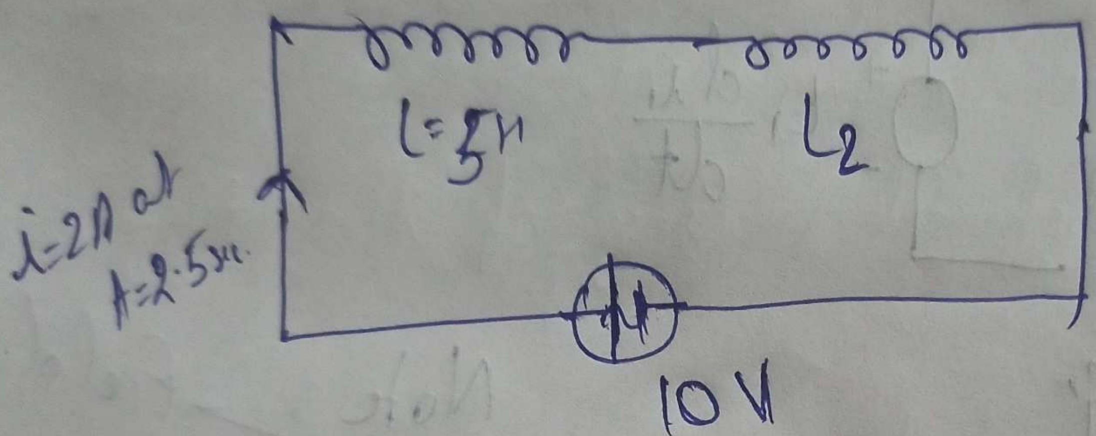
So, $M_{12} = M_{21} = M$

Q 1



find L_2 & L_{eq}. Initial current is zero i.e. $i(t=0) = 0$

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For any query contact- 9771474020

Thank You

To be Contd..