## Module 3 : Magnetic Circuits 4 Hrs

Electromagnetic Induction: **Self and mutual; Magnetically coupled circuits; Series and parallel magnetic circuits; Dot convention**

## Course Outcome (CO2)

**Analyze the parameters of magnetically coupled circuits** and compare various types of electrical machines

$v = L\frac{di}{dt}$

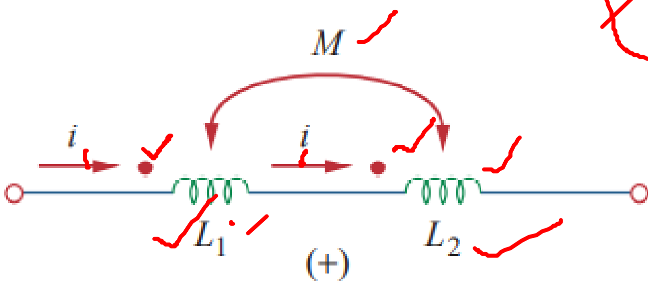
# Coupled coils in series

$L_{eq}$

- Series aiding
- Series opposing

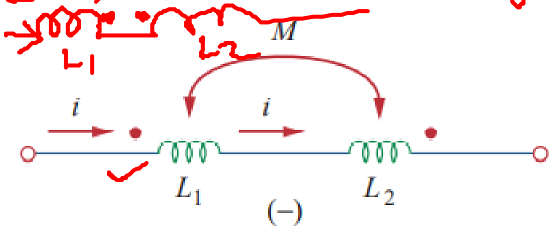
$= \frac{di}{dt}\left[L_1 + L_2 + 2M\right]$

$v = L_1\frac{di_1}{dt} + L_2\frac{di}{dt} + M\frac{di_1}{dt} + M\frac{di}{dt}$




$$L_{eq} = L_1 + L_2 + 2M$$

$v = L_1\frac{di}{dt} + L_2\frac{di}{dt} - M\frac{di}{dt} - M\frac{di}{dt}$




$$L = L_1 + L_2 - 2M$$

$v = L_{eq}\frac{di}{dt}$

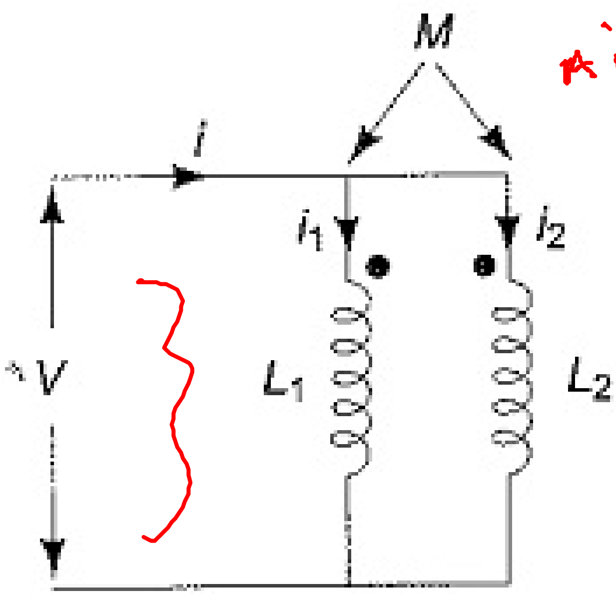
$L_{eq} = L_1 + L_2 - 2M$

# Coupled circuits in parallel

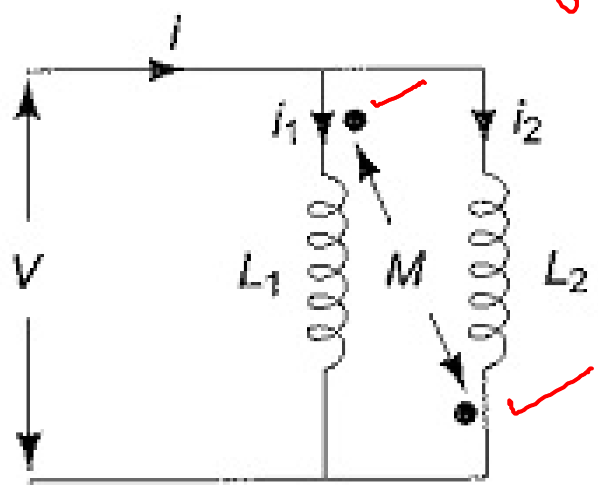
$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$$

opposing

aiding




(a)




(b)

$$i = i_1 + i_2 \Rightarrow \frac{di}{dt} = \frac{di_1}{dt} + \frac{di_2}{dt}$$

$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}$$

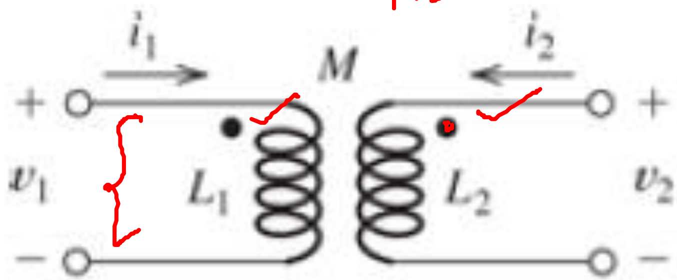
$$v = L_1 \frac{di_1}{dt} + M \frac{di_2}{dt}$$

$$v = L_2 \frac{di_2}{dt} + M \frac{di_1}{dt}$$

$$v = L_{eq} \frac{di}{dt}$$

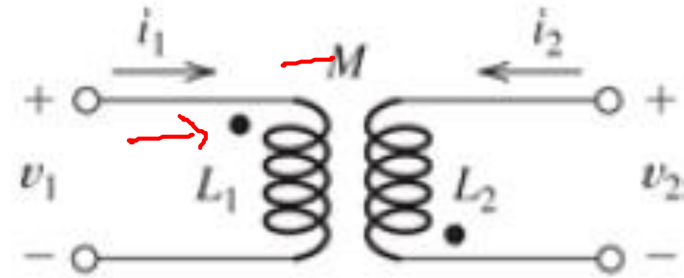
# VI relationship in coupled circuits

Aiding



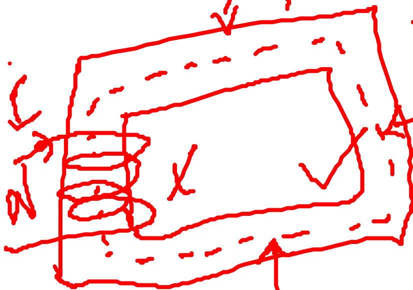

$$v_1 = L_1 \frac{di_1}{dt} + M \frac{di_2}{dt}$$

$$v_2 = M \frac{di_1}{dt} + L_2 \frac{di_2}{dt}$$




$$v_1 = L_1 \frac{di_1}{dt} - M \frac{di_2}{dt}$$

$$v_2 = -M \frac{di_1}{dt} + L_2 \frac{di_2}{dt}$$




$d\phi$ ✓ e

S = reluctance

$MMF = IN$

$= NI$ AT

$MMF = \phi S$ ✓

$F = \phi S$

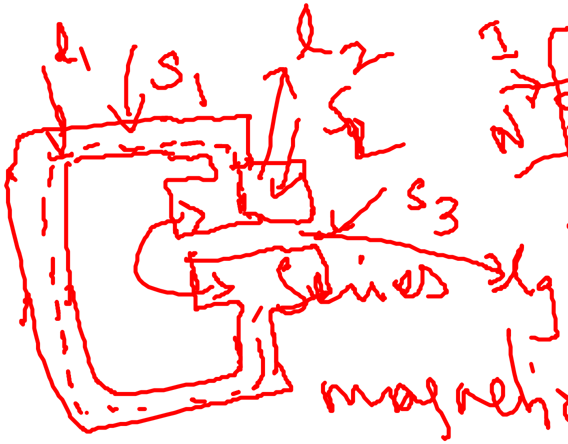
Air

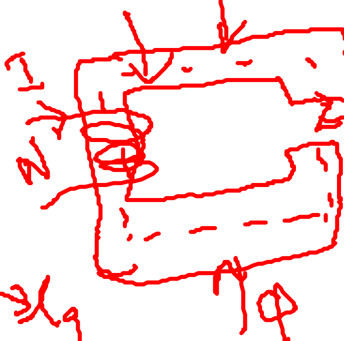
$\mu_r$

$\mu_r$

iron core

$\mu = \mu_0 \mu_r$

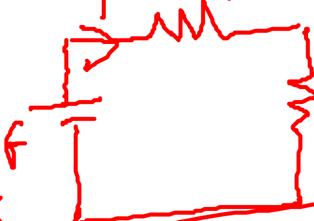



Air gap

$\mu_r = 1$

$S_1 = l_1 / \mu_0 \mu_r A$




$S_2 \rightarrow \dfrac{l_g}{\mu_0 A}$

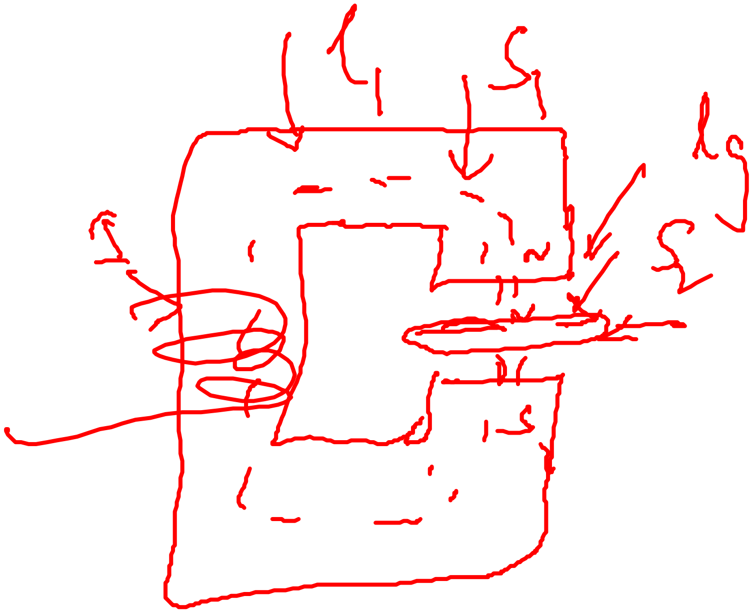
magnetic circuit

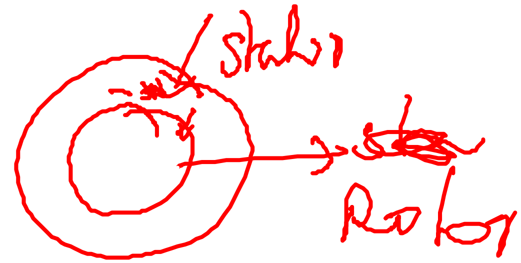
$MMF = \phi (S_1 + S_2)$

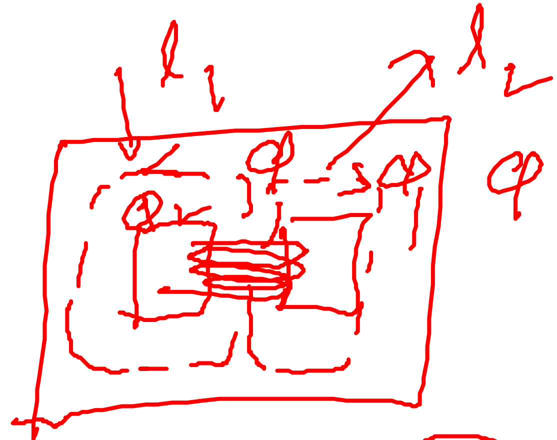
$S = \dfrac{l}{\mu_0 \mu_r A}$

$S_T = S_1 + S_2$

$MMF = N I$




$\phi/2$

$$\phi = \phi_1 + \phi_2$$

parallel connected magnetic circuit