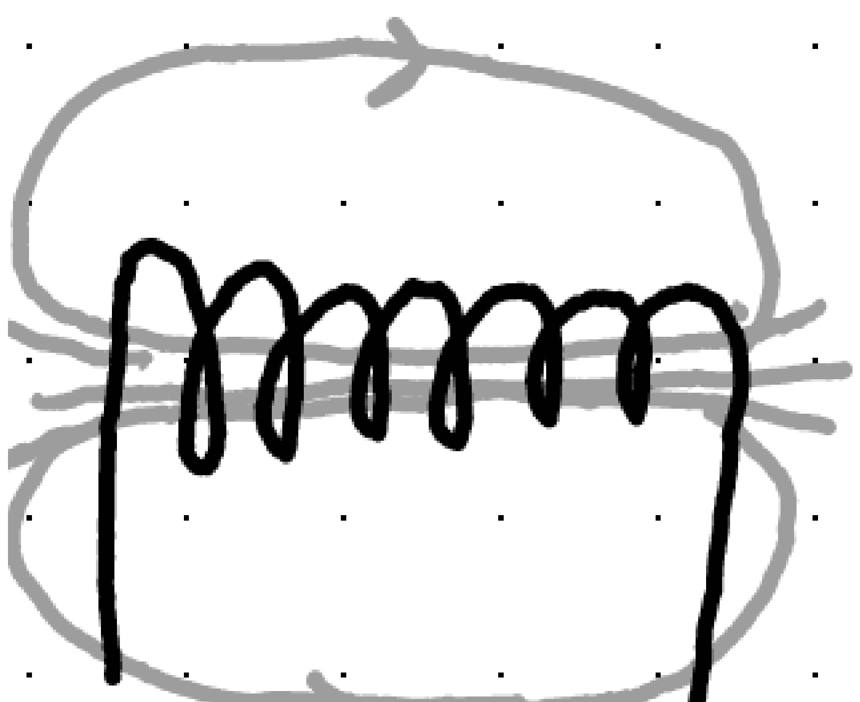
Circuit Analysis : ECED 2001

The inductance is the property of an electric conductor by which the change in current produces an electromotive force (E.M.F)



When an electric current flows through the inductor's coil, it creates a magnetic field around it

Faraday's Law:

When the magnetic flux changes with time, EMF (Voltage) is produced

$$V = -N \frac{d\Phi}{dt}$$

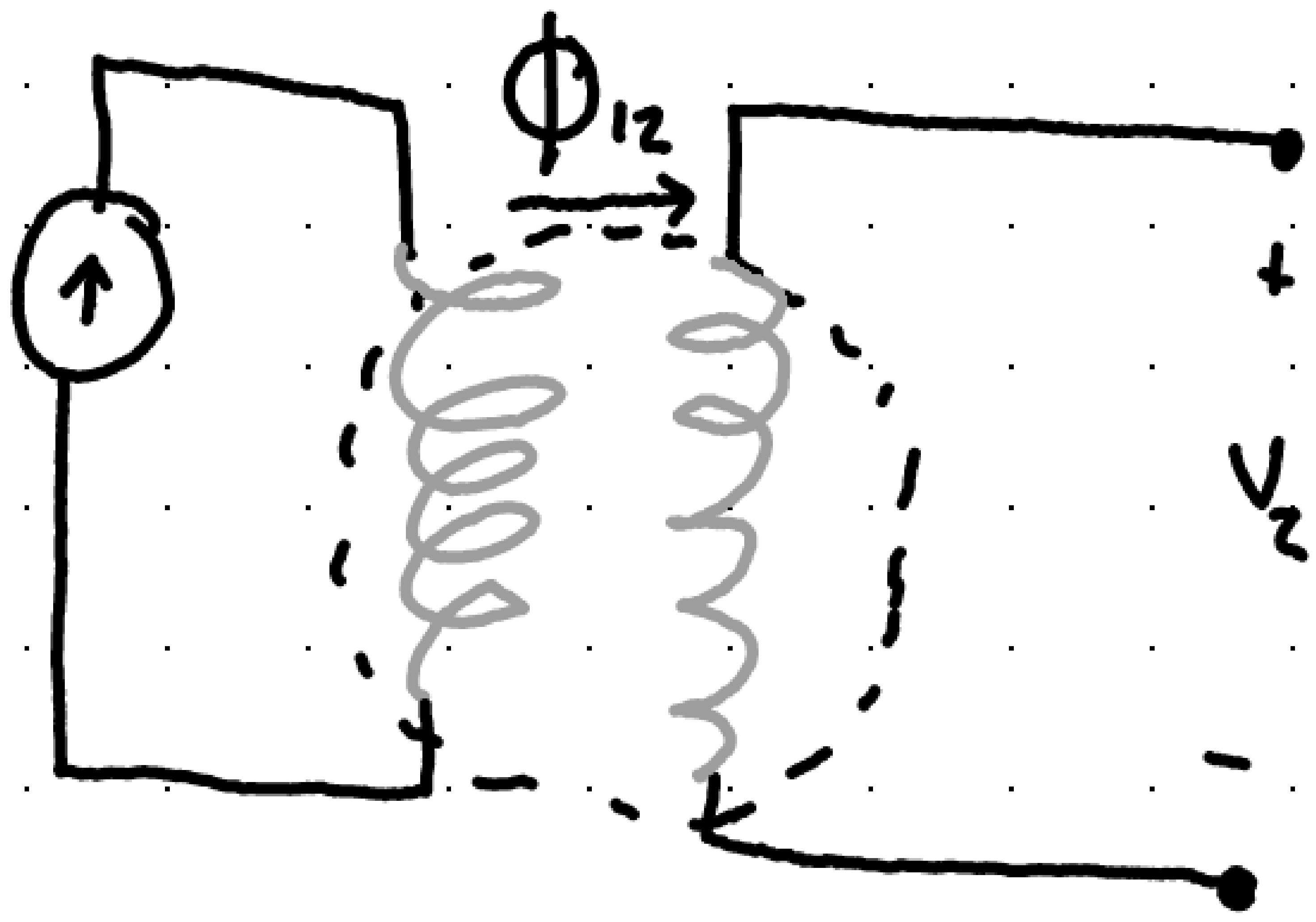
↑ Number of turns

Lenz's Law

Direction of an induced current is always such that the magnetic field created by that current opposes the change in the original magnetic field that caused it.

$$V = -L \frac{dI}{dt}$$

↑ Self Inductance



Number of Turns of Coil 2

$$M = \frac{N_2\,\Phi_{12}}{i_1} = \frac{N_1\,\Phi_{21}}{i_2}$$

Mutual Inductance

The Coefficient of Coupling

$$K = \frac{\Phi_{12}}{\Phi_1} = \frac{\Phi}{\Phi_2}$$

$0 \leq K \leq 1$

Where:

Φ_1 The total magnetic flux generated by the first coil

Φ_{12} The portion of Φ_1 that reaches the second coil

And funnily enough!

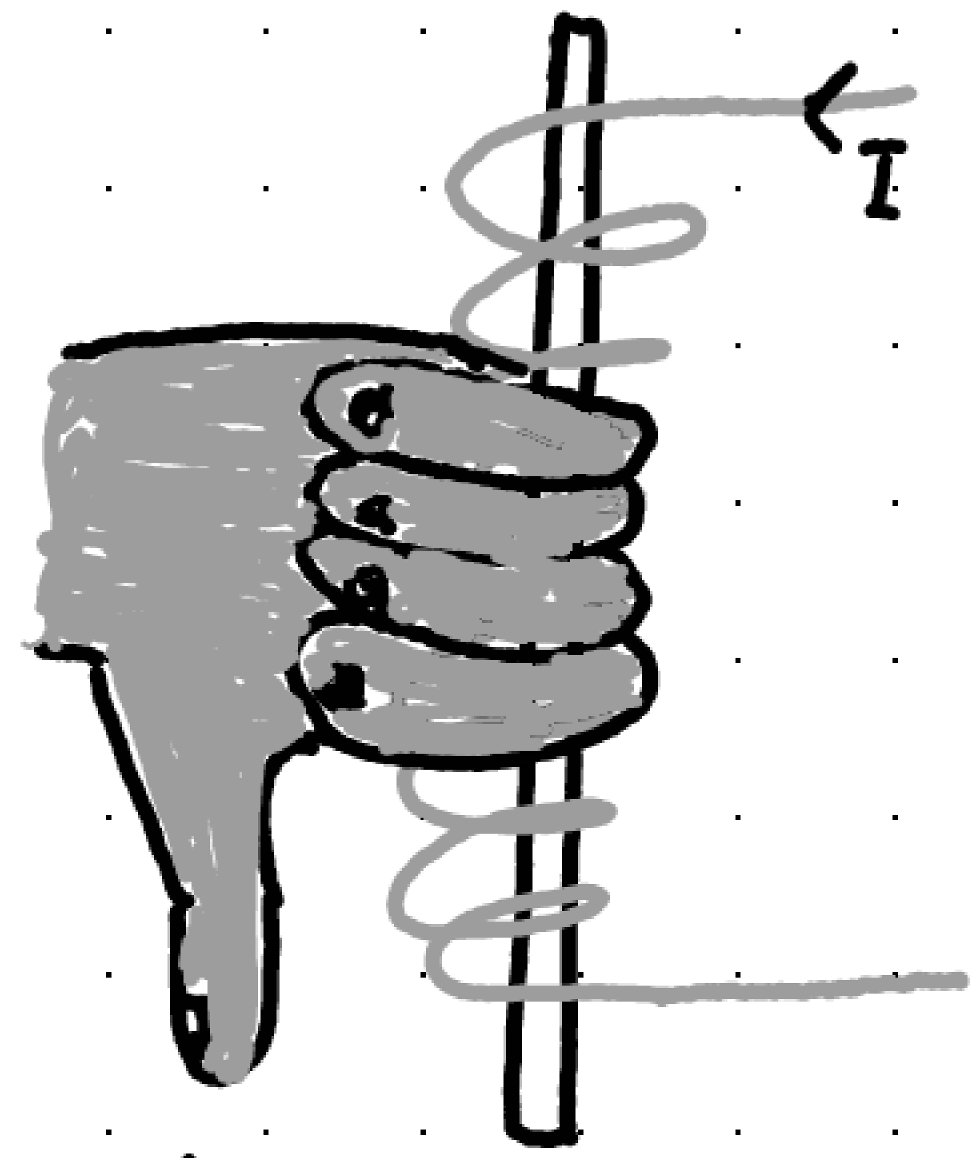
$$M^2 = \frac{N_1\,\Phi_1}{i_1} \times \frac{N_2\,\Phi_2}{i_2} \times \frac{\Phi_{21}}{\Phi_2} \times \frac{\Phi_{12}}{\Phi_1}$$

$$L_1 \times L_2 \times K \times K$$

$$M = \sqrt{L_1 L_2 K^2}$$

Right Hand Rule!

- Fluxes flowing in the same direction Add
- Fluxes opposing Subtract



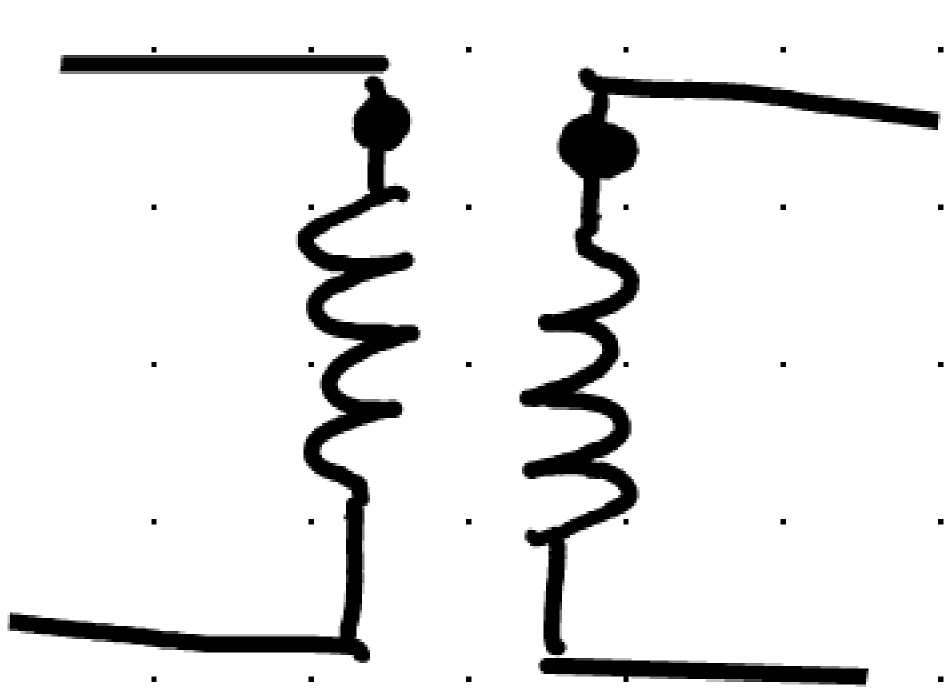
Φ_1

$$V = \begin{pmatrix} \text{Self induced} \\ \text{voltage} \end{pmatrix} \pm \begin{pmatrix} \text{Mutual induced} \\ \text{voltage} \end{pmatrix}$$

$$V_1 = \left(L \frac{di_1}{dt} \right) \pm \left(M \frac{di_2}{dt} \right)$$

The polarity of the voltage induced in the nearby coil depends on the coils winding!

Dot Convention



- If both currents enters the dot, you have

$$V = \left(L \frac{di_1}{dt} \right) + \left(M \frac{di_2}{dt} \right)$$

- If each current is doing something different

$$V = \left(L \frac{di_1}{dt} \right) - \left(M \frac{di_2}{dt} \right)$$

Using Phasors

Time:

$$V_1 = \left(L \frac{di_1}{dt}\right) \pm \left(M \frac{di_2}{dt}\right)$$

Phasor:

$$V_1 = (j\omega L I) \pm (j\omega M I_2)$$

Coupled Coils in Series

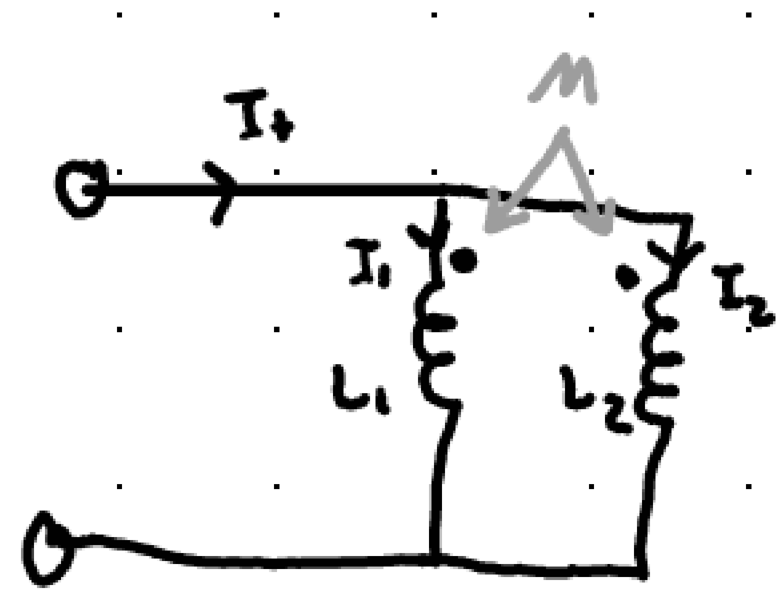
Series Added Connection

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

Series opposing connection

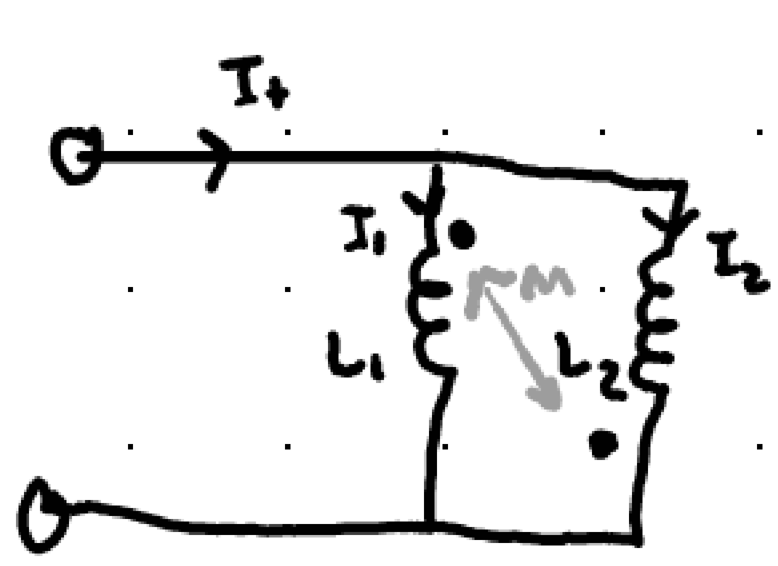
$$L_{eq} = L_1 + L_2 - 2M$$

Coupled Coils in parallel



Parallel Added Connection

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



Parallel opposing connection

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