

Announcements

- Lecture recordings can only be accessed from within the UTK network
 - VPN if off-campus
- Homework 1 is posted, due 2/4 before 10:30am
 - Submitted to canvas as a single pdf
 - First two problems are ECE 201 review
- Office Hours may start late on Thursday
- Can begin self-assigning lab groups of 2-3 in Canvas (people → Groups tab)

COVID Policy

- Update to Mask Policy
 - Please wear masks during lecture
- Do not come to class if you have, or might have been exposed to COVID-19
 - E-mail me to let me know
 - Watch recorded lectures
 - Fill out a support form at
 - <https://covidsupport.utk.edu/>
 - Needed for missed assignments

Course Content

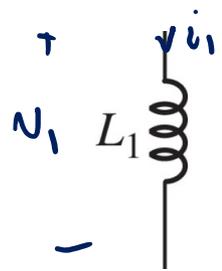
- Magnetically Coupled Circuits (Ch 13)
- Sinusoidal Steady-State Analysis (Ch 10)
- AC Circuit Power Analysis (Ch 11)
- Circuit Analysis in the s-Domain (Ch 14)
- Frequency Response (Ch 15)
- Two-Port Networks (Ch 16)
- Fourier Circuit Analysis (Ch 17)

A Note on Chapter 13

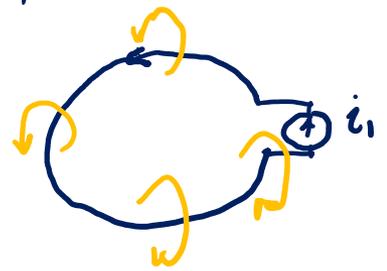
- Bold quantities, e.g. \mathbf{V}_1 , \mathbf{Z}_{in} are phasors – ignore these for now (will cover later)

Inductance: Review

We know the circuit behavior $\Rightarrow v_i = L_1 \frac{di_i}{dt}$



More fundamentally



Ampere's Law

$$\Phi_{i_s} = \alpha i_i$$

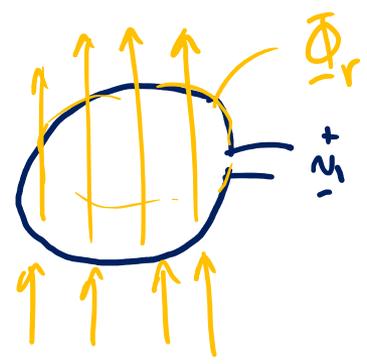
some geometric/materials constant

for an inductor

$$\Phi_r = \Phi_s$$

$$v_i = \alpha \frac{di_i}{dt}$$

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Faraday's Law

$$v_i = \frac{d\Phi_r}{dt}$$

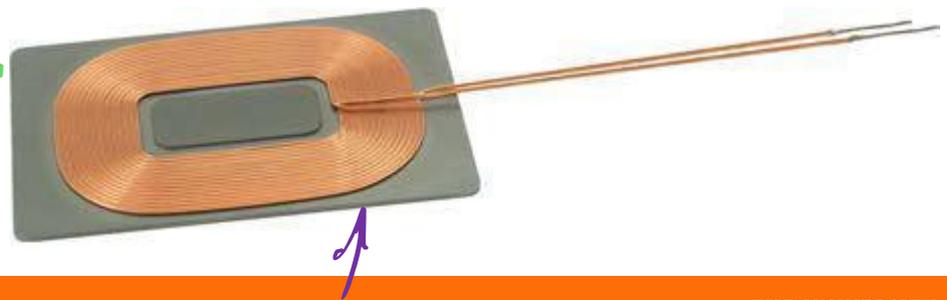
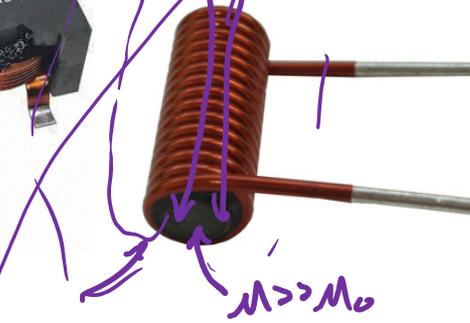
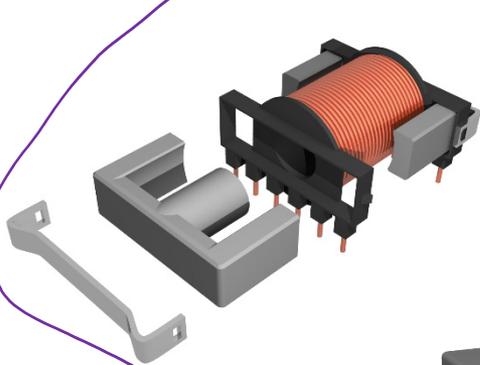
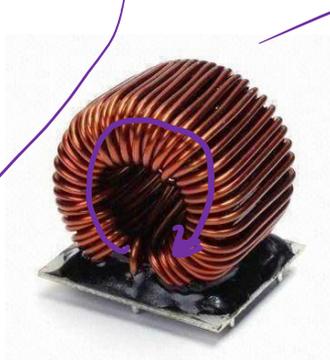
for an N-turn inductor

$$\Phi_s = \alpha i_i N$$

$$v_i = N \frac{d\Phi_r}{dt}$$

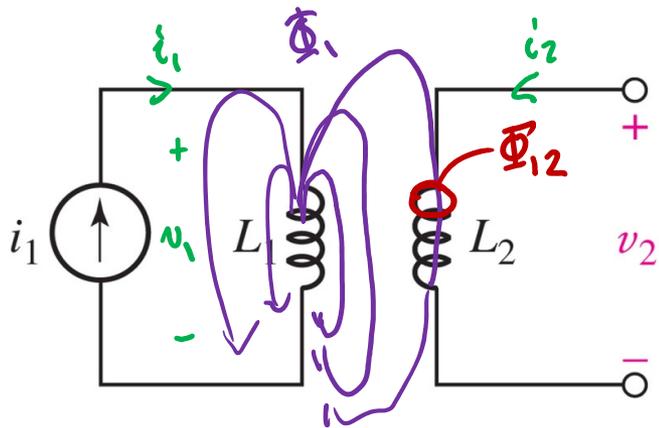
$$v_i = \underbrace{\alpha N^2}_{L_1} \frac{di_i}{dt}$$

Some Inductor Examples



Magnetic Coupling

→ Occurs when (purposefully or not) flux from one winding/inductor goes through another



Case 1: $i_1 > 0$ $i_2 = \phi$

L_1 behaves the same as before

$$\Phi_1 = \alpha_1 N_1 i_1 \quad v_1 = N_1 \frac{d\Phi_1}{dt}$$

$$v_1 = \underbrace{N_1^2 \alpha_1}_{L_1} \frac{di_1}{dt} = \underbrace{L_1}_{L_1} \frac{di_1}{dt}$$

Φ_{12} is the portion of Φ_1 that goes through the windings of L_2

$$v_2 = N_2 \frac{d\Phi_{12}}{dt}$$

let's say $\Phi_{12} = \alpha_{12} N_1 i_1$

$$v_2 = \underbrace{\alpha_{12} N_1 N_2}_{M} \frac{di_1}{dt}$$

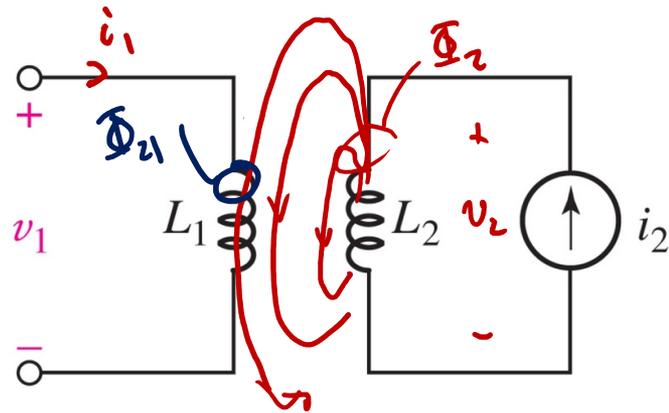
Mutual inductance M

when $i_2 = \phi$

$$v_1 = L_1 \frac{di_1}{dt}$$

$$v_2 = M \frac{di_1}{dt}$$

Magnetic Coupling



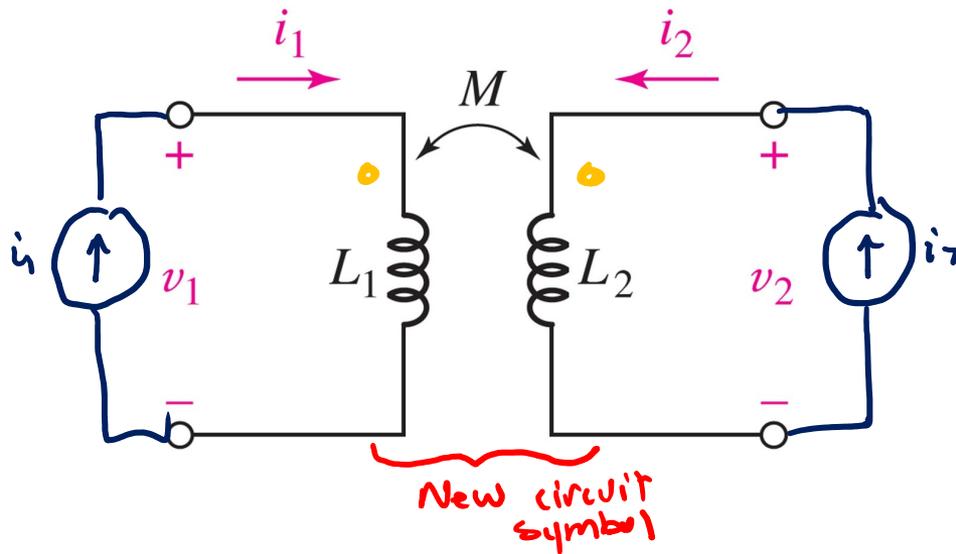
$$i_2 > 0, \quad \dot{i}_1 = \phi$$

Same circuit, just flipped horizontally

$$\left\{ \begin{array}{l} v_2 = L_2 \frac{di_2}{dt} \\ v_1 = M \frac{di_2}{dt} \end{array} \right.$$

M is the same in either case.

Mutual Inductance



With both sources on
Apply superposition

when $i_1 > 0$

$$\begin{cases} v_1 = L_1 \frac{di_1}{dt} \\ v_2 = M \frac{di_1}{dt} \end{cases}$$

when $i_2 > 0$

$$\begin{cases} v_1 = M \frac{di_2}{dt} \\ v_2 = L_2 \frac{di_2}{dt} \end{cases}$$

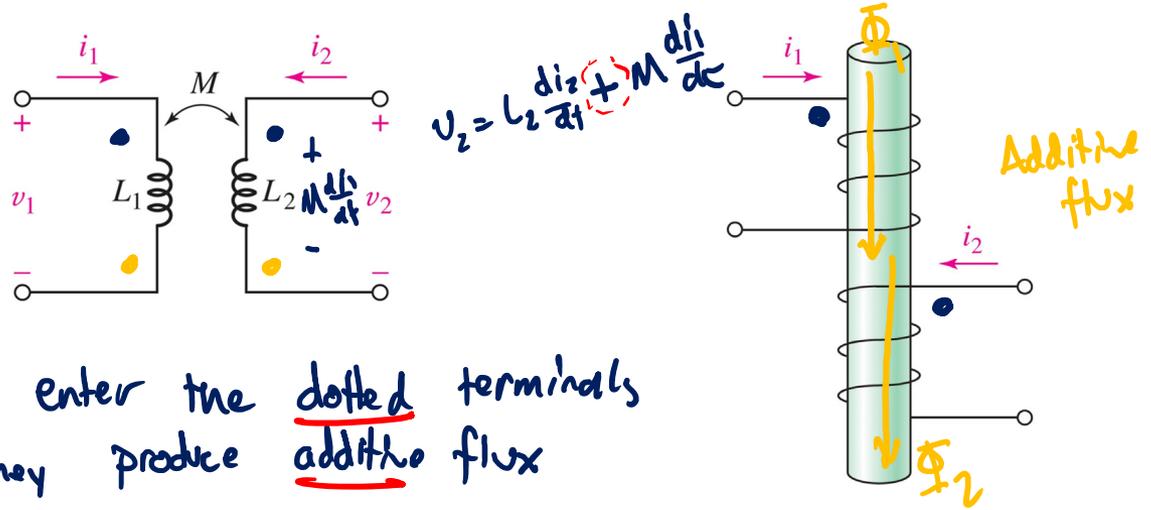
By superposition

$$\begin{cases} v_1 = L_1 \frac{di_1}{dt} + M \frac{di_2}{dt} \\ v_2 = M \frac{di_1}{dt} + L_2 \frac{di_2}{dt} \end{cases}$$

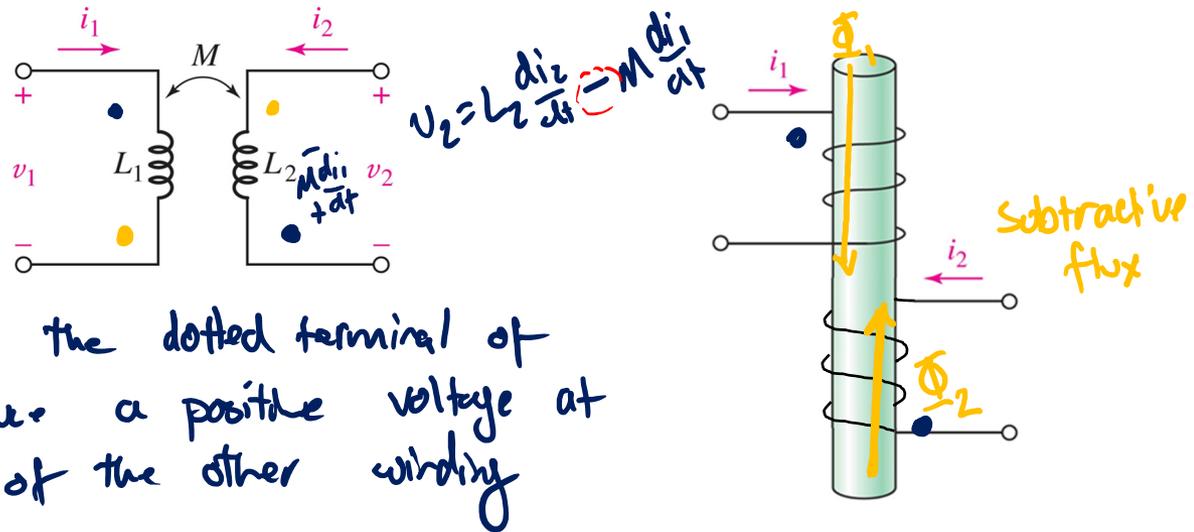
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sign depends on winding polarity

Symbols and Dot Convention

★ Make sure to use passive sign convention



Physical: If both i_1 & i_2 enter the dotted terminals of the windings, they produce additive flux



Circuit: Current flowing into the dotted terminal of one winding will produce a positive voltage at the dotted terminal of the other winding