EELE 250: Circuits, Devices, and Motors

Inductance and Transformers

Assignment Reminder

- Read Chapter 15
- No quiz this week.
- • Practice problems:
- **P15.7, P15.12, P15.37, P15.62, P15.63, P15.68**
- Lab #8 next week: MEET AT THE POWER LAB, EPS 119. Don't go to your regular lab room, go directly to EPS 119.

Faraday's Law

- Magnetic induction voltage:

$$e = \frac{d\lambda}{dt}$$

This means that a voltage *e* is induced in a coil whenever its flux linkages are *changing*.

- The induced voltage polarity opposes the change in flux linkages.

Reluctance and Inductance

- The *reluctance* of a path carrying a magnetic flux is

$$\mathcal{R} = \frac{l}{\mu A}$$

- l is the path length
- A is the cross sectional area
- μ is the magnetic permeability of the material
- The inductance $L = N^2 / \mathcal{R} = \lambda / i$

Mutual Inductance

- Two coils wound on the same core share flux linkages.
- λ_{21} flux links in coil 2 caused by current in coil 1
- λ_{12} flux links in coil 1 caused by current in coil 2

- Self inductance: $L_1 = \lambda_{11} / i_1$ and $L_2 = \lambda_{22} / i_2$

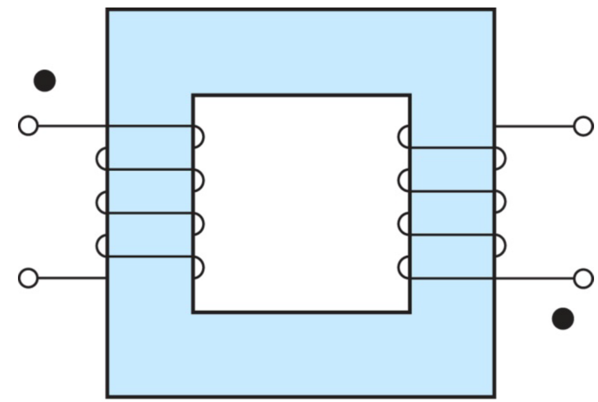
- Mutual inductance: $M = \lambda_{21} / i_1 = \lambda_{12} / i_2$

Mutual inductance (cont.)

- Faraday's Law: e = dλ/dt
- For mutually-coupled coils:

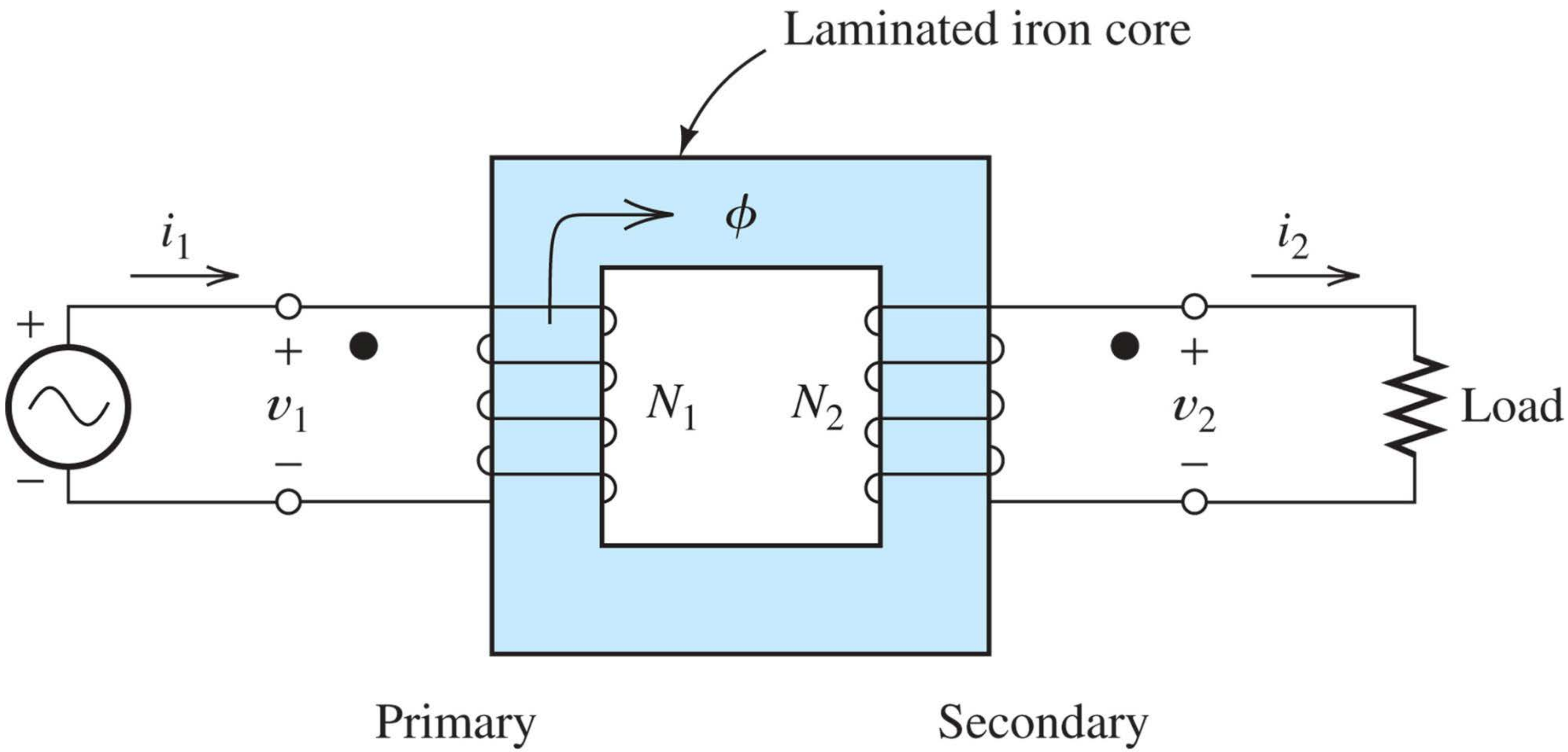
$$e_1 = \frac{d\lambda_1}{dt} = L_1 \frac{di_1}{dt} \pm M \frac{di_2}{dt}$$

$$e_2 = \frac{d\lambda_2}{dt} = L_2 \frac{di_2}{dt} \pm M \frac{di_1}{dt}$$



Dot labels: currents entering at the dots produce aiding fluxes

Ideal transformer model



N_2 / N_1 is the *turns ratio*

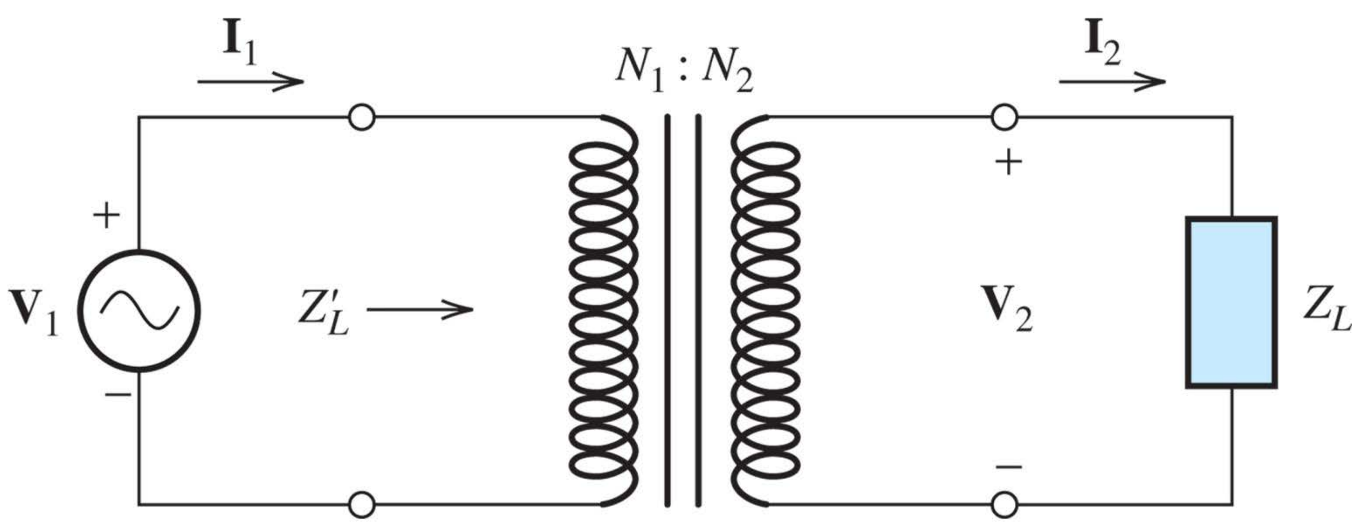
$$v_2(t) = (N_2 / N_1)\, v_1(t)$$

Transformer Equations

- $V_{2\text{rms}} = (N_2/N_1)\, V_{1\text{rms}}$ $\qquad$ $I_{2\text{rms}} = (N_1/N_2)\, I_{1\text{rms}}$
- A "step up" transformer ($N_2 > N_1$) takes the input AC voltage and creates a higher output AC voltage (with lower current)
- A "step down" transformer ($N_2 < N_1$) takes the input AC voltage and creates a lower output AC voltage (with higher current)
- Input power = Output power

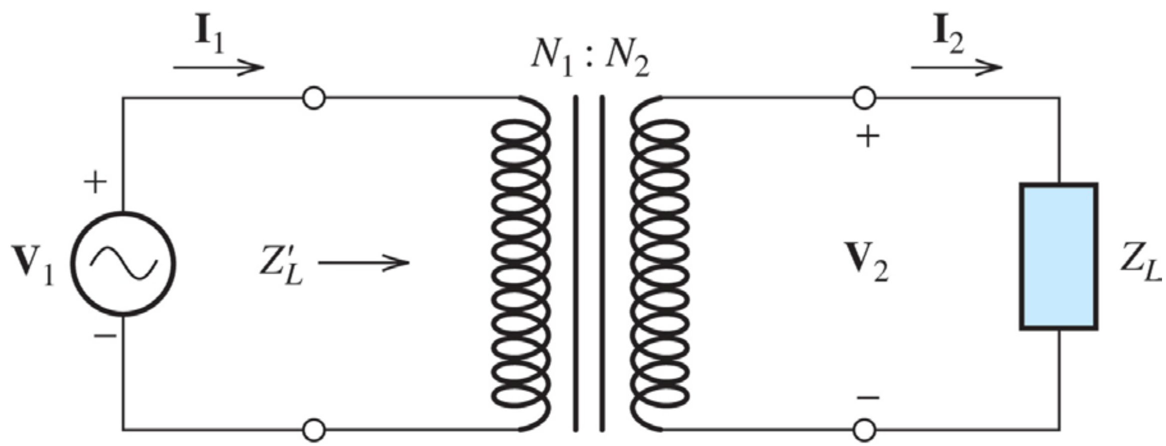
Impedance Transformation

- Because the transformer exchanges voltage for current, or vice versa, the *impedance* viewed from the primary or secondary is also transformed.



Impedance Transformation (cont.)

$$Z_L = \frac{V_2}{I_2} = \frac{\left(N_2 / N_1 \right) \cdot V_1}{\left(N_1 / N_2 \right) \cdot I_1} = \left(\frac{N_2}{N_1} \right)^2 \cdot \frac{V_1}{I_1}$$



→ A step-up transformer (N2>N1) makes the attached impedance look "smaller"

→ A step-down transformer (N2<N1) makes the attached impedance look "bigger"

$$Z'_L = \frac{V_1}{I_1} = \left(\frac{N_1}{N_2} \right)^2 \cdot Z_L$$