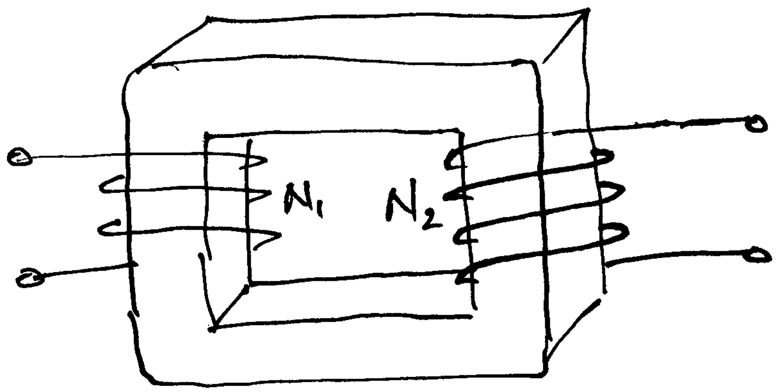
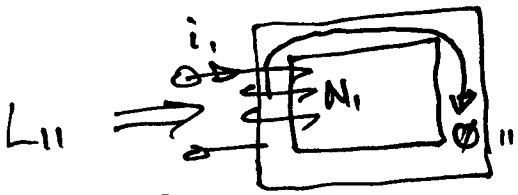
MUTUAL INDUCTANCE

- Section 4.4 in text, pp. 73-77.
- see also handout on Basic Magnetic Circuits

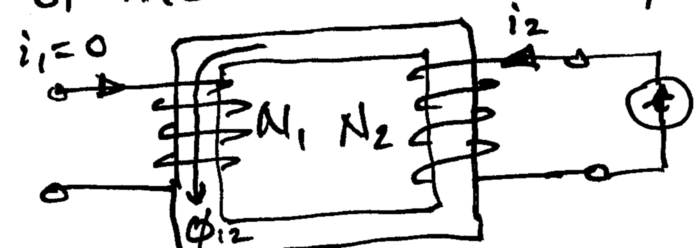


- Fundametal definition of inductance: $L = \frac{\lambda}{i} = \frac{N\Phi}{i}$



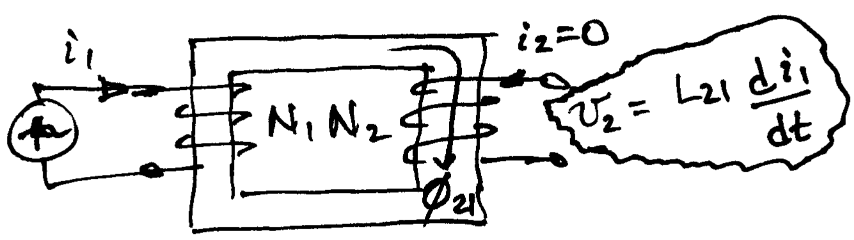
Self-Inductance

$$\boxed{L_{11} = \frac{N_1 \phi_{11}}{i_1} = \frac{\lambda_{11}}{i_1}} = \frac{N_1^2}{R}$$



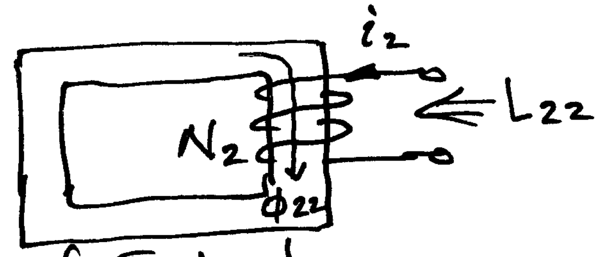
Mutual Inductance

$$\boxed{L_{12} = \frac{N_1 \Phi_{12}}{i_2} = \frac{\lambda_{12}}{i} = \frac{N_1 N_2}{R}}$$



$$\boxed{L_{21} = \frac{N_2 \Phi_{21}}{i_1} = \frac{\lambda_{21}}{i} = \frac{N_2 N_1}{R}}$$

Mutual Inductance

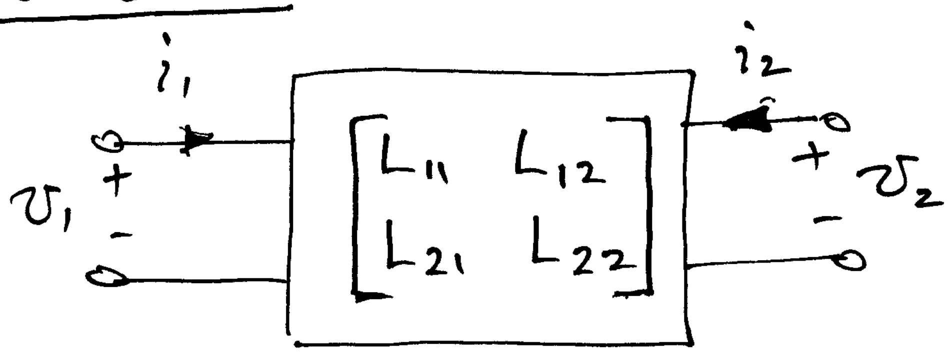


Self Inductance

$$\boxed{L_{22} = \frac{N_2 \Phi_{22}}{i_2} = \frac{\lambda_{22}}{i_2} = \frac{N_2^2}{R}}$$

How to Use the Concept of Mutual Inductance

Two-Port Device:



Note: Reference direction of currents is into terminals at (+) side of voltage.

In time domain:

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} L_{11} & L_{12} \\ L_{21} & L_{22} \end{bmatrix} \begin{bmatrix} \frac{di_1}{dt} \\ \frac{di_2}{dt} \end{bmatrix}$$

In phasor domain:

$$\begin{bmatrix} \tilde{V}_1 \\ \tilde{V}_2 \end{bmatrix} = \begin{bmatrix} j\omega L_{11} & j\omega L_{12} \\ j\omega L_{21} & j\omega L_{22} \end{bmatrix} \begin{bmatrix} \tilde{I}_1 \\ \tilde{I}_2 \end{bmatrix}$$

Also of note:

In some texts, since L_{12} and L_{21} are mutal inductances, they are called M_{12} and M_{21}. Same thing.