Transformer

Transformer :

Machine to transform levels of voltage and current but not power or volt-ampere.

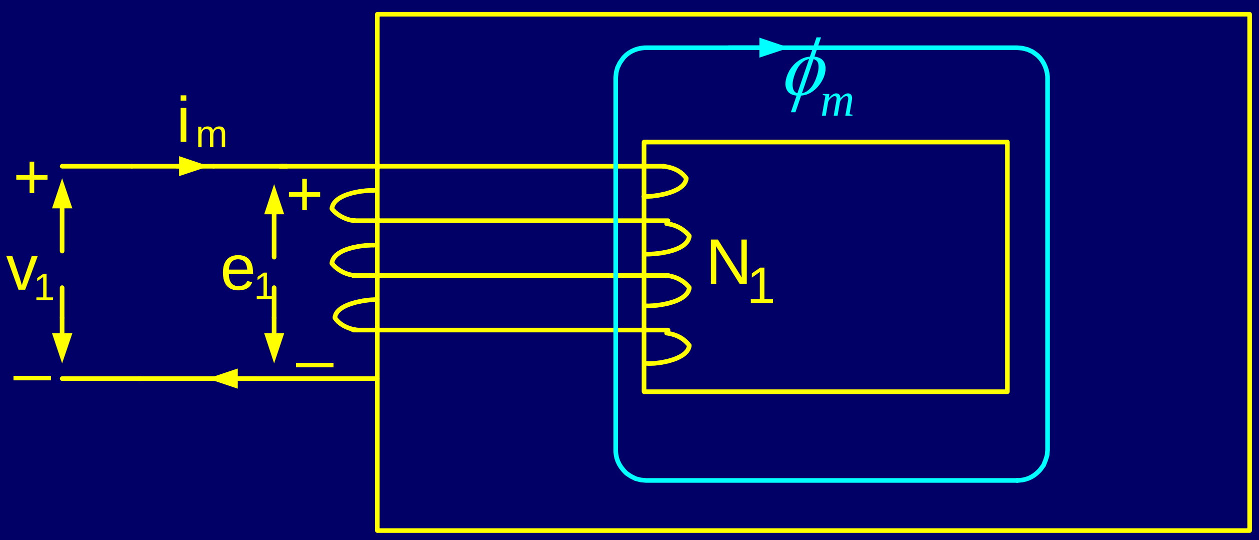
From ampere's law:

$$\phi_m = \frac{N_1 i_m}{\text{reluctance}}$$

- Core
- Winding

N_1 = no. of turns of the coil
i_m = current in the coil

Direction of flux given by right hand thumb rule



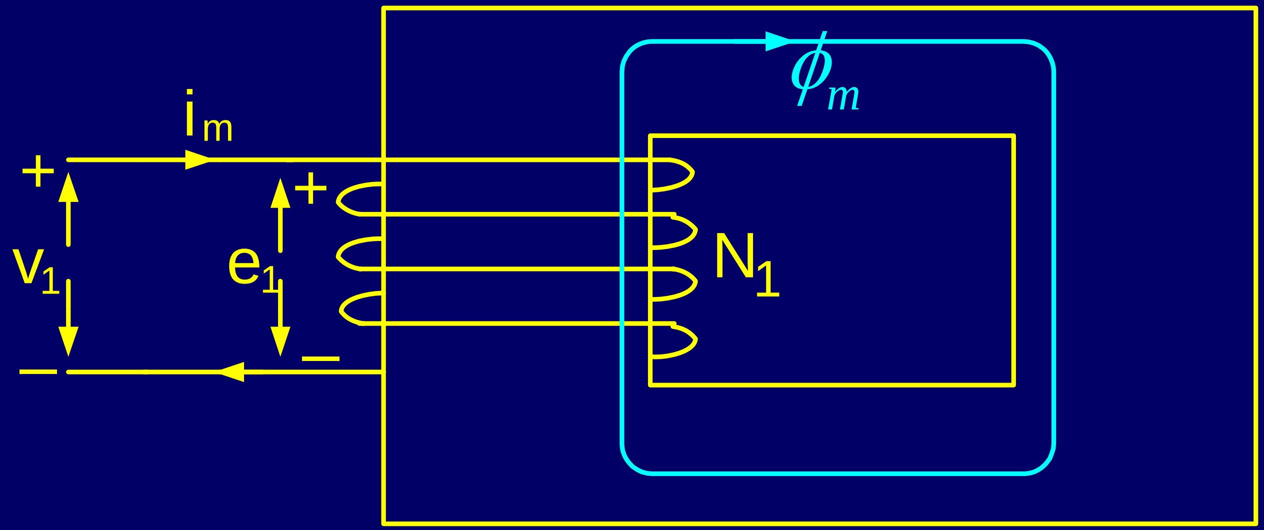
From Faraday's law:

$$v_1 = e_1 = N_1 \frac{d\phi_m}{dt}$$

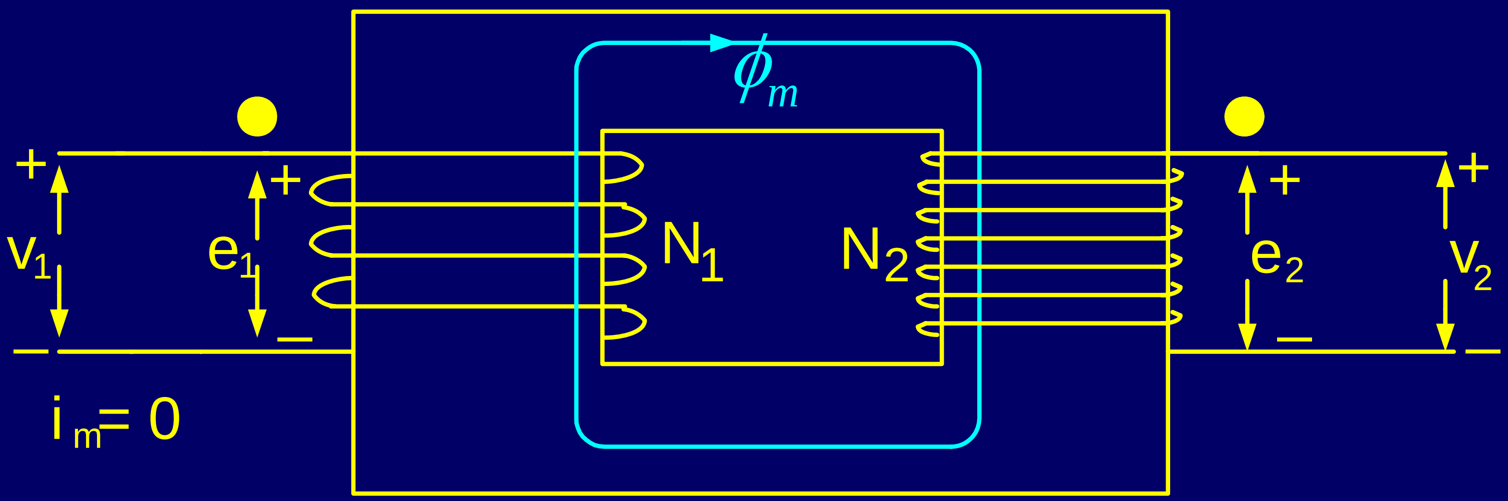
Magnitude of core flux is determined by the induced voltage and hence applied voltage in case of an ideal transformer.

$$\phi_m = \frac{N_1 i_m}{\text{reluctance}}$$

For an ideal transformer, $i_m = 0$



Voltage induced in winding 2



Ideal transformer: Reclutance of core material is zero

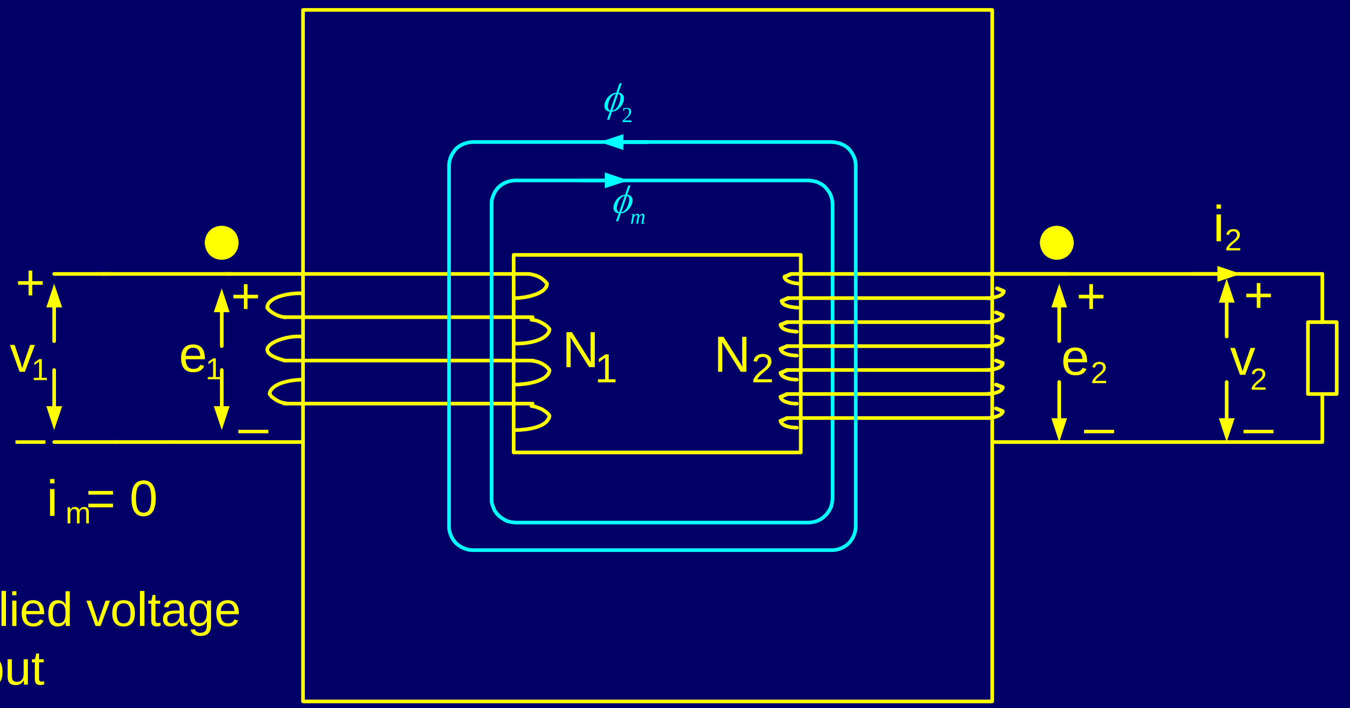
$$v_1 = e_1 = N_1 \frac{d\phi_m}{dt}$$

$$v_2 = e_2 = N_2 \frac{d\phi_m}{dt}$$

Polarity of induced voltage is given by Lenz's law : "dotted" terminals gets ' similar polarity

$$\frac{v_1}{v_2} = \frac{e_1}{e_2} = \frac{N_1}{N_2}$$

Ideal Transformer on load



v_1 being the applied voltage remains same, but

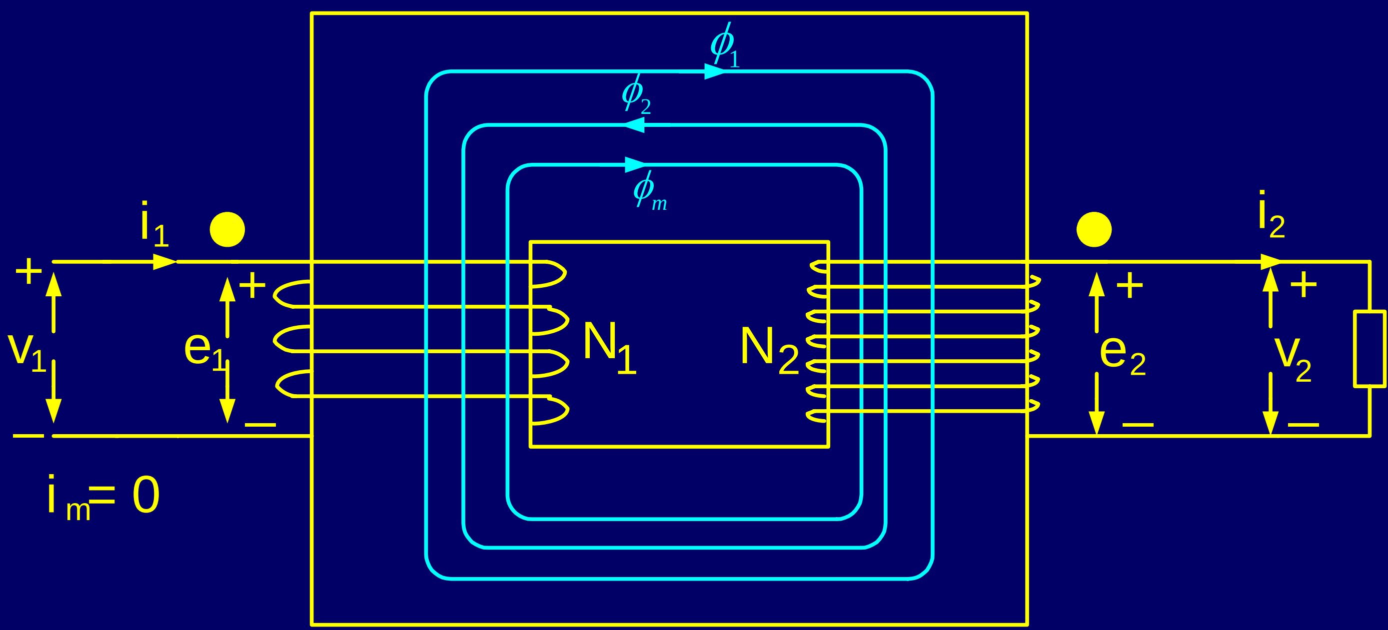
$$e_1 = N_1 \frac{d(\phi_m - \phi_2)}{dt}$$

Therefore, $e_1 < v_1$

Hence a current i_1 flows from v1 to “dot” terminal of winding 1.

Flow of current i_1 in N_1 sets a flux ϕ_1 in the core

Ideal Transformer on load



Steady state will reach when, $\phi_1 = \phi_2$

$$\phi_1 = \frac{N_1 i_1}{\text{reluctance}}$$

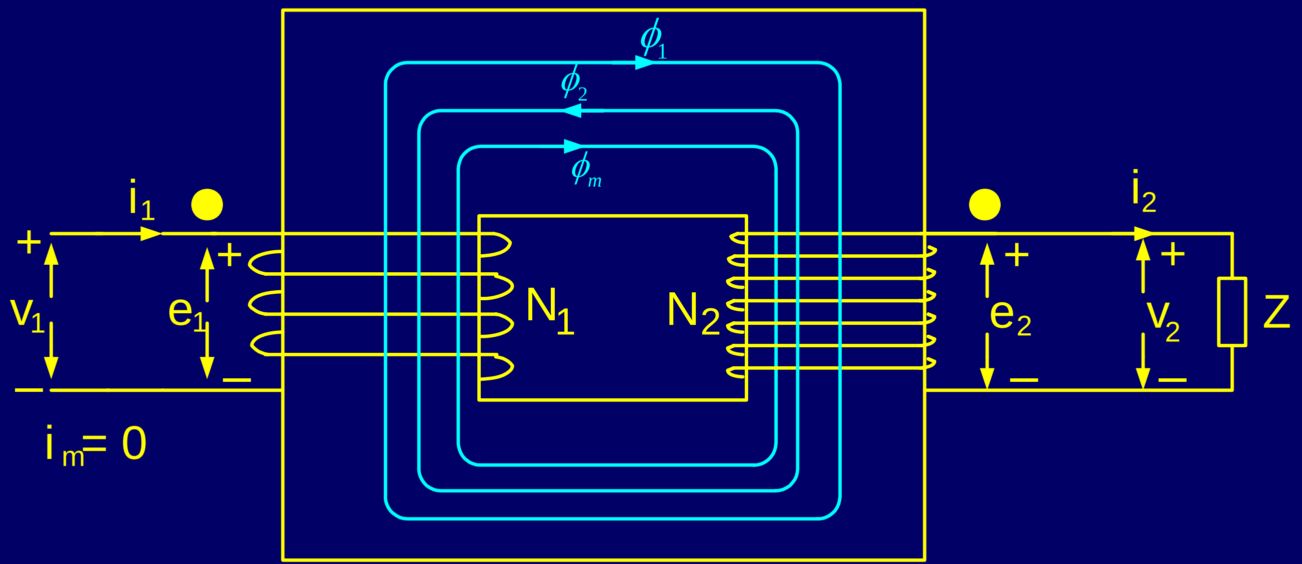
$$\phi_2 = \frac{N_2 i_2}{\text{reluctance}}$$

Therefore at steady state

$$N_1 i_1 = N_2 i_2$$

$$\frac{i_1}{i_2} = \frac{N_2}{N_1}$$

Ideal Transformer on load



$$\frac{v_1}{v_2} = \frac{e_1}{e_2} = \frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\frac{i_1}{i_2} = \frac{N_2}{N_1} = \frac{e_2}{e_1} = \frac{v_2}{v_1}$$

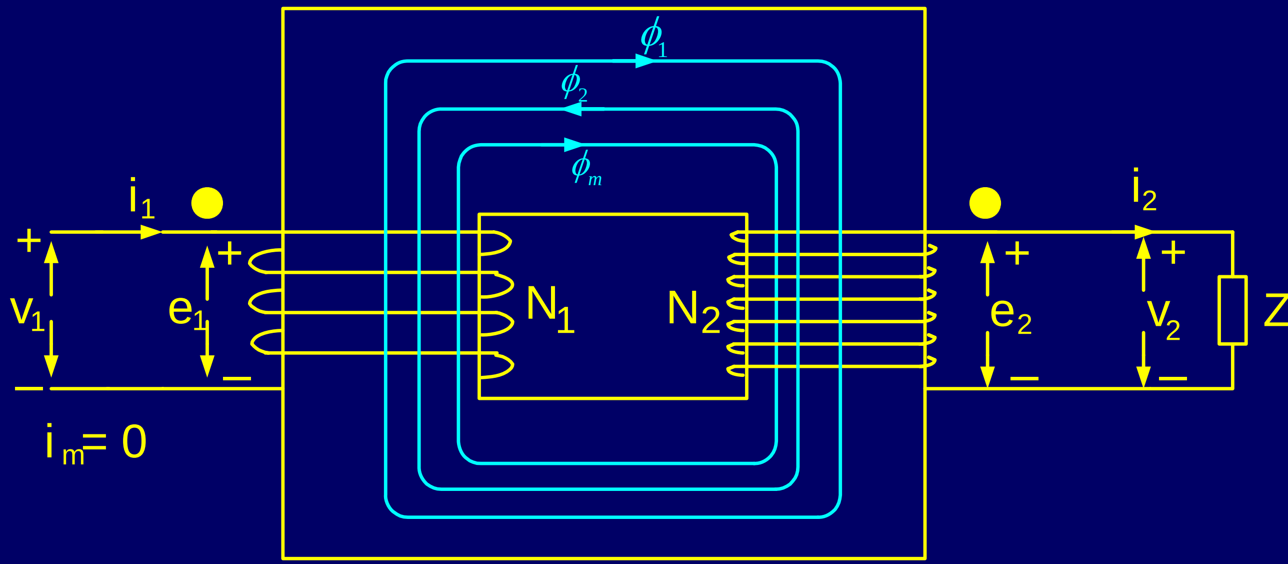
Therefore,

$$v_1 i_1 = v_2 i_2$$

$$e_1 i_1 = e_2 i_2$$

Volt-amperes at both the sides are same

Ideal Transformer on load



Impedance seen by winding-1,

$$Z = \frac{v_2}{i_2} = \frac{e_2}{i_2}$$

Impedance seen by winding-2,

$$Z^{/} = \frac{v_1}{i_1} = \frac{\dfrac{N_1 v_2}{N_2}}{\dfrac{N_2 i_2}{N_1}} = \left(\frac{N_1}{N_2}\right)^2 \frac{v_2}{i_2} = \left(\frac{N_1}{N_2}\right)^2 Z$$