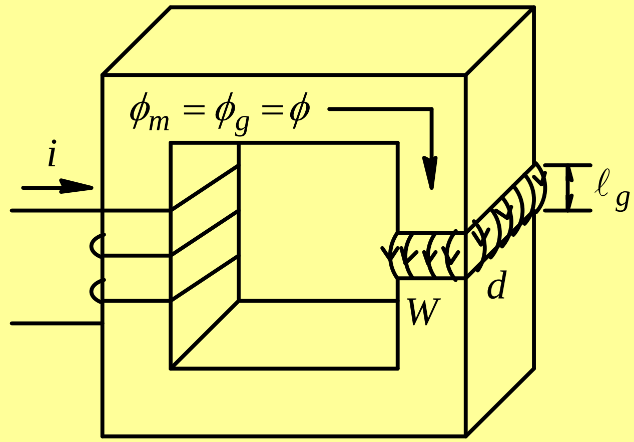
Magnetic Concepts

- Applications

AMPERE-TURNS AND FLUX

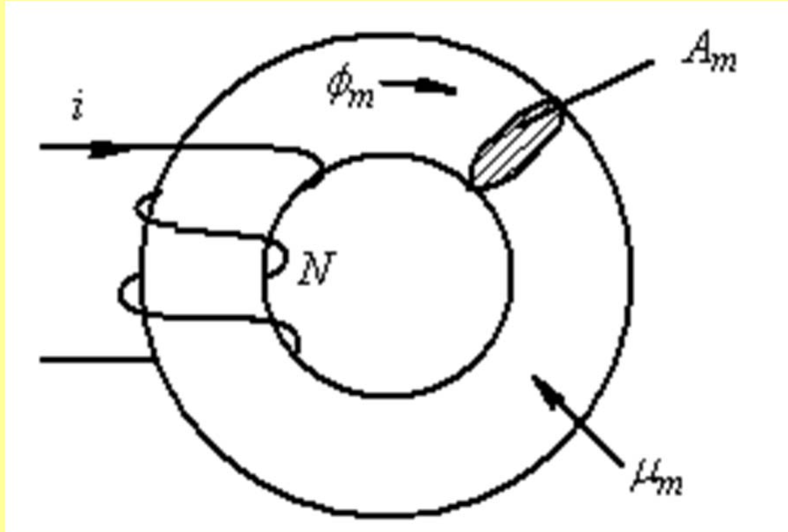


$$H_m \ell_m + H_g \ell_g = Ni$$

$$\phi\left(\underbrace{\frac{\ell_m}{A_m \mu_m}}_{\Re_m} + \underbrace{\frac{\ell_g}{A_g \mu_o}}_{\Re_g}\right) = Ni$$

$$\phi = \frac{Ni}{\Re} \qquad \Re = \Re_m + \Re_g$$

INDUCTANCE



$$\lambda_m = N\phi_m = L_m i$$

$$i \xrightarrow{\times\left(\frac{N}{\ell_m}\right)} H_m \xrightarrow{\times(\mu_m)} B_m \xrightarrow{\times(A_m)} \phi_m \xrightarrow{\times(N)} \lambda_m$$

$$L_m = \frac{N^2}{\dfrac{\ell_m}{\mu_m A_m}}$$

Energy Storage due to Magnetic Fields

$$W = \frac{1}{2} L_m i^2 \ [J]$$

$$L_m = \frac{N^2}{\Re_m} = \frac{N^2}{\dfrac{\ell_m}{\mu_m A_m}}$$

$$i = \frac{H_m \ell_m}{N}$$

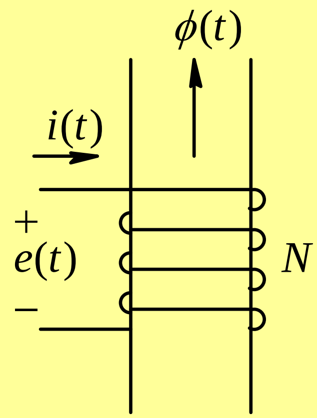
$$\therefore W = \frac{1}{2}\left(\frac{N^2}{\dfrac{\ell_m}{\mu_m A_m}}\right)\left(\frac{H_m^2 \ell_m^2}{N^2}\right)$$

$$= \frac{1}{2}\left(A_m \ell_m\right)\left(\mu_m H_m^2\right)$$

$$= \frac{1}{2}\left(A_m \ell_m\right)\frac{B_m^2}{\mu_m}$$

$$w = \frac{1}{2}\frac{B^2}{\mu} \ [J/m^3]$$

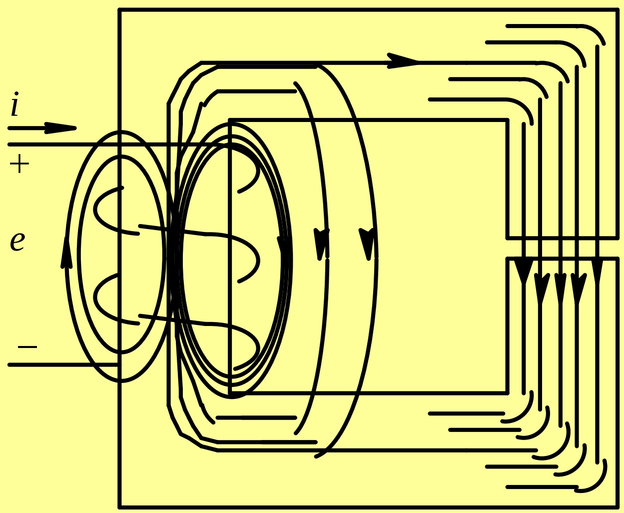
FARADAY'S LAW: INDUCED VOLTAGE IN A COIL DUE TO TIME-RATE OF CHANGE OF FLUX LINKAGE



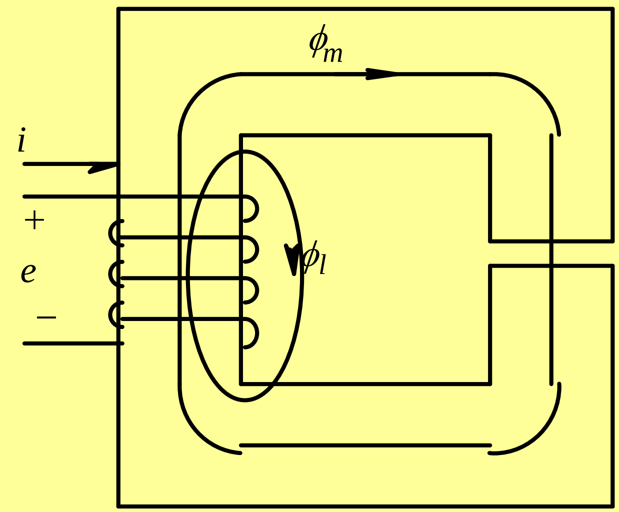
$$e(t) = \frac{d}{dt}\lambda(t) = N\frac{d}{dt}\phi(t)$$

$$\phi(t) = \phi(0) + \frac{1}{N}\int_0^t e(\tau)\cdot d\tau$$

LEAKAGE AND MAGNETIZING INDUCTANCES



(a)



(b)

$$\lambda = N\phi = \underbrace{N\phi_m}_{\lambda_m} + \underbrace{N\phi_\ell}_{\lambda_\ell} = \lambda_m + \lambda_\ell$$

$$\underbrace{\frac{\lambda}{i}}_{L_{self}} = \underbrace{\frac{\lambda_m}{i}}_{L_m} + \underbrace{\frac{\lambda_\ell}{i}}_{L_\ell}$$

$$L_{self} = L_m + L_\ell$$

$$\lambda = (L_m + L_\ell)i$$

$$e(t) = \underbrace{L_m \frac{di}{dt}}_{e_m(t)} + L_\ell \frac{di}{dt}$$

LEAKAGE AND MAGNETIZING INDUCTANCES

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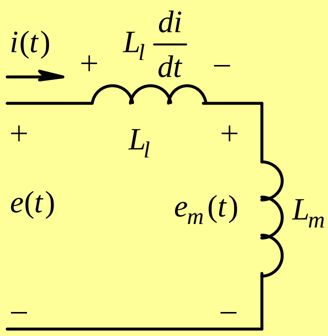
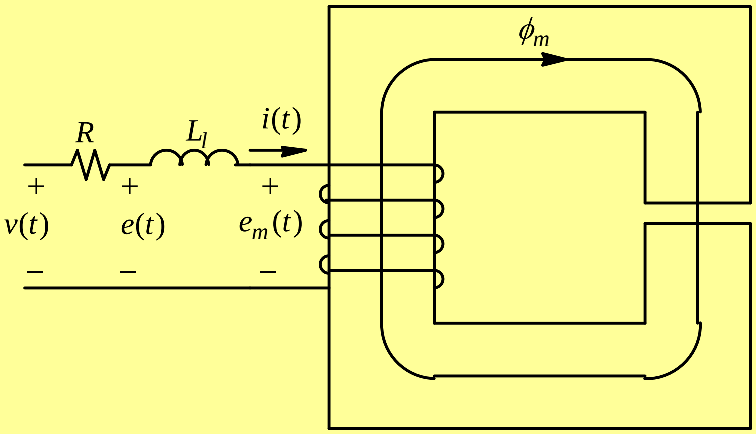
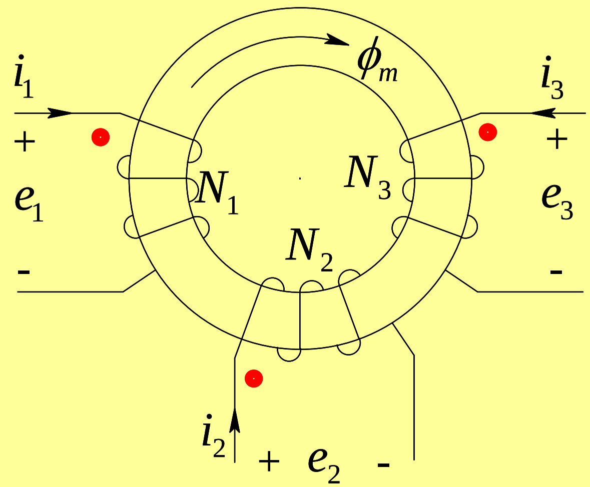


(a)



(b)

TRANSFORMERS



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

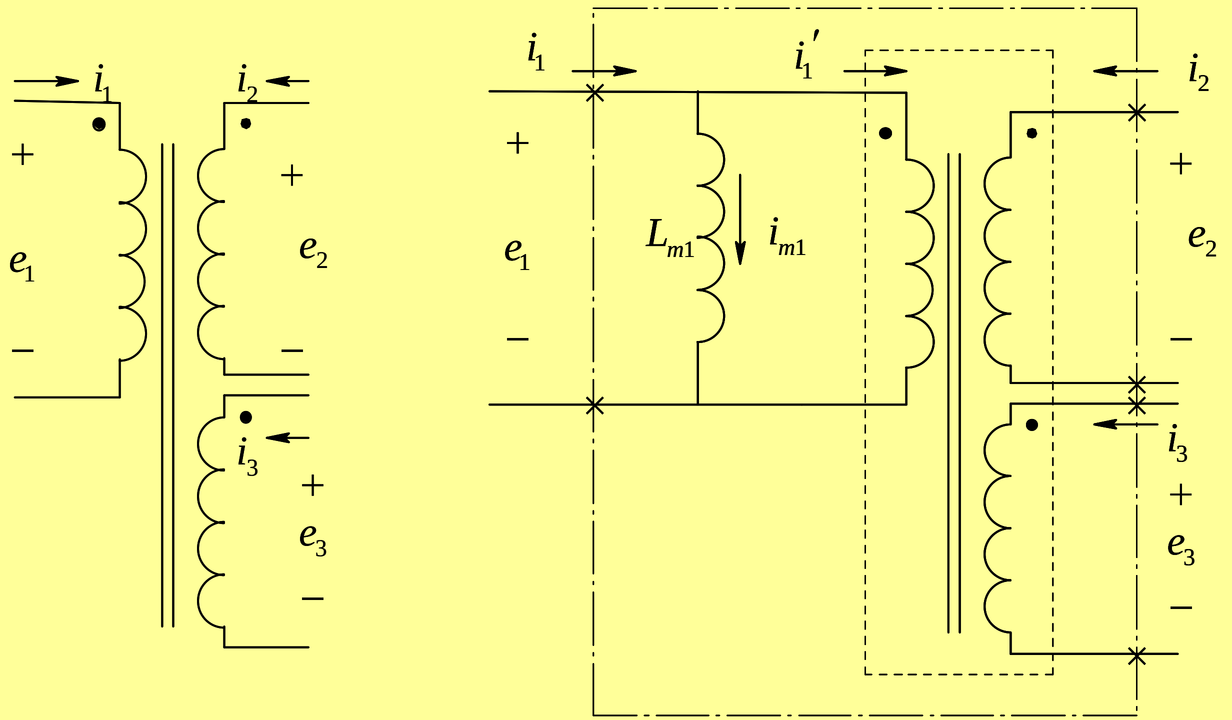
$$e_2 = N_2 \frac{d\phi_m}{dt}$$

$$e_3 = N_3 \frac{d\phi_m}{dt}$$

$$\frac{d\phi_m}{dt} = \frac{e_1}{N_1} = \frac{e_2}{N_2} = \frac{e_3}{N_3} \quad \Rightarrow \quad \phi_m = \frac{1}{N_1}\int e_1 dt = \frac{1}{N_2}\int e_2 dt = \frac{1}{N_3}\int e_3 dt$$

$$\phi_m = \frac{N_1 i_1 + N_2 i_2 + N_3 i_3}{\Re_m}$$

Transformer Equivalent Circuit



(a) (b)

$$N_1 i_{m1} = \Re_m \phi_m$$

$$N_1 i_1 + N_2 i_2 + N_3 i_3 = N_1 i_{m1}$$

$$N_1 \underbrace{(i_1 - i_{m1})}_{i_1'} + N_2 i_2 + N_3 i_3 = 0$$

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

$$\phi_m = \frac{N_1 i_{m1}}{\Re_m}$$

$$e_1 = \left(\frac{N_1^2}{\Re_m}\right)\frac{di_{m1}}{dt} \qquad L_{m1} = \frac{N_1^2}{\Re_m}$$

Summary

- Magnetic Concepts