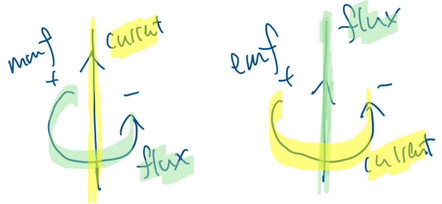
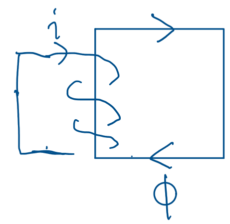
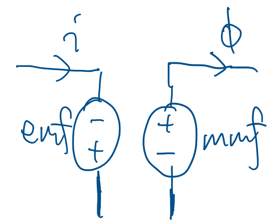
330 review (5/6)

Friday, May 1, 2020 4:43 PM



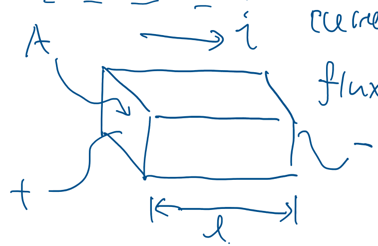




confusing polarities.

mmf = net current

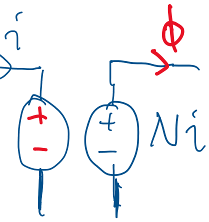
emf = $-\frac{d}{dt}$ net flux



current density $J = \frac{i}{A}$

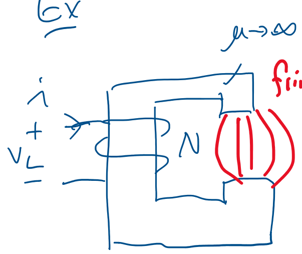
flux density $B = \frac{\phi}{A}$

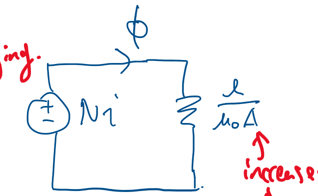
$\frac{d\lambda}{dt} = N\frac{d\phi}{dt}$



flux linkage helps with polarities

Ex



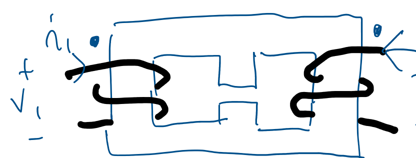


$\lambda = N\phi$

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

resistance $= \frac{v}{i} = \frac{1}{\text{conductivity}} \cdot \frac{\ell}{A}$

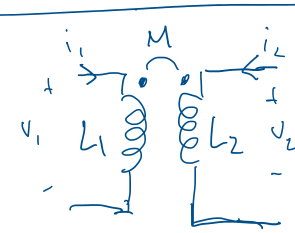
reluctance $= \frac{\text{mmf}}{\phi} = \frac{1}{\text{permeability}} \cdot \frac{\ell}{A}$

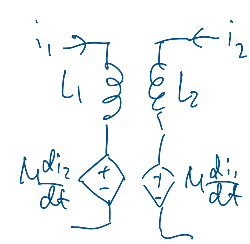


canonical model

current **into** dots | flux **out** of mmf

+ve term **at** dot





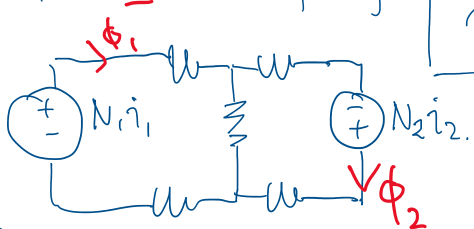
$\lambda_1 = +L_1 i_1 \pm M i_2$

$\lambda_2 = \pm M i_1 + L_2 i_2$

dot convention, guaranteed to have $M \geq 0$.

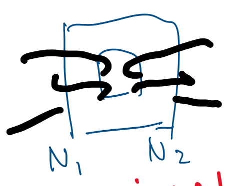
$K = \frac{M}{\sqrt{L_1 L_2}}$ ↗ $=1$ perfect coupling. ↘ $=0$ completely decoupled.

max $M \leq \sqrt{L_1 L_2}$

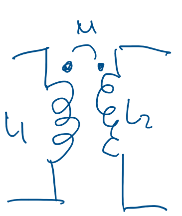


$\lambda_1 = N_1\phi_1$, $\lambda_2 = N_2\phi_2$.

$v_1 = \frac{d\lambda_1}{dt}$, $v_2 = \frac{d\lambda_2}{dt}$.

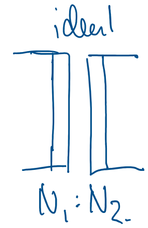


≈ ignore losses assume linear



≈ no inductive behavior

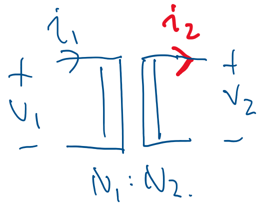
ideal



← too idealized to be practically useful.

i_1 i_2 v_2 λ_1 | referring to primary assume linear

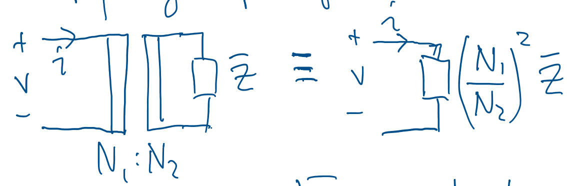
behavior



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

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

referring to primary



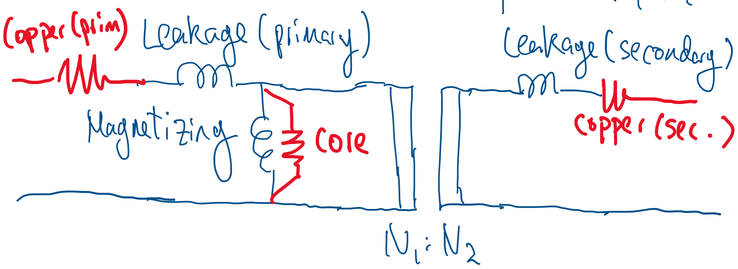


Figure out values by performing short-circuit & open circuit tests.

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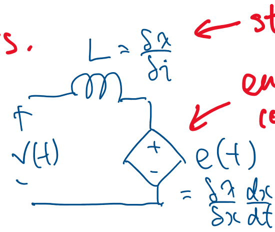
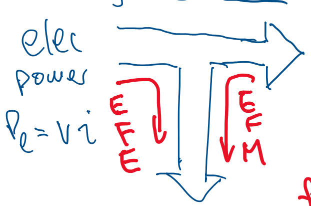
$\lambda(i, x) \leftarrow$ derive from physics.

$$v = \frac{d\lambda}{dt} = \underbrace{\frac{\delta\lambda}{\delta i}\frac{di}{dt}}_{\text{transformer}} + \underbrace{\frac{\delta\lambda}{\delta x}\frac{dx}{dt}}_{\text{speed.}}$$



Power flow chart



force in direction of increasing x

$$\text{Energy} = \int_0^{\lambda} i(\lambda', x)\, d\lambda'$$

fixed, so $\Delta EFM = 0$.

$$= i\lambda - \underbrace{\int_0^{i} \lambda(i', x)\, di'}_{\text{Co-Energy}}$$

$$\text{force} = \frac{d\,EFM}{dx} = -\frac{\delta W_m}{\delta x} \quad (\lambda \text{ const})$$

$\delta EFE = 0$.

$$\frac{dW_m}{dt} = P_e - P_m$$

$$\Delta W_m = \int P_e\,dt + \int -P_m\,dt \qquad = +\frac{\delta W_m'}{\delta x} \quad (i \text{ const})$$

assume conservation

$$= \int i\frac{d\lambda}{dt}\,dt + \int -f\frac{dx}{dt}\,dt$$

$$= \underbrace{\int i\,d\lambda}_{EFE} + \underbrace{\int -f\,dx}_{EFM}$$

$\frac{d\lambda}{dt} = v = 0 \Rightarrow \Delta EFE = 0$. (short-circuit)

$\frac{dx}{dt} = 0 \Rightarrow \Delta EFM = 0$ (mechanically fixed)

<u>Ex</u> $\lambda = L(x)\, i$, $L(x) = N^2/$

$W_m = \frac{1}{2} L(x)^{-1} \lambda^2 \rightarrow$ energy stored in airgap → force wants to close gap.

$W_m' = \frac{1}{2} L(x)\, i^2$

force to decrease energy and increase co-energy.

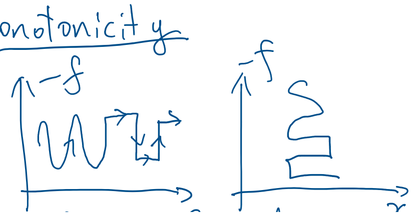
Energy conversion cycles.

$$P_e(t) \longrightarrow P_m(t)$$

dW_m

arbitrary arbitrary

Monotonicity



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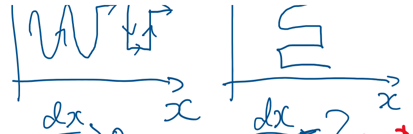
$P_e(t) \longrightarrow P_m(t)$

arbitrary $\quad \dfrac{dW_m}{dt} \quad$ arbitrary

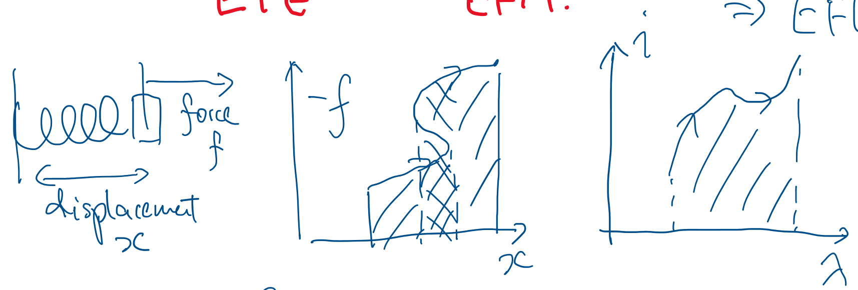


$\dfrac{dx}{dt} \geq 0$ OK $\qquad \dfrac{dx}{dt} = ?$ must split!

$$\Delta W_m = \underbrace{\int_{T_1}^{T_2} P_e(t)\,dt}_{EFE} + \underbrace{\int_{T_1}^{T_2} -P_m(t)\,dt}_{EFM.}$$

$\Delta W_{m,cycle} = 0$

$\Rightarrow EFE_{cycle} + EFM_{cycle} = 0.$



EFE cycle $\quad$ EFM cycle.

↳ if $EFE_{cycle} > 0$, motor
if $EFE_{cycle} < 0$, generator.

$EFM = \int -f(t)\,dx(t) \qquad EFE = \int i(t)\,d\lambda(t)$

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place dots.

$i_{ab} = +i_2 = -i_1$

$v_1 = L_1 \dfrac{di_1}{dt} + M\dfrac{di_2}{dt} = (-L_1 + M)\dfrac{di_{ab}}{dt}$

$v_2 = M\dfrac{di_1}{dt} + L_2\dfrac{di_2}{dt} = (-M + L_2)\dfrac{di_{ab}}{dt}$

$V_{ab} = V_2 - V_1 = \underbrace{(-M + L_2 + L_1 - M)}_{L_{equiv.}}\dfrac{di_{ab}}{dt}$

$25 + 1 - 5 - 5 = \boxed{16\text{ H}}$

$\phi_1 = \phi_2 = \dfrac{N_1 i_1 + N_2 i_2}{R},$

$\lambda_1 = \dfrac{N_1^2}{R} i_1 + \dfrac{N_1 N_2}{R} i_2$

$\lambda_2 = \dfrac{N_1 N_2}{R} i_1 + \dfrac{N_2^2}{R} i_2.$

$L_2 = 25, \quad M = 5, \quad L_1 = 1$

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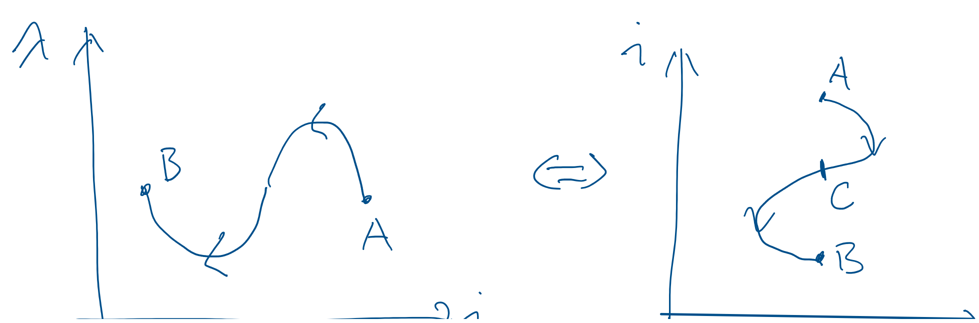
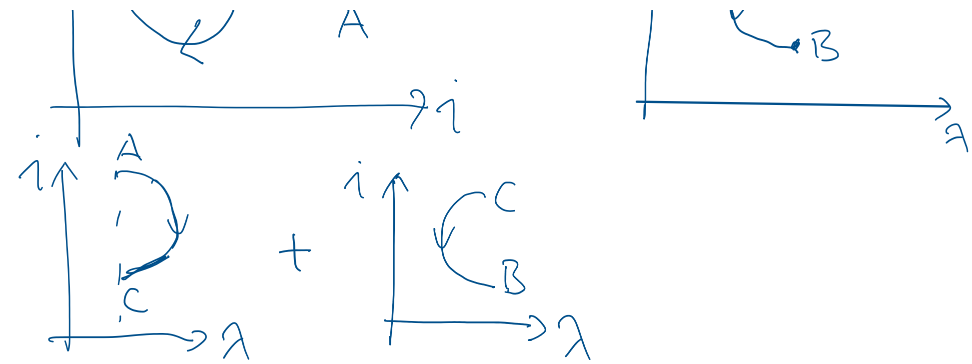
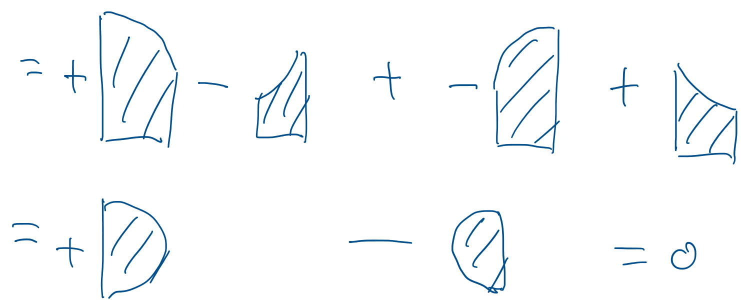
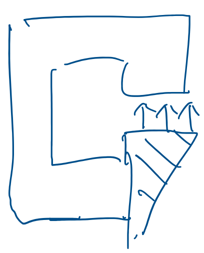






$= 0$



electromagnet!

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$$L(x) = \frac{N^2}{R(x)}, \quad R(x) = \frac{x}{\mu_0 A},$$

$$W_m' = \frac{1}{2} L(x)\, i^2 = \frac{i^2}{2} \frac{\mu_0 A N^2}{x}$$

$$f = +\frac{dW_m'}{dx} = -\frac{I_{dc}^2}{2} \frac{\mu_0 A N^2}{x^2} \quad (\text{increasing } x)$$

magnitude = the number, sign indicates direction

$A_p > A_d$; $f \propto -A$, so A_d has greater force??
(what does greater mean in this case?)