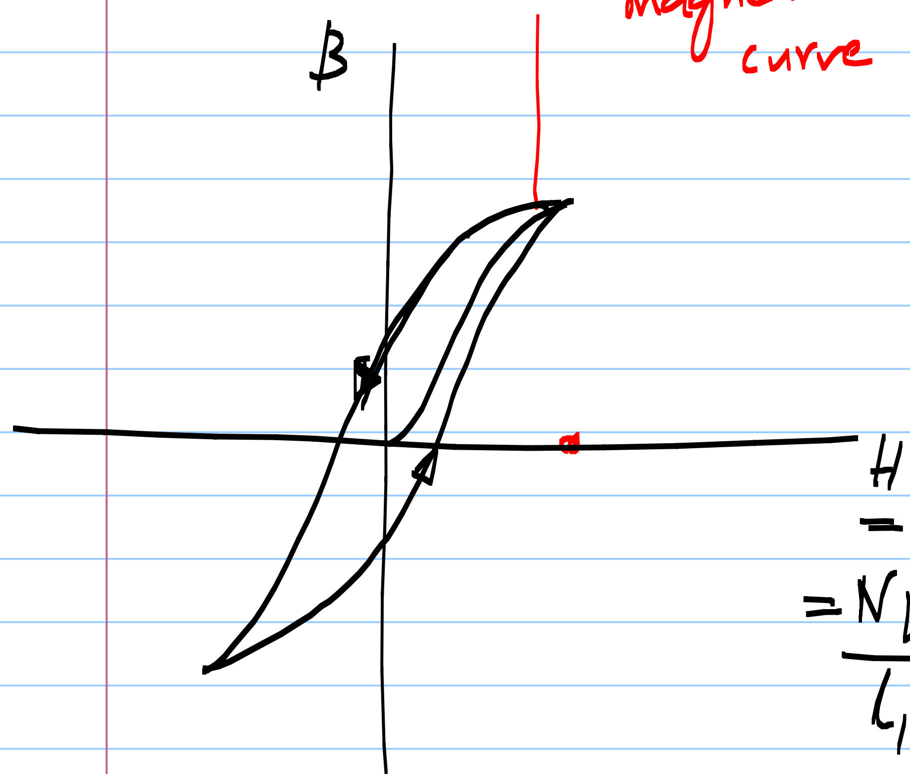
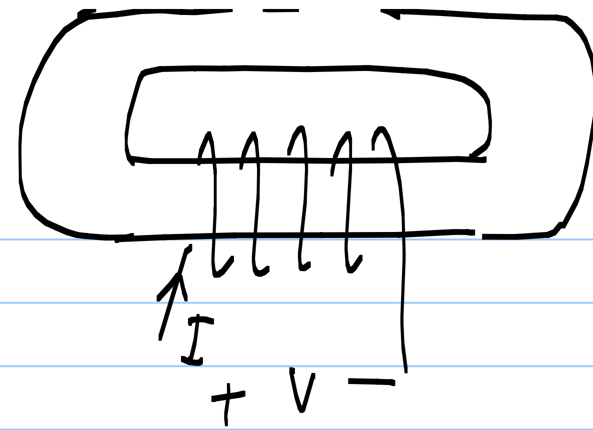
Lecture 41



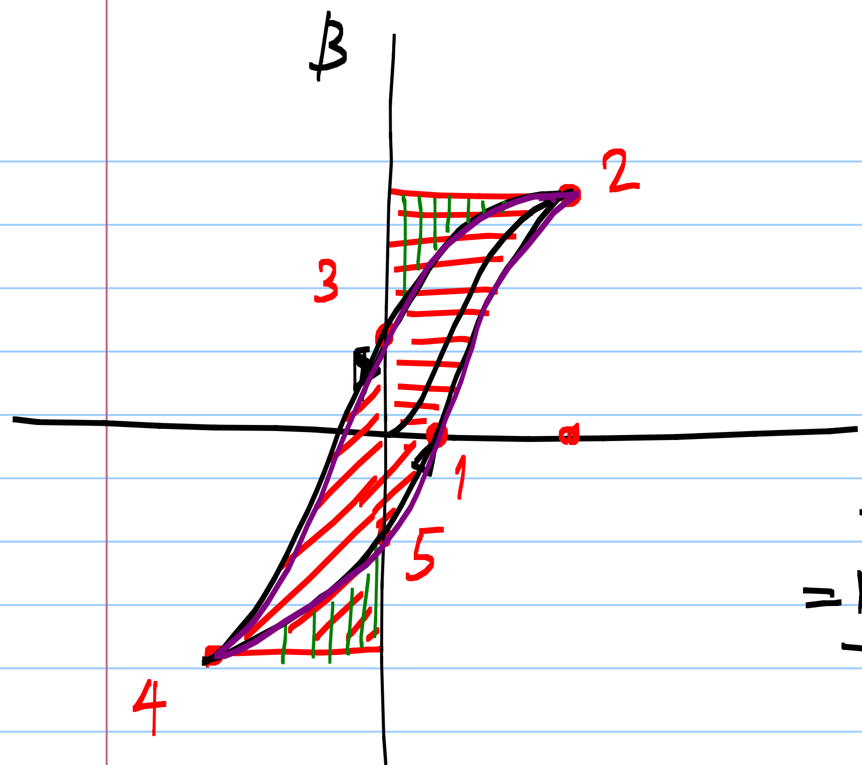
$$H = \frac{N i}{l_{loop}}$$



$$V = \frac{d\psi}{dt} = N \cdot \frac{d\phi}{dt} = NA \cdot \frac{dB}{dt}$$

$$i = \frac{H \cdot l_{loop}}{N}$$

$$p(t) = v \cdot i = A\, l_{loop} \cdot H \cdot \frac{dB}{dt}$$



$$p(t) = v \cdot i = A\, l_{loop} \cdot H \cdot \frac{dB}{dt}$$

$$E = \int_{t_1 - B_1}^{t_2 - B_2} A \cdot l_{loop} \cdot H \cdot \frac{dB}{dt} \cdot dt = A\, l_{loop} \int_{B_1}^{B_2} H \cdot dB$$

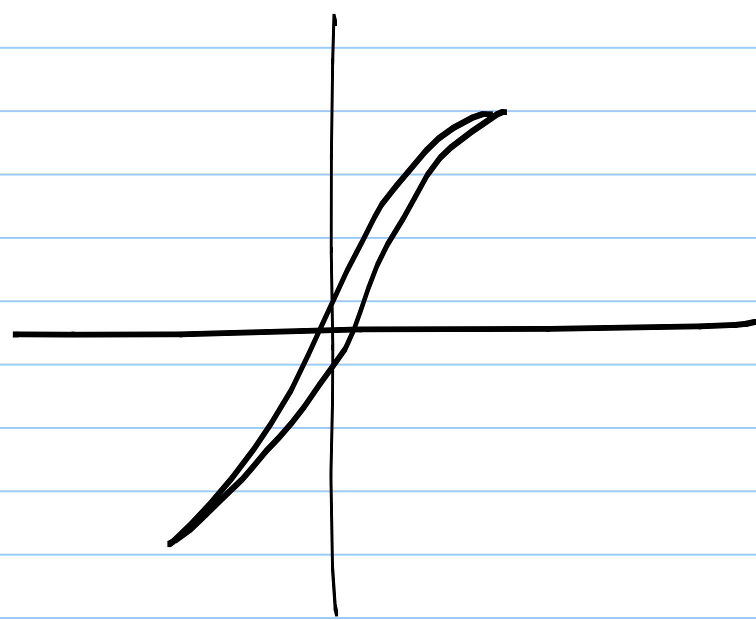
$$H = \frac{N i}{l_{loop}}$$

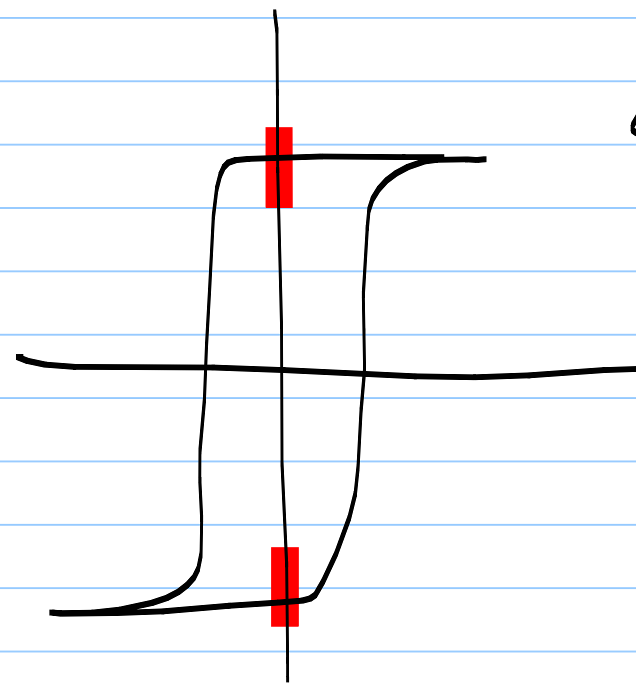
Area of the BH loop: <u>Energy lost / cycle / volume</u>

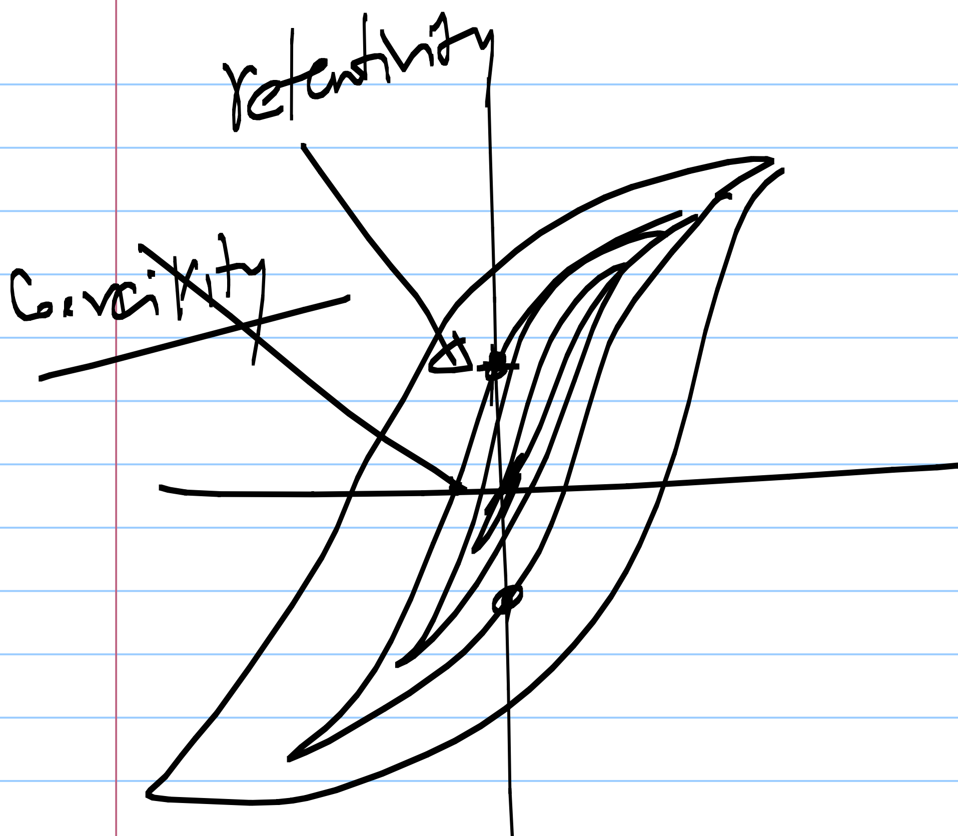
Hysteresis loss

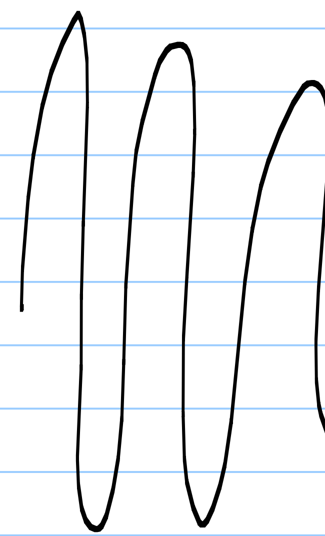
Power lost: Volume of the core × B.H loop area × f

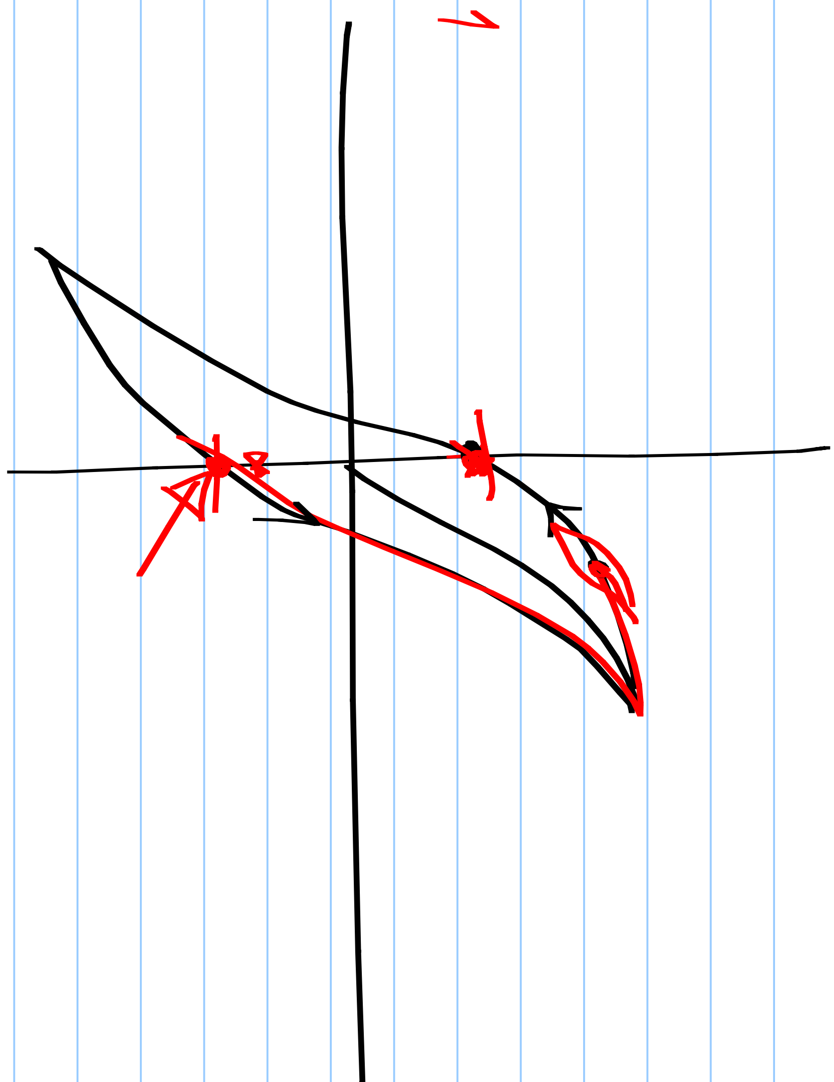
B_p^x . x: 1.5 — 2.5 (Steinmetz index)

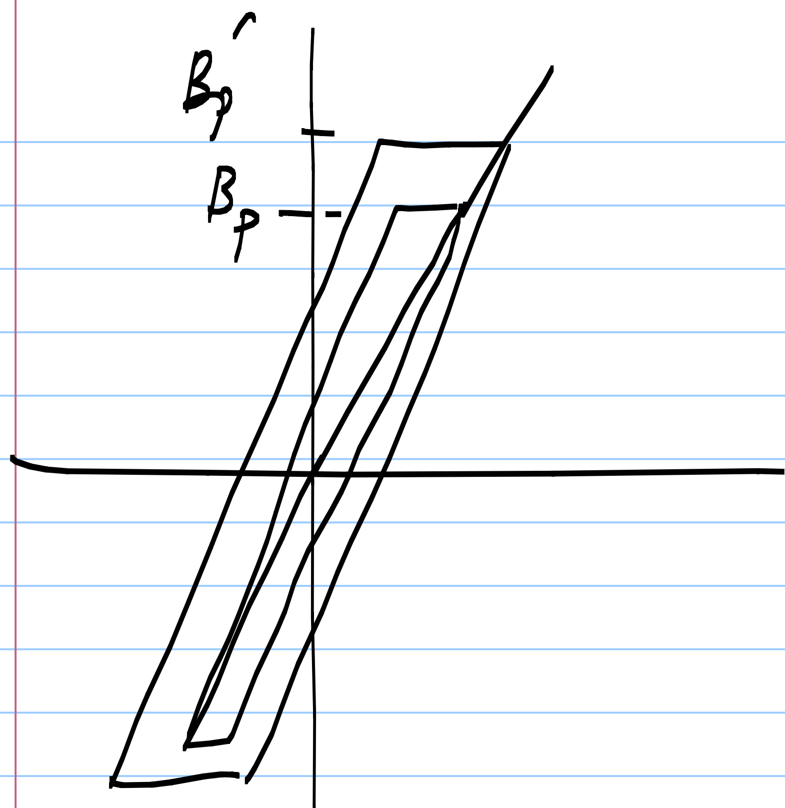


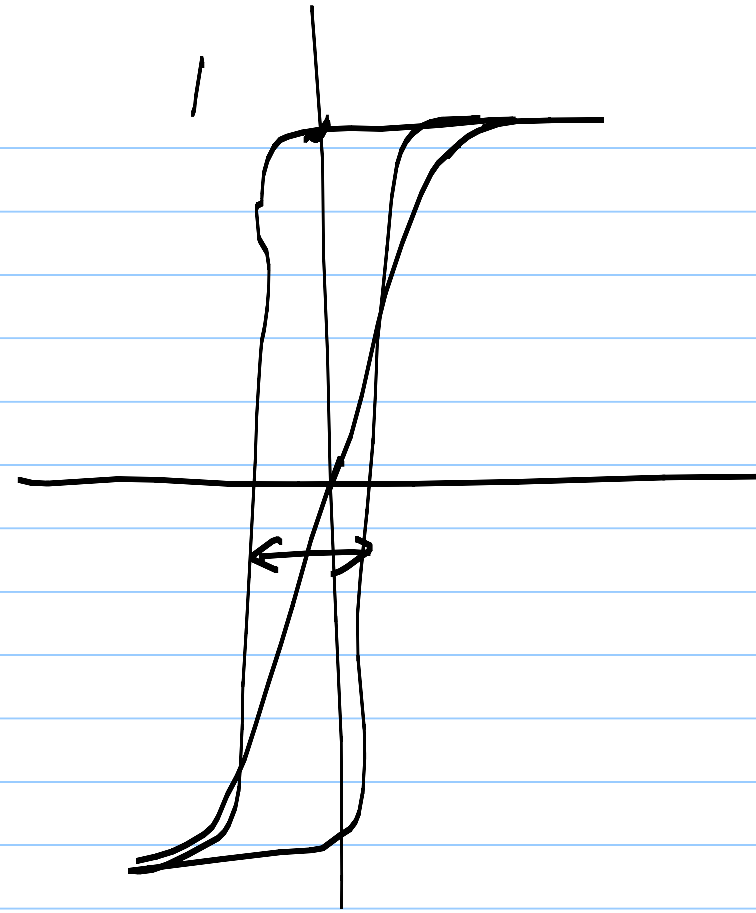


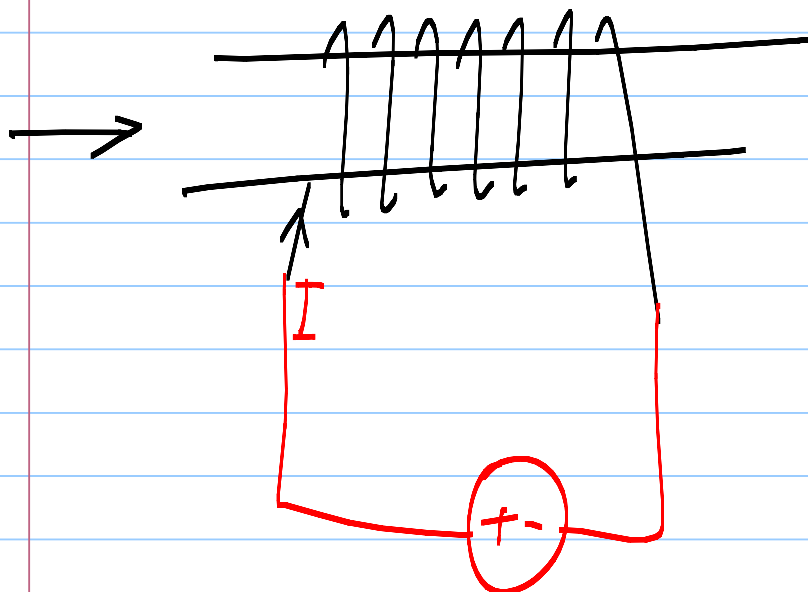

retentivity
Coercivity






B_p'
B_p

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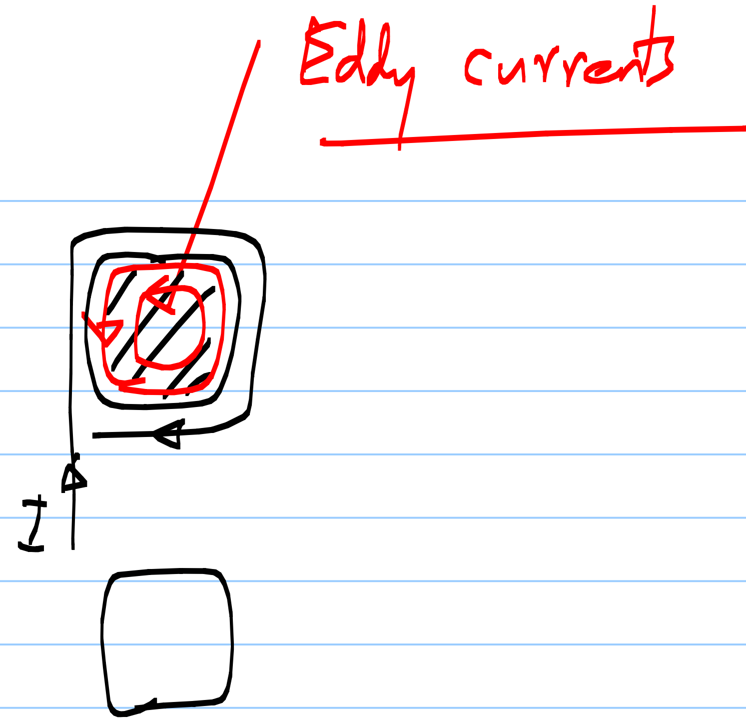
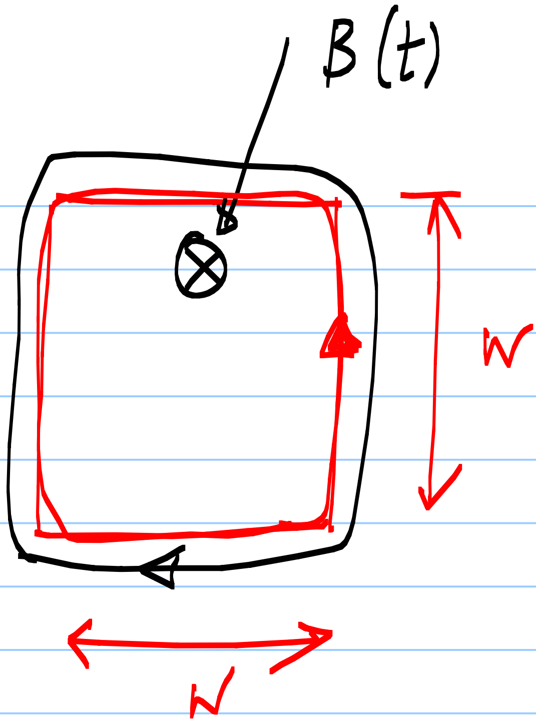

Eddy currents
I

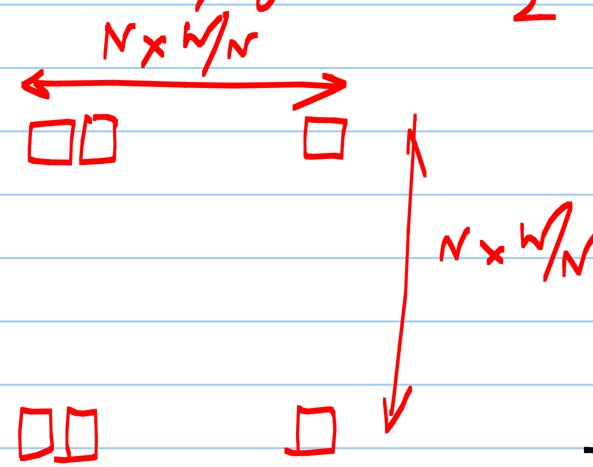


R_{loop}

$$P_{loss} = \left(w^2 \cdot \frac{dB}{dt} \right)^2 \frac{1}{R_{loop}}$$

$$\left(\frac{\left(\frac{w}{N}\right)^2 \frac{dB}{dt}}{R_{loop}/N} \right) \times N^2$$

$$P_{loss,avg} = w^4 \frac{\omega^2 B_p^2}{2} \cdot \frac{1}{R_{loop}}$$

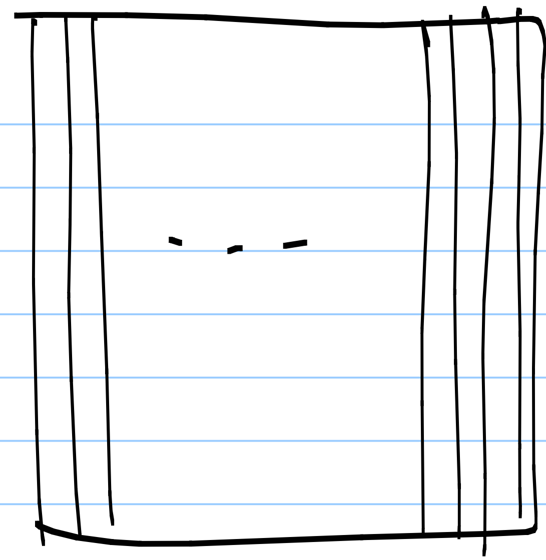


$$B = B_p \sin \omega t$$

$$\frac{dB}{dt} = \omega B_p \cos \omega t$$

$$N^2 \cdot \frac{w^4}{N^4} \frac{\omega^2 B_p^2}{2} \cdot \frac{N}{R_{loop}}$$

$$= \frac{1}{N} \cdot P_{loss,orig}$$



Eddy current loss

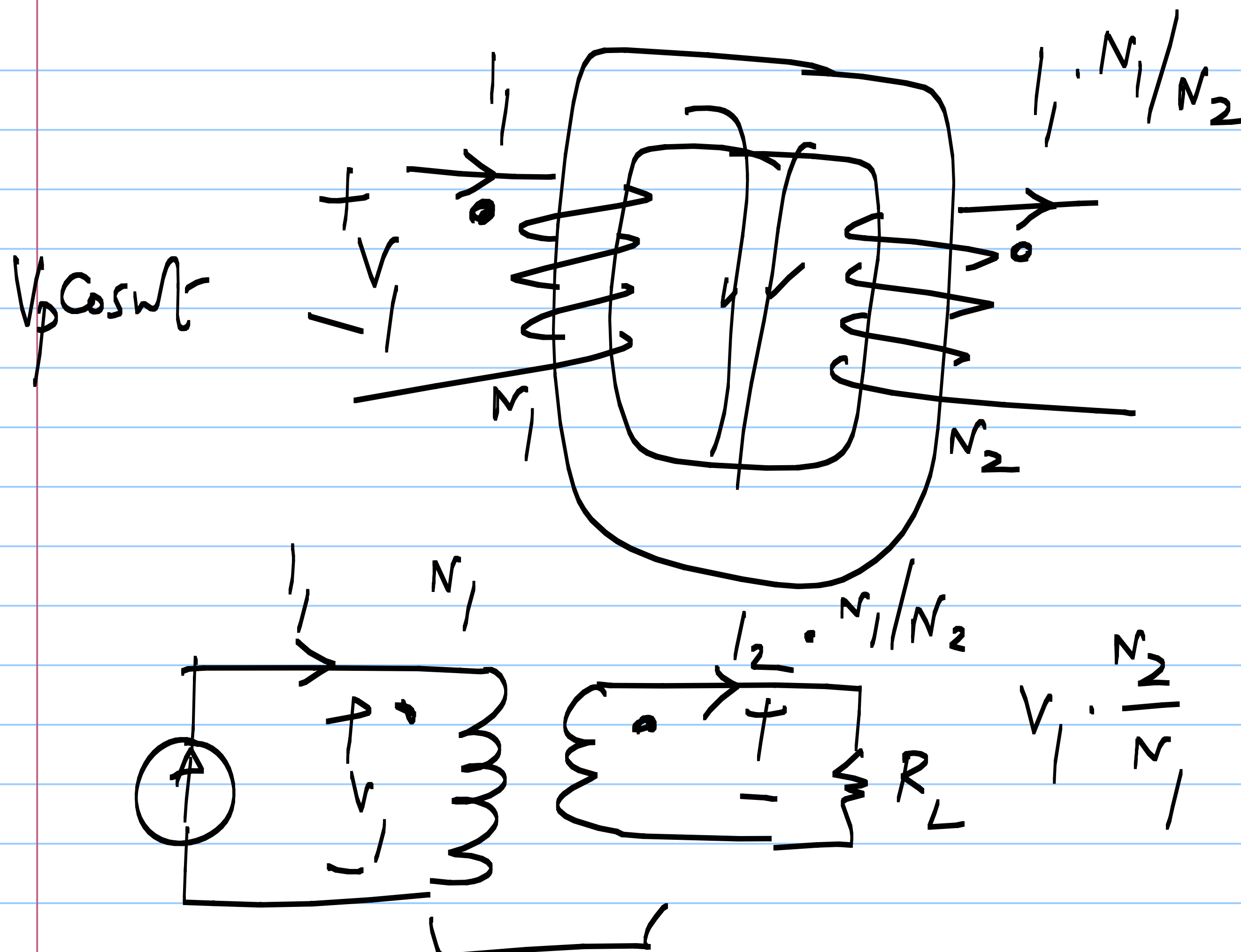
$\propto f^2$

Reduce eddy losses by

* Reducing σ_{core} (Alloy)
* Powdered epoxy
* Lamination

Losses in a ferromagnetic core inductor:

* wire resistance
* Hysteresis loss $\propto B_p^{x} \cdot f$
* Eddy current loss $\propto B_p^{2} \cdot f^{2}$



$\left\{ L_1, L_2 \to \infty \right.$

$k \to 1$

$L \to \infty$

$I \to 0$