Capacitors and Inductors

Capacitor

- Stores charge and energy.

$$Q = CV$$

$$I = C\frac{dV}{dt}$$

- Energy:

$$U_C = \tfrac{1}{2}CV^2$$

- Energy density:

$$u_E = \tfrac{1}{2}\varepsilon_0 E^2$$

Inductor

- Stores magnetic flux and energy.

$$N\Phi_B = LI$$

$$\varepsilon = -L\frac{dI}{dt}$$

- Energy:

$$U_L = \tfrac{1}{2}LI^2$$

- Energy density:

$$u_B = \tfrac{1}{2}\frac{B^2}{\mu_0}$$

Capacitors and Inductors in AC Circuits

Capacitor

$$V_{\max} = I_{\max} X_C$$

$$X_C = \frac{1}{\omega C}$$

- X_C = "capacitive reactance"
- Current leads voltage (ICE)

Inductor

$$V_{\max} = I_{\max} X_L$$

$$X_L = \omega L$$

- X_C = "capacitive reactance"
- Current lags behind voltage (ELI)

Power

$$P = IV$$

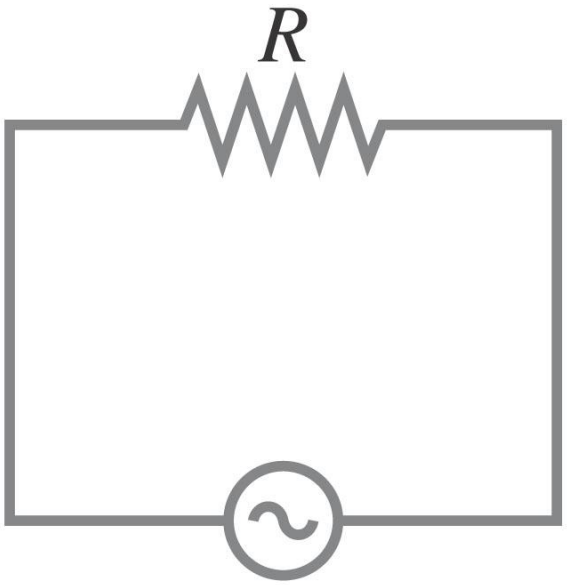
Power dissipated by a resistor:

$$P = I^2 R$$

$$P = \frac{V^2}{R}$$

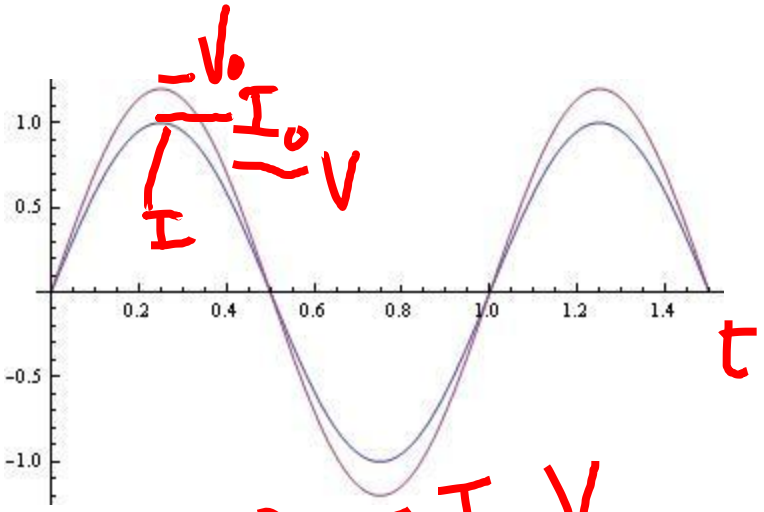
Power

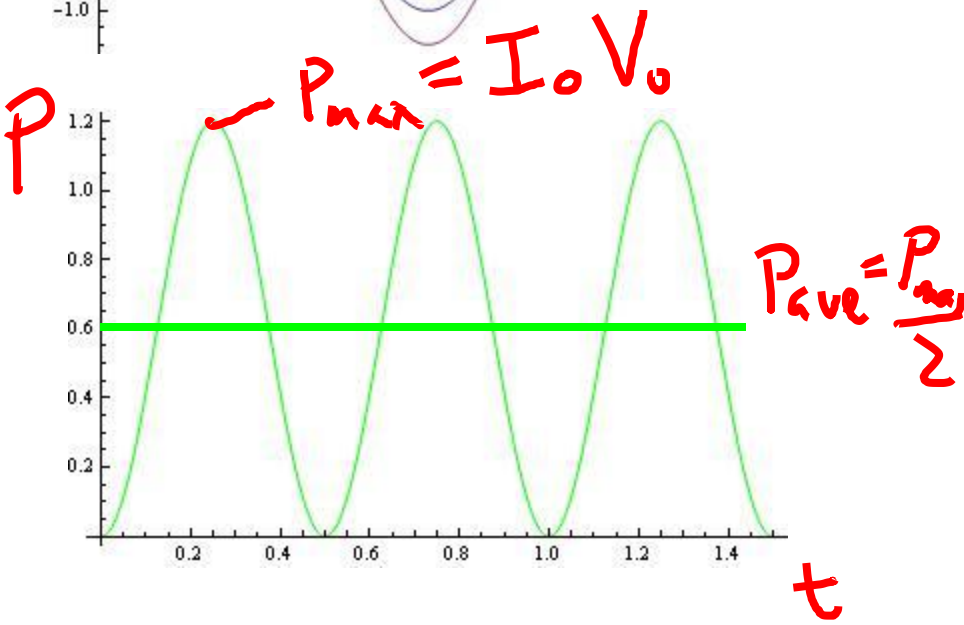
$V = IR$



(a)

Figure 30.15a





$P_{ave} = \frac{1}{2} I_0 V_0$

$\boxed{P_{ave} = I_{RMS} V_{RMS}}$

$I_{RMS} = \frac{I_0}{\sqrt{2}}$

$V_{RMS} = V_0/\sqrt{2}$

Power

ICE

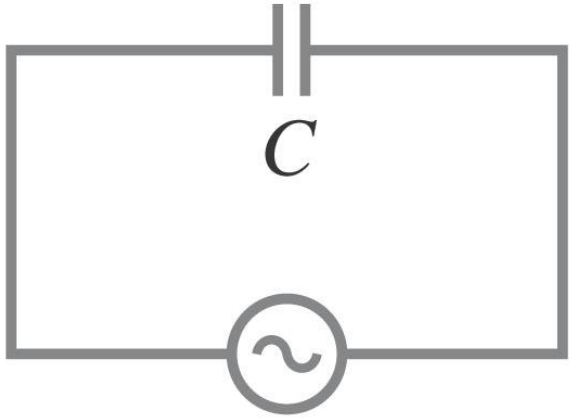
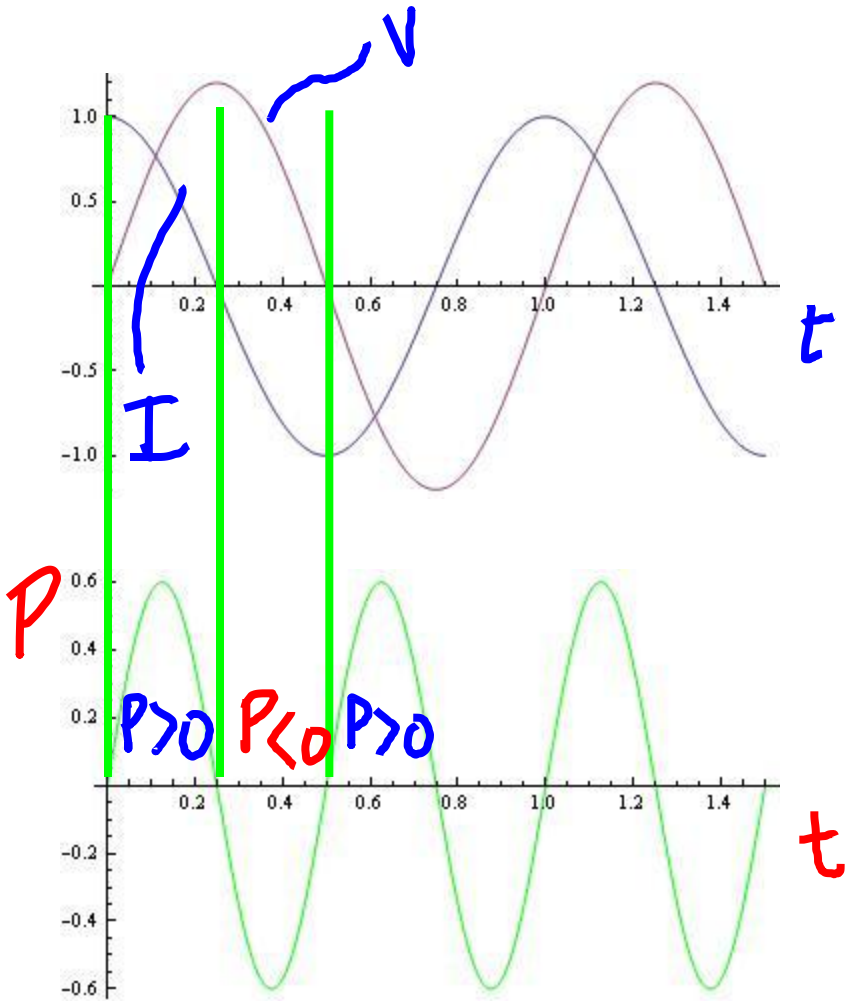


Figure 30.17a

(a)

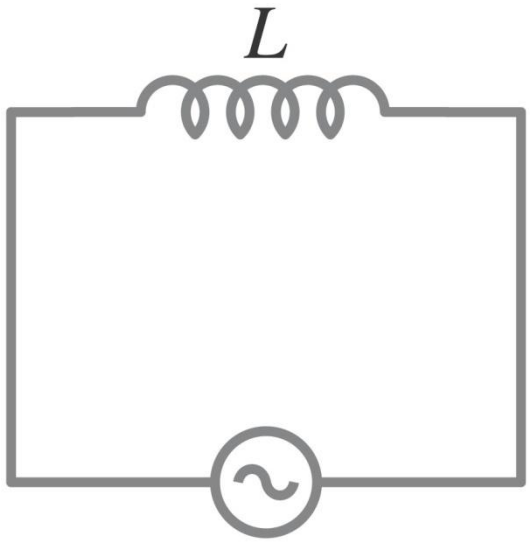
$U_c = \frac{1}{2} C V^2$

$P_{ave} = 0$



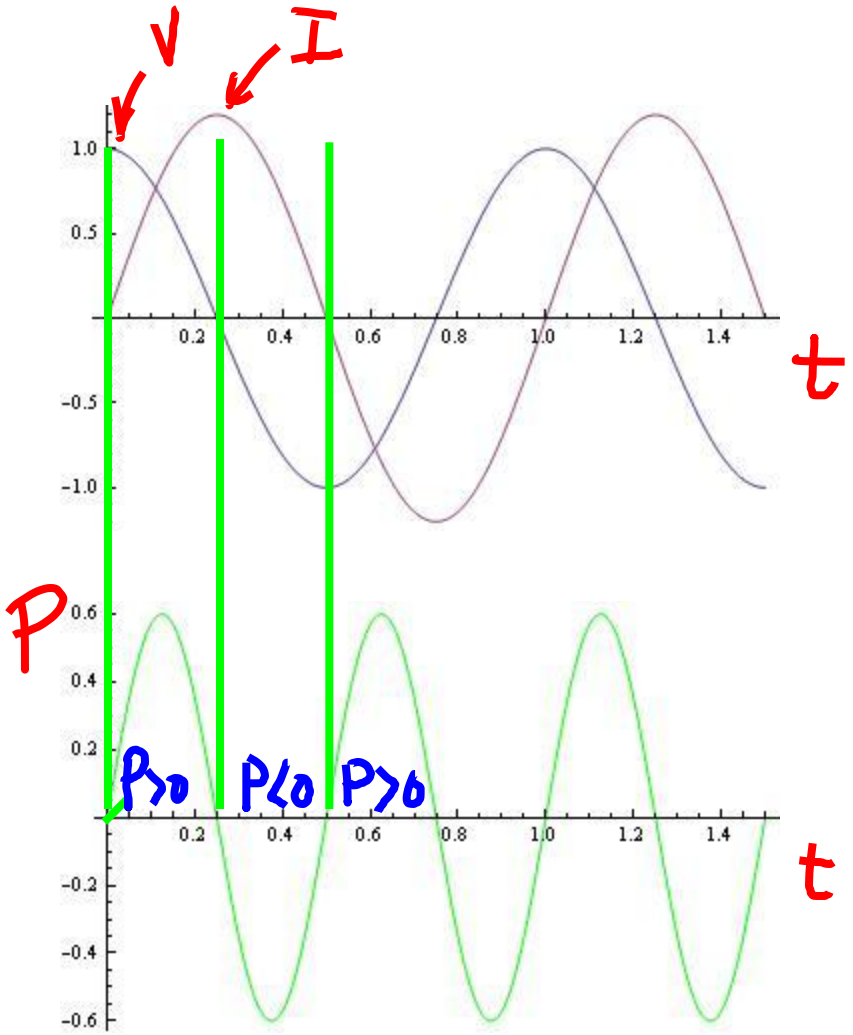
ELI

Power



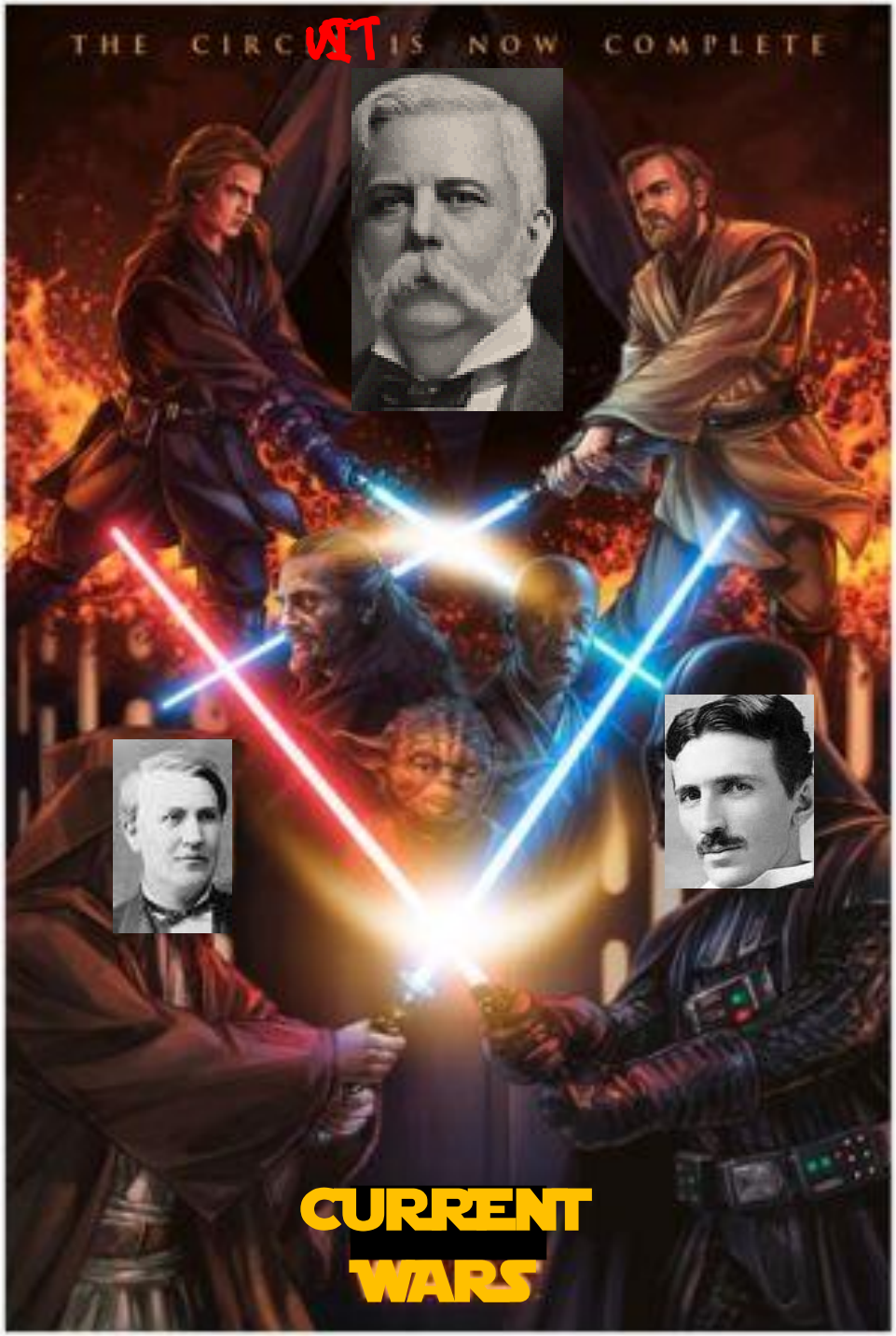
(a)

Figure 30.16a



$U_L = \frac{1}{2} L I^2$

$P_{ave} = 0$



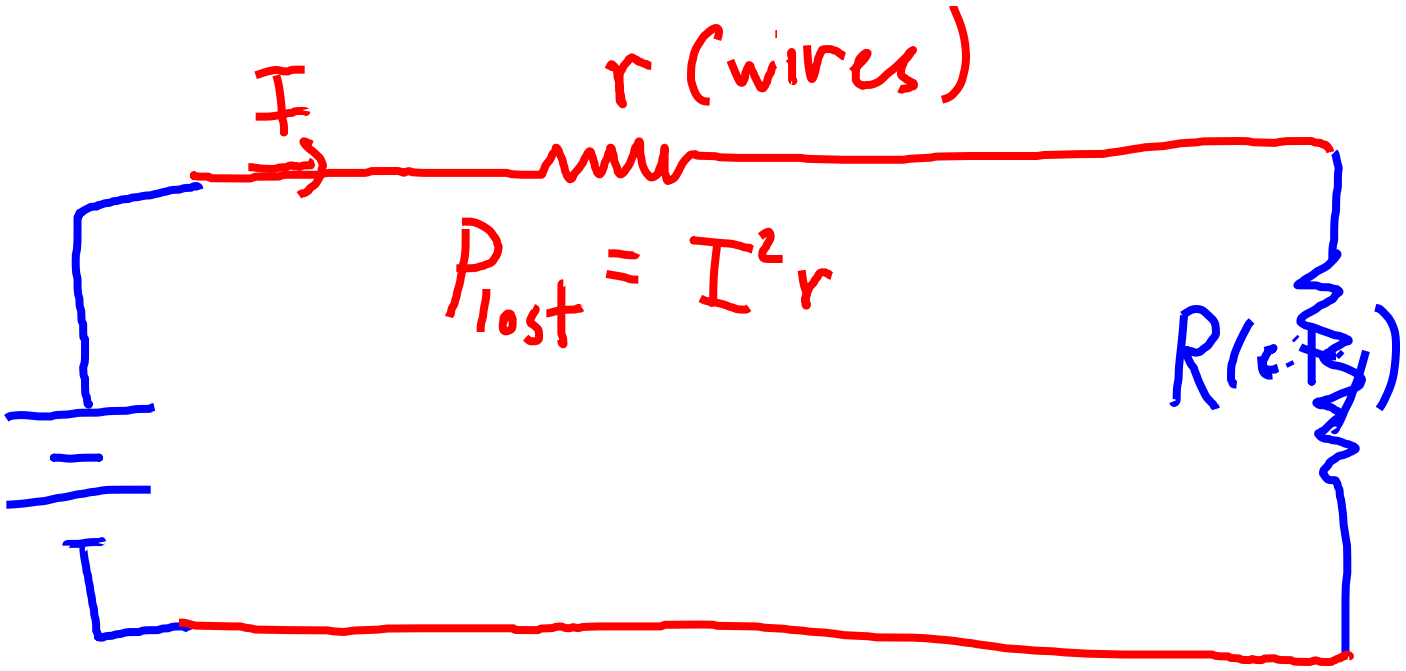
George Westinghouse

Thomas Edison

Nikola Tesla

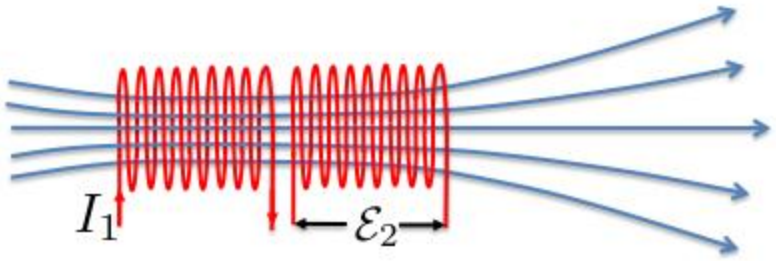
Images from:
http://www.movieposterdb.com/poster/ebdfeed0/
http://prweb.com
http://en.wikipedia.org/wiki/Nikola_Tesla
http://inventors.about.com/library/inventors/blwestinghouse.htm

DC's Deficiency



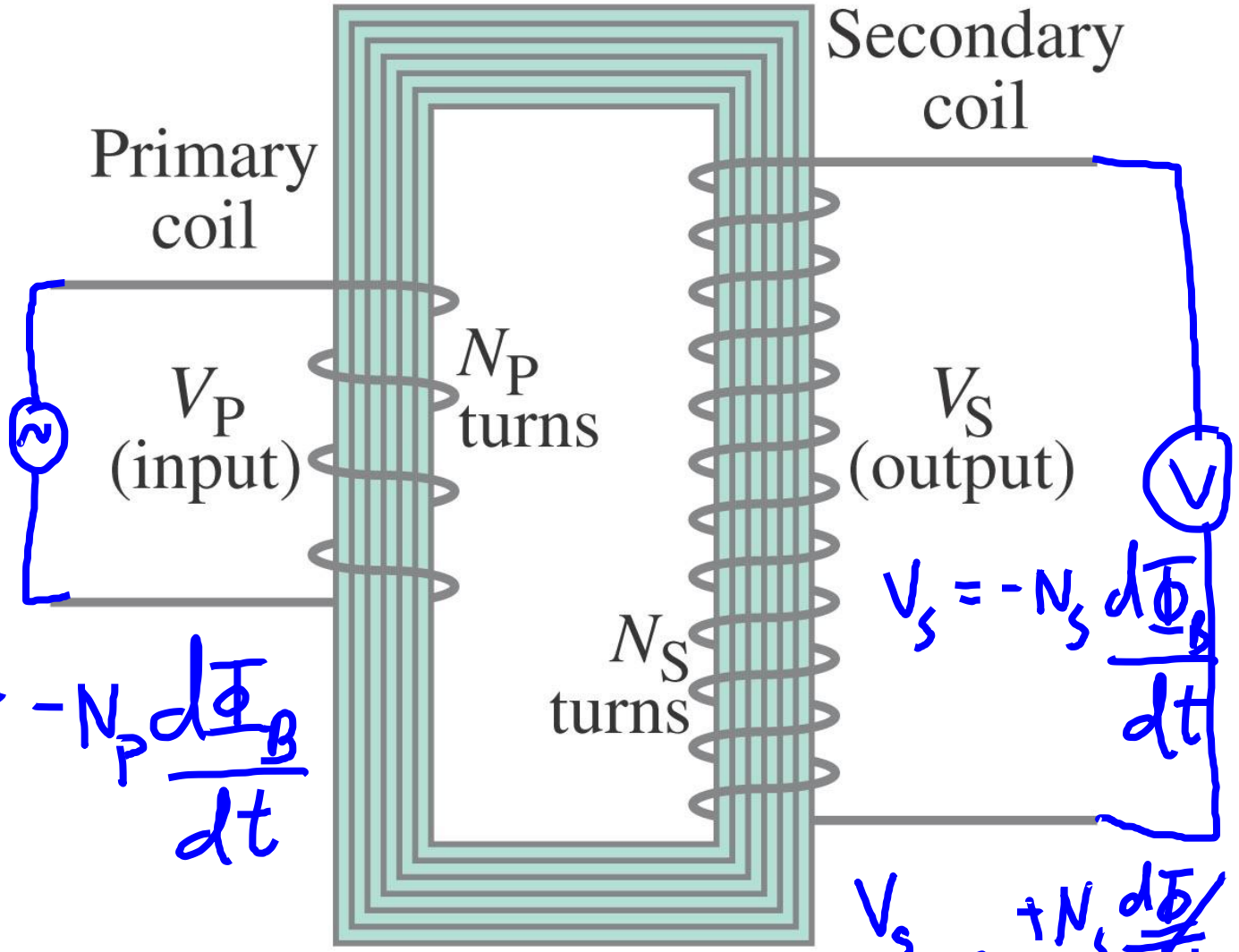
Mutual Inductance

- Emf will be induced in a coil when the flux through that coil is changing: $\varepsilon = -\frac{d}{dt}\int \vec{\mathbf{B}} \bullet \hat{\mathbf{n}} dA$
- That flux could be produced by current in a different coil: $B \propto I \Rightarrow \frac{dB}{dt} \propto \frac{dI}{dt}$
- So, a changing current in one coil, induces an emf in another coil: $\varepsilon_2 = M\frac{dI_1}{dt}$
- *M* = mutual inductance, a geometric and materials property.



http://www.ic.sunysb.edu/Class/phy141md/doku.php?id=phy142:lectures:23

Transformer



$$V_P = -N_P \frac{d\Phi_B}{dt}$$

$$V_S = -N_S \frac{d\Phi_B}{dt}$$

$$\frac{V_S}{V_P} = \frac{+N_S \frac{d\Phi_B}{dt}}{+N_P \frac{d\Phi_B}{dt}} = \frac{N_S}{N_P}$$

Figure 29.24

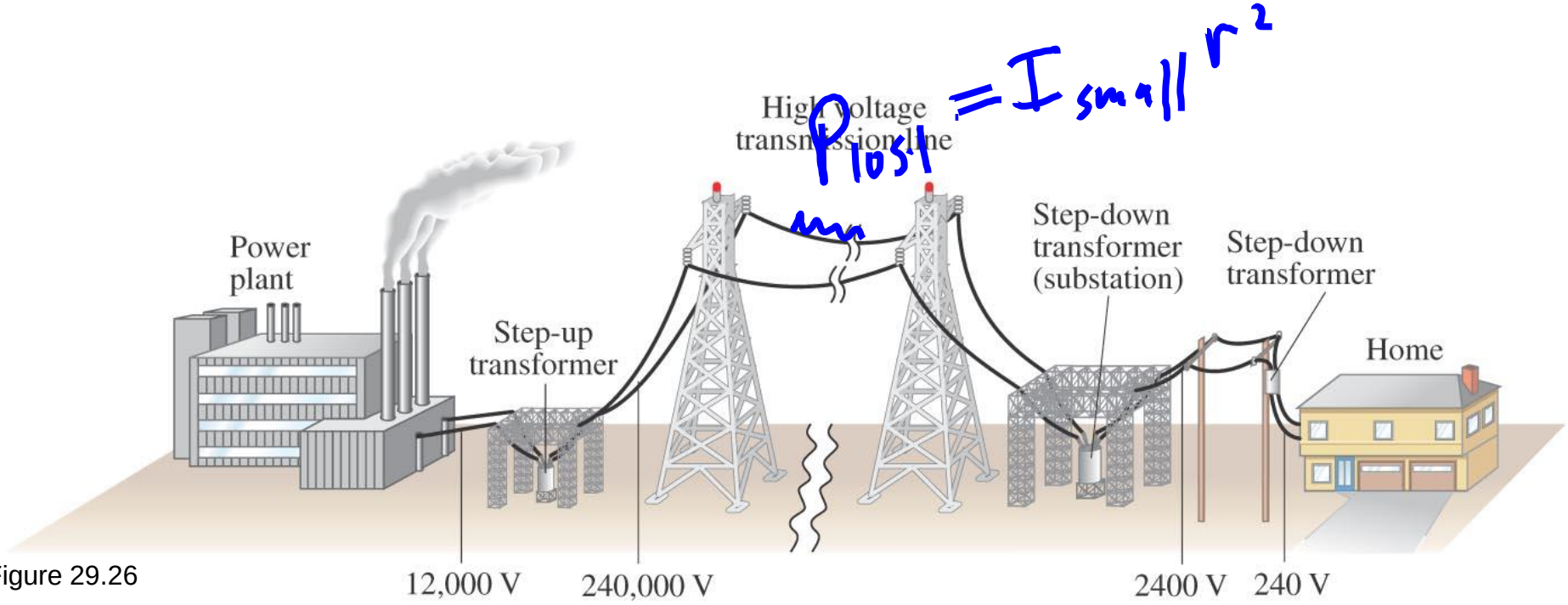


Figure 29.26