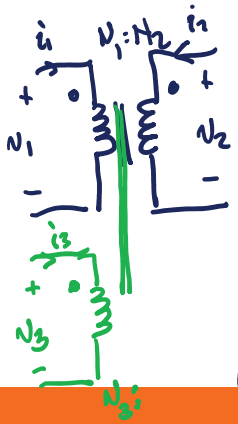
Ideal Transformer

L_1 & L_2 are "large" $\quad k \approx 1$

Recall: Inductors & Transformers cannot have DC voltage applied to any winding
- $v = L\frac{di}{dt}$ → const. voltage implies constant, non-zero $\frac{di}{dt}$ & $i \to \pm\infty$
- $v = N\frac{d\phi}{dt}$ → only get voltage from time-varying signals
- Materials: any core material saturates at some maximum flux/Area

$E = \frac{1}{2}L_{eq}I^2 = \frac{1}{2}L_{eq}\left(\frac{1}{L_{eq}}\int_0^t v\,dt\right)^2 \to \frac{1}{2}\frac{1}{L_{eq}}\int_0^t v\,dt \to E_{stored} \approx \phi$

Ideal transformer w/ L_1 & L_2 "large" has no energy storage



$$i_1 v_1 + i_2 v_2 = \phi$$
$$i_1 \cancel{v_2}\frac{N_1}{\cancel{N_2}} + i_2 \cancel{v_2} = \phi$$

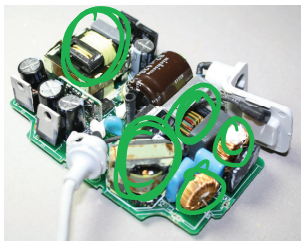
$$N_3 i_3 + N_1 i_1 + N_2 i_2 = \phi$$
$$\frac{v_3}{N_3} = \frac{v_1}{N_1} = \frac{v_2}{N_2}$$

>2 windings

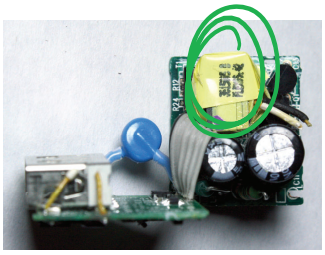
sum of scaled currents equal

scaled voltages are equal

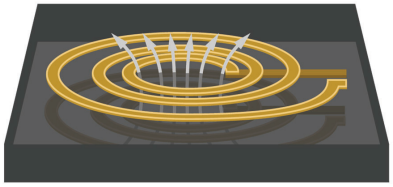
Applications of Coupled Inductors



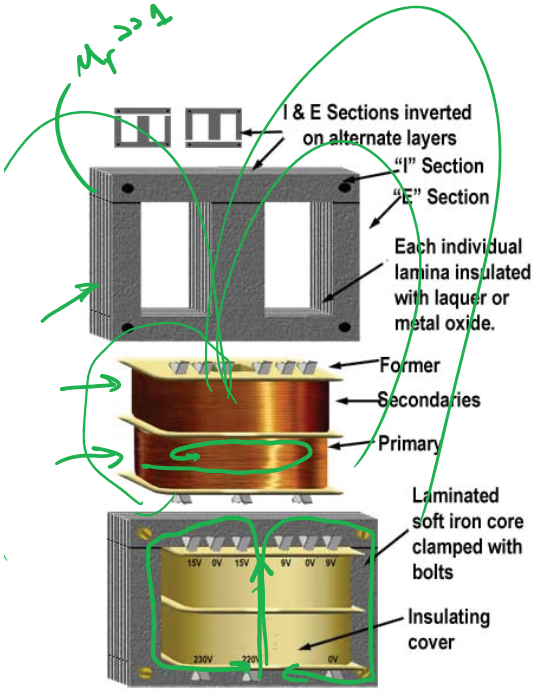
Laptop charger



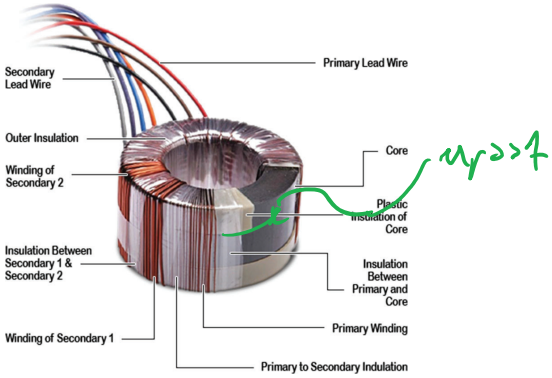
Cell phone charger



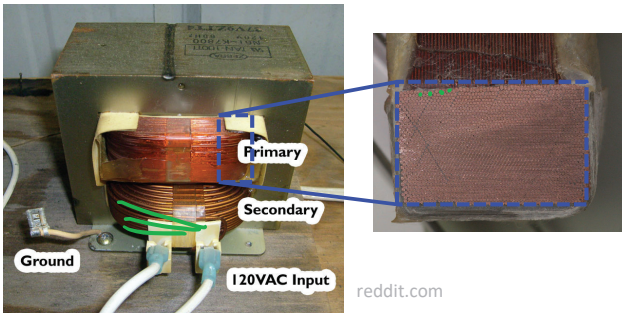
Transformer Design



http://www.learnabout-electronics.org/ac_theory/transformers03.php

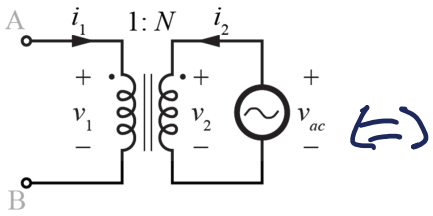


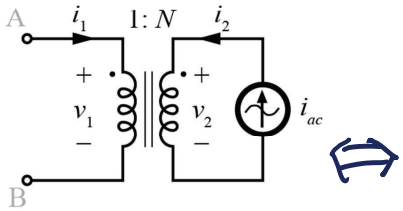
https://www.altrancorp.com/products/toroidal-power-transformers/

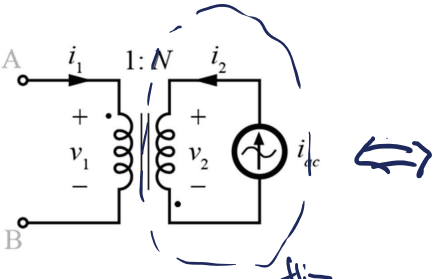


reddit.com

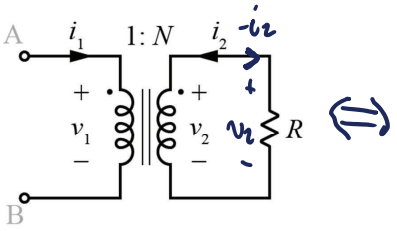
Transformer Reflection

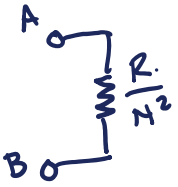






$v_1 = \frac{v_2}{N}$ & $i_1 + N i_2 = 0 \rightarrow i_1 = -N i_2$

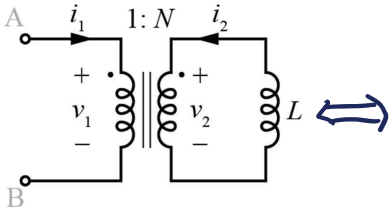


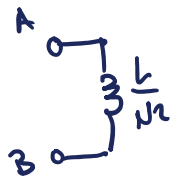


$v_2 = -i_2 R$

$N v_1 = -\left(-\frac{i_1}{N}\right) R$

$$v_1 = i_1 \frac{R}{N^2}$$

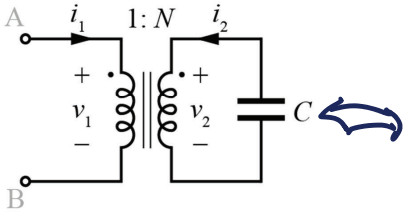


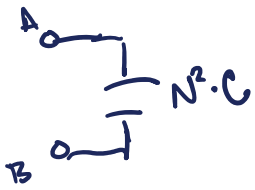


$v_2 = L \frac{d}{dt}(-i_2)$

$N v_1 = L \frac{d}{dt}\left(\frac{i_1}{N}\right)$

$$v_1 = \frac{L}{N^2} \frac{di_1}{dt}$$



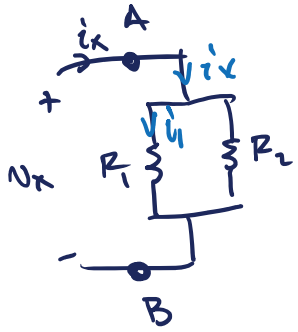


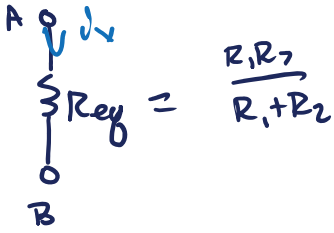
$-i_2 = C \frac{dv_2}{dt}$

$\frac{i_1}{N} = C \frac{d}{dt} N v_1$

$$i_1 = N^2 C \frac{dv_1}{dt}$$

Side-note on equivalent circuits:





$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$

i_1 no longer exists