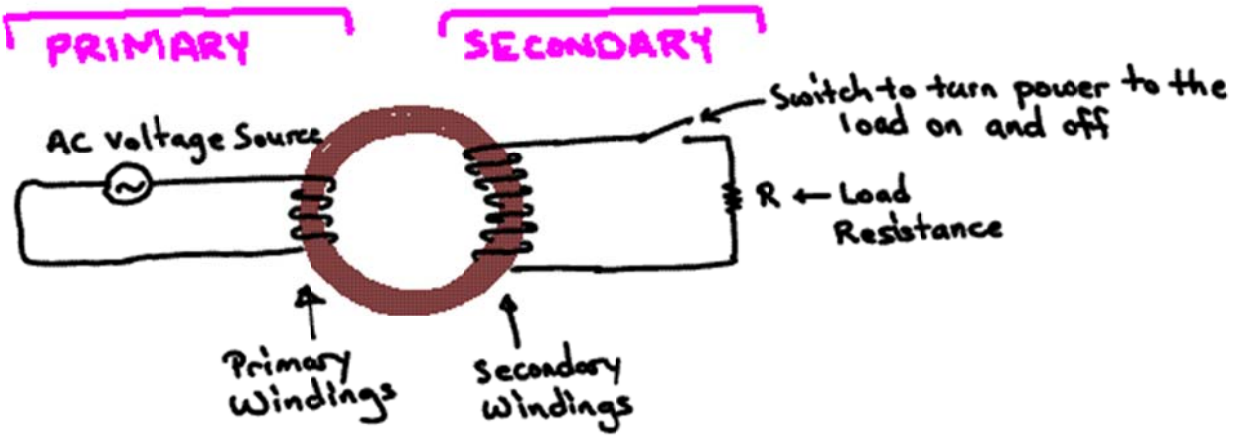
AP Physics - Magnetism - Transformers

Note Title 4/9/2008

Transformers

A transformer is a device used to increase or decrease AC voltage, as needed for a particular application. They work by running alternating current through a primary coil, which sets up a changing $\vec{B}$ field in a ferromagnetic core. A secondary coil is also wrapped around the core. The changing $\vec{B}$ field through the secondary coil's windings induces EMF and current flow in the secondary coil.



- Note that because EMF is only induced if $\vec{B}$ is changing, power can only be transmitted as AC, not as DC!
- Assuming that all flux that leaves primary coils passes through the secondary coils (this is why we use the ferromagnetic core),

$$\mathcal{E}_p = V_p = N_p \frac{\Delta \Phi_p}{\Delta t} \quad \text{and} \quad \mathcal{E}_s = V_s = N_s \frac{\Delta \Phi_s}{\Delta t}$$

where $\Phi_p = \Phi_s$

$$\frac{V_p}{N_p} = \frac{\Delta \Phi}{\Delta t} = \frac{V_s}{N_s}$$

$$\frac{V_p}{N_p} = \frac{V_s}{N_s}$$

Therefore we can control the output voltage by changing the ratio of primary and secondary windings

$$\boxed{V_s = V_p \frac{N_s}{N_p}}$$

So, if the secondary has 1000 windings, the primary has 10 windings, and the voltage source creates 120v, the load will see a voltage of:

$$V_L = V_s = (120v)\left(\frac{1000 \text{ turns}}{10 \text{ turns}}\right)$$

$$V_L = 12{,}000\,v$$

As you can see, it is very easy to create extremely high voltages with transformers!

Also, assuming no flux is lost, and none of the current generates heat in the windings, we have a perfectly efficient transformer where $\text{Power}_{in} = \text{Power}_{out}$.

Ideal Transformer

$P_{primary} = P_{secondary}$

$I_p V_p = I_s V_s$ and $V_s = \frac{N_s}{N_p} V_p$

$I_p V_p = I_s\left(\frac{N_s}{N_p} V_p\right)$

$\therefore \boxed{I_s = I_p \frac{N_p}{N_s}}$