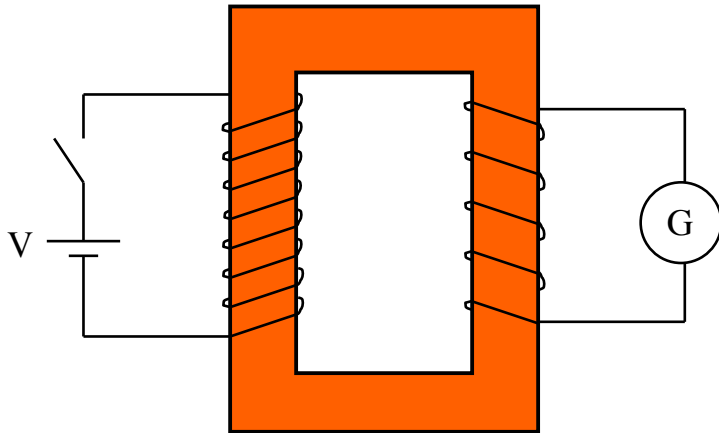


TRANSFORMERS

(the real kind)



1.

When the magnetic field generated by the current through the primary coil CHANGES, an induced EMF and current is set up in the secondary coil. There is also an EMF set up in the primary coil. These we can write as:

$$\epsilon_{\text{primary}} = N_p \frac{\Delta\phi_B}{\Delta t} \quad \text{and} \quad \epsilon_{\text{secondary}} = N_s \frac{\Delta\phi_B}{\Delta t}$$

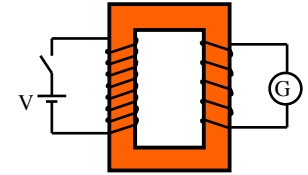
Taking the ratio of the two (and remembering the magnetic flux change is the same for both coils), we get:

$$\frac{\epsilon_p}{\epsilon_s} = \frac{N_p \left(\frac{\Delta\phi_B}{\Delta t} \right)}{N_s \left(\frac{\Delta\phi_B}{\Delta t} \right)}$$

$$\Rightarrow \frac{\epsilon_p}{\epsilon_s} = \frac{N_p}{N_s}$$

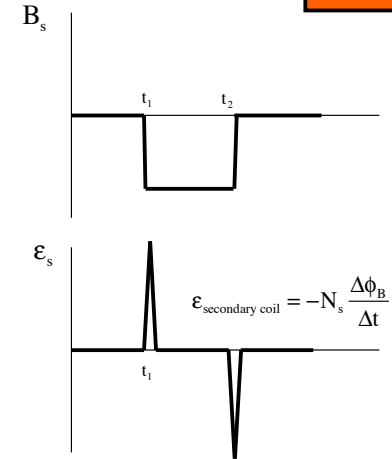
3.

At time t_1 , the switch is closed.
The switch is left closed for a period of time.
At time t_2 , the switch is opened.



The first graph shows how the magnetic field through the yoke acts.

The second graph show the induced EMF in the secondary coil.



2.

Even though the two circuits are not electrically connected, power is transferred from the primary circuit to the secondary circuit through the magnetic coupling between the two circuits. In theory, the transfer should be energy-loss free. In that case, we can write:

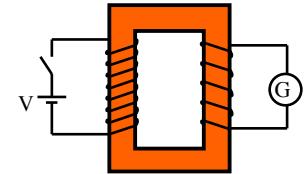
$$P_{\text{primary}} = P_{\text{secondary}}$$

$$\epsilon_p i_p = \epsilon_s i_s$$

$$\left(N_p \frac{\Delta\phi_B}{\Delta t} \right) i_p = \left(N_s \frac{\Delta\phi_B}{\Delta t} \right) i_s$$

$$\Rightarrow (N_p) i_p = (N_s) i_s$$

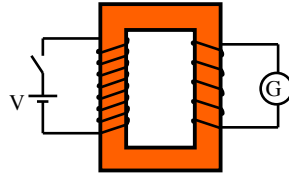
$$\Rightarrow \frac{N_p}{N_s} = \frac{i_s}{i_p}$$



4.

In summary, if the winds ratio is such that there are more winds in the primary coil, then:

$$N_p > N_s \text{ and } \frac{N_p}{N_s} = \frac{\epsilon_p}{\epsilon_s} = \frac{i_s}{i_p}$$

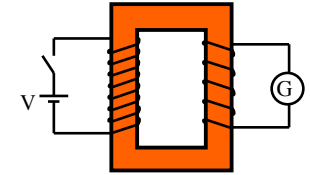


In that case, the induced EMF in the secondary coil will be less than the induced EMF in the primary coil; the induced current in the secondary coil will be greater than the induced current in the primary coil, and the transformer itself is termed a “step down” transformer as that is what is happening—the voltage between the primary and secondary circuits is STEPPED DOWN.

5.

If the winds ratio is such that there are more winds in the secondary coil, then:

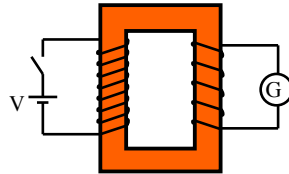
$$N_p < N_s \text{ and } \frac{N_p}{N_s} = \frac{\epsilon_p}{\epsilon_s} = \frac{i_s}{i_p}$$



In that case, the induced EMF in the secondary coil will be greater than the induced EMF in the primary coil; the induced current in the secondary coil will be less than the induced current in the primary coil, and the transformer itself is termed a “step up” transformer as that is what is happening—the voltage between the primary and secondary circuits is STEPPED UP.

6.

Example Problem: You’ve gone to Europe. You’ve taken your favorite hair dryer, which runs on 110 volt AC. The Europeans use 220 volt AC, so you must use a transformer to adjust the power to 110 volts.



- a.) What kind of a transformer do you need to use?
- b.) If your secondary coil has 84 turns in it, how many turns does your primary coil have?
- c.) Let’s assume your hair dryer draws 3 amps. Which circuit, the primary or the secondary, must have 3 amps in it?
- d.) How much current will there be in the primary coil if the secondary has 3 amps flowing through it?

7.