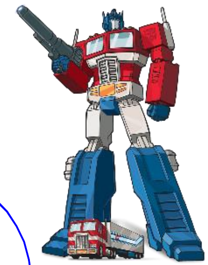
Name:______________________________ Phys 12

6.8 Transformers

Power line driving safety: https://www.youtube.com/watch?v=fLVzvMTgGDY



Where and why do we use transformers? Not the machine robot kind…but these ones:

In order to receive electrical power in our homes generated from power plants, electricity needs to be transported long distances. We know that the more wire we use in our circuit, the more resistance we introduce, thus more energy we waste.

To combat this problem, we step up the voltage to ~100 000V in transmission lines and back down to 120V to use in our homes. *Why is having a larger potential difference useful?*

Conservation of energy states that power entering the power lines = the power leaving the power lines. For the same power: $P = VI$

More voltage means less current. Less current means less power wasted in the wires: $P = I^2R$

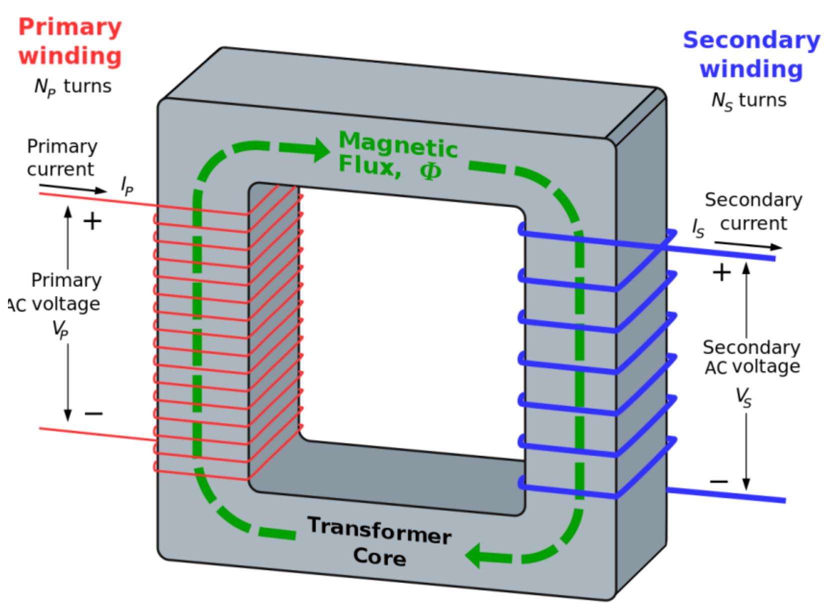
To increase or decrease the voltage, we use a **transformer**.

These transformers use the electromagnetic induction to convert voltage from one value to another.

Alternating current enters the **primary coil,** which produces a **changing magnetic field.** This changing magnetic field changes the **magnetic flux** through the **secondary coil**, which induces an **alternating current** through the **secondary coil**.

With the same change in magnetic flux ($\Delta\Phi$), more windings (N) produce a larger voltage according to Lenz's Law:

$$\varepsilon = \frac{N\Delta\Phi}{\Delta t}$$



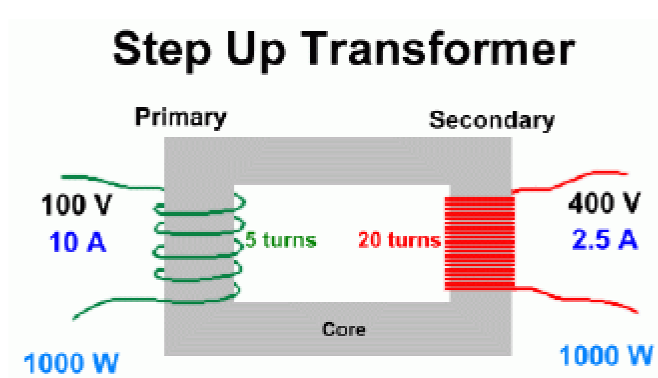
Animation of this process: https://www.youtube.com/watch?v=agujzHdvtjc

Step Up Transformer

Uses: **increasing** the voltage

How: **More secondary coils** than primary coils

Where it is used:
Between electric power plant and transmission lines



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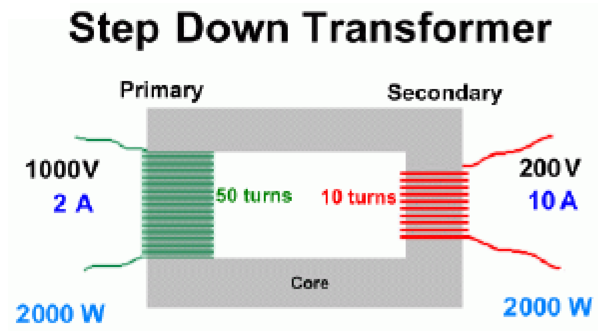
Step Down Transformer

Uses: **decreasing** the voltage

How: **Less secondary coils** than primary coils

Where it is used:
Between transmission lines and your home



Although we're increasing or decreasing the voltage, **energy is still conserved.** That means **power is conserved:**

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

$P_p = V_p I_p$ $P_s = V_s I_s$

$P_p = P_s \rightarrow V_p I_p = V_s I_s \rightarrow \frac{V_p}{V_s} = \frac{I_s}{I_p}$

V_p = Primary Voltage | N_p = Primary Coils | I_p = Current in Primary Coils

V_s = Secondary Voltage | N_s = Secondary Coils | I_s = Current in Secondary Coils

Ex. 1: A step up transformer is used to concert 120V to 1.50×10^4 V. If the primary coil has 24 turns, how many turns does the secondary coil have? (ANS: 3.0×10^3 turns)

$N_s = ?$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} \qquad N_s = \frac{N_p V_s}{V_p} = \frac{24(1.50\times10^4 V)}{120} = 3.0\times10^3 \text{ turns}$$

Ex. 2: A step-up transformer has 1000 turns on its primary coil and 1×10^5 turns on its secondary coil. If the transformer is connected to a 120 V power line, what is the step-up voltage? (ANS: 12000V)

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} \qquad V_s = \frac{V_p N_s}{N_p} = \frac{120(1\times10^5)}{1000} = 12000 V$$

Ex. 3: A step-down transformer reduces the voltage from a 120 V to 12.0 V. If the primary coil has 500 turns and draws 3.00×10^{-2} A,

a) What is the power delivered to the secondary coil? (ANS: 3.6W)

$$P_s = V_s I_s = P_p = V_p I_p = 120V(3.00\times10^{-2} A) = 3.6 W$$

b) What is the current in the secondary coil? (ANS: 0.30A)

$$P_p = P_s = V_s I_s$$

$$3.6 W = 12.0 V \, I_s$$

$$I_s = 0.30 A$$

HW: Worksheet 6.9 #ALL