Science 30	Unit C: Physics
Lesson 7 - Power Transmission and Transformations	84 mins

Power Transmission

- Is it better to transmit power at high voltage or low voltage?
    - Higher! Less power lost to heat! (and sound…buzzing lines)
    - More electrons (current) needs to transfer the same amount of power

$$P = IV$$

P = Power Needed at home
V = Voltage in the line
I = current needed to transfer that power

Calculate the Current needed to produce 5 kW of power:
120V transmission vs 5000V transmission

$$I = \frac{P}{V}$$

$I = \frac{5000W}{120V} = 41.7A$	$I = \frac{5000W}{5000V} = 1A$
Power lost to heat $P = I^2R$	Power lost to heat $P = I^2R$
R = resistance of the line = 5 Ω	
$P = I^2R = (41.7A)^2 * 5\Omega$	$P = I^2R = (1A)^2 * 5\Omega$
$P = 8680W$	$P = 5W$

$$\%_{powerloss} = \frac{power\ lost\ to\ heating}{power\ transmitted} * 100\%$$

$$\%_{120V} = \frac{8680W}{5000W} * 100\% = 173\% .... \textit{ the voltage wouldn't arrive}$$

$$\%_{powerloss} = \frac{5W}{5000W} * 100\% = 0.1\%$$ (much more acceptable)

Transformers

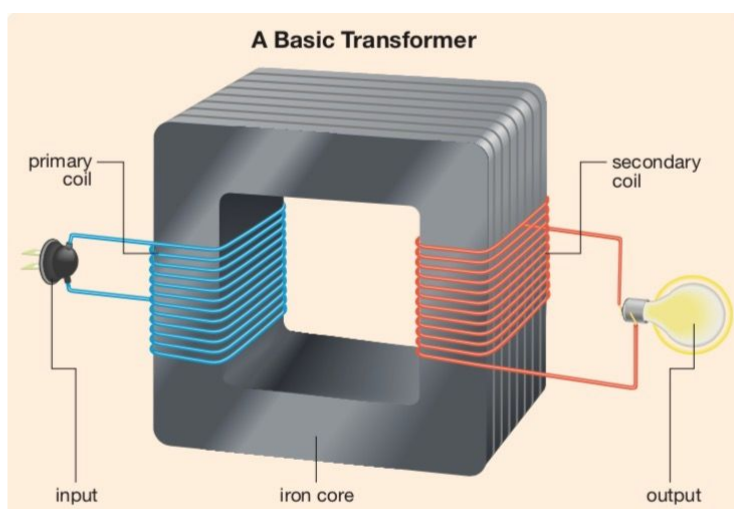
Transformer: a device that transforms the AC voltage of one circuit into a different AC voltage for another circuit using separate coils of wire wound around a common iron core

Primary Coil: the coil to which the input voltage is applied in a transformer

Secondary Coil: the coil that supplies the output voltage of a transformer

Would this work with AC or DC Current?

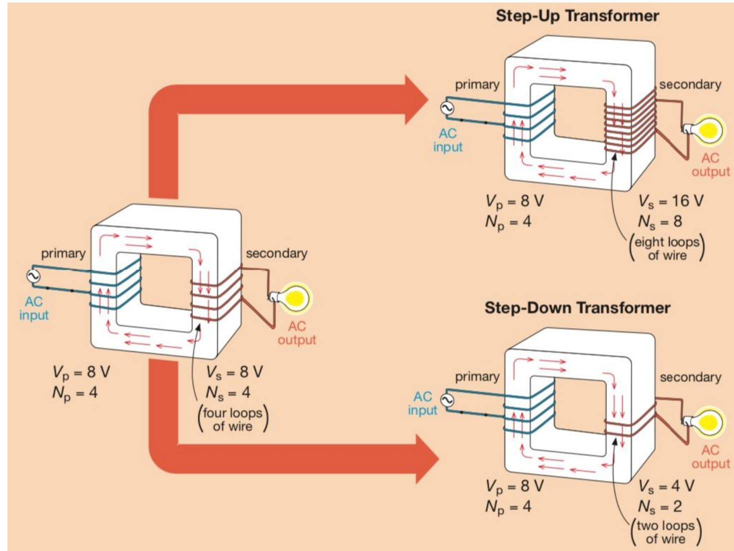
- Use the magnet moving in a coil example again… only MOVING magnets work… therefore the magnetic field needs to be CHANGING to allow the secondary coil to produce a current.
- AC will only worK



Step Up Vs Step Down

- Using a magnetic field will cause the same amount of current per Coil
    - More coils in the secondary = higher voltage output (more current with same resistance = higher Voltage)
    - Less coils in the secondary = lower voltage output (less current with same resistance = higher Voltage)

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$$ This is the equation for the ideal transformer.



Science 30 - Lesson 31 - Unit C - Power Transmission and Transformations

Name: ______________________________________

Example:

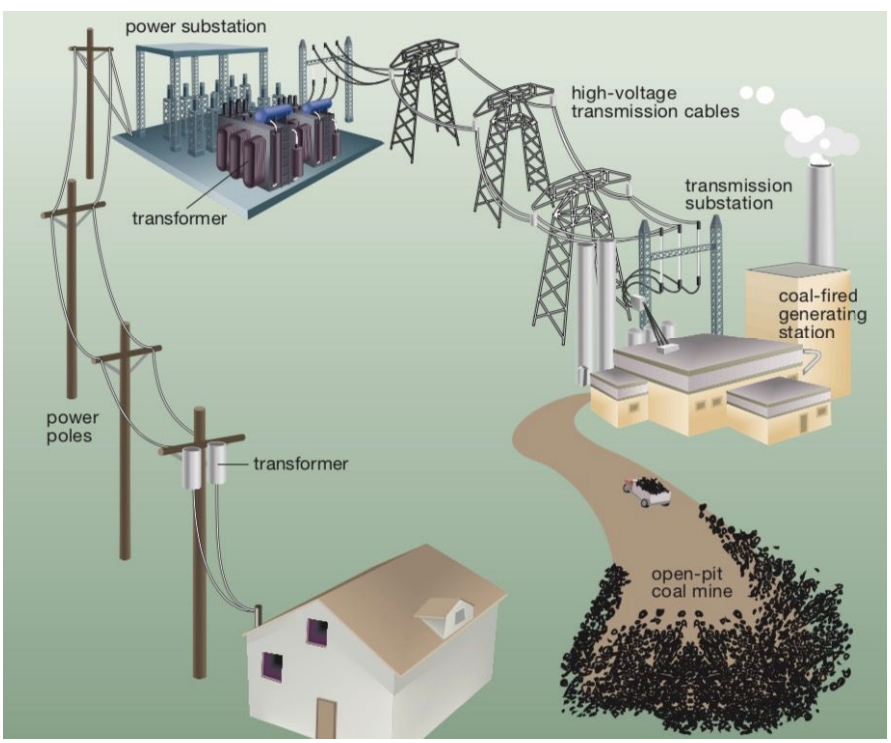
1. A large neon sign is powered by a high-voltage power supply. The power supply takes a 240-V input and then uses a transformer to increase the voltage to 12 000 V to operate the sign.
   a. Does the power supply use a step-up or step-down transformer?

   b. If the transformer has 125 turns of wire on the primary coil, determine the number of coils on the secondary coil.

   c. The power supply requires 25.0 A of input current. Determine the output current that powers the sign.

Practice:

1) Transformers play a vital role in the distribution and transmission of electrical energy. In the following diagram, transformers can be seen playing a role at the generating station, at the power substation, and on the power poles.



a) The transformer on a power pole takes an input voltage of 4.00 kV and then delivers 240 V to a home. Is this device a step-up or step-down transformer?

b) If there are 180 turns of wire on the secondary coil of this transformer, determine the number of turns of wire on the primary coil.

c) If the maximum current supplied to the home is 100 A, determine the current supplied to the transformer.

2) The generator at the coal-fired generating station supplies the station's transformer with 20.0 kV. The transformer then boosts this voltage value to 230 kV for transmission.
   a) Is this device a step-up or step-down transformer?

   b) Most of the customers of the utility company only require 240 V or 120 V to run the appliances in their households. Explain why the utility company boosts the 20.0 kV from the generator to even higher values.

   c) If the power transmitted is 1.2 MW, calculate the current flowing through the transmission cables.

   d) Use the transformer equation to determine the current the generator is supplying to the transformer at the generating station.

   e) Check your answer to question d. using a different equation.

3) An ideal transformer has 100 turns of wire in the primary coil and 1000 turns of wire in the secondary coil. If the voltage and current in the primary coil is 120 V and 10.0 A, respectively, determine

a) the voltage and current in the secondary

b) the power in the primary and the secondary

Use the information below to answer the next question

Generating Electricity with Fossil Fuels

Type of Emission	Amount Released Generating Electrical Energy (g/kW·h)		
	Coal-Combustion Technology		Natural Gas Combustion Technologies
	Traditional Generating Station	Experimental, Low-Emission Generating Station	
$CO_2(g)$	about 1.0×10^3	less than 8.0×10^{2}**	about 4.0×10^{2}***
$SO_x(g)$	less than 1.9*	less than 0.2**	less than 0.003***
$NO_x(g)$	less than 1.4*	less than 0.05**	less than 0.01***
particulate matter	less than 0.14*	less than 0.03**	less than 0.02***

* maximum value allowed under Alberta Emission Standards (2001)
** data from experimental, low-emission generating stations
*** data from natural gas combined-cycle generating stations

4) A family just purchased a new refrigerator that consumes 450 kWih of electrical energy every year. The previous refrigerator was an old, ineffcient model that consumed 605 kWh of electrical energy every year.

a) If the cost of electrical energy is 8.5¢/kWh, how much money will this family save on their electric bill each year by using their new refrigerator?

b) The utility company that provides electrical energy to this family uses a traditional coal-burning facility that pulverizes the coal into a fine powder before burning it to produce steam to drive the turbines. Calculate by how much the family will have reduced their annual emissions of CO2(g), SOx(g), NOx(g), and particulate matter by switching to the newer refrigerator.

c) Consider your answers to questions 4.a. and 4.b. Which reduction do you think is the most significant?