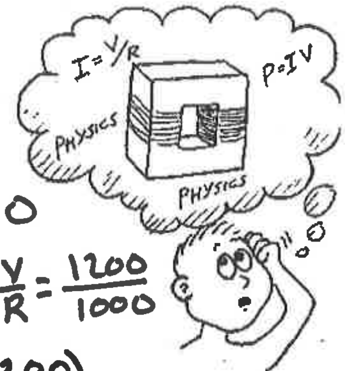
MAGNETISM
LCHS Honors Physics

Name ______________________

Transformers

Consider a simple transformer that has a 100-turn primary coil and a 1000-turn secondary coil. The primary is connected to a 120-V alternating source, and the secondary is connected to an electrical device with a resistance of 1000 ohms.



1. What will be the voltage output of the secondary?
   1200 V $V_S = V_P \frac{N_S}{N_P} = 120\left(\frac{1000}{100}\right) = 1200$
2. What current flows in the secondary circuit? 1.2 A $I = \frac{V}{R} = \frac{1200}{1000}$
3. Now that you know the voltage and the current, what is the power in the secondary coil? 1440 W $P = IV = 1.2(1200)$
4. Neglecting small heating losses, and knowing that energy is conserved, what is the power in the primary coil? 1440 W
5. Now that you know the power and the voltage across the primary coil, what is the current drawn by the primary coil? 12 A $P = IV$ ~~1400~~ 1440 $= I(120)$ $I = \frac{1440}{120} = 12$ A

Circle the correct answers.

6. The results show that when the secondary coil has more turns than the primary, voltage is stepped (up) (down) from primary to secondary, and current is correspondingly stepped (up) (down).

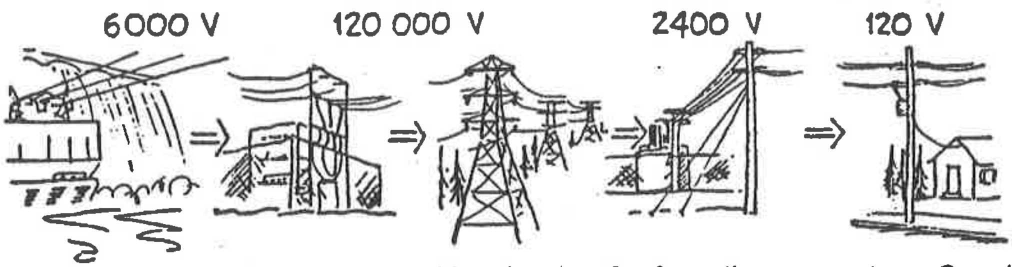
7. For a step-up transformer, there are (more) (fewer) turns in the secondary coil than the primary. For such a transformer, there is (more) (less) current in the secondary than in the primary.

8. A transformer can step up (voltage) (energy and power), but in no way can it step up (voltage) (energy and power).

9. If a 120-V source is used to power a toy electric train that operates on 6 V, then a (step-up) (step-down) transformer with a ratio of primary turns to secondary turns equal to (1 /20) (20/1) should be used.

10. A transformer operates on (DC) (AC) because the magnetic field within the iron core must (continually change) (remain steady).

POWER TRANSMISSION



Many power companies provide power to cities that are far from the generators. Consider a city of 100 000 persons who each use 120 W of power (equivalent to the operation of two 60-W light bulbs per person). The power consumed is 100 000 persons x 120 W/person, or 12 million W (= 12 MW).

1. What current corresponds to this amount of power at the common 120 V used by consumers?

P=VI

12,000,000 W = I x 120 V

$$I = \frac{P}{V} = \frac{12{,}000{,}000}{120}\frac{W}{V} = 100{,}000 \quad A$$

This is an enormous current, more than can be carried in the thickest of wires without overheating. More power would be dissipated in the form of heat than would reach the faraway city. Fortunately, the important quantity is *IV* and not *I* alone. Power companies transmit power over long distances at very high voltages so that the current in the wires is low and heating of the power lines is minimized.

2. If the 12 MW of power is transmitted at 120,000 V, the current in the wires is

$$I = \frac{P}{V} = \frac{12{,}000{,}000}{120{,}000}\frac{W}{V} = 100 \quad A$$

This amount of current can be carried in long-distance power lines with only small power losses due to heating (normally less than 1%). However, the corresponding high voltages wired to houses would be very dangerous so step-down transformers are used in the city.

3. What ratio of primary turns to secondary turns should be on a transformer to step 120 000 V down to 2400 V? ______________ $\frac{120000}{2400} \Rightarrow 50:1$

4. What ratio of primary turns to secondary turns should be on a transformer to step 2400 V down to the 120 V used in household circuits? ______________ $\frac{2400}{120} \Rightarrow 20:1$

5. What is the main benefit of ac power compared to dc power?

Ac Power Can be Steped up or down and used more efficiently.

$P_p = P_s$ $\quad V_p * I_p = V_s * I_s$ $\quad \frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$

Transformer Problems

(more than meets the eye)

1. For step-up transformer which is correct? (a) Np >Ns (b)Ns>Np

2. In order to reduce resistance losses, electric power is transmitted how?

   High Voltage & Low Current

3. A transformer has 800 turns on its primary coil and 600 turns on its secondary.
   (a) What type of transformer is this?

   STEP Down

   (b) If the input to the primary coil is 4.0 A at 120 V what is the output of the secondary coil?

   $\frac{V_s}{V_p} = \frac{N_s}{N_p} \Rightarrow V_s = 120\left(\frac{600}{800}\right) = 90\text{ V}, \quad I_s = (4)\left(\frac{8}{6}\right) = 5.3\text{A}$

4. The number of turns on the secondary coil of an ideal transformer is 450 and on the primary is 75.
   (a) What type of transformer is this? STEP Down

   (b) What is the ratio of the current in the primary coil to the current in the secondary?

   $I_p/I_s = N_s/N_p = 75/450 \Rightarrow 1:6$

   (c) What is the ratio of the voltage in the primary coil to the voltage in the secondary?

   $V_p/V_s = 6:1$

5. An ideal transformer steps up 8.0 V to 2000 V the 4000 turn secondary coil produces 2.0 A.
   (a) Find the number of turns on the primary coil.

   $N_p/N_s = V_p/V_s \Rightarrow N_p/4000 = 8/2000 \quad N_p = 4000(8/2000) = 16$

   (b) Find the current in the primary coil.

   $I_p/I_s = V_s/V_p \Rightarrow I_p = 2\left(\frac{4000\ 2000}{8}\right) = 8000\text{ Amps}$

6. An electric arc-welder machine requires 200 A output. The transformer in the welder has 1200 turns on the primary coil and draws 2.5 A at 240 V.
   (a) How many turns are on the secondary coil?

   $\frac{N_s}{N_p} = \frac{I_p}{I_s} \quad N_s = N_p\left(\frac{I_p}{I_s}\right) = 1200\left(\frac{2.5}{200}\right) = 15$

   (b) What is the voltage of the secondary coil?

   $\frac{V_s}{V_p} = \frac{N_s}{N_p} \Rightarrow V_s = V_p\left(\frac{N_s}{N_p}\right) = 240\left(\frac{15}{1200}\right) = 3\text{ Volts}$