

17 Electromagnetism

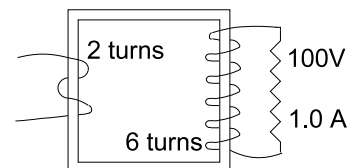
Name _____

Worksheet C: Transformers and Electrical Power Transmission

Inquiry Physics

Consider a simple transformer that has a 200-turn primary coil and a 1000-turn secondary coil. The primary is connected to a 120 V alternating current source, and the secondary is connected to an electrical device with a resistance of 1000 ohms.

1. What is the secondary voltage? _____ V SHOW YOUR WORK
2. What is the secondary current? _____ A SHOW YOUR WORK
3. Now that you know the voltage and the current, what is the power in the secondary coil? _____ W
SHOW YOUR WORK
4. Neglecting small heating losses (so energy is conserved), what is the power in the primary coil? _____ W
5. Now that you know the primary power and voltage, what is the primary current? _____ A
SHOW YOUR WORK
6. The results show that when the secondary coil has more turns than the primary, voltage is stepped _____ from primary to secondary, and current is correspondingly stepped _____.
7. For a step-up transformer, there are _____ turns in the secondary coil than the primary. For such a transformer, there is _____ current in the secondary than in the primary.
8. A transformer can step up voltage, but it cannot step up the amount of _____ available, because that quantity is conserved.
9. If a 120 V source is used to power a toy electric train that operates on 6.00 V, then a _____ transformer with a ratio of primary turns to secondary turns of _____ to one should be used.
10. A transformer operates on _____ current because the magnetic field within the iron core must continually change.
11. What is the primary voltage across the transformer shown at right?
SHOW YOUR WORK
12. What is that transformer's primary current?
SHOW YOUR WORK
13. To operate a neon sign, the voltage must be stepped up from 120 V to 15,000 V.
There will be _____ secondary turns for each primary turn.



POWER TRANSMISSION

Many power companies provide power to cities that are far from the generators. Consider if the 35,000 people in Bartlesville each use 120 W of power (equivalent to the operation of two 60.0 W light bulbs per person). The power consumed is 35,000 persons times 120 watts per person, or $4,200,000$ watts.

14. What current corresponds to this amount of power at the common 120 V used by consumers? SHOW YOUR WORK

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.

15. Our city is fed by $138,000\text{ V}$ power lines. For $4,200,000\text{ W}$ of power, how much current would travel in those lines? SHOW YOUR WORK

This amount of current can be carried in long-distance power lines with only small power losses due to heating (normally less than 1%). But wiring this voltage to houses would be very dangerous. Thus step-down transformers are used in the city.

16. The ratio of primary turns to secondary turns for a transformer stepping $138,000\text{ V}$ down to $13,800\text{ V}$ would be _____ to one. SHOW YOUR WORK

A transformer of that type is found in a neighborhood substation. Other transformers (on power line poles in many neighborhoods, or in metal boxes on the ground in areas with underground wiring) service several homes and step down the voltage from $13,800\text{ V}$ to 120 V .

17. The ratio of primary turns to secondary turns for the neighborhood transformers would be _____ to one. SHOW YOUR WORK

You can see that it is necessary to step the voltage up and down for power transmission. This is the main benefit of using alternating current (AC) instead of direct current (DC) in most power lines – transformers need AC to operate. An interesting history tale goes with the United States' adoption, early in the twentieth century, of AC over DC electricity. The famous inventor Thomas Edison (who invented the electric light bulb, phonograph, etc.) marketed a DC power system, but it was limited to lower voltages because it could not use transformers. Thus his system's power lines could only stretch a few city blocks, requiring multiple generators throughout a city. Nikola Tesla (after whom a unit of magnetic field strength is named) created an AC system that competed with Edison's. Tesla's system used transformers and was shown to be superior to Edison's when a generator installed at Niagara Falls was able to supply electricity to cities far away. Edison retaliated by warning of the dangers of high-voltage AC power. He hired henchmen to gather stray dogs, which were electrocuted at Edison's lab and dumped near AC power installations to spread fear of the technology. Edison even invented a high-voltage AC electric chair for executions. Despite these nefarious deeds, Tesla's system won out and is the one we use today.