Electric Power Distribution

Question:

Electric power reaches the University via high voltage transmission lines. What fraction of the electric charges traveling on those transmission lines pass through this room?

1. About 1%
2. About 0.01%
3. Exactly 0.0%

Observations About Power Distr.

- Household power is AC (alternating current)
- Power comes in voltages like 120V & 240V
- Power is transmitted at "high voltage"
- Power transformers are visible everywhere
- Power substations are visible on occasion

Ohm's Law

- The currents passing through most wires and other devices experience voltage drops
- In an "ohmic device," the voltage drop is proportional the current:

  voltage drop = resistance · current

  where resistance is constant for the device

Power in Ohmic Devices

- A calculation:

  power consumption = voltage drop · current

  voltage drop = resistance · current

  power consumption = resistance · current^2
- Impact of the calculation:
  - Wires waste power as heat
  - Doubling current *quadruples* wasted power

Power Transmission

- Power delivered to a city is:

  power delivered = current · voltage drop
- Power wasted in transmission wires is:

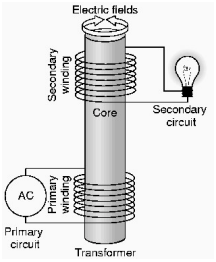
  power wasted = resistance · current^2
- For efficient power transmission:
  - Use low-resistance wires (thick, short copper)
  - Use low current and high voltage drop

Voltage Hierarchy

- High voltage is dangerous
- High current is wasteful
- Use the following hierarchy:
  - low voltage circuits in neighborhoods
  - medium voltage circuits in cities
  - high voltage circuits across the countryside
- Use transformers to transfer power

Transformer

- *Alternating* current in one circuit induces an alternating current in a second circuit
- Transfers *power* between the two circuits
- Doesn't transfer *charge* between the two circuits

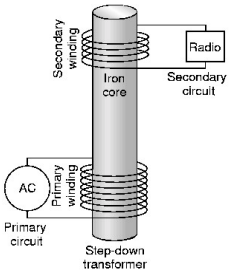


Current and Voltage

- Power arriving in the primary circuit must equal power leaving the secondary circuit
- Power is the product of voltage · current
- A transformer can change the voltage and current while keeping power unchanged!

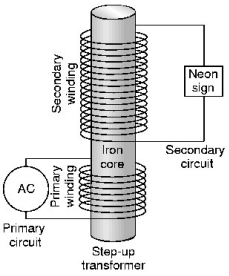
Step Down Transformer

- Fewer turns in secondary circuit so charge is pushed a shorter distance
- Smaller voltage rise
- A larger current at low voltage flows in the secondary circuit



Step Up Transformer

- More turns in secondary circuit so charge is pushed a longer distance
- Larger voltage rise
- A smaller current at high voltage flows in the secondary circuit



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