

**University of Virginia**

**Department of Physics**

Physics 606: How Things Work II

Lecture #16 Slides:

**Power Distribution**

## Power

- Power is energy per unit of time
- Power is measured in joules/second or watts
- Batteries are power sources
- Loads are power consumers

## Battery Power

- Current: units of charge pumped per second
- Voltage rise: energy given per unit of charge

$$\text{current} \cdot \text{voltage rise} = \text{power produced}$$

## Load Power

- Current is units of charge passed per second
- Voltage drop: energy taken per unit of charge

$$\text{current} \cdot \text{voltage drop} = \text{power received}$$

## 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<sup>2</sup>
- 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<sup>2</sup>
- 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