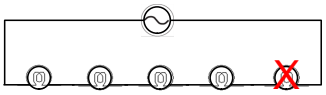
3.C.4 - Electric Power

1. Physics Democracy Part One!

Consider the strand of Christmas tree lights, connected to a source of constant voltage:



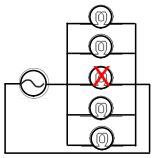
What happens if one of the bulbs burns out?

The remaining lights don't change	The whole strand goes out	Remaining lights get brighter	The remaining lights get dimmer	Half go out and the rest stay on

Answer: The whole strand goes out: continuity disrupted.

2. Physics Democracy Part Two!

Consider this light strand, connected to a source of constant voltage:



What happens if a bulb burns out?

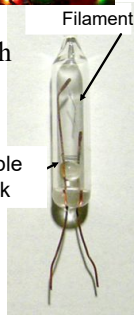
The remaining lights don't change	The whole strand goes out	The remaining lights get brighter	The remaining lights get dimmer

Answer: The remaining lights don't change. Rabbit Hole!

Christmas Light Lore

Engineers have designed quality light products for Christmas.

A bulb that burns out nowadays probably has a fusible link between electrodes, which shorts them so current flows to remaining bulbs. The result is that remaining bulbs glow more brightly (less resistance draws more current).



Some lights have electrodes that spring together to make contact if a bulb falls out.

LED lights exist now that never burn out!

Electrical Power (Units = Watts (J/s))

We've calculated mechanical and thermal power, here's electrical power!

$P = I\Delta V$ AP Equation	P = power (J/s) I = current (A = C/s) ΔV = voltage (V = J/C)

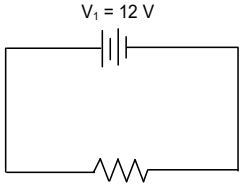
See Resource P. 6.

Unit analysis:

$$P = I\Delta V = \frac{C}{s} \bullet \frac{J}{C} = \frac{J}{s} = W$$

3. Power Example One

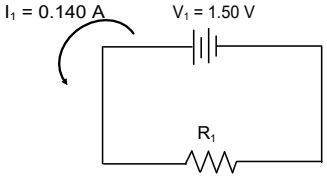
What is the power of the following circuit?



$$P = \frac{V^2}{R} = \frac{(12V)^2}{4.5\Omega} = 32W$$

4. Power Example Two

What is the power of the following circuit?



$$P = IV$$

$$= 0.140\,A \bullet 1.50\,V = 0.21\,W$$

Power Loss

Thermal power losses of resistors are referred to as 'joule heat', or I^2R losses ("I squared R").

Often this is undesirable, as in the heating of electronic circuitry during operation.

Other times it is part of the design, as in resistance heaters.

Fried Circuit!

Selling Power

Electrical energy is sold to consumers in terms of kilowatt-hours (kWh).

Ex: A utility company might charge customers 0.13 $/kWh.

Unit analysis: kWh converts to energy (Joules):

$$1kW \bullet h = 1000W \bullet 1h = 1000\frac{J}{s} \bullet 3600s = 3.6E6J$$

5. Appliance Example

A. How much energy would it take (in Joules, and kWh), and how much would it cost to run an electric blanket for two hours, if you are charged $0.12/kWh?

Use Resources P. 5 for appliance information.

= $

Appliance Example Answer

Blanket data from table: average power = 180W

Energy used:

$$Energy(J) = P \bullet t = 180\frac{J}{s} \bullet 2h \bullet \frac{3600s}{h} = 1.3E6J$$

$$Energy(kWh) = P \bullet t = 0.180kW \bullet 2h = 0.36kWh$$

Cost:

$$Energy\,Used \bullet Rate = 0.36kWh \bullet \$0.12/kWh = \$\ 0.043$$

4.3 cents for two hours of comfort, what a bargain!

6. Hair Dryer Example

What's the resistance of a 120 V hair dryer?

Use Resources P. 5 for appliance data.

Hair Dryer Answer

Resistance, which is futile:

Current = 10.0 A (from Resources 4)

$$V = IR$$

$$R = \frac{V}{I} = \frac{120V}{10A} = 12\Omega$$

Homework

3.C.4 Problems.
Due: Next Class.