March 31, 2017

Ohm's Law Observations

Connect the two batteries together

Find a ~~100 Ω~~, 330 Ω, 560 Ω, and 1,000 Ω resistor

Make a simple circuit connecting all four resistors together in one continuous line.

Measure voltage R ↑ V ↑

Trend?

Make a simple circuit with only one resistor at a time.

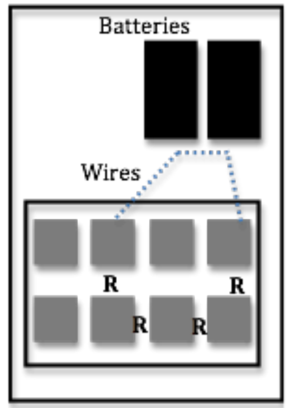
Measure voltage * One resistor will take all available voltage

Trend?

Make a simple circuit with only one resistor at a time.

Measure current R ↑ I ↓

Trend?



R = Resistor

Ohm's Law

- Voltage, current, and resistance are connected though Ohm's Law

  * $V = I R$

- Voltage used, referred to as the 'voltage drop'

- Resistance varies directly with voltage and indirectly with current. *Resistors take all voltage if alone
  - *At least for all Ohmic materials (materials that follow Ohm's Law - based on reactions to heat)*
    - *Ohmic: Silver, copper, etc...*
    - *Non-Ohmic: PN transistors, diodes*

Electrical Power

- The rate at which electrical energy is utilized in a circuit
  - Electrical energy transformed into other forms of energy (kinetic energy, thermal energy, etc…)

$$P = I \cdot V$$

- I = current flowing through device
- V = 'voltage' or potential difference across device

- Combination Formulas: $P = I^2 \cdot R$ $\quad P = \dfrac{V^2}{R}$

  **Using Ohm's Law*

Electrical Power

- Power used by a device can change based on the current and voltage available.
- One constant with the device is the resistance it affords.

Power Question

- The equation $P = V^2/R$ indicates that the power dissipated in a resistor decreases if the resistance increases whereas the equation $P = I^2R$ implies the opposite. Is there a contradiction here? Explain?

$\downarrow P = \frac{V^2}{R} \uparrow$

Assume voltage is constant

* Current would have to change

$\uparrow P = I^2 \cdot R \uparrow$

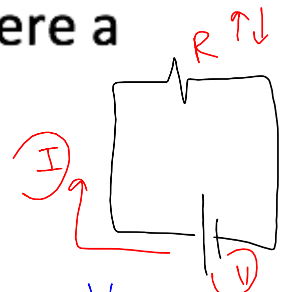
$V = IR$

$I = \frac{V}{R}$

$I = \frac{V^2}{R^2}$

$P = \frac{V^2}{R^2} \cdot R$

Current stays constant



V + I can't both stay the same

Answer

- To say that $P = V^2/R$ indicates a decrease in power as resistance increases assumes a constant voltage

- To say that $P = I^2R$ indicates an increase in power as resistance increases assumes a constant current.

- Only one of those can be true for any given situation.

- If the resistance changes and the voltage is constant, then the current must also change. (Resistance goes up, power goes down)

- If the resistance changes and the current is constant, then the voltage must also change. (Resistance goes up – all values go up)

What you pay for....

- When you get your power bill…you're not *actually* paying for power. You pay for energy usage
- Power companies use the **kilowatt-hour**
- To calculate:
  - Find power in kW
  - Find time in hours
  - Multiply together to get kW-hours
  - Multiply by rate to find total cost

Example 4

A 550.0 W toaster is in use for 10.0 minutes each morning, four mornings a week for four weeks making perfectly toasted bagels for all! If the power company charges 12.0 cents per kilowatt-hour, how much must you pay to toast your tasty bagels?

P

P = 550 W = 0.55 kW

time

10 min × 4 mornings × 4 weeks

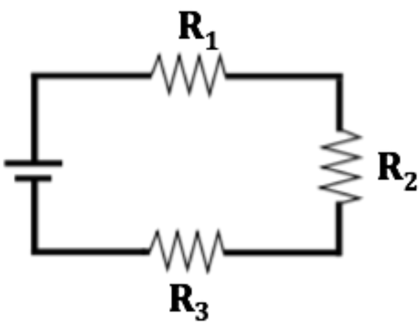
160 min.

2.66 hours

(0.55)(2.66) = 1.46 kw-hours = ¢17.56

Summary

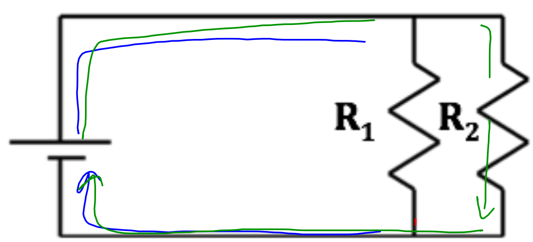
- **Series Circuits:**



- Current stays constant (one path)
- Voltage is divided R↑ V↑
- Equivalent Resistance

$$R_{eq} = R_1 + R_2 + R_3 + \ldots$$

- **Parallel Circuits:**



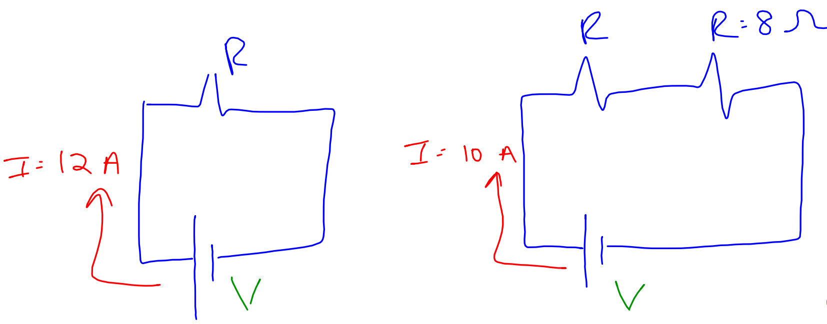
- Current gets split
  R↑ I↓
- Voltage is the same

Equivalent Resistance

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

Example 7

The current of a series circuit is originally 12.0 A. An 8.00 Ω resistor is added to the series which causes the current to drop to 10.0 A. If there was no change in voltage, what was the original resistance of the circuit?



$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{8}$

$V = IR = 12 \cdot R$

$V = IR$

$V = 10(R+8)$

$12R = 10(R+8)$

$R = 40\,\Omega$

Example 8

Four identical light bulbs are connected in a **parallel** circuit. Each light bulb receives a current of 0.240 A. The equivalent resistance of the light bulbs is 2.50 Ω. What is the resistance of each individual bulb?

$R = 10\Omega$