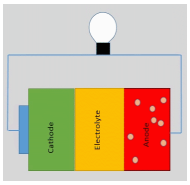
Voltage, Current, Resistance, and Electric Power Notes

Remember that electricity is the movement of electrons. The movement of these charged particles can be harnessed to do work.

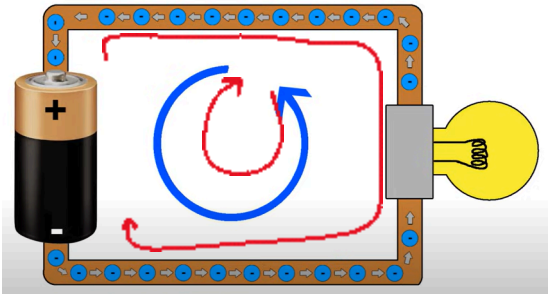
Voltage or Potential difference (V):

- Measured in volts (V)
- Potential difference (ΔV), aka voltage: the change in electrical potential energy per coulomb of charge between two points. It is an electromotive force or a force that moves electrons from one place to another.
  - Depends on the electric field and on the initial and final positions, not on the amount of charge.
  - Think of it like pressure that forces electrons to flow in an electrical circuit.
- The work that must be performed against electric forces to move a charge between the two points in question, divided by the charge.
- A **battery** maintains a constant potential difference between the terminals.
  - 1.5V (AAA, AA, C, and D cell) or 9.0V of 12.0V



Current (I): flow of electric charge due to a voltage source (battery or outlet). It is the rate at which charges flow through an area.

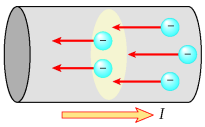
- Measured in ampere (A). *Also known as "amp"*
- The rate at which electric charges pass through a given area
- $I = \frac{q}{t} = \frac{charge\ in\ C}{time\ in\ s}$ (*how fast is charge moving*)



Circuit: a closed loop of current

"Conventional Current": defined as the flow of positive charge. The flow of negative charge is equivalent to the amount of positive charge in the opposite direction. Physicists draw direction of current the other way from + to –, while electron flow is – to +.

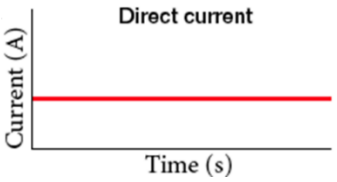
- In conducting wires, current (I) is opposite the direction of electron flow.



***Types of Current:**

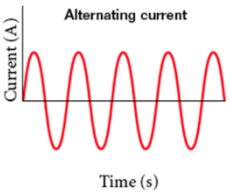
Direct Current:

- Batteries use chemical energy to give electrons potential energy but eventually that chemical energy is depleted.
- Electrons always flow in one direction called direct current (DC).



Alternating Current:

- Generators change mechanical energy into electrical energy. Example: falling water or moving steam.
- Electrons vibrate back and forth, alternating so it is called alternating current (AC).
  - Terminals switch signs 60 times per second (60Hz)
  - AC is better for transferring electrical energy to your home.



Resistance (R): how much a conductor impedes current. A material's tendency to resist the flow of charge (current).

- Measured in Ohms (Ω)
- The opposition present to electric current by a material or device. *The opposition to the flow of charge*.
- Ohm's Law: $R = \frac{\Delta V}{I} = \frac{potential\ difference\ (\Delta V)}{current\ (A)}$ or $\Delta V = I \cdot R$
  - Valid only for certain materials whose resistance is constant over a wider range of potential differences.
- ALL electrical devices have resistance (including wire). Any object with resistance is called a ***resistor***.
- We will assume that power sources (ex. Batteries), meters, and wires have no resistance.

Factors that Affect Resistance:

Factor	Less Resistance	More Resistance

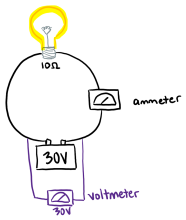
Length	Shorter Length	Longer Length
Cross-Sectional Area	Larger area (thick wire)	Smaller area (thin wire)
Material	Copper wire	Iron wire
Temperature	Lower temperature	High temperature

Applications:

- Resistors in a circuit can change the current.
  - Variable resistors (potentiometers) are used in dimmer switches and volume controls.
  - Resistors on circuit boards control the current to components.

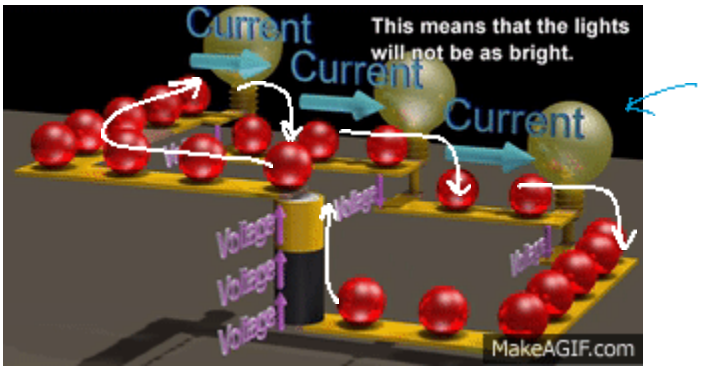
Example:

1. What is the current, in amperes, of a circuit with a potential difference of 30V passing through a lightbulb with a resistance of 10Ω?



A stereo with a resistance of 65Ω is connected across a potential difference of 120V. What is the current in this device?

2. The current in a microwave oven is 6.25A. If the resistance of the oven's circuitry is 17.6Ω, what is the potential difference between across the oven?



Electric Power (P): the rate at which charge carriers do work. It is the rate of energy consumption.

- Measured in Watts (W)
- Electrical power is equal to the product of voltage (potential difference) and current.
- $P = \Delta V \cdot I = \Delta V \cdot (\frac{\Delta V}{R}) = \frac{\Delta V^2}{R}$

Examples:

1. A small electronic device is rated at 0.25W when connected to 120V. What is the resistance of this device?

2. An electric heater is operated by applying a potential difference of 50.0V across a wire of total resistance 8.00Ω. Find the current in the wire and the power rating of the heater.