Electronics 101

What is electricity?

- The flow of electrons and electric charge through a material

Conductors

- Materials that allow for easy movement of electrons
- All metals are conductors, because their electrons are loosely bound to individual atoms.
- This is also why metal is easily malleable
- Other materials can conduct as well:
  - salt water, graphite

Insulators

- Materials that do not allow their electrons to move easily
- rubber, ceramic, plastics, glass, pure water, air, etc.

Semiconductors

- Materials between conductors and insulators
  - silicon, germanium, gallium arsinide, silicon carbide
  - Electron mobility in semiconductors can be modified by adding impurities, called dopants

Conductance and Resistance

one is the inverse of the other.

Conductivity is a spectrum

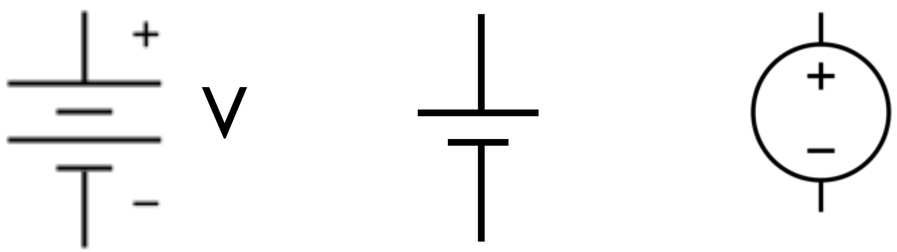
- Much like opacity and transparency.
- Shown here is the volume resistivity of common materials

Silver	1.59×10^{-8}
Copper	1.68×10^{-8}
Platinum	1.06×10^{-7}
Mercury	9.8×10^{-7}
Nichrome	1.10×10^{-6}
Germanium	4.6×10^{-1}
Sea water	2×10^{-1}
Silicon	6.40×10^{2}
Glass	10×10^{10}
Hard rubber	1×10^{13}
Air	1.3×10^{16}
Teflon	10×10^{22}

Voltage

- Voltage is the difference in electrical potential (the total amount of free charge) between two points.

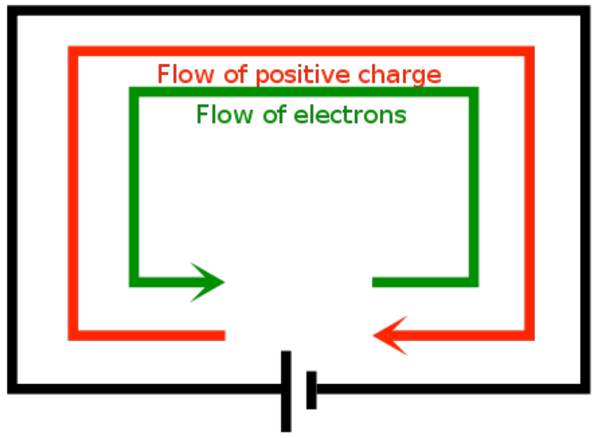
- Voltage is not like temperature, there are no absolute voltages. Voltage is always measured between two points.



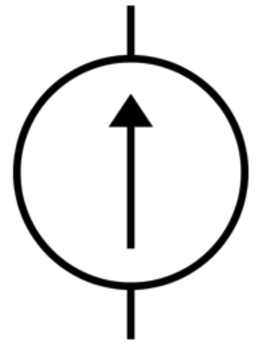
Symbols for voltage sources

Current

- Current is a measure of the flow electrons in a closed loop.
- Current always flows in a loop in electronic circuits.
- Real current flow is "backwards", compared with how we describe current flow in electronic circuits.
- Conventional current describes the movement of positively charged electron "holes", rather than the flow of electrons.
- Current is the flow of "holes" from a high potential to a lower potential.



Symbol for current source



Ohms Law

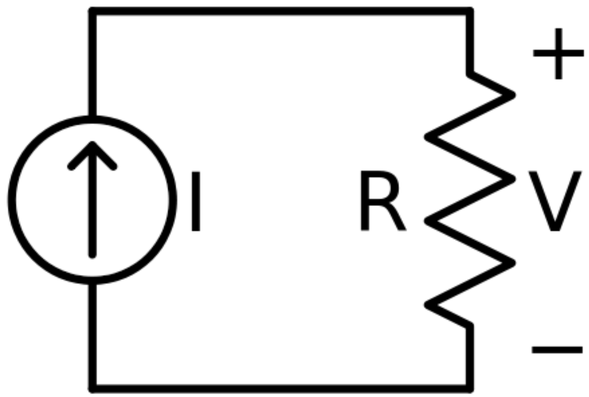
$$V = IR$$

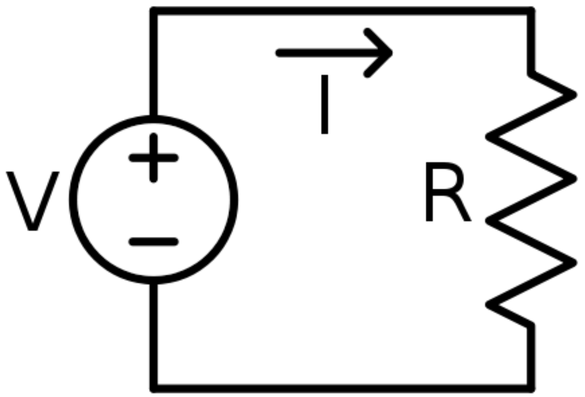
$$I = V/R$$

$$R = V/I$$

- Voltage, Current, and Resistance are all connected through Ohm's Law

Examples





Circuit Abstractions

Ideal Wire

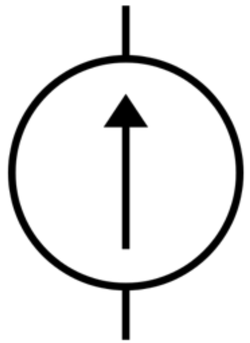
Has infinite conductance
➡ Therefore Zero Resistance

Ideal Resistor

Has a resistance of R
➡ Conductance of 1/R

Not dependent on frequency or temperature

Circuit Abstractions

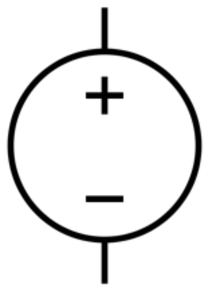


Ideal Current Source

Puts out exactly the current that is specified, all the time.

➡ Must be connected in a loop.

Circuit Abstractions



Ideal Voltage Source

Puts out exactly the voltage that is specified, all the time.

➡ Cannot be in parallel with a voltage source of a different voltage.

Kirchoff's Laws

- KVL - Kirchoff's Voltage Law:
    - The sum of all voltages around a closed loop must equal zero
- KCL - Kirchoff's Current Law:
    - The sum of all currents entering a node must equal zero
    - OR: What goes in, must come out.

Examples on whiteboard

Homework

- Watch these two lectures on MIT's OCW site:
  - http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/video-lectures/lecture-1/
  - http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/video-lectures/lecture-2/
    - HINT: Download the videos, and watch at 1.5x or 2x speed in VLC, slowing it down to normal when you stop understanding
- Test your understanding by finishing this homework:
  - http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/assignments/hw1.pdf
  - (Skip Exercise 1-3 and Problem 1-1.)