Circuits and Electricity

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What is Electricity?

Electricity is a form of energy caused by charged particles

Charged Particles:

Atoms are made up of three particles, protons, electrons, and neutrons. Protons have a positive charge, electrons have a negative charge, and neutrons are neutral. When an atom loses an electron, it becomes positively charged and when it gains an electron it becomes negatively charged.

Types of Electricity:

Static Electricity:

- In static electricity, charged particles gather, like when you touch metal and get shocked.

Dynamic electricity:

- In dynamic electricity, charged particles move in the same direction, like in a current.

When dealing with electricity, we measure voltages and currents

What is Voltage?

Voltage is the measure of energy carried by charged particles

Supply:

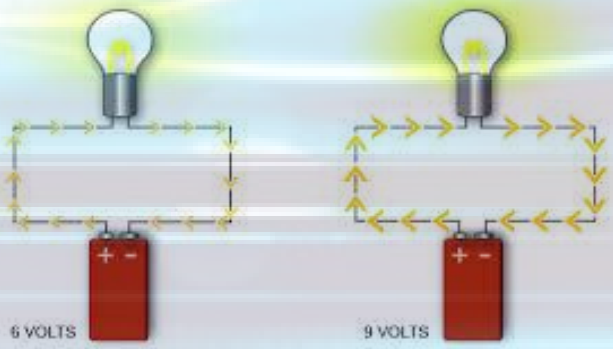
- Usually supplied by a power source such as a battery.

Symbol:

- Voltage is measured in Volts and the symbol for volts in equations is a capital “V”

Measure:

- Voltage is measured using a voltmeter.



What is a Current?

A current is the ordered flow of charged particles

Medium:

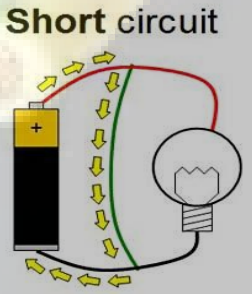
- Currents flow through a medium such as wires.

Symbol:

- They are measured in Amperes (A) and their symbol is "I".

Measure:

- Currents are measured using ammeters.



Path:

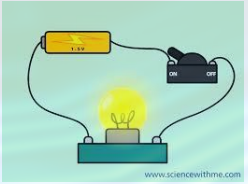
- Currents flow from a power source to a "load". The load converts the electric energy into another type of energy such as a bulb which changes electric energy into light and heat energy.

Short Circuits:

- Currents follow the path of least resistance and this can cause a short circuit. For example, the image above represents a short circuit. The electric current goes through the path with only the wire instead of the path with the bulb because the wire has less resistance than the bulb. As a result there is a short circuit. Short circuits can be very dangerous since there is little resistance preventing the electrons from moving freely. This can heat up the wire and cause an explosion.

What are Circuits?

A circuit is a path that an electric current flows through



Why Wires?

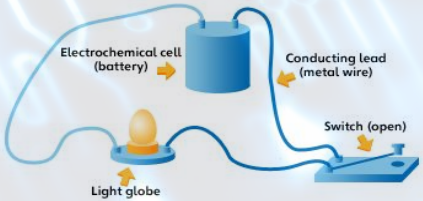
- Wires are made out of metal, which is a conductive material, so electric currents can flow through them easily.

Open vs. Closed:

- Open circuits are circuits with a break in the conductive material (wire) which prevents the electrons from completing their journey to the other side of the circuit. Closed circuits are circuits without any breaks in the middle, so the electric current flows through the entire circuit.

Circuit Parts:

- Circuits are made up of more than just power sources and loads, they can also include switches, capacitors, and inductors. Switches have two states, open and closed. When a switch is open no current can flow through it, when it is closed, currents can flow through it.



Capacitors

A two-terminal electrical component, that is made of charged plates, one positive and one negative

Charge:

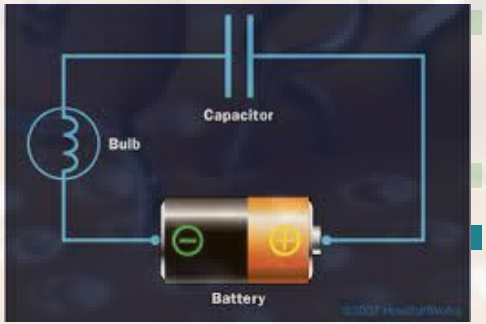
- When a capacitor is fully charged , the current stops flowing and the circuit is essentially an open circuit.

Capacitance:

- Capacitance is the ability to store electric charge. The higher the capacitance, the more current flowing. Capacitance is usually shown on most capacitors.

Measure:

- Capacitance is measured in Farads and the symbol is “F”.
- The symbol of Capacitors is “C”.



Inductors

A coil that stores energy in the form of a magnetic field

Charge:

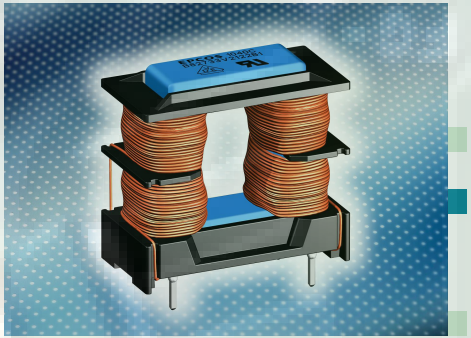
- Once and inductor is fully charged, the current stays flowing, but the circuit is an short circuit.

Inductance:

- Inductance is the amount of energy an inductor can store. The inductance of an inductor is directly proportional to the amount of turns the coil has.

Measure:

- Inductance is measured in Henrys and the symbol is “H”
- The symbol for Inductors is “L”.



Conductors

An object or type of material that allows the flow of an electrical current in one or more directions easily.

Conductivity:

- Conductivity is how easy it is for the current to flow through the material. Conductivity depends on how many free electrons are in the material. Metal is one of the most conductive materials because it has a lot of free electrons.

Conductivity of some common materials

Material	Bulk Conductivity (W/mK)
Silver, Pure	418.0
Copper 11000	388.0
Aluminum 6061 T6	167.0
Zinc, Pure	112.2
Iron, Cast	55.0
Solder, 60% Tin	50.0
Titanium	15.6
ThermalGrease,T660	0.90
Fiberglass	0.040
Air, stp	0.025

Resistors

An electrical component that limits or regulates the flow of electrical current in a circuit

Usage:

- Resistors can be used to provide a specific voltage for an active device such as a transistor.

Resistance:

- Resistance is a material's opposition to the flow of electric current.

Measure:

- Resistance is measured in Ohms and the symbol is "Ω"

Resistance of Wires:

- The resistance of wires is assumed to be 0 Ohms which is why they are the prefered material for electrical circuits.

There are many thousands of different Types of Resistor and are produced in a variety of forms because their particular characteristics and accuracy suit certain areas of application, such as High Stability, High Voltage, High Current etc, or are used as general purpose resistors where their characteristics are less of a problem

Series and Parallel

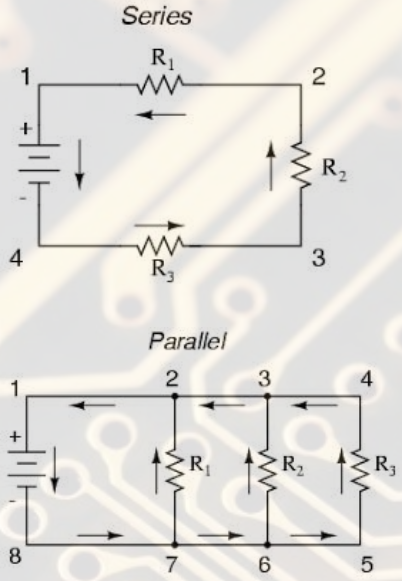
There are two ways of wiring circuits: in ***Series*** or ***Parallel***

What are They?

- Series circuits share one point of connection
- Parallel circuits share two points of connection

Pros and Cons:

- While Series are more straightforward with connection points, if one component breaks the whole circuit fails.
- If a component breaks in Parallel the rest of the circuit is still operable.



Parallel circuits are usually safer and are commonly used in houses

Formulas

When you add resistors, inductors, or capacitors in a circuit you are changing the amount of resistance, inductance, and capacitance.

There are formulas to help you add these new values:

Series:

- Resistors:

$$R_{total} = R_1 + R_2 + R_3$$

- Capacitors:

$$C_{total} = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} \cdots}$$

- Inductors:

Inductors combine the same as Resistors in both series and parallel

Parallel:

- Resistors:

$$R_{TOTAL} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}}$$

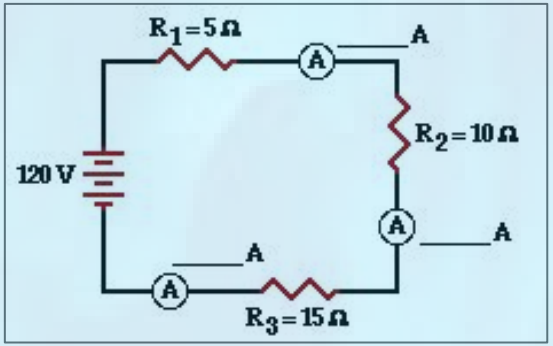
- Capacitors:

$$C_{Total} = C_1 + C_2 + C_3$$

- Inductors:

Example:

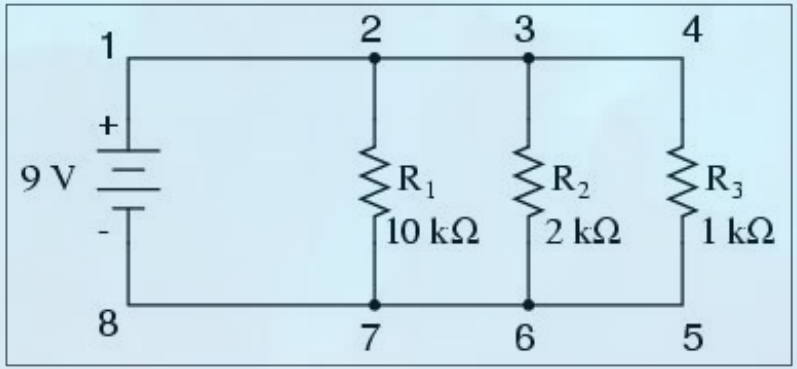
Resistors in Series and Parallel:



Using the formula: $R_{Total}=R_1+ R_2+ R_3$

5+10+15=30

The resistance of this circuit is 30 Ω



Using the formula: $1/R_{Total}=1/R_1+ 1/R_2 + 1/R_3$

1/10 + 1/2 + 1/1 = 1/(16/10) = 10/16

The resistance of this circuit is 10/16 Ω

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