420-N23-LA Introduction to IOT

Electronics Laws and Components

Intro to Electronics

Components
Batteries and
Breadboards
R-Pi vs Arduino

Voltage, Current, Power, Resistance

- The three most basic units in electricity are voltage (**V**), current (**I**, *uppercase "i")* and resistance (**R**). Voltage is measured in volts, current is measured in amps and resistance is measured in ohms.
- Picture a system of pipes. The voltage is equivalent to the *water pressure*, the current is equivalent to the *flow rate*, and the resistance is like the *pipe diameter*.
- OHMS Law: $I = \frac{V}{R}$

Garden Watering

Let's see how this relation applies to the plumbing system. Let's say you have a tank of pressurized water connected to a hose that you are using to water the garden.

- What happens if you increase the pressure in the tank?
  - This makes more water come out of the hose. The same is true of an electrical system: Increasing the voltage will make more current flow.

- Let's say you increase the diameter of the hose
  - This also makes more water come out of the hose. This is like decreasing the resistance in an electrical system, which increases the current flow.

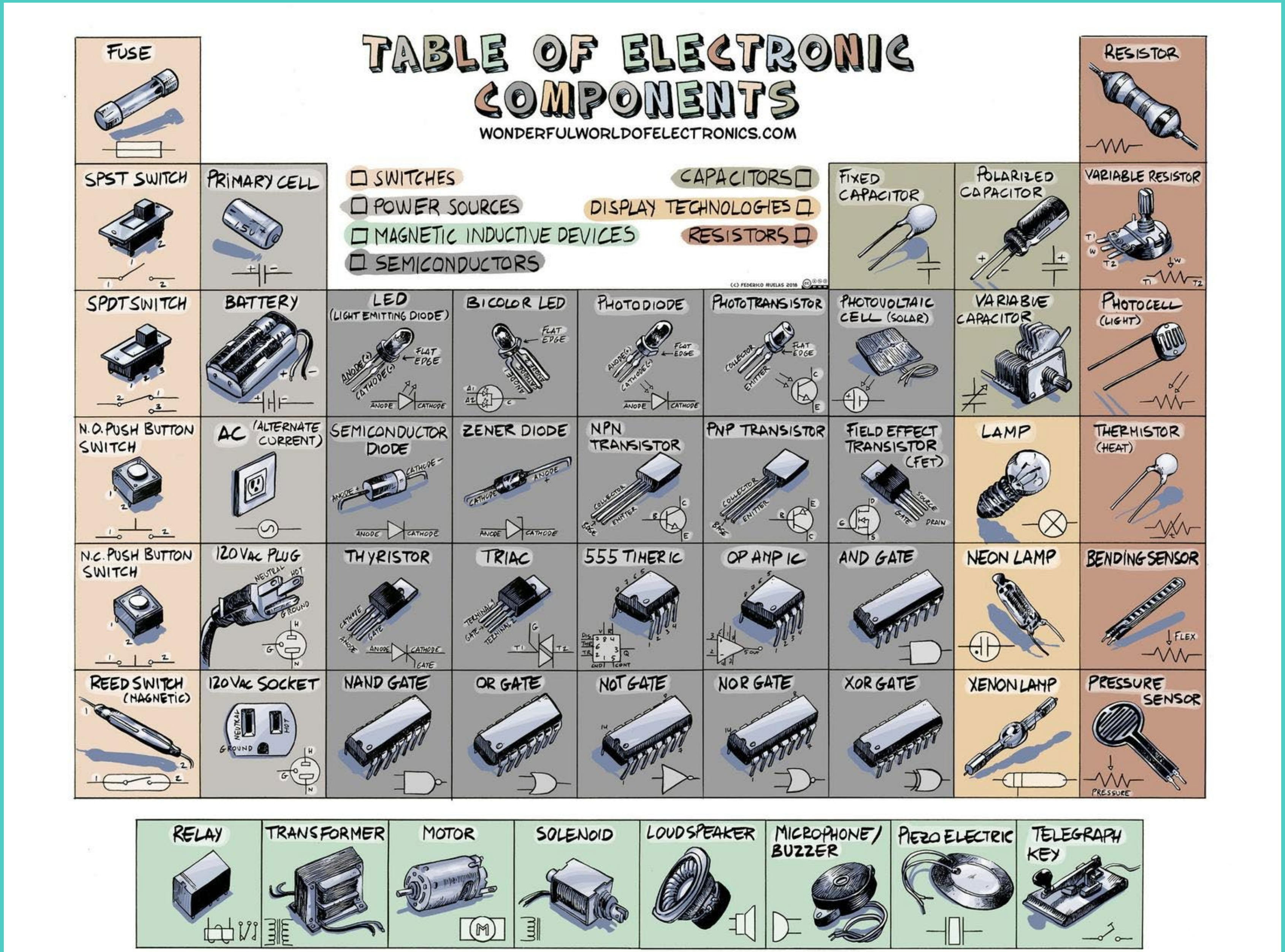
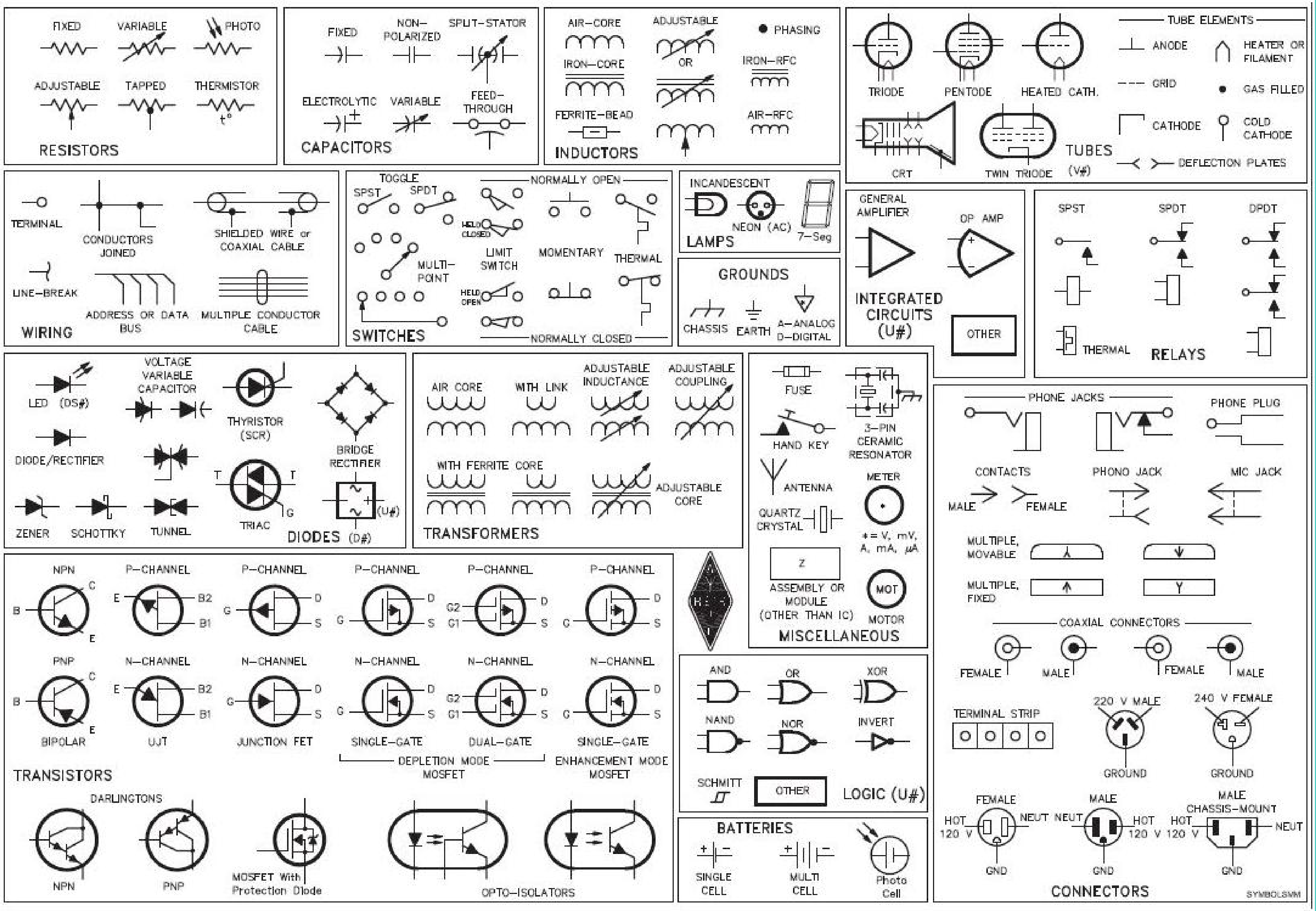


TABLE OF ELECTRONIC COMPONENTS
WONDERFULWORLDOFELECTRONICS.COM
SWITCHES
POWER SOURCES
MAGNETIC INDUCTIVE DEVICES
SEMICONDUCTORS
CAPACITORS
DISPLAY TECHNOLOGIES
RESISTORS
FUSE
RESISTOR
SPST SWITCH
PRIMARY CELL
FIXED CAPACITOR
POLARIZED CAPACITOR
VARIABLE RESISTOR
SPDT SWITCH
BATTERY
LED (LIGHT EMITTING DIODE)
BICOLOR LED
PHOTODIODE
PHOTOTRANSISTOR
PHOTOVOLTAIC CELL (SOLAR)
VARIABLE CAPACITOR
PHOTOCELL (LIGHT)
N.O. PUSH BUTTON SWITCH
AC (ALTERNATE CURRENT)
SEMICONDUCTOR DIODE
ZENER DIODE
NPN TRANSISTOR
PNP TRANSISTOR
FIELD EFFECT TRANSISTOR (FET)
LAMP
THERMISTOR (HEAT)
N.C. PUSH BUTTON SWITCH
120 Vac PLUG
THYRISTOR
TRIAC
555 TIMER IC
OP AMP IC
AND GATE
NEON LAMP
BENDING SENSOR
REED SWITCH (MAGNETIC)
120 Vac SOCKET
NAND GATE
OR GATE
NOT GATE
NOR GATE
XOR GATE
XENON LAMP
PRESSURE SENSOR
RELAY
TRANSFORMER
MOTOR
SOLENOID
LOUDSPEAKER
MICROPHONE/ BUZZER
PIEZO ELECTRIC
TELEGRAPH KEY

Schematic Symbols for Common Electronics and Electrical Components



Fundamental Components

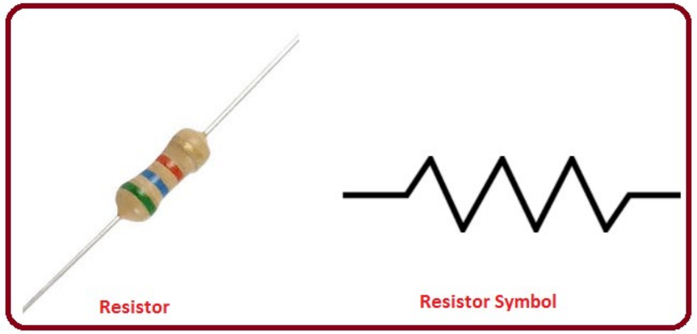
1. Resistor / Potentiometer
2. Diode
3. Light Emitting Diodes
4. Switch / Button
5. Capacitors
6. Transistors
7. Logic Gates

Fundamental Components (ANSWERS)

- Resistor / Potentiometer
  - Limits current from A to B.
- Diode
  - Allows current from A to B but not B to A.
- Light Emitting Diodes
  - A diode! But lights when current it applied from A to B.
- Switch / Button
  - A switch switches A->B, A->C, a button permits A->B only when pressed.
- Capacitors
  - Store electricity like a battery. Filters noise. Charge/Discharge quickly.
- Transistors
  - Permit current A->B when C is activated.
- Logic Gates
  - AND / OR / NOT / XOR.

Resistor

- Resistor
  - Resistor is an electrical component that reduces the electric current.
  - A resistor is a two-terminal device that is used to resist the flow of current. It is one of the most commonly used components in electrical circuits.
- Resistance
  - The resistor's ability to reduce the current is called resistance and is measured in units of **ohms**
  - Ohm is denoted by the Greek letter omega. Each resister has a different value of resistance which tells us how strongly it resists the flow of current.



Resistor

- Resistance
  - More the value of resistance more is the capability of resisting the current.
  - Resistance will be considered as one ohm if the potential difference between the two ends of the conductor is 1V and a current flowing through it is 1 Ampere.
  - Resistance can be derived from Ohm's law which indicates voltage is directly proportional to the current flowing through the conductor.
  - $R = V / I$

Resistance

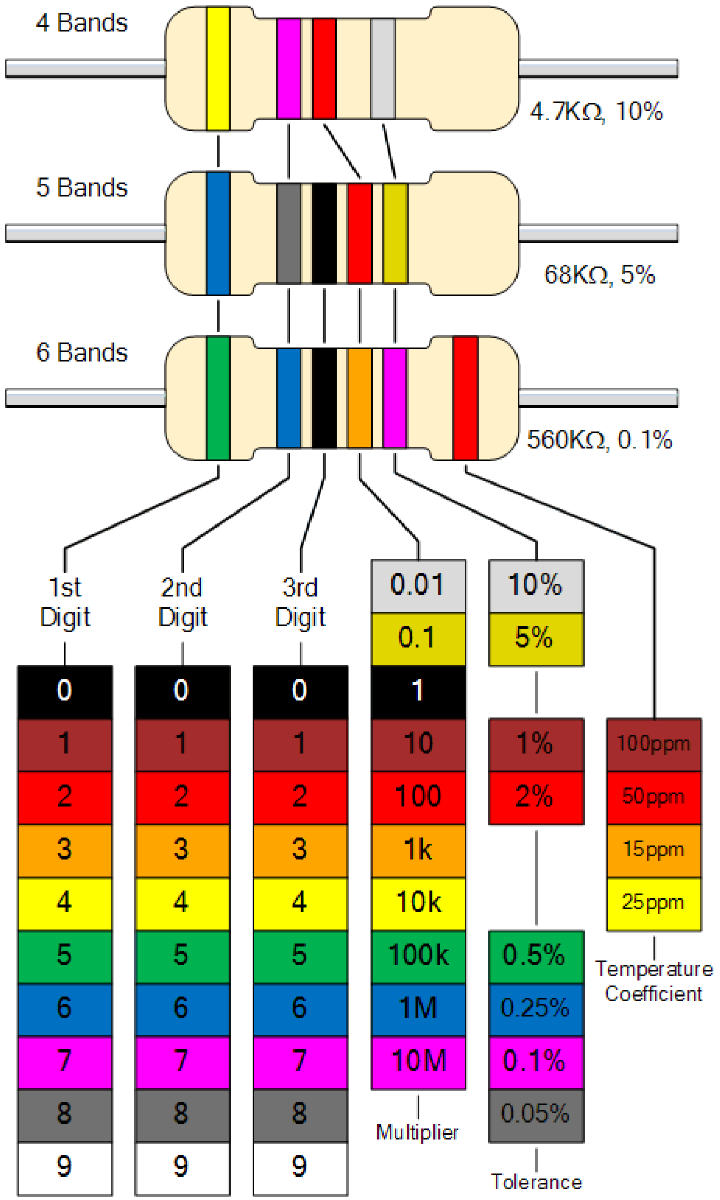
- Some resistors come with four colored strips.
  - The fourth strip indicates the value of tolerance. Tolerance is the value of the deviation of resistance from its given value on the resistor.
  - Gold color of forth strip indicates tolerance is 5% .
  - Silver color indicates tolerance is 10%.
  - No forth strip, tolerance is considered as 20%. Suppose, if resistance has 50-ohm resistance with no forth strip. Then tolerance of such resistor can be 50 ±20%.

Identifying Resistance

- Calculate the value of the number digits.
- Multiply this by your multiplier.
- Make sure the tolerance is ok for your project.

Digit, Digit, Multiplier = Colour, Colour x 10 ^{colour} in Ohm's (Ω)

Yellow Violet Red = 4 7 2 = 4 7 x 10^2 = 4700Ω or 4k7 Ohm.



Multimeter

- A **multimeter** or a voltmeter is an electronic measuring instrument that combines several measurement functions in one unit.
- A typical **multimeter** can measure voltage, current, and resistance.
- Also, CONTINUITY (does current flow from point A to point B).

Try it - Exercise 1

- Voltage
  - Set your voltmeter setting to “V” or “Vdc”, typically a range under 25v.
  - Measure the voltage from a 9v battery or a 3.25volt AA battery pack, briefly across terminals from positive to negative.
  - Make note of the voltage.
- Resistance
  - Set your MM to the resistance setting.
  - Measure a known resistor value – match it to the display.
  - A 420 ohm resistor SHOULD display a value of 415-425(ish).
  - Values are not 100% accurate for cheap parts.
  - Some resistors may not even work (try another).
  - If 3 resistors aren’t working, you’re doing something wrong. ☺

AC vs. DC

- DC is “Direct Current”. This is a current which is constant, moves in one direction and doesn’t change (can go a bit lower over time, when the battery dies).

- DC usually comes from a battery source, or from a power adapter (for your laptop for instance).

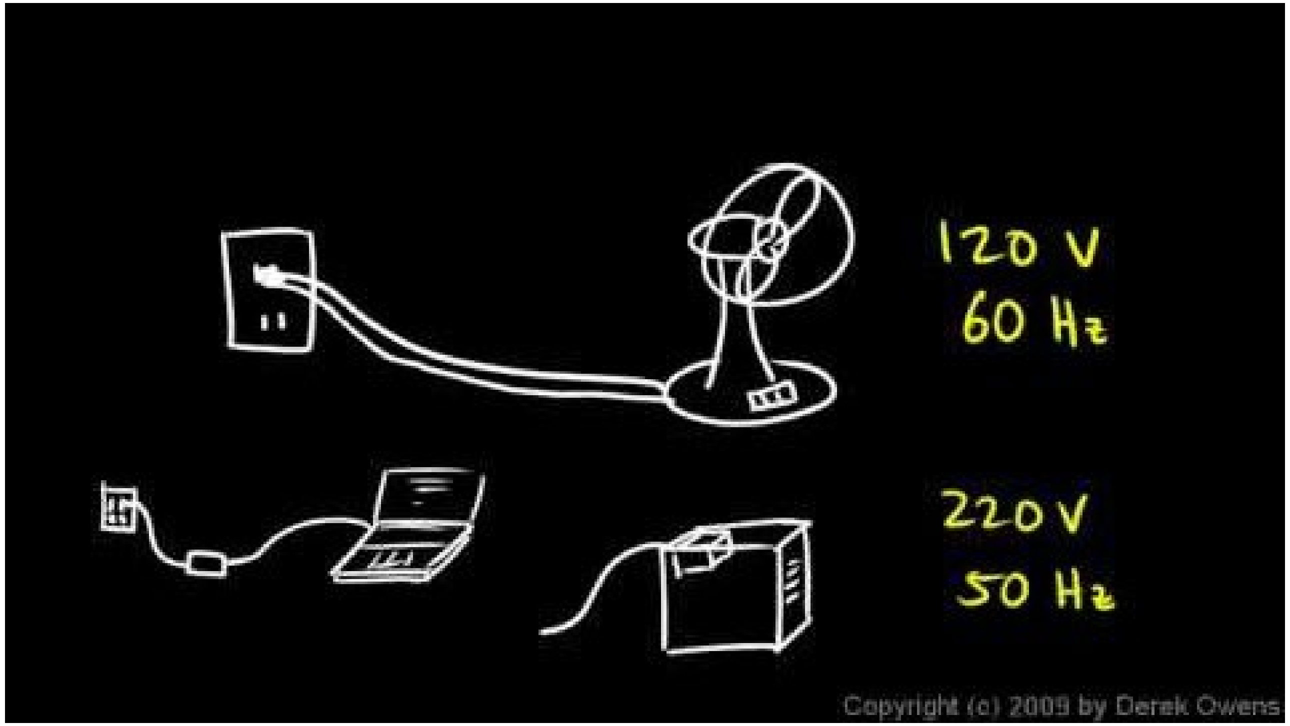
- AC is “Alternating Current” and changes direction periodically. This is a SINE WAVE type of current. The sine wave has a certain frequency. In Canada – it’s 120v and 60 hertz (60 times per second). For Europe and some other places, it’s 220 and 50hz.

- AC power is more dangerous, if you create a circuit of power it can affect your heart – so that’s why it’s important to be cautious with this.
- AC signals can travel MUCH further than DC, this is the main reason behind AC power.
- A transformer can transform AC to DC

AC vs. DC

- AC power is more dangerous, if you create a circuit of power it can affect your heart – so that's why it's important to be cautious with this.
- AC signals can travel MUCH further than DC, this is the main reason behind AC power.
- A transformer can transform AC to DC

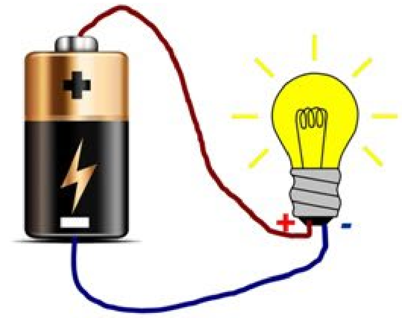
AC vs. DC



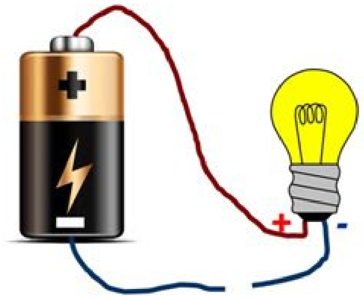
Electric Circuits

- An electric circuit is **a closed path** in which electrons move to produce electric currents.
- In its most simple form, an electrical circuit consists of three fundamental parts:
  - A **power source** to drive electrical current around the circuit (a battery)
  - A **conductor** to carry the current around the circuit (some cable)
  - A **load** that has resistance (a bulb, a heating element, a motor etc.)

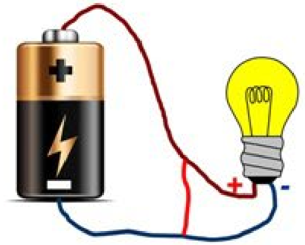
A Circuit (Basic States of Circuits)



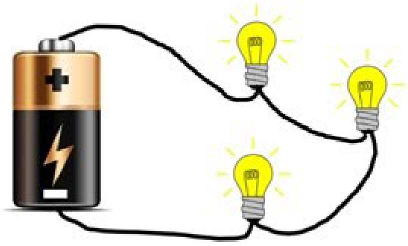
Closed Circuit



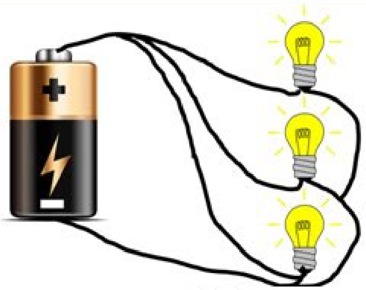
Open Circuit



Short Circuit



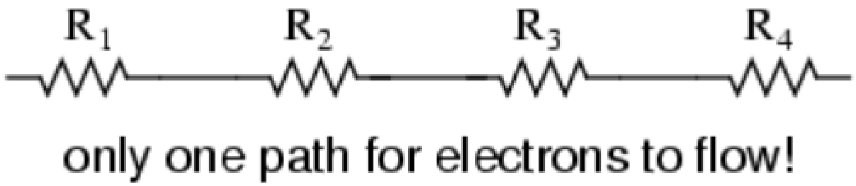
Series Circuit



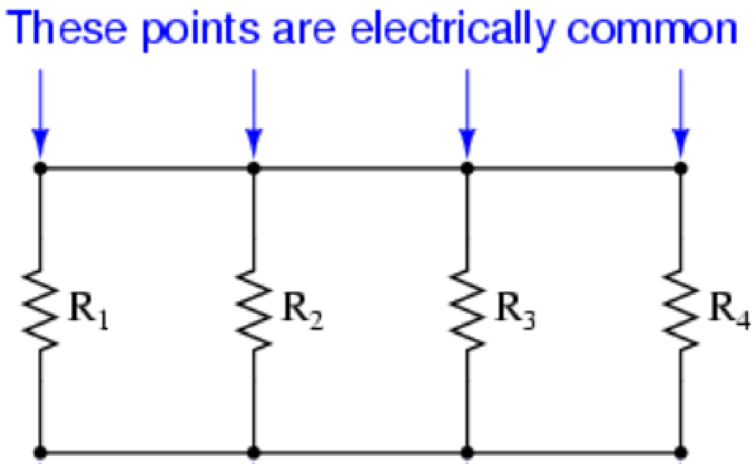
Parallel Circuit

Series and Parallel Circuits

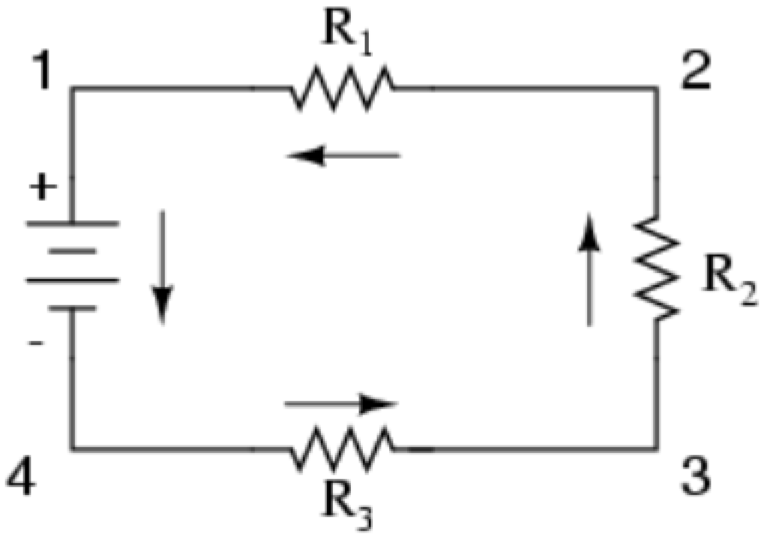
- There are two basic ways in which to connect more than two circuit components:
  - **Series** : The basic idea of a "series" connection is that components are connected end-to-end in a line to form a single path for electrons to flow.



  - **Parallel:** The basic idea of a "parallel" connection is that all components are connected across each other's leads. There are many paths for electrons to flow, but only one voltage across all components:



Series Circuit

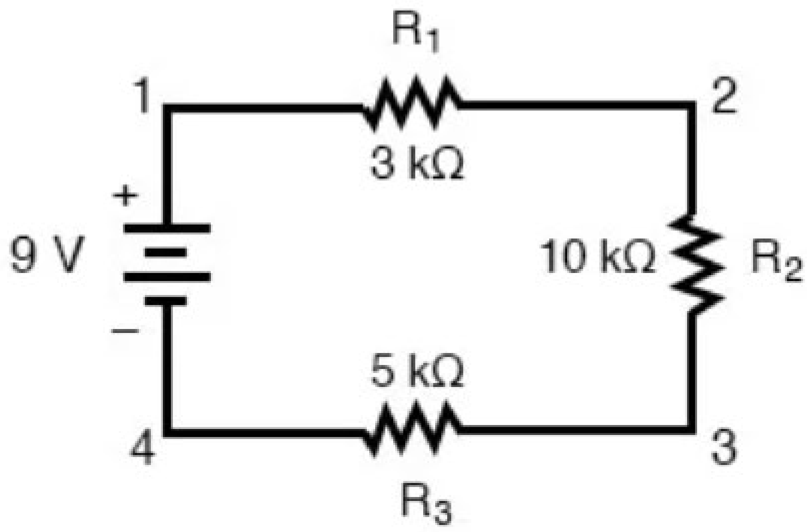


- Three resistors (labeled R_1, R_2, and R_3), connected in a long chain
- from one terminal of the battery to the other.
- The defining characteristic of a series circuit is that **there is only one path for electrons to flow**.
  - In this circuit the electrons flow in a counter-clockwise direction, from point 4 to point 3 to point 2 to point 1 and back around to 4.

Series Circuit

- **Current**: The amount of current is the same through any component in a series circuit.
- **Resistance**: The total resistance of any series circuit is equal to the sum of the individual resistances.
- **Voltage**: The supply voltage in a series circuit is equal to the sum of the individual voltage drops.

Example: Series Circuit



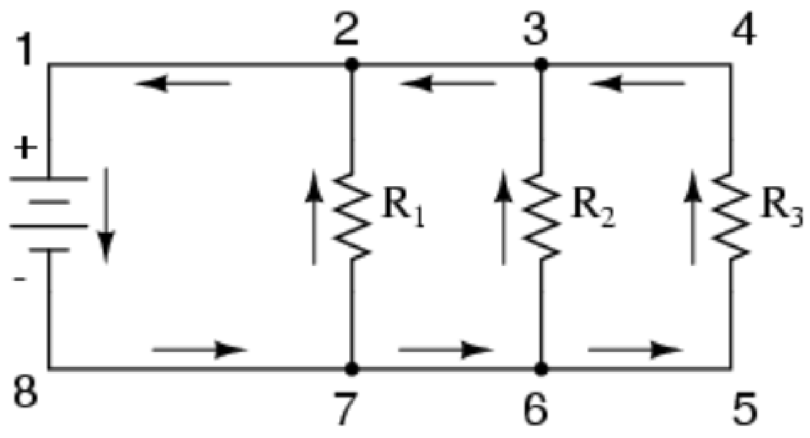
Calculating Circuit Current Using Ohm's Law

- $R_{Total}=R_{1+}R_{2+}R_3$
- $R_{Total}=3+10+5=18\ k\ \Omega$
- $I_T= V_{Total}/R_{total}$
- $I_T=9/18= 500\ mA$

Calculate the components voltage Using Ohm's Law

- $V_1= R_1*I_{total}= 500\ mA \times 3\ k\ \Omega= 1.5\ V$
- $V_2= R_2*I_{total}= 500\ mA \times 10\ k\ \Omega= 5\ V$
- $V_3= R_3*I_{total}= 500\ mA \times 5\ k\ \Omega= 2.5\ V$

Parallel Circuit

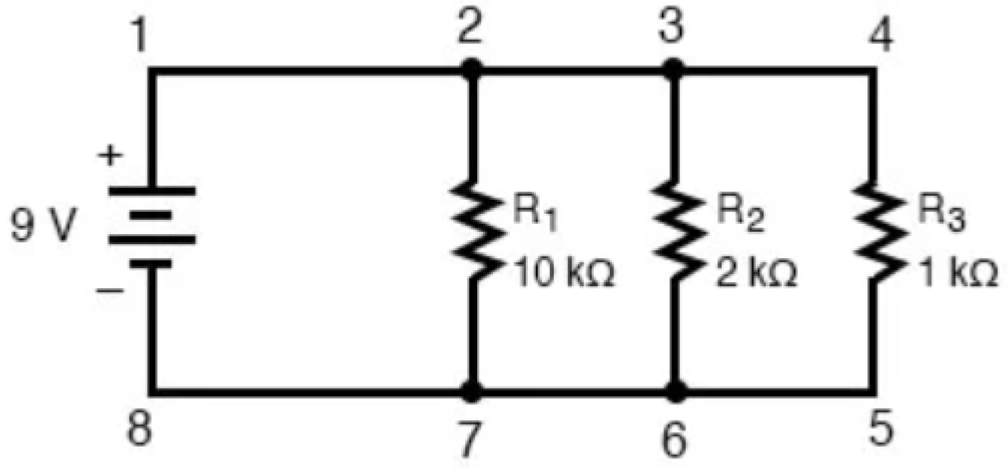


- three resistors, but this time
  - more than one continuous path for electrons to flow.
- The defining characteristic of a parallel circuit is that all components are connected between the same set of electrically common points. Looking at the schematic diagram, we see that points 1, 2, 3, and 4 are all electrically common. So are points 8, 7, 6, and 5.
  - all resistors as well as the battery are connected between these two sets of points.

Parallel Circuit

- **Voltage:** Voltage is equal across all components in a parallel circuit.
- **Current:** The total circuit current is equal to the sum of the individual branch currents.
- **Resistance:** Individual resistances *diminish* to equal a smaller total resistance rather than *add* to make the total.

Example: Parallel Circuit

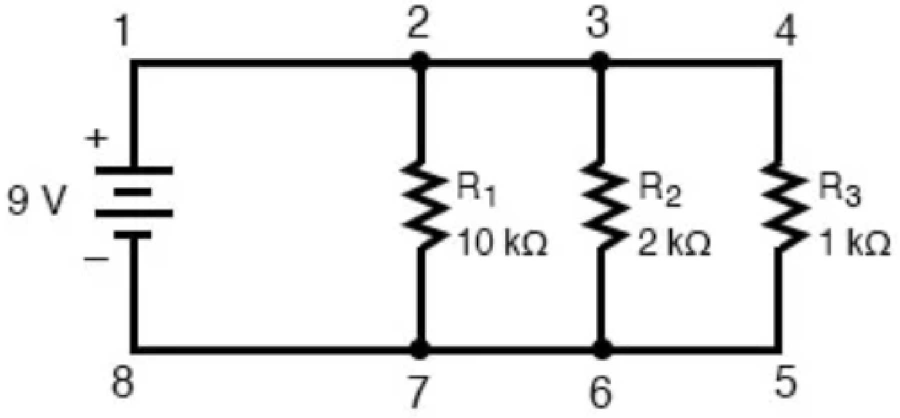


- The first principle to understand about parallel circuits is that the **voltage is equal across all components in the circuit**. time.

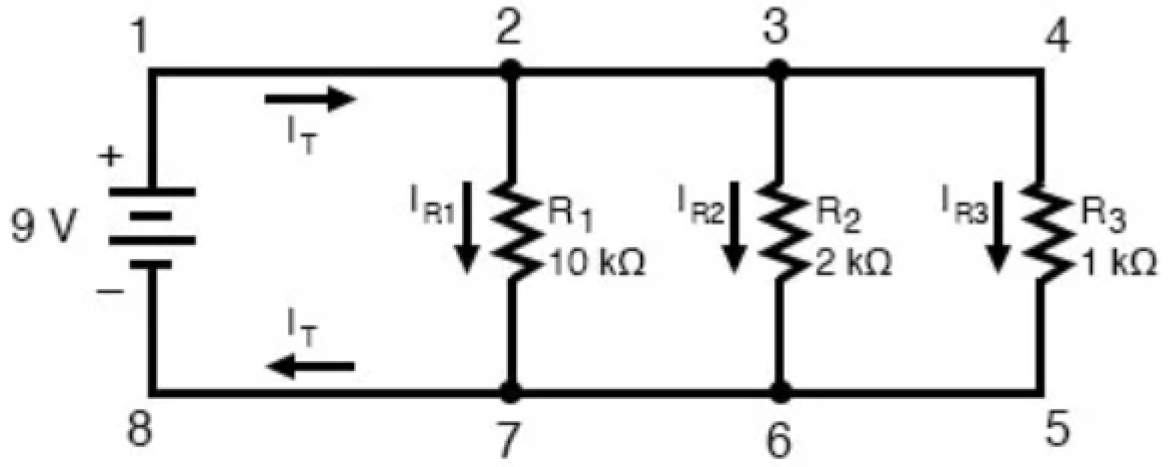
	R_1	R_2	R_3	Total	
W	9	9	9	9	Volts
I					Amps
R	10k	2k	1k		Ohms

Example: Parallel Circuit

- $I_1 = V_{Total}/R_1 = \dfrac{9\ \text{V}}{10\ \text{k}\Omega} = 0.9\ \text{mA}$
- $I_2 = V_{Total}/R_2 = \dfrac{9\ \text{V}}{2\ \text{k}\Omega} = 4.5\ \text{mA}$
- $I_3 = V_{Total}/R_3 = \dfrac{9\ \text{V}}{1\ \text{k}\Omega} = 9\ \text{mA}$



	R_1	R_2	R_3	Total	
E	9	9	9	9	Volts
I	**0.9m**	**4.5m**	**9m**		Amps
R	10k	2k	1k		Ohms
	↑ Ohm's Law	↑ Ohm's Law	↑ Ohm's Law		



Switches

- A switch is the simplest electronic device, it’s like a drawbridge that opens and closes to let electricity through or not.
- A switch is used to change an open circuit to a closed circuit (in most cases).
- Switches have a configuration code like SPDT, SPST, DPST (single pole double throw, single pole single throw, double pole single throw).

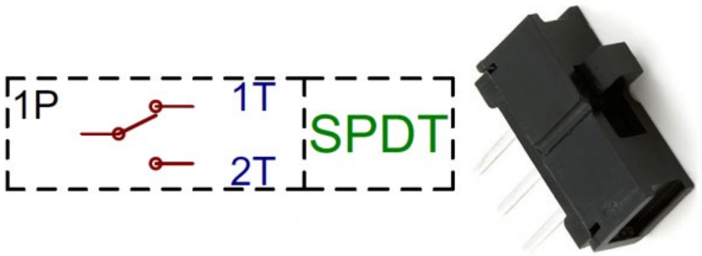
Switches

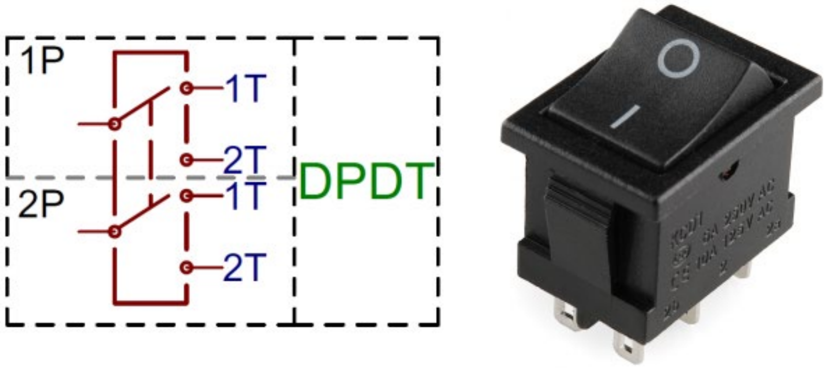
- **SP**ST: If a switch has 2 switches built into it, it's a "double pole", a normal single switch is a "single pole".

- SP**ST**: The second part means, do we simply switch ON-OFF (single throw) or do we switch from A to B (like a railway, double throw).

- See next slide to get a visual example.

Switches

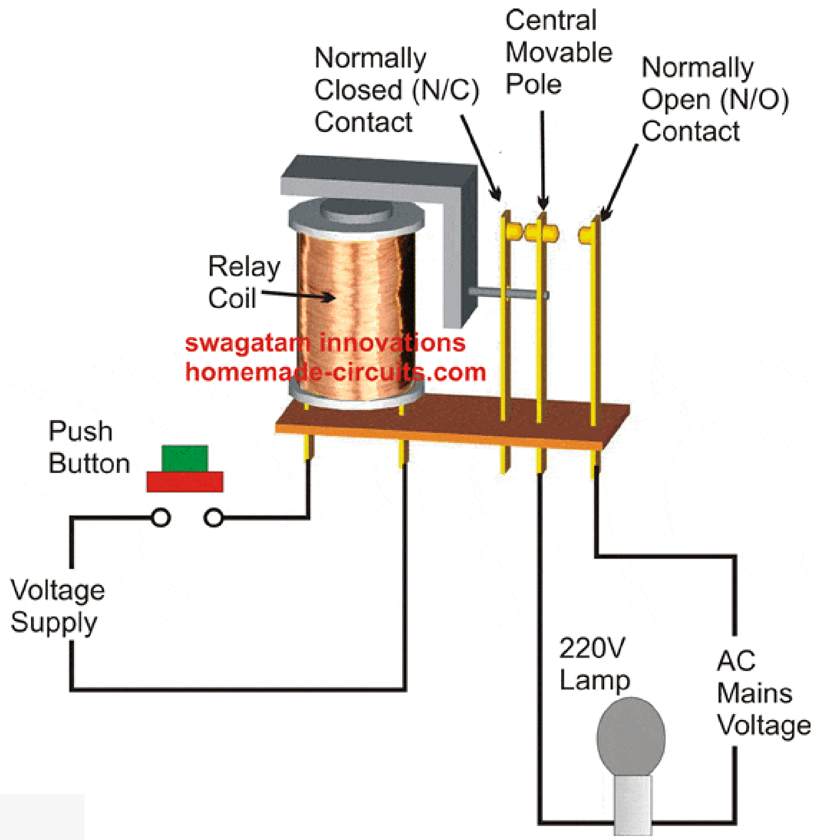




Relays

- A relay allows a very small amount of energy (push button/voltage supply) to control a very high current (220v lamp, AC mains voltage).

- This is a physical switch controlled electronically.



Capacitors

- A capacitor is a bit like a battery, but it has a different job to do. A battery uses chemicals to store electrical energy and release it very slowly through a circuit; sometimes (in the case of a quartz watch) it can take several years.
- A capacitor stores energy in an electric field generally releases its energy much more rapidly—often in seconds or less. If you're taking a flash photograph, for example, you need your camera to produce a huge burst of light in a fraction of a second. A capacitor attached to the flash gun charges up for a few seconds using energy from your camera's batteries.

Capacitors

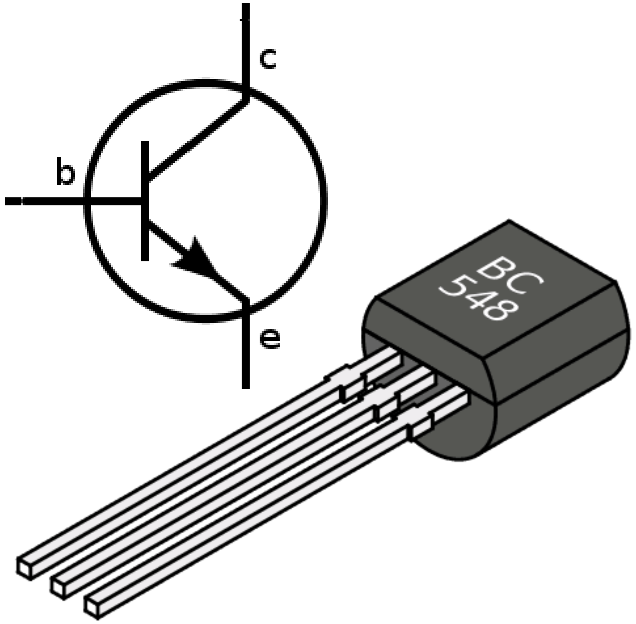
- The amount of electrical energy a capacitor can store depends on its capacitance. The capacitance of a capacitor is a bit like the size of a bucket: the bigger the bucket, the more water it can store; the bigger the capacitance.

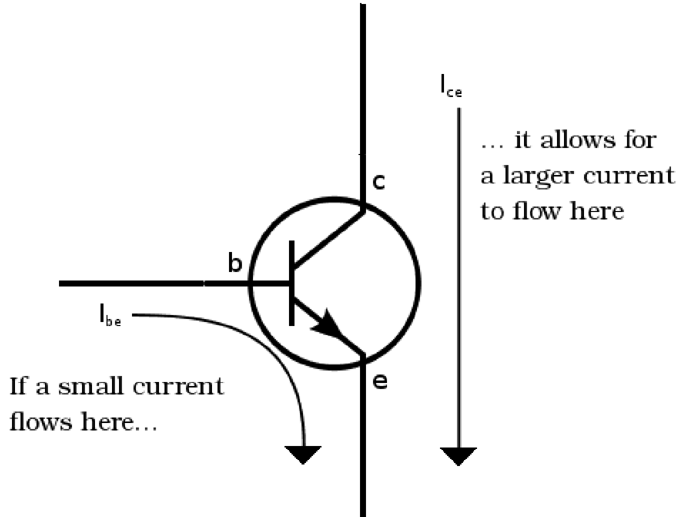
- Capacitance is measured in “Farads”, “MicroFarads”... 20uF, 1F

Transistors

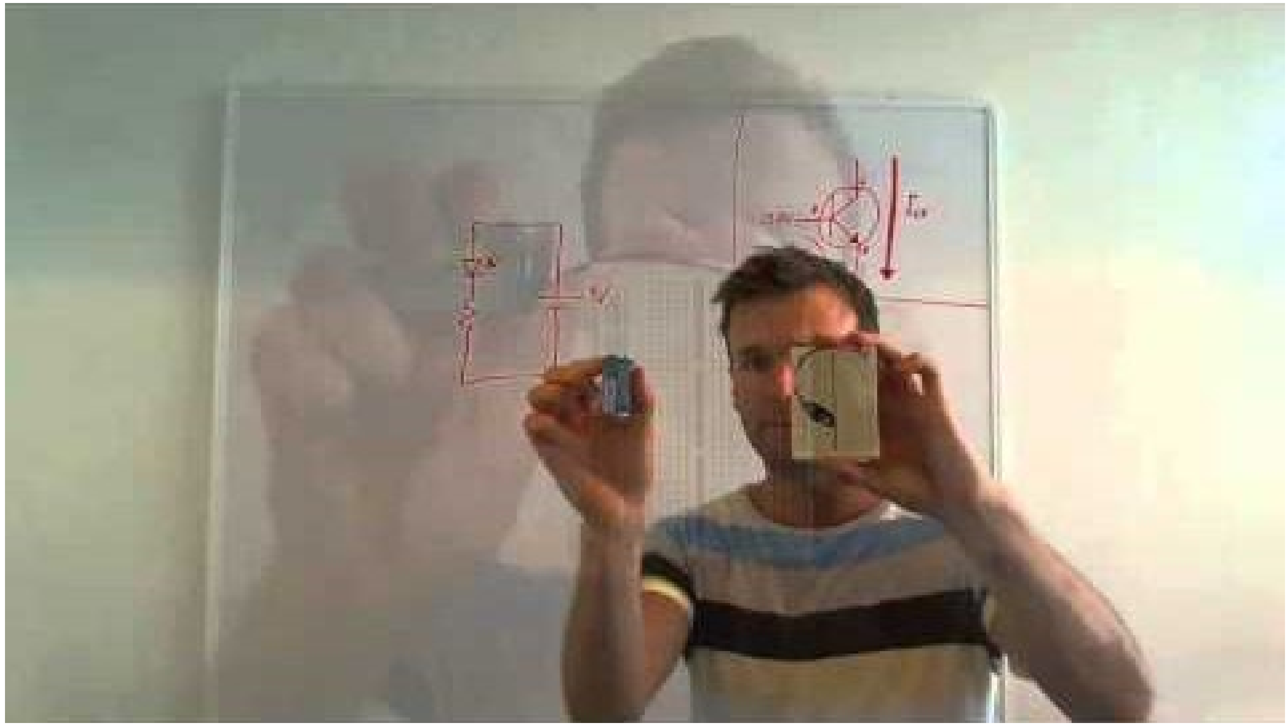
- The transistor is like an electronic switch. It can turn a current on and off. A simple way you can think of it is to look at the transistor as a relay without any moving parts. A transistor is similar to a relay in the sense that you can use it to turn something ON and OFF.

It has three pins: Base (b), collector (c) and emitter (e). And it comes in two versions: NPN and [PNP](). The schematic symbol for the NPN looks like this:





How a Transistor Works (From an Experienced Dude)

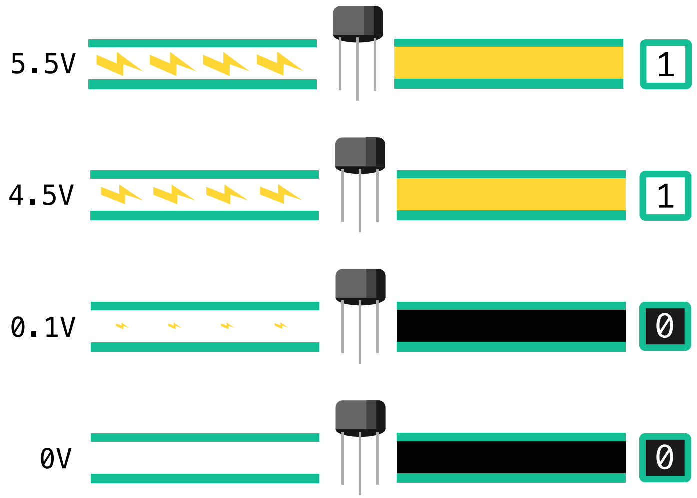


Interesting Fact

Your computer is comprised of billions of transistors.

A computer deals with 0 and 1 (as you know now).

A transistor with current at the base = 1
A transistor without current at the base = 0

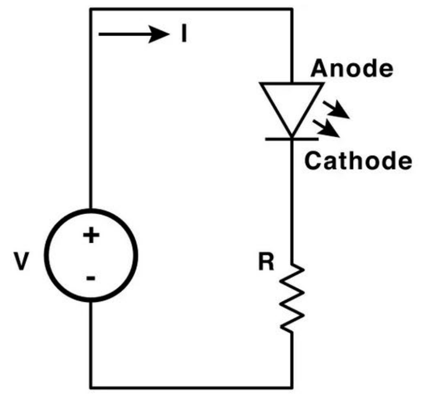


A LED Circuit

- A circuit with an LED must be constructed specifically to protect the LED from an overload of current.
- USUALLY the current is way too strong for any LED.
- A calculator: https://www.digikey.ca/en/resources/conversion-calculators/conversion-calculator-led-series-resistor

FORMULA

$$R = \frac{V_s - V_f}{I_f}$$

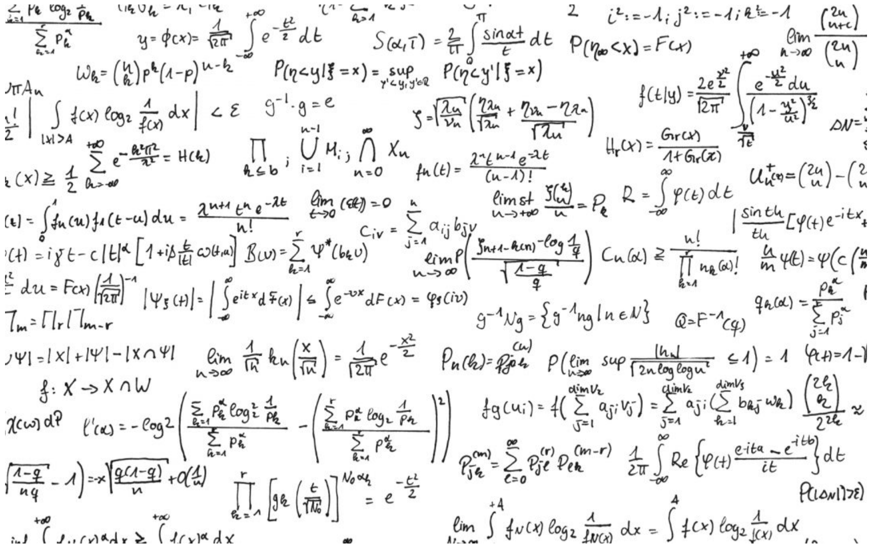


LED Color	Typical Vf Range
Red	1.8 to 2.1
Amber	2 to 2.2
Orange	1.9 to 2.2
Yellow	1.9 to 2.2
Green	2 to 3.1
Blue	3 to 3.7
White	3 to 3.4

Exercise

- Group 1: Calculate
  - Given a RED LED, at 20 milliamperes, using a 9V battery, what resistor must you use?

- Group 2: Calculate
  - Given three RED LED’s in series, 20mA, using a 9V battery, what resistor must you use?



Answers

Group 1

$V_R = 9 - 2 = 7v$

$R = V / I_R = 7\ v / 0.020A$

$R = 350$ ohms

Group 2

$V_{LEDs} = 2+2+2=6\ v$

$V_R = 9 - 6 = 3\ v$

$R = V / I_R = 3\ v / 0.020A$

$R=150$ ohms