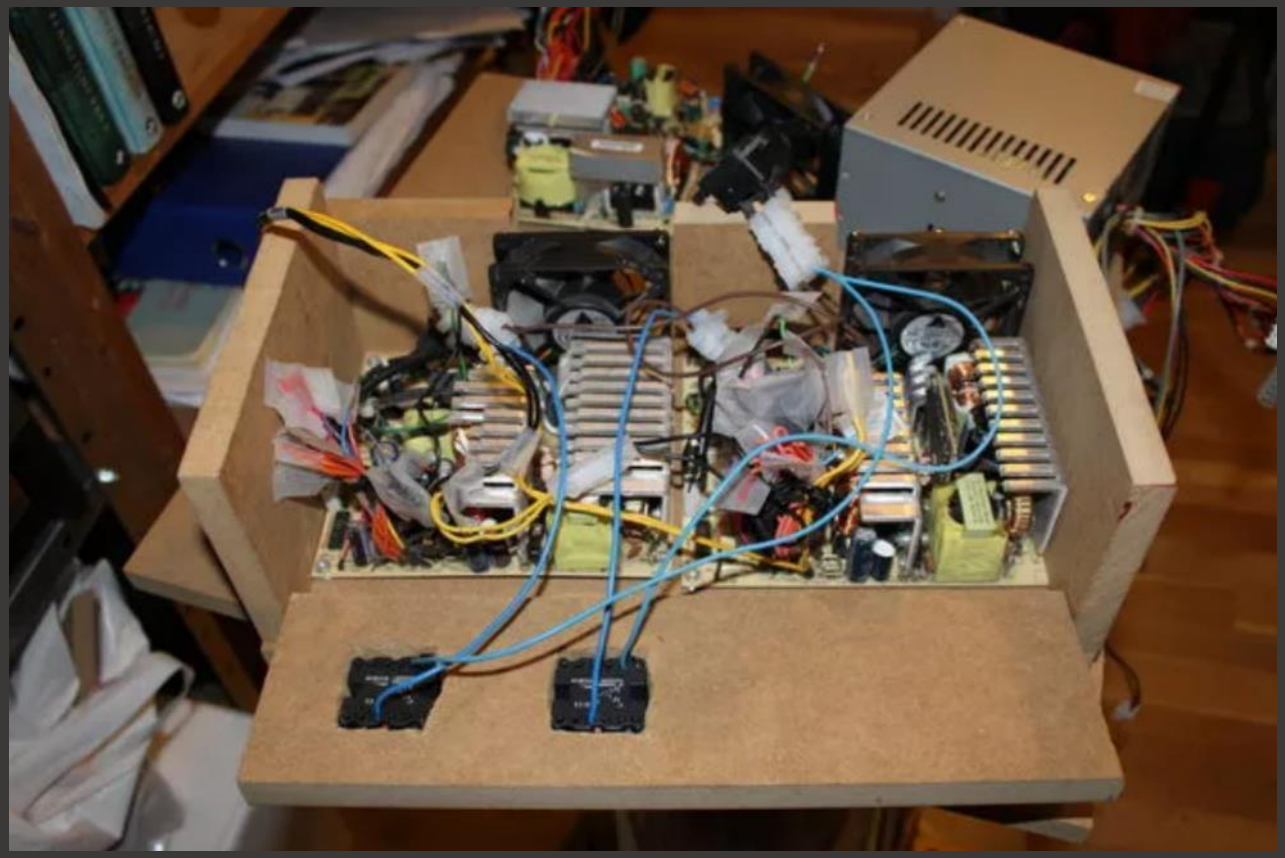
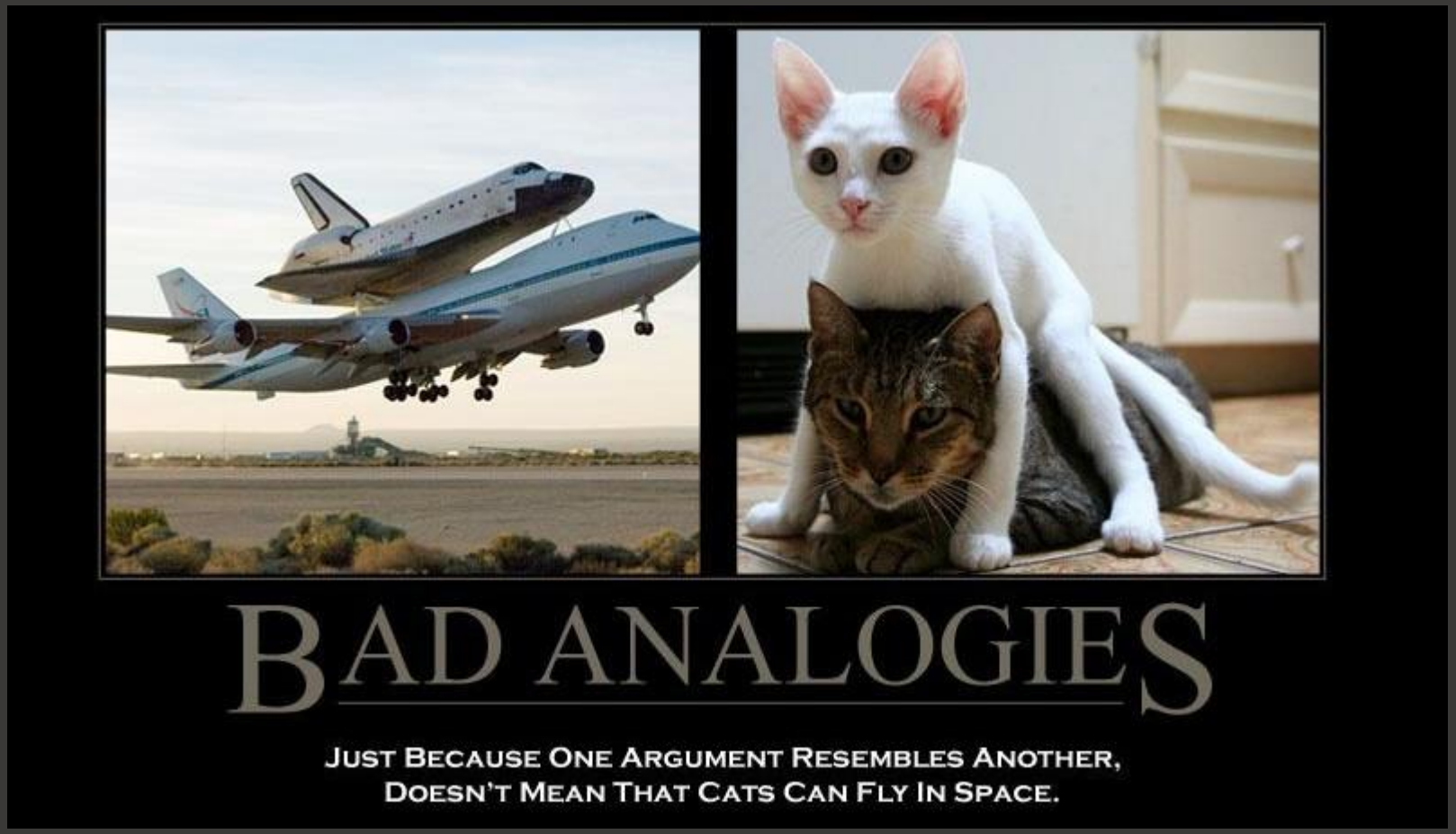
Intro to Electronics

Dec-2023

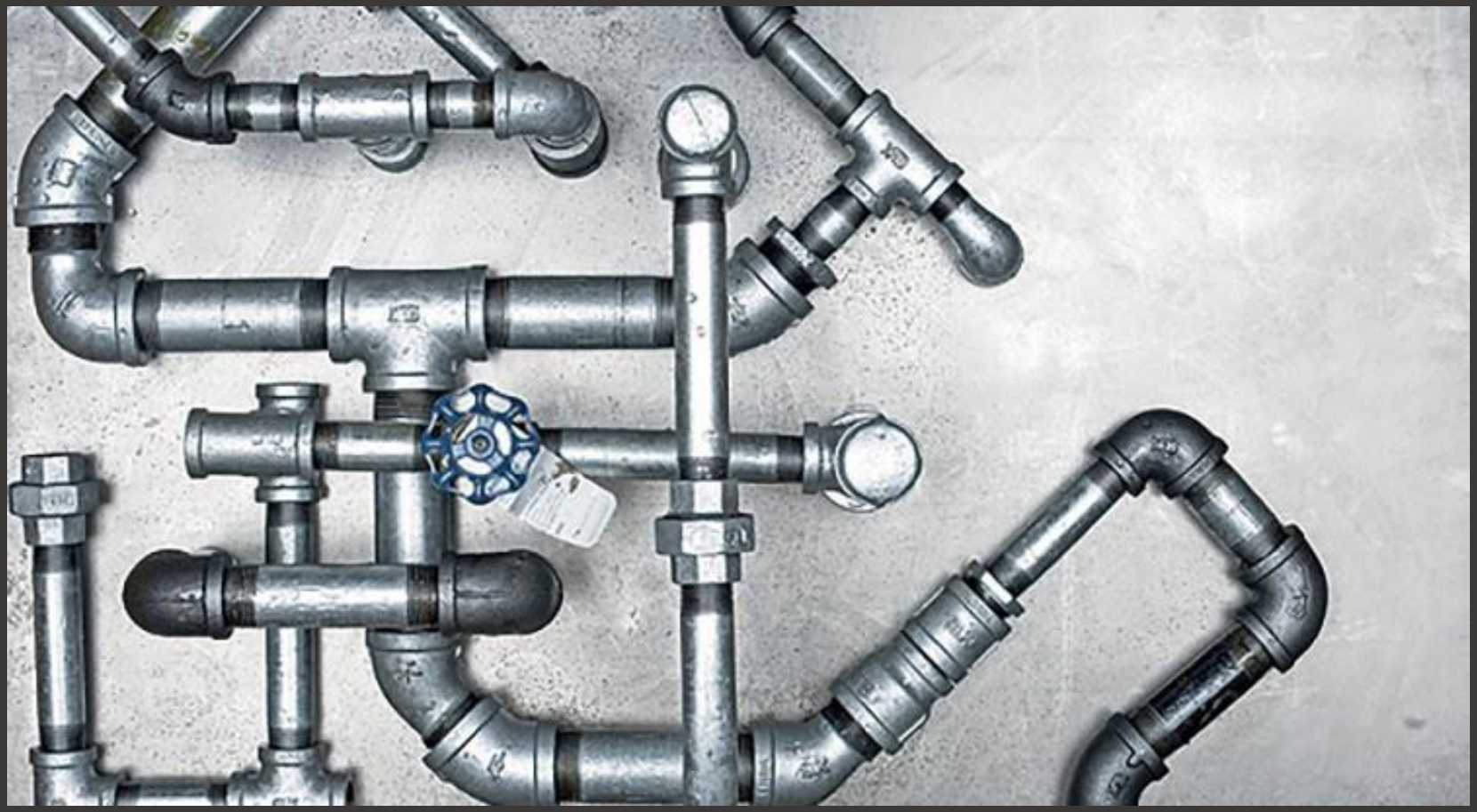


WARNING WARNING WARNING WARNING WARNING

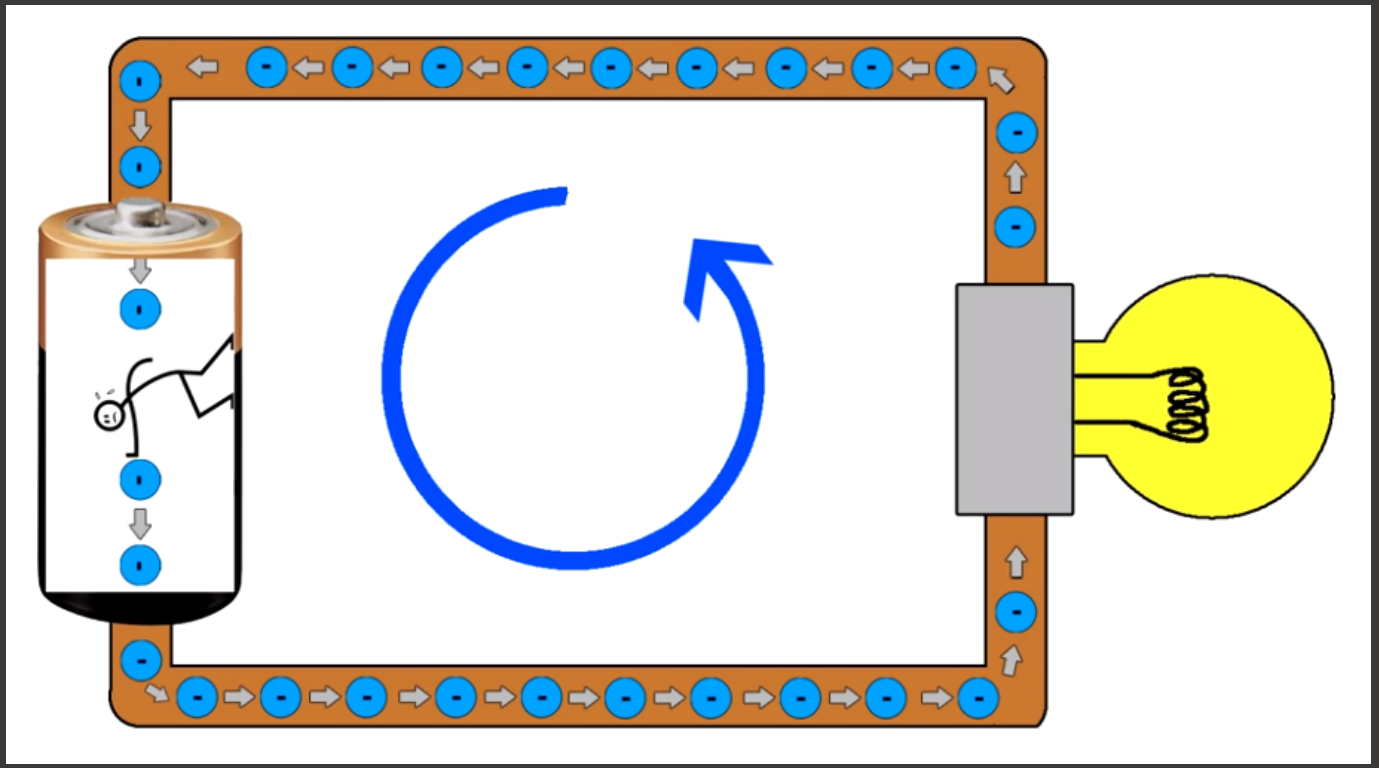
Rules of thumb, assumptions and mixed-quality analogies to come!



Plumbing Analogy

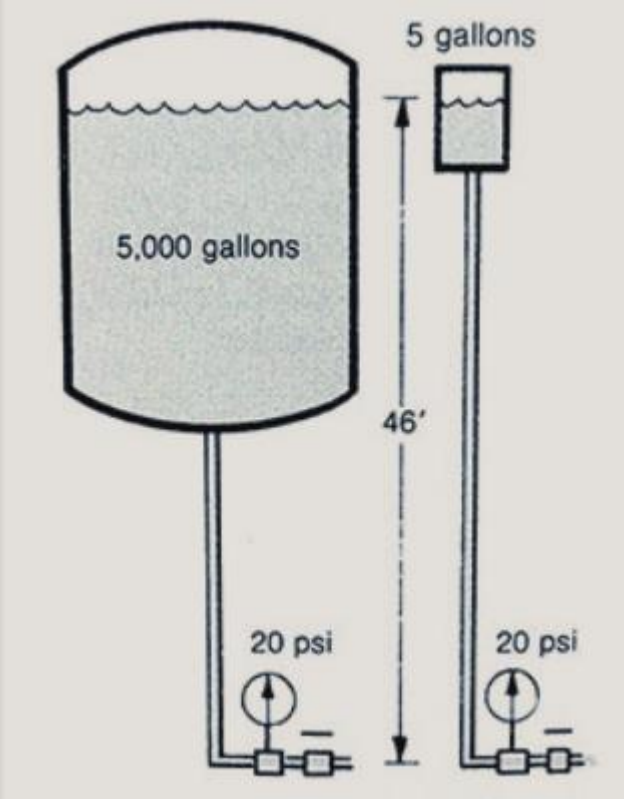


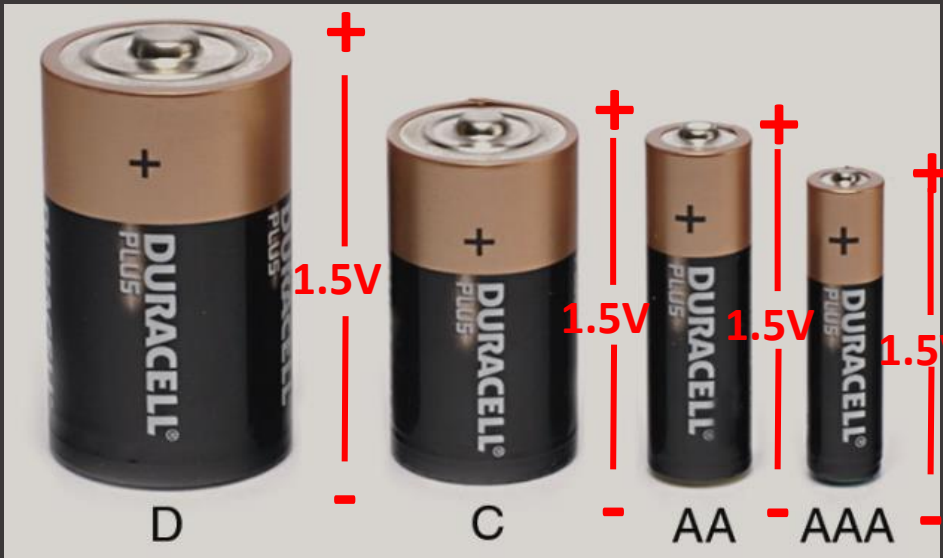
Powering a Light Bulb



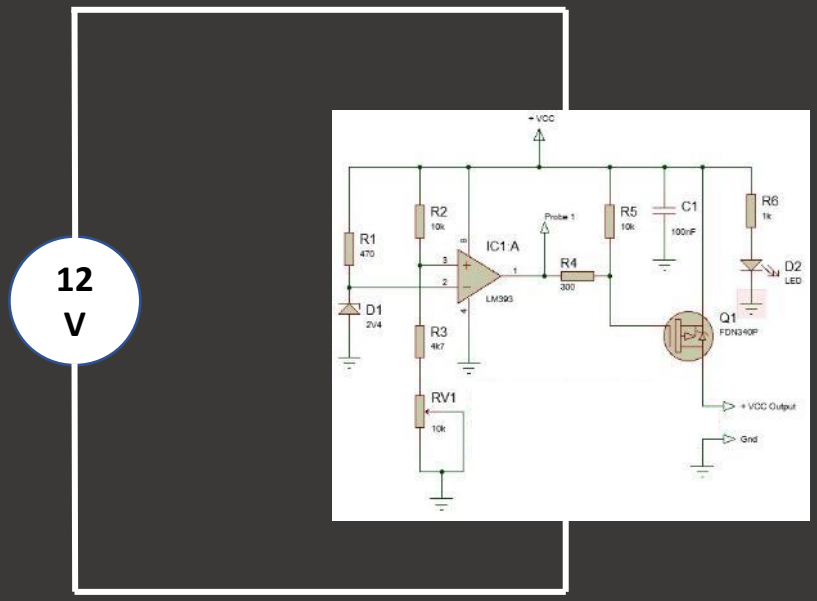
Voltage is the pressure (pushing force)
Pushes electrons through a circuit

Voltage


5 gallons
5,000 gallons
46'
20 psi
20 psi

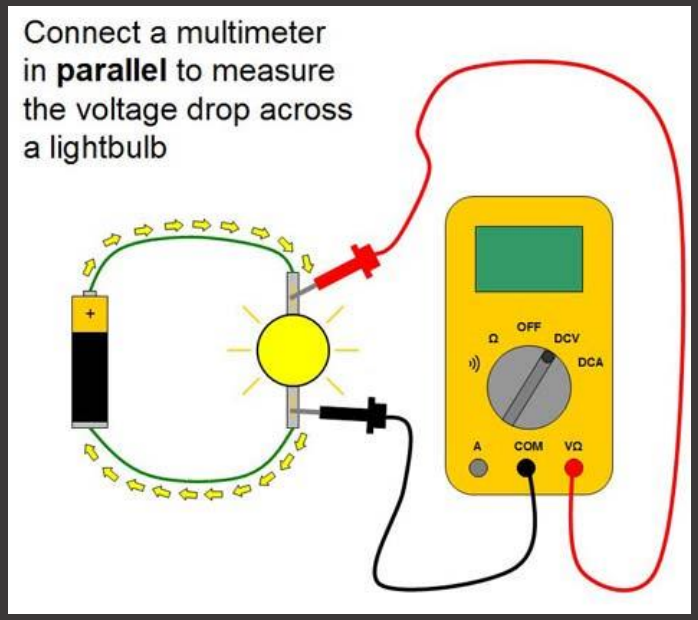

+
1.5V
-
+
1.5V
-
+
1.5V
-
+
1.5V
-
DURACELL
PLUS
D
C
AA
AAA

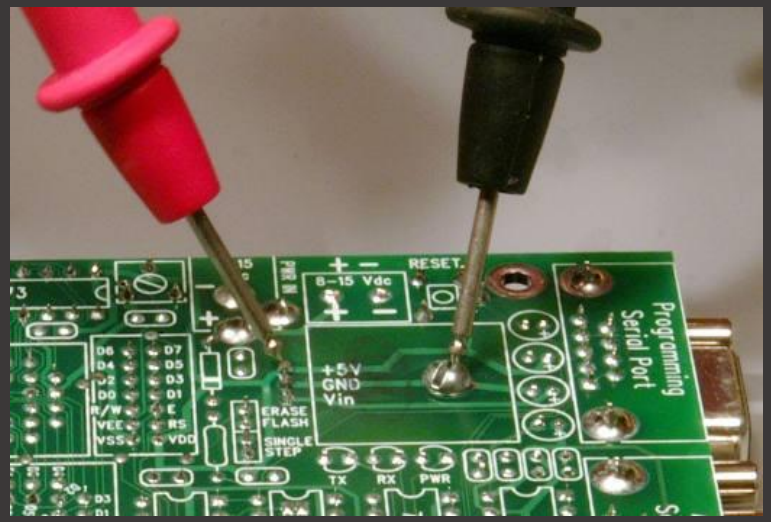
Powering a Complex Circuit



Voltage is applied **<u>across</u>** any circuit to power it

Measuring Voltage



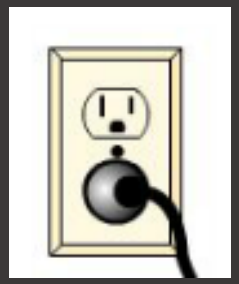


Voltage is measured between/across two points:

- Positive minus negative
- Convention - red minus black

Common Voltages

Volts DC:
9V or 9VDC or 9V DC



110 volts AC
110V or
110V AC or
110VAC

12V DC or
12V

Let’s Try It!

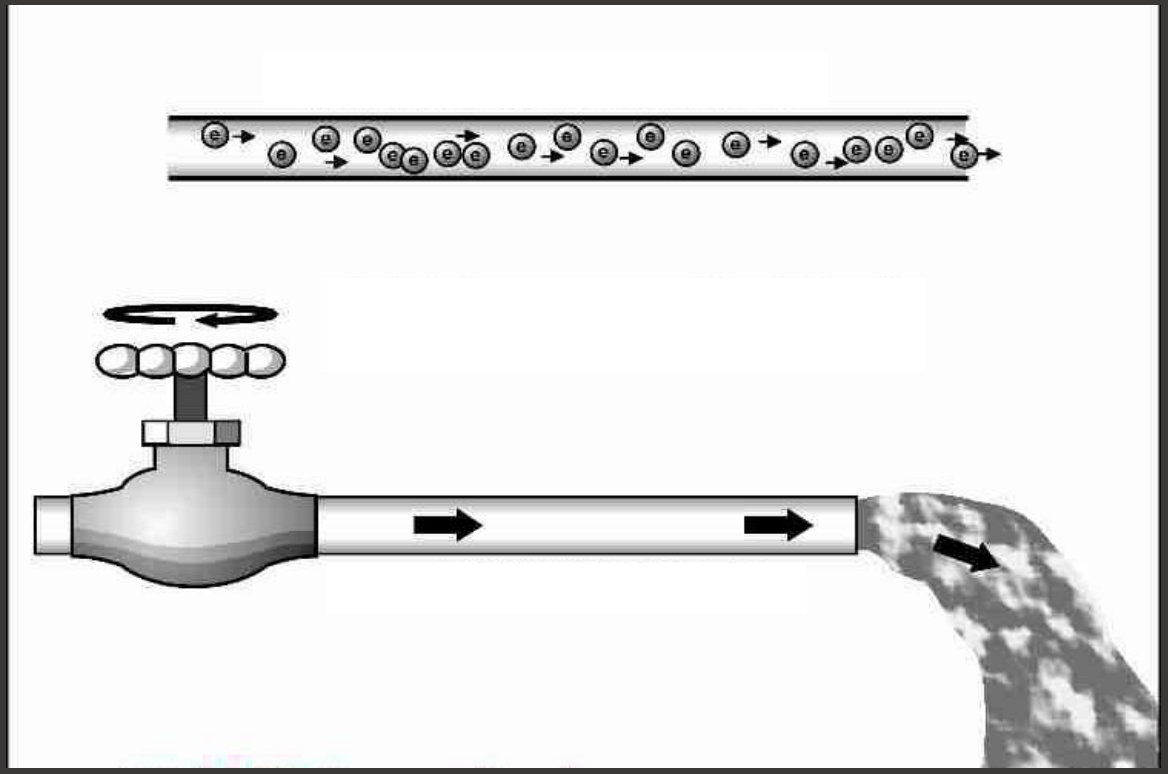
5V DC

Jumper

2.5V DC

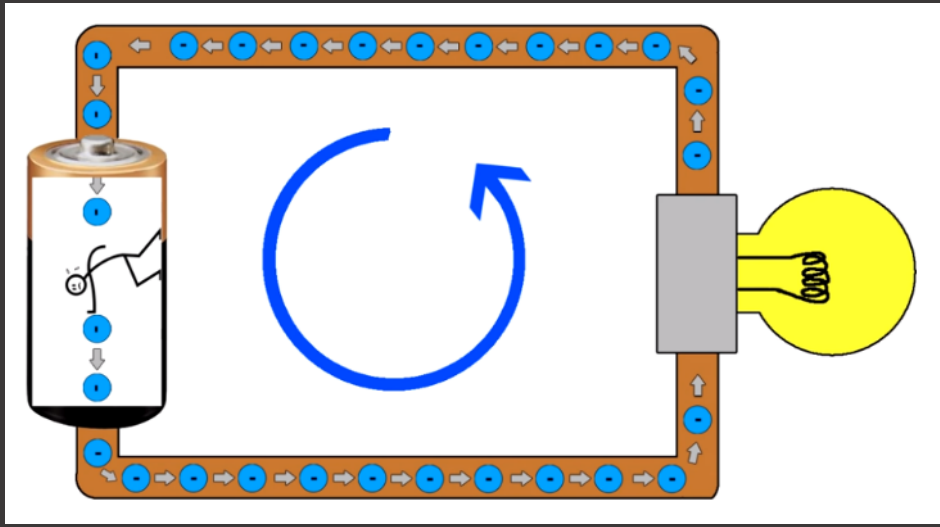
Ground

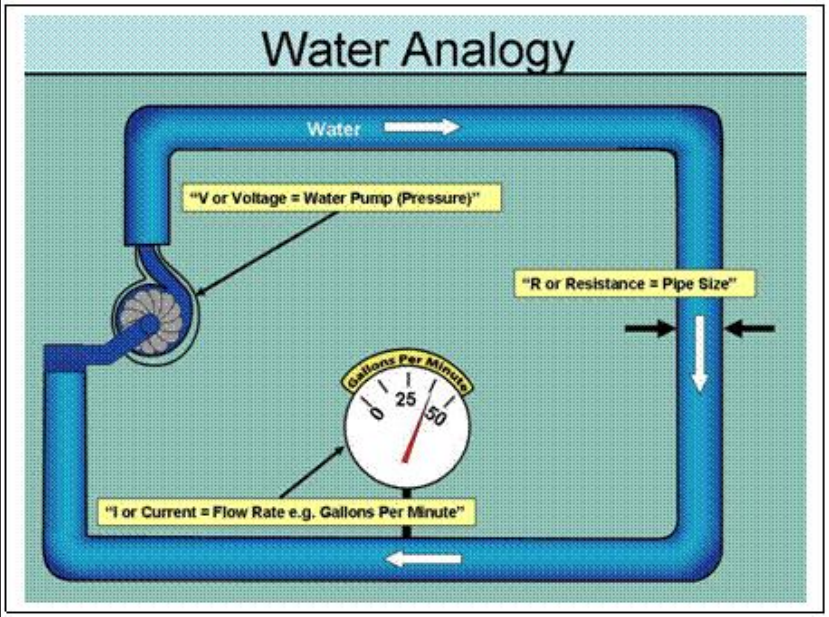
Current



Current is the flow of electrons
Similar to the flow of water

Current

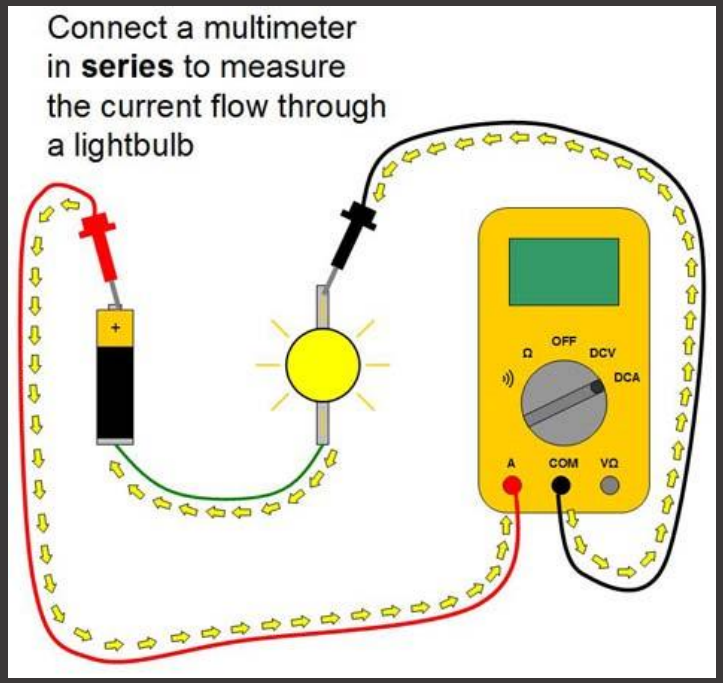




Measured in amps

1A (1 amp) = 6.25×10^{18} electrons per second

Measuring Current

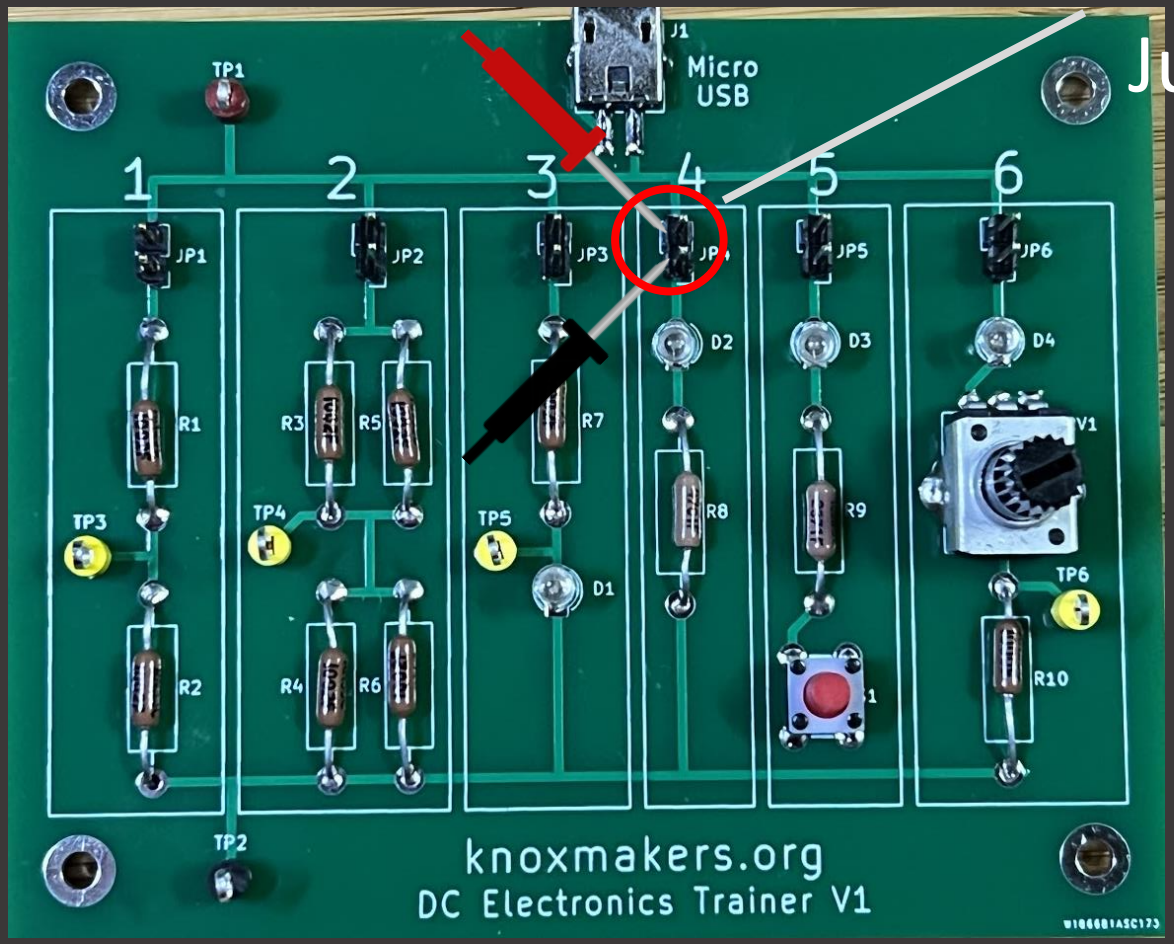


Current can be measured by passing it through a multimeter

Let's Try It!

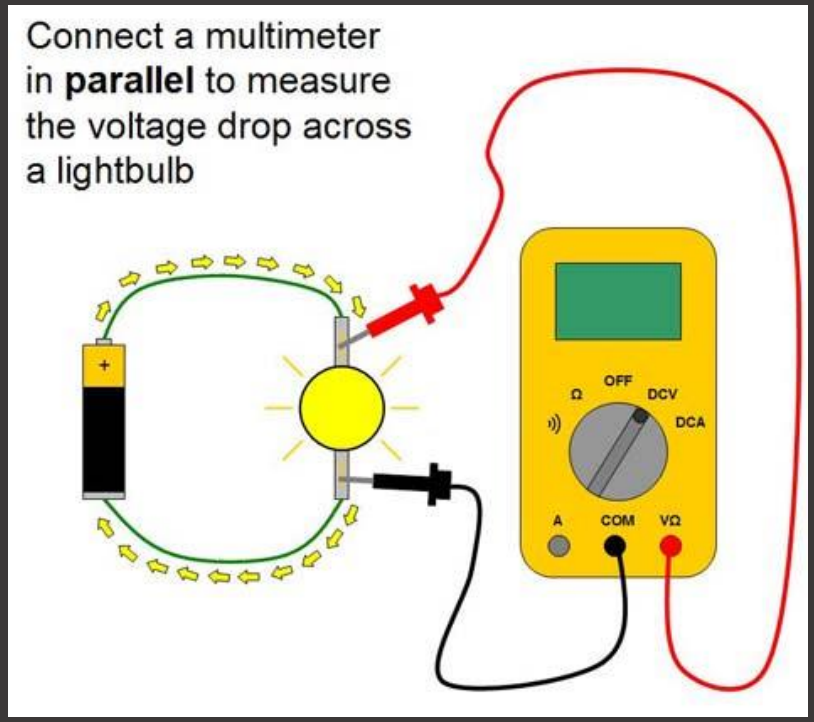
~0.5mA DC

Remove Jumper

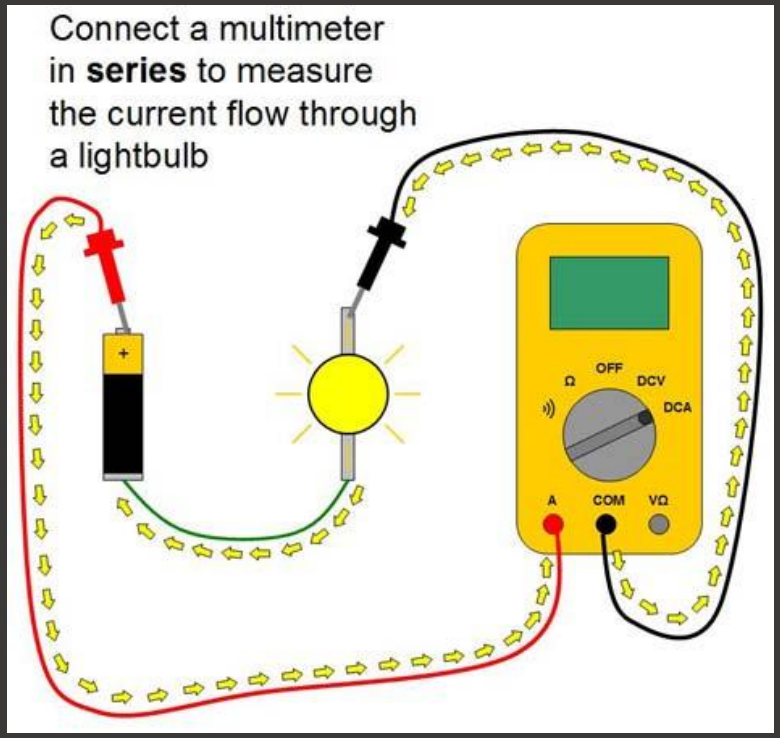


“Voltage Across” – “Current Through”

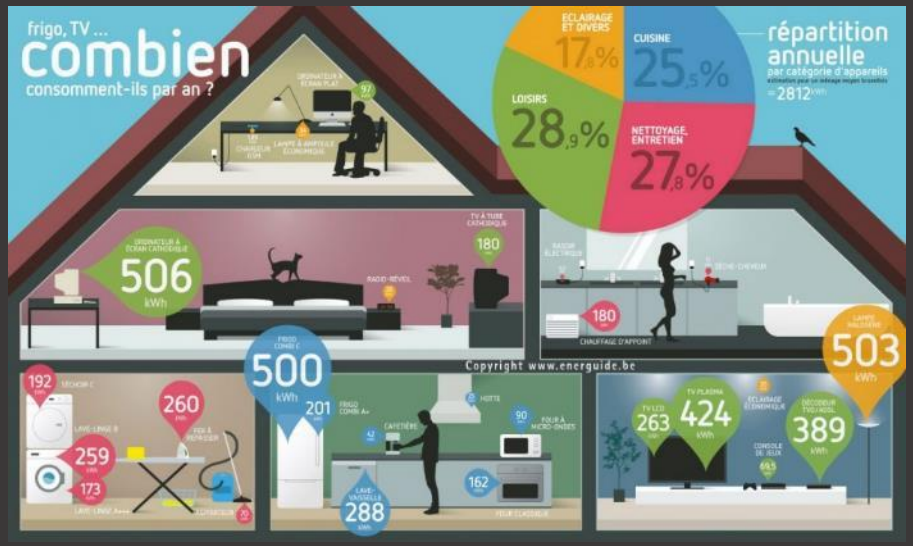
Voltage



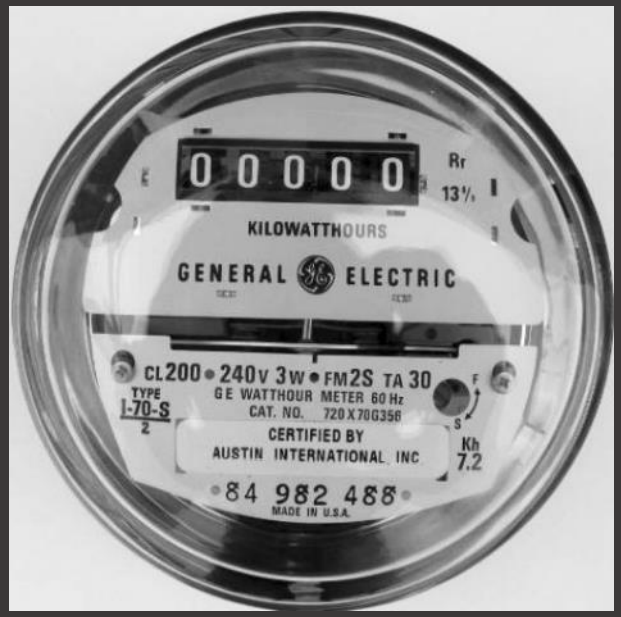
Current



Power



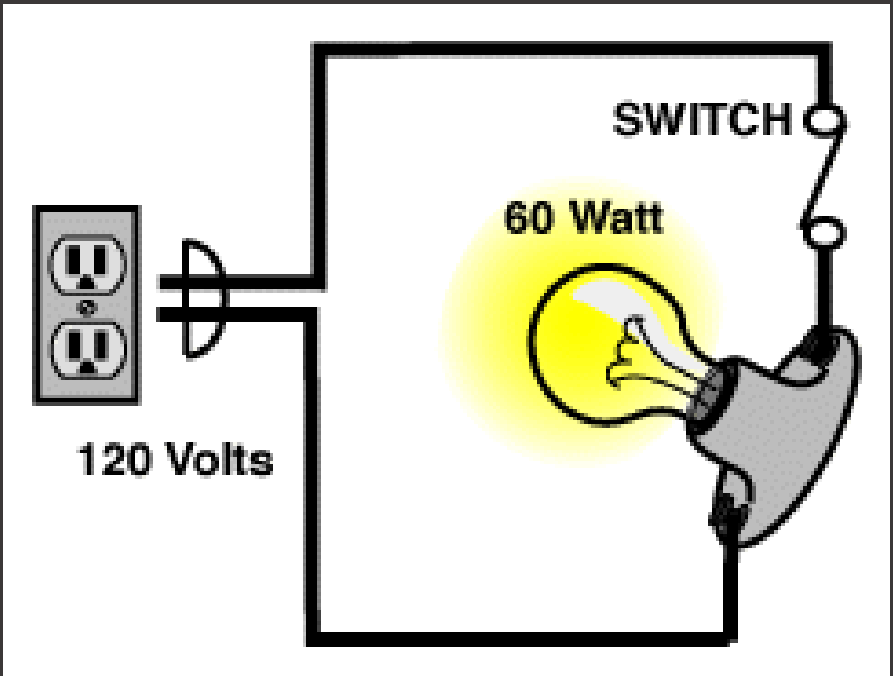
Power = Watts = Amount of energy used at a particular point in time



Energy = Power x Time = W x hr
Total energy used over a period of time

Calculating Power

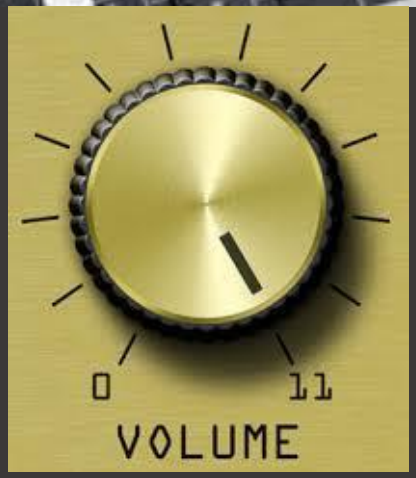
Power = Voltage x Current



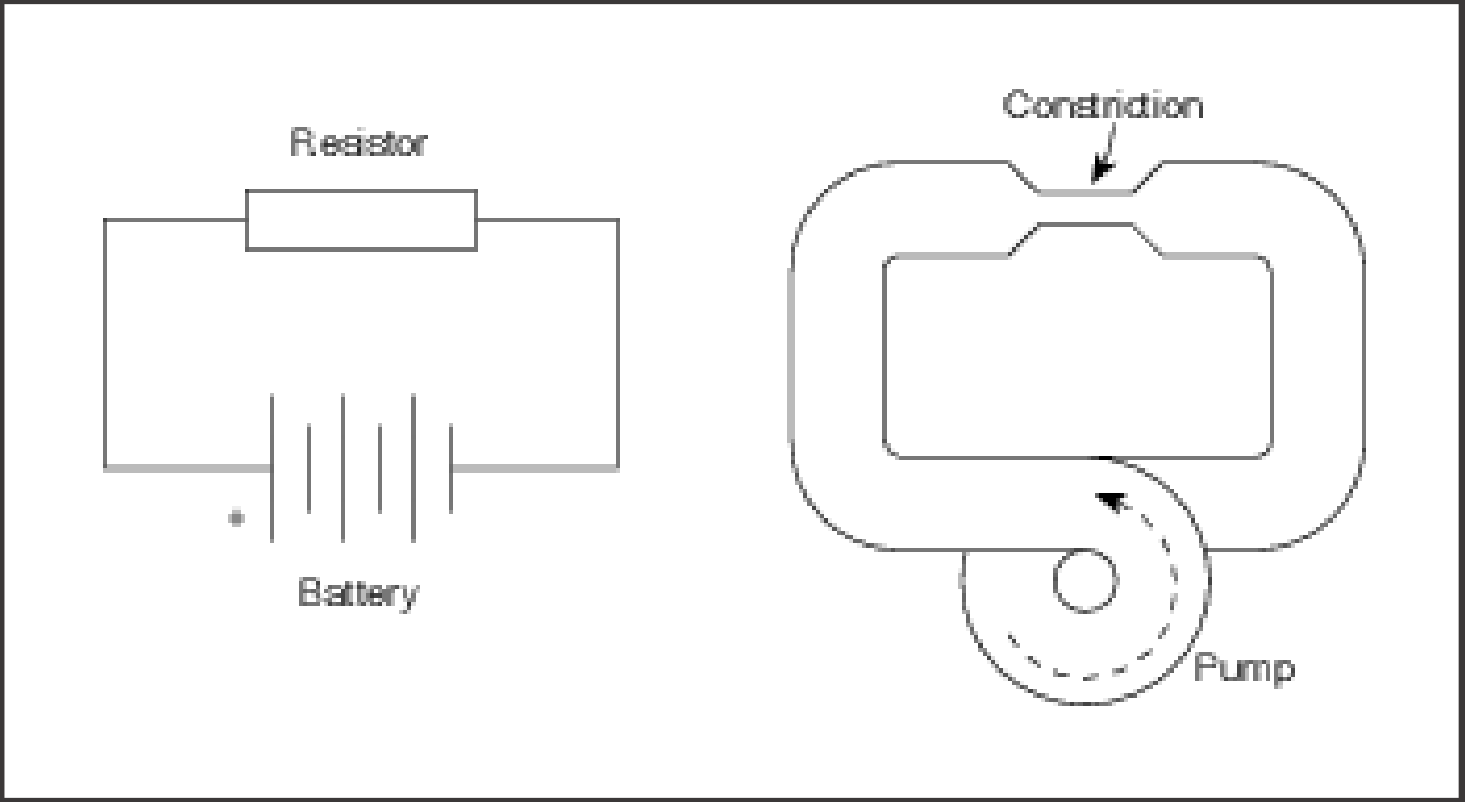
120V x 0.5A = 60W

Resistors – A minute to learn, a lifetime to master

We use them every day



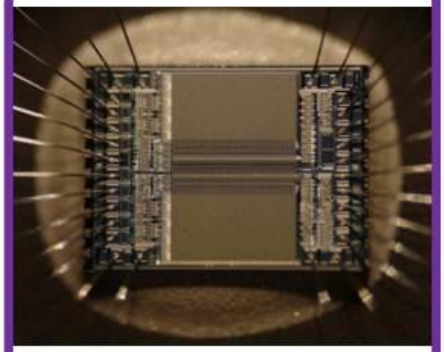
Resistors – Resist the flow of current



Resistance – measured in Ohms (Ω)

Conductors vs Insulators

Conductors

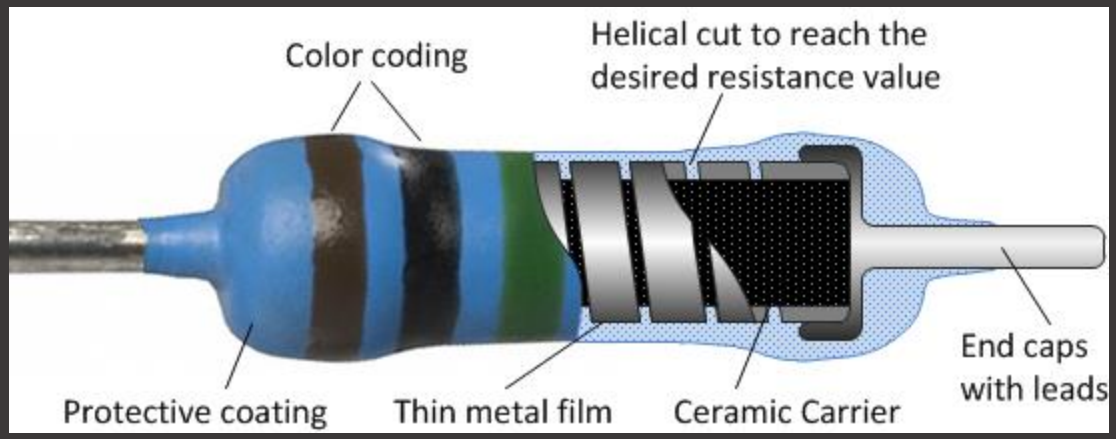


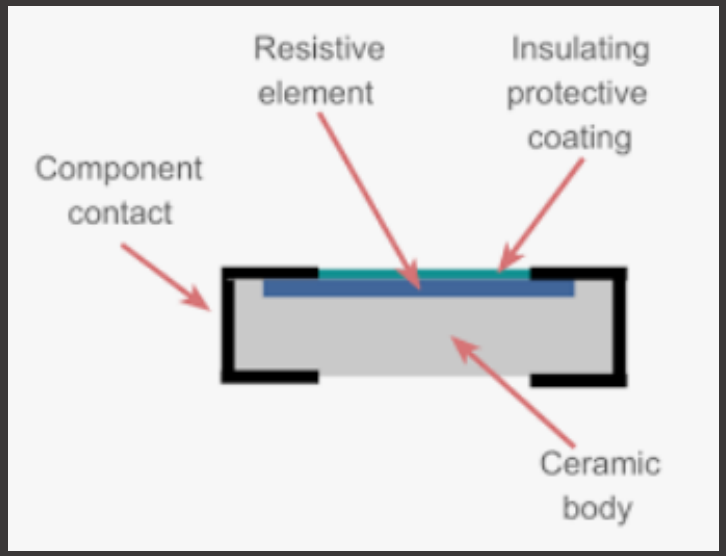
Semi-conductors

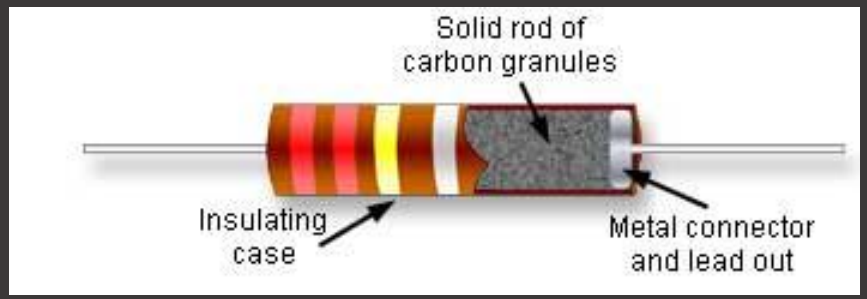
Insulators

All Shapes and Sizes

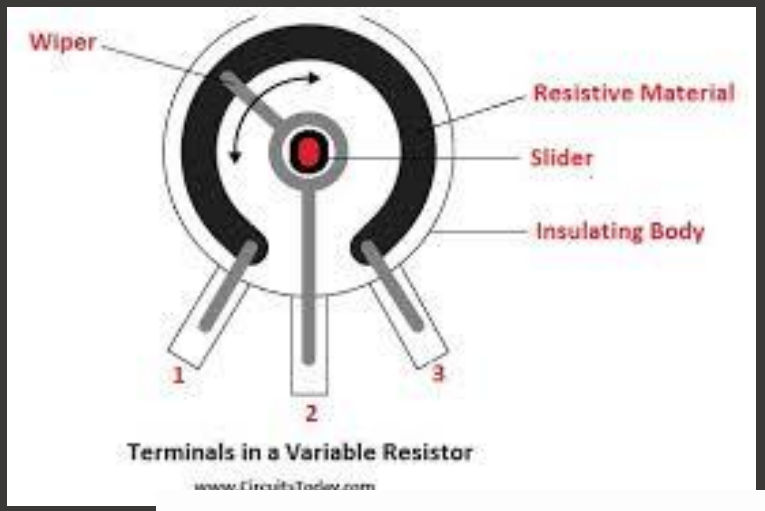
Fixed Resistors – Construction



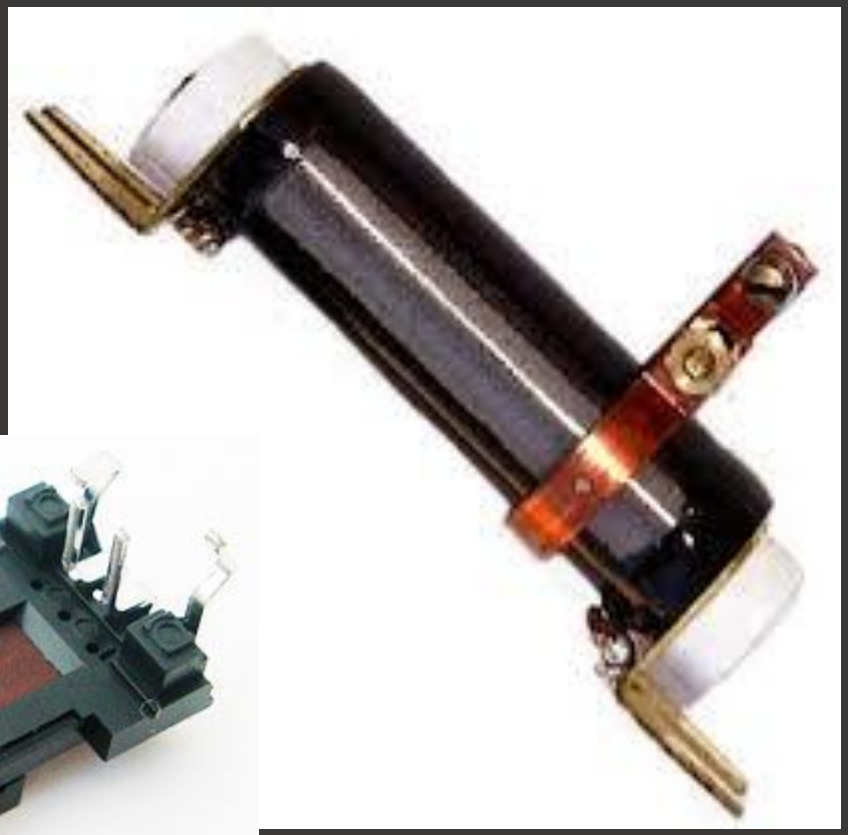


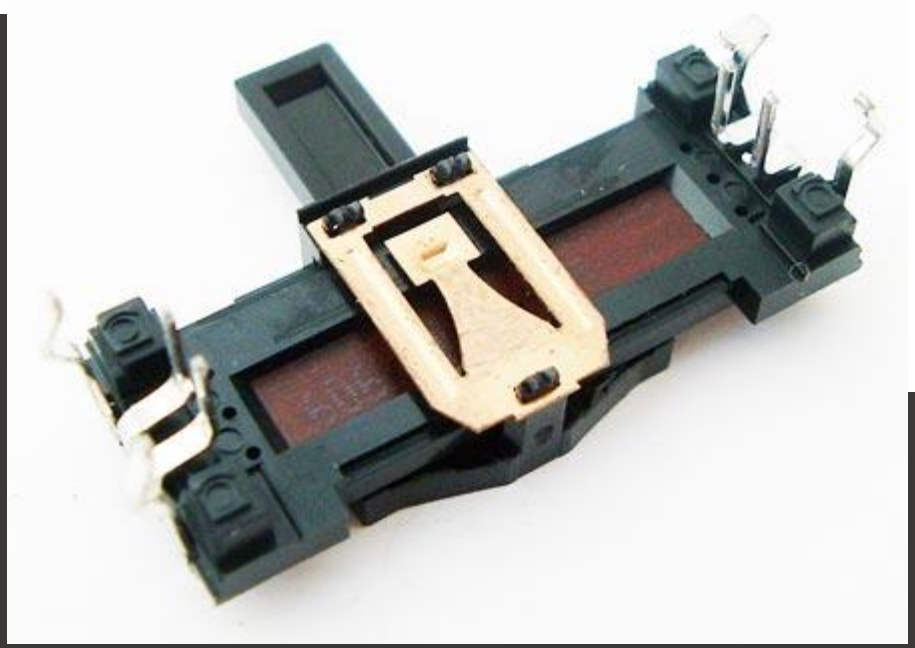


Variable Resistors – Construction

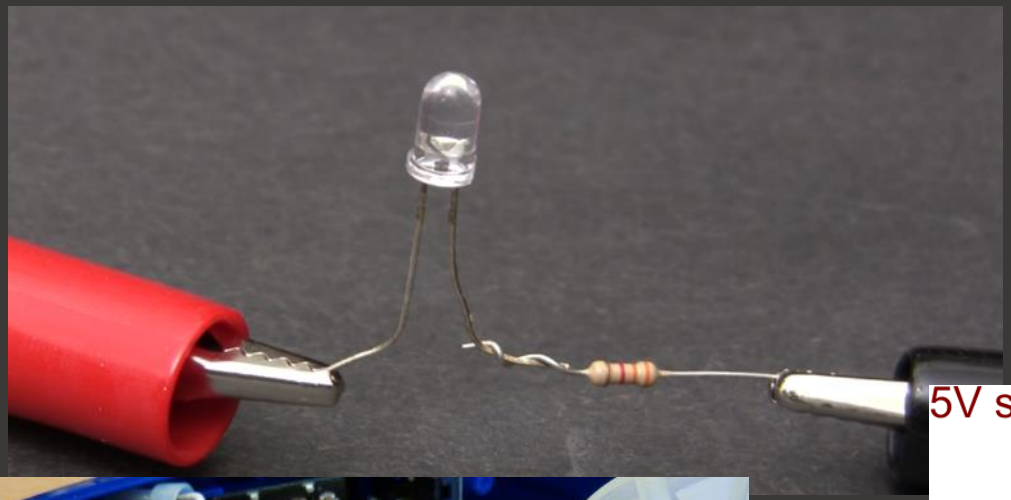


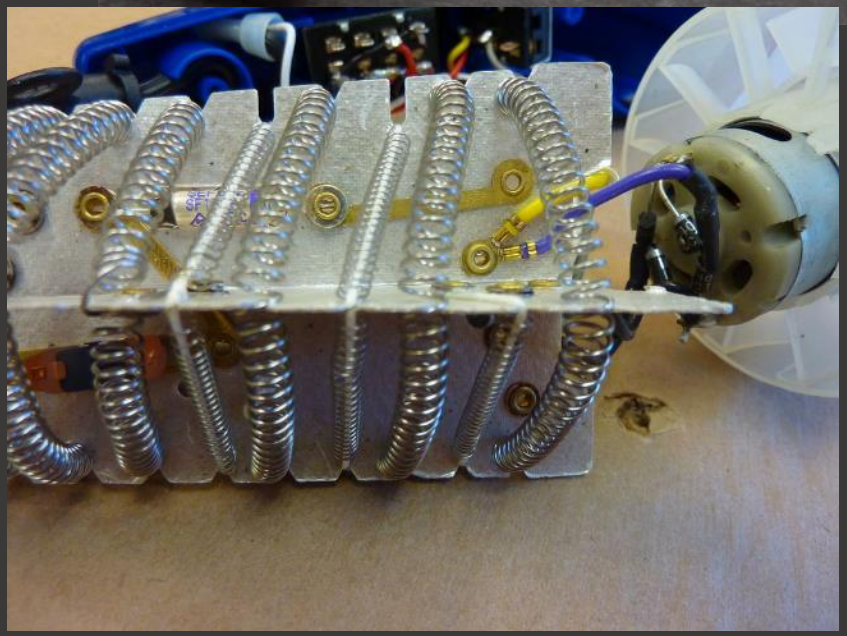
Terminals in a Variable Resistor

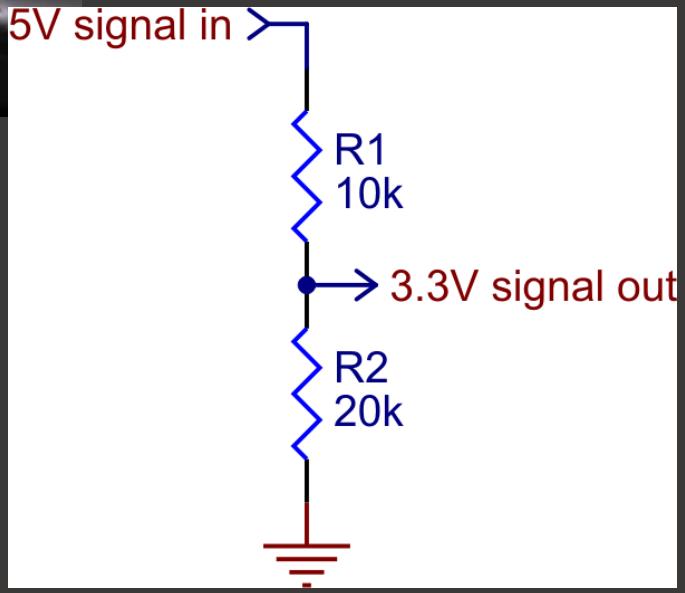




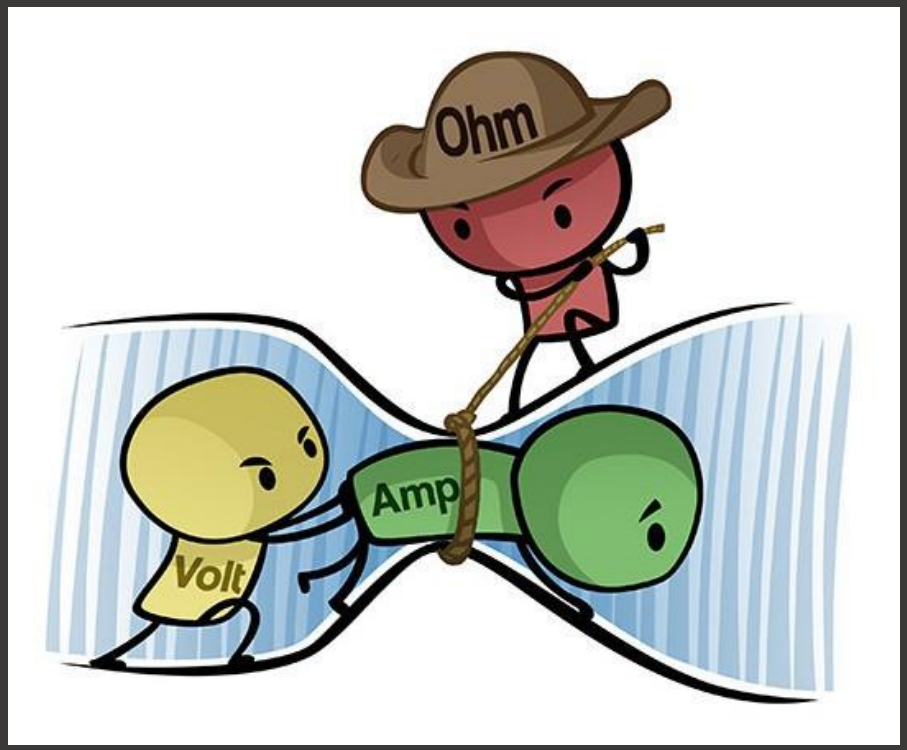
Resistors – Simple but useful!







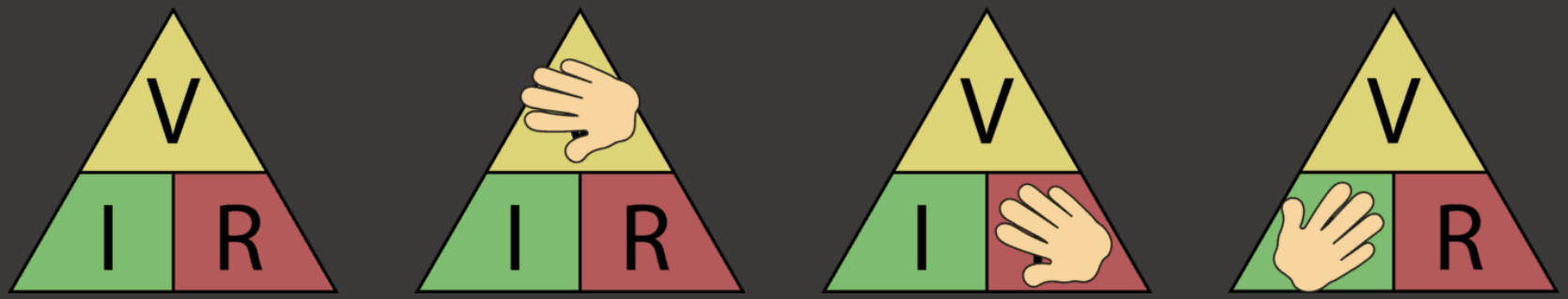
Ohm's Law



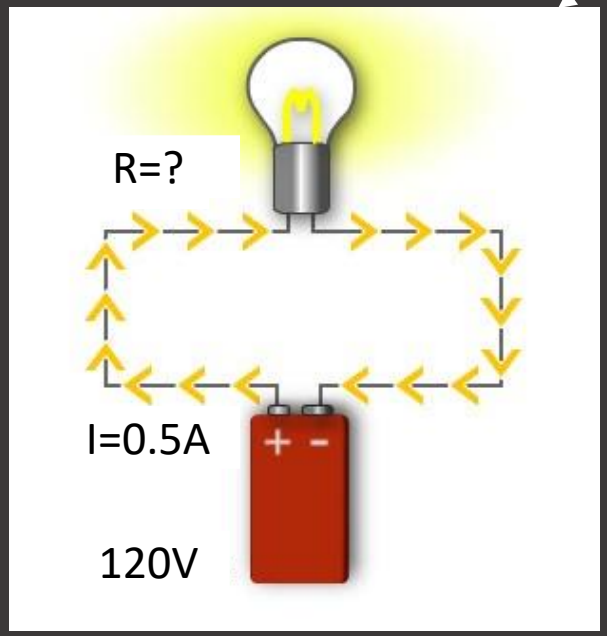
$$V = I * R$$

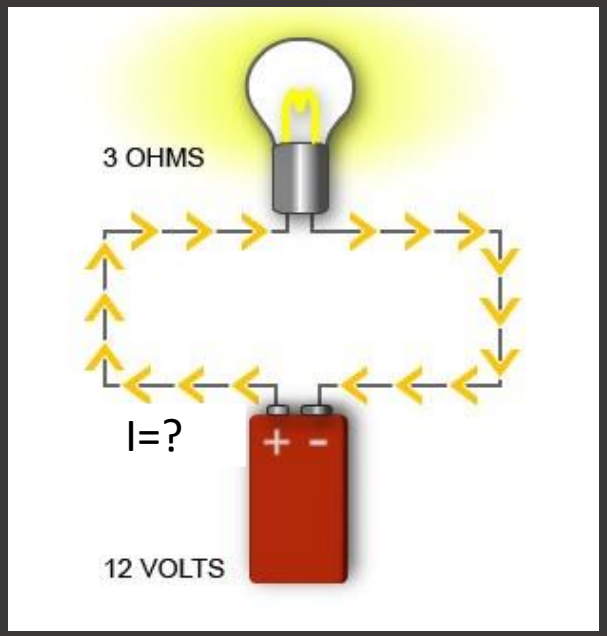
Special Relationship between voltage, current, resistance

Ohm's Law



$V = I * R$ $R = V / I$ $I = V / R$

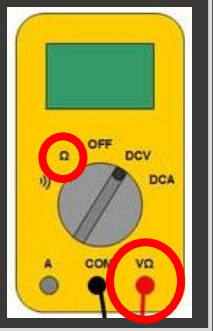




Let's Try It!

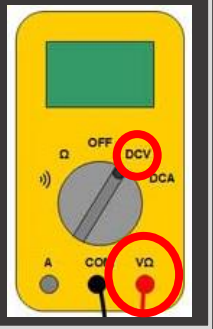
Remove jumper, measure R

R = 4.7kΩ



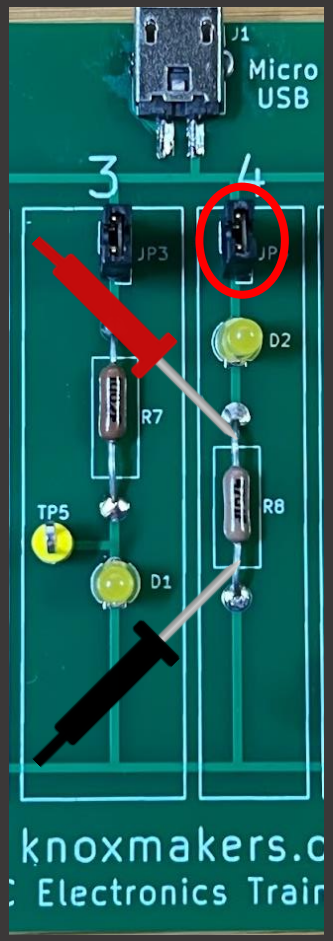
Place jumper, measure V

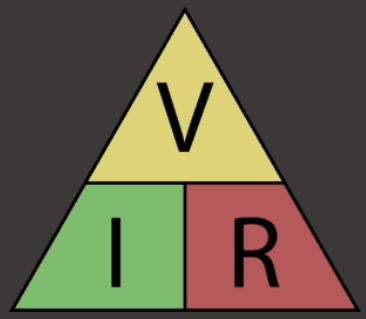
V = 2.5V



Remove jumper, measure I

V = 0.53mA



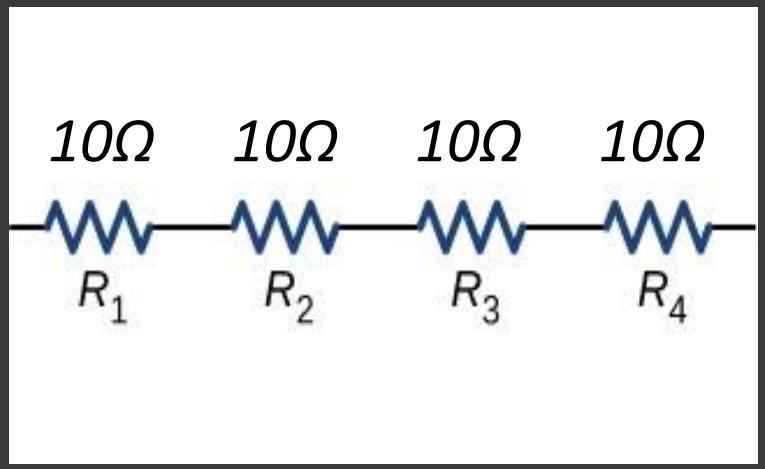


V = I * R

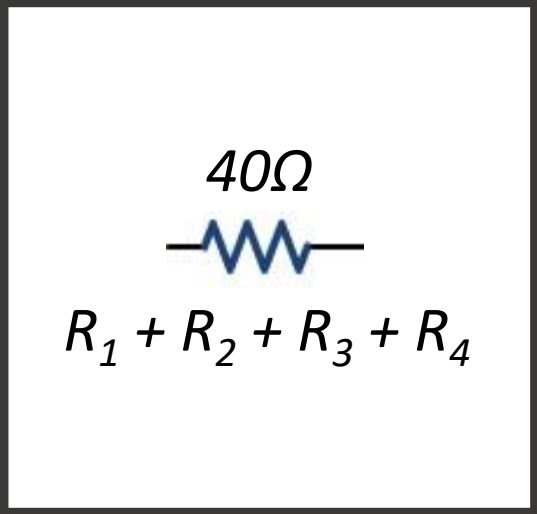
R = V / I

I = V / R

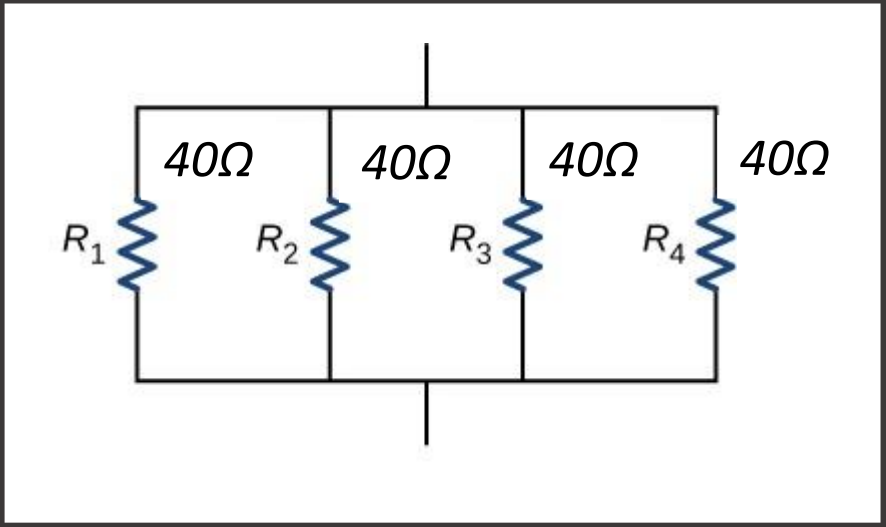
Resistors in Series



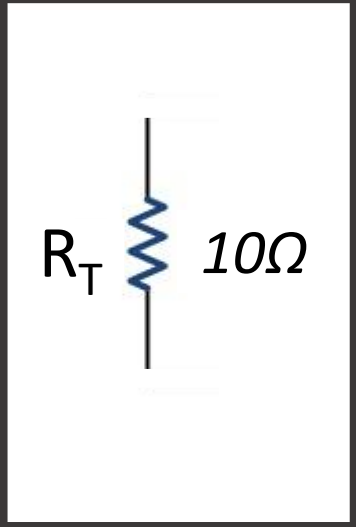
=



Resistors in Parallel



=

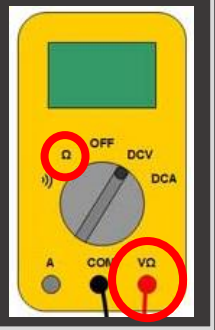


$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}$$

Let's Try It!

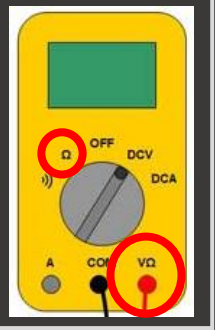
Remove jumpers, measure each R

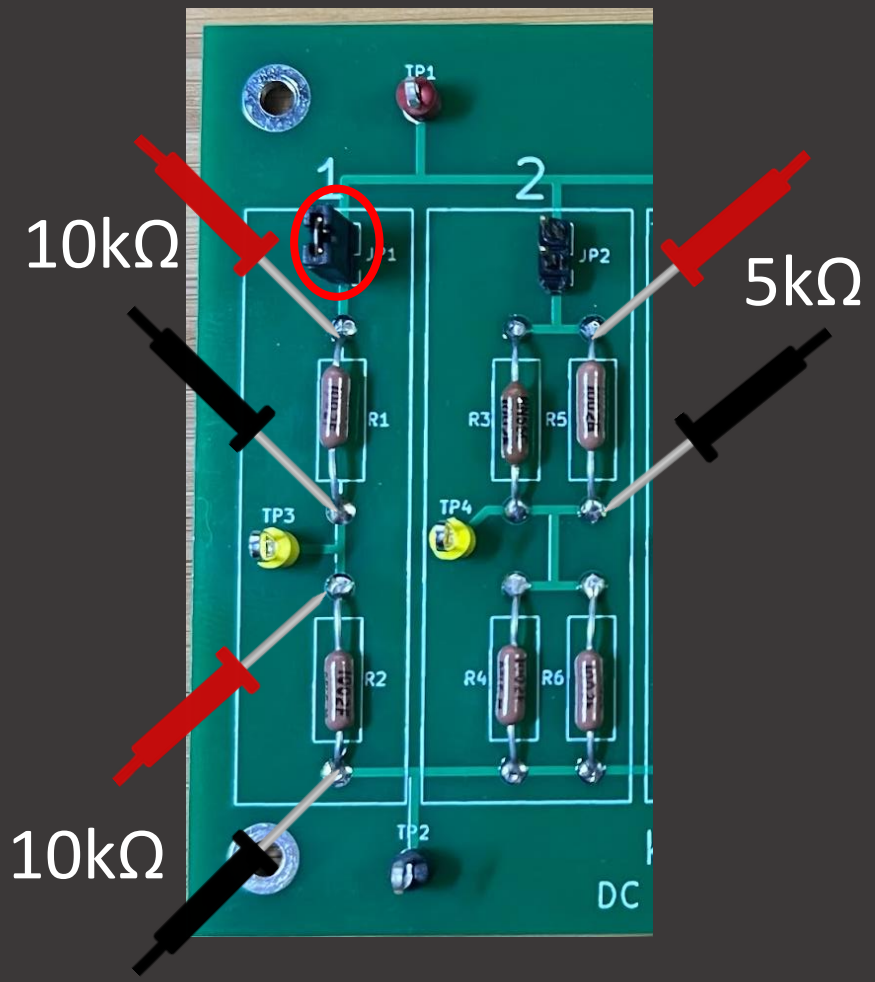
$R_1 = R_2 = 10k\Omega$



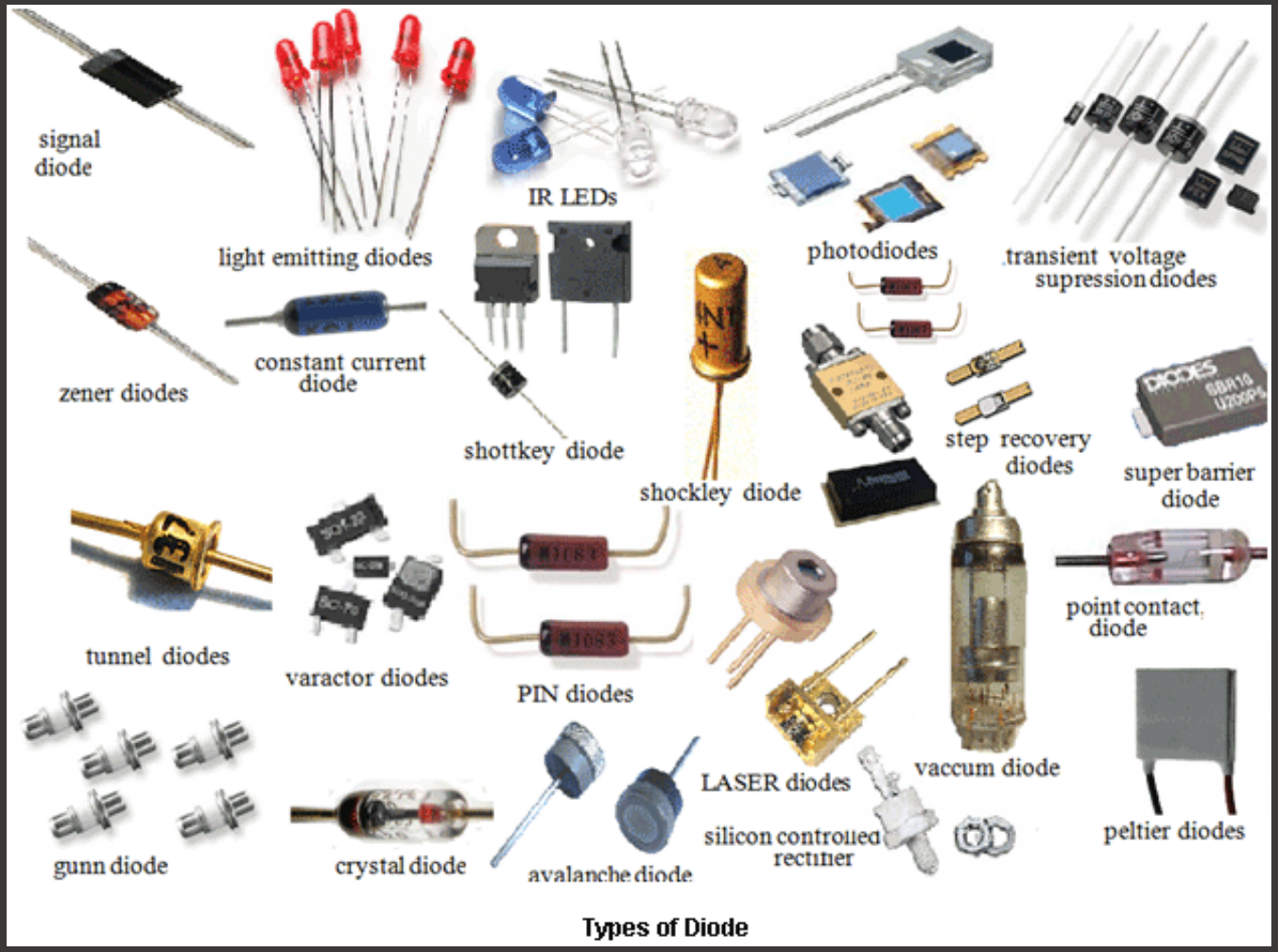
$R_3//R_5 = 5k\Omega$

$R_3 = R_5 = 10k\Omega$





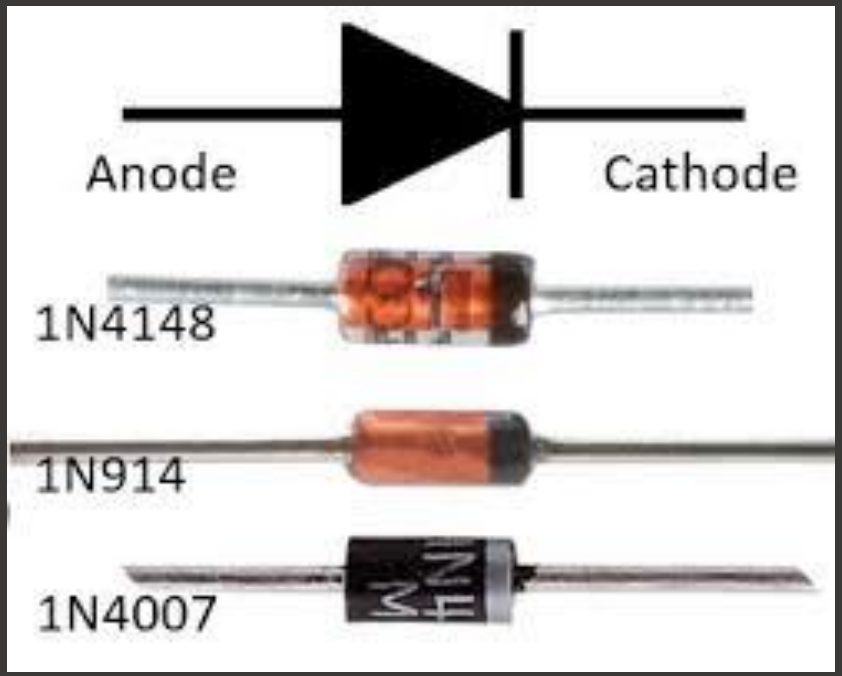
Diodes/LEDs


signal diode
light emitting diodes
IR LEDs
photodiodes
transient voltage supression diodes
zener diodes
constant current diode
shottkey diode
shockley diode
step recovery diodes
super barrier diode
tunnel diodes
varactor diodes
PIN diodes
point contact diode
vaccum diode
LASER diodes
silicon controlled rectifier
peltier diodes
gunn diode
crystal diode
avalanche diode
Types of Diode

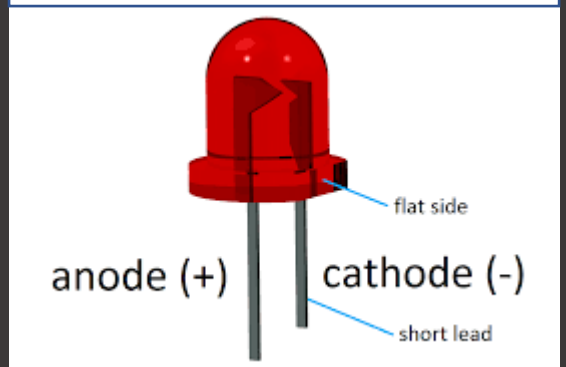
Diodes – Everyday Uses

Diodes – One-Way Gate

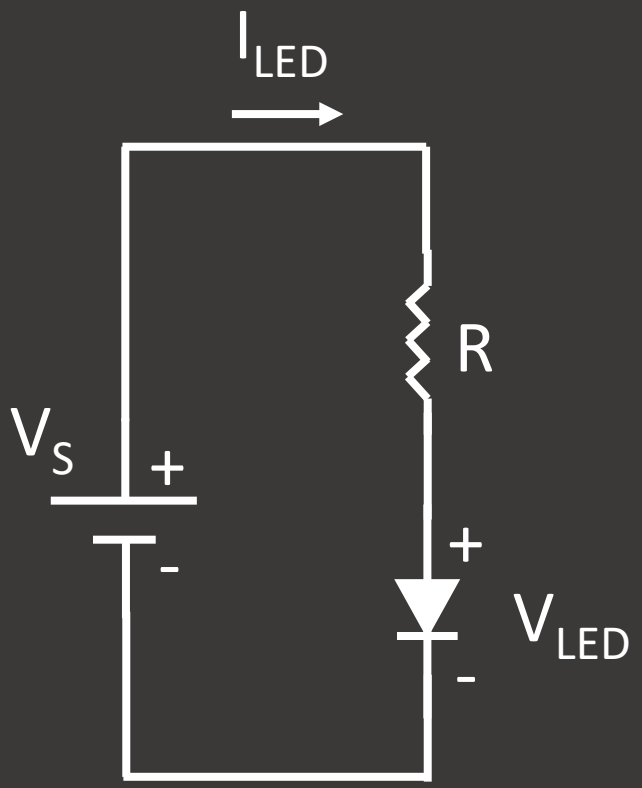
Current Flow



LED



How to use a diode

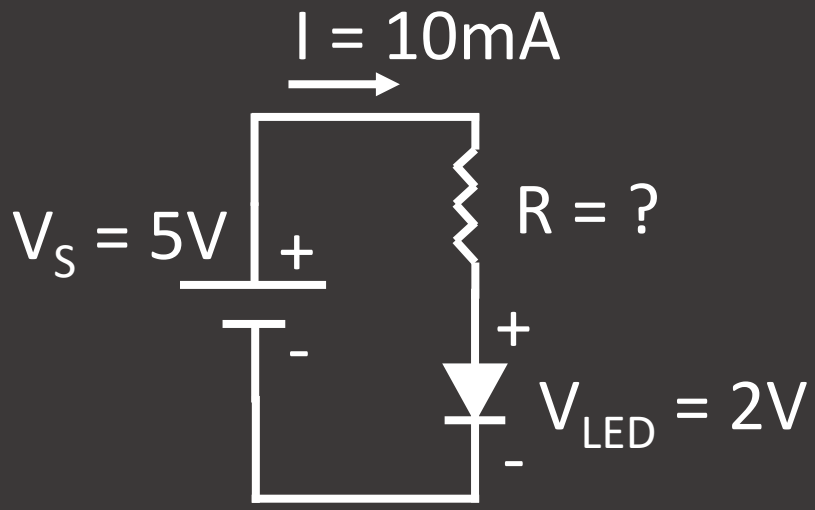


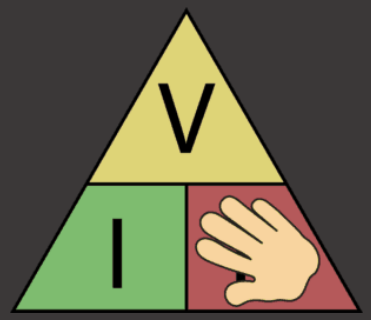
$V_S \geq V_{LED} + 1V$

I_{LED} ~ 10-20mA

V_{LED} ~ 1.8-3.3V

Practical Circuit





R = V / I

R = (5V – 2V) / 0.01A

= 3V / 0.01A

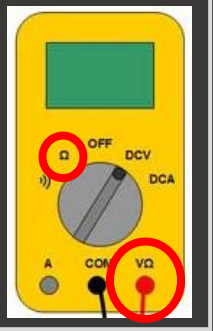
= 300Ω

Let's Try It!

Turn knob to set brightness

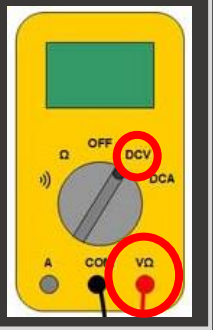
Remove jumper, measure R

R = 100Ω



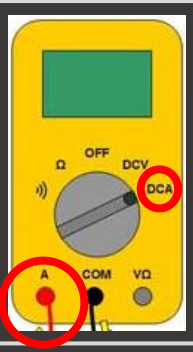
Place jumper, measure V

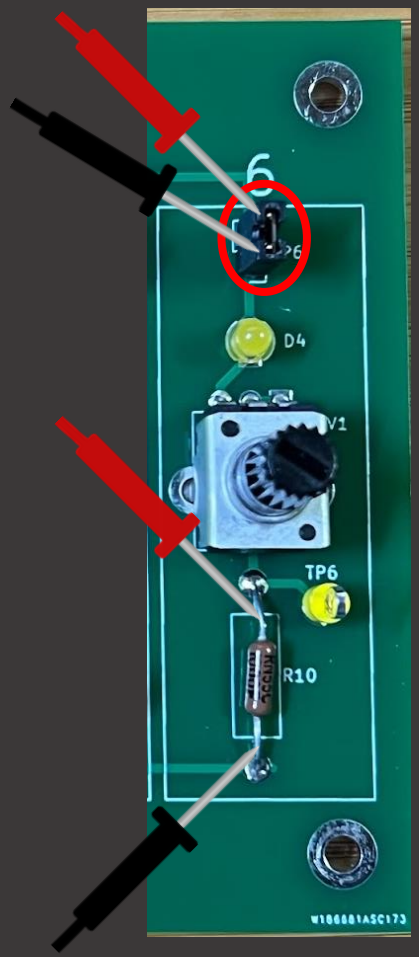
V = 2.5V

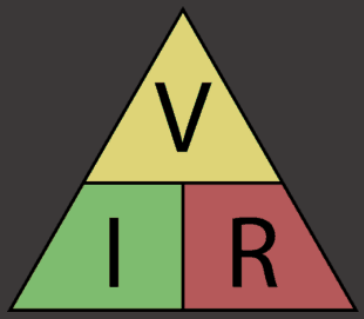


Remove jumper, measure I

V = 0.53mA







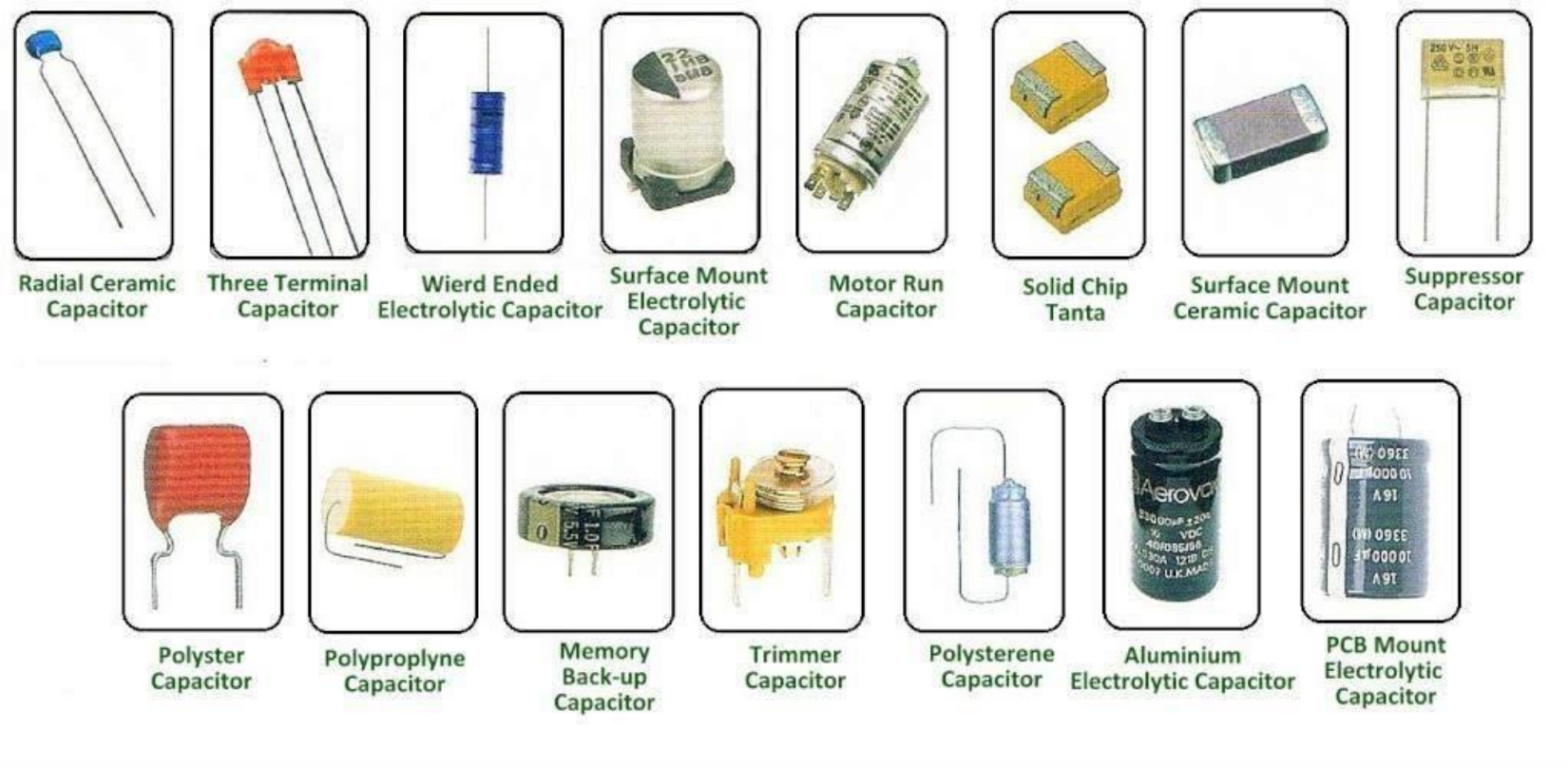
V = I * R

R = V / I

I = V / R

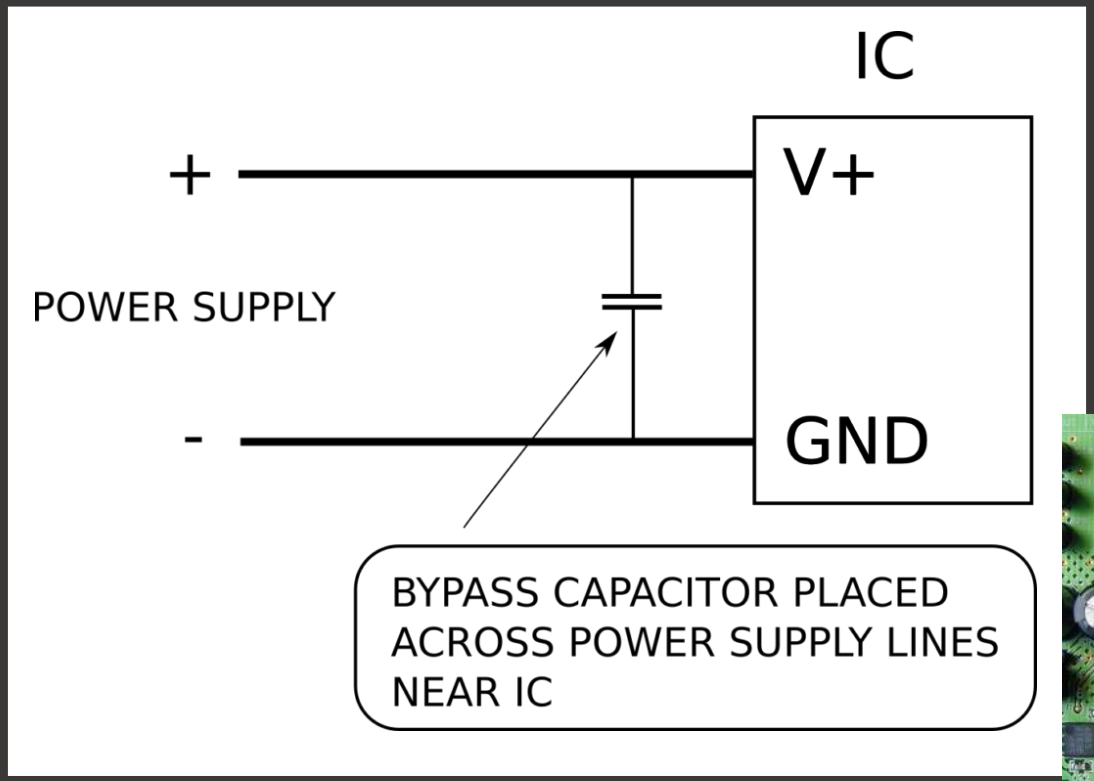
Switches

Capacitors


Radial Ceramic Capacitor
Three Terminal Capacitor
Wierd Ended Electrolytic Capacitor
Surface Mount Electrolytic Capacitor
Motor Run Capacitor
Solid Chip Tanta
Surface Mount Ceramic Capacitor
Suppressor Capacitor
Polyster Capacitor
Polyproplyne Capacitor
Memory Back-up Capacitor
Trimmer Capacitor
Polysterene Capacitor
Aluminium Electrolytic Capacitor
PCB Mount Electrolytic Capacitor

Similar to Batteries

“Supply Bypass” Capacitors



Further Reading

Falstad Circuit Simulator – Runs in Browser
Kahn Academy – Introduction to EE
Mattermost Channel
YouTube Videos
All About Circuits

- https://www.allaboutcircuits.com/education/

Sparkfun – learn.sparkfun.com
Adafruit - learn.adafruit.com/