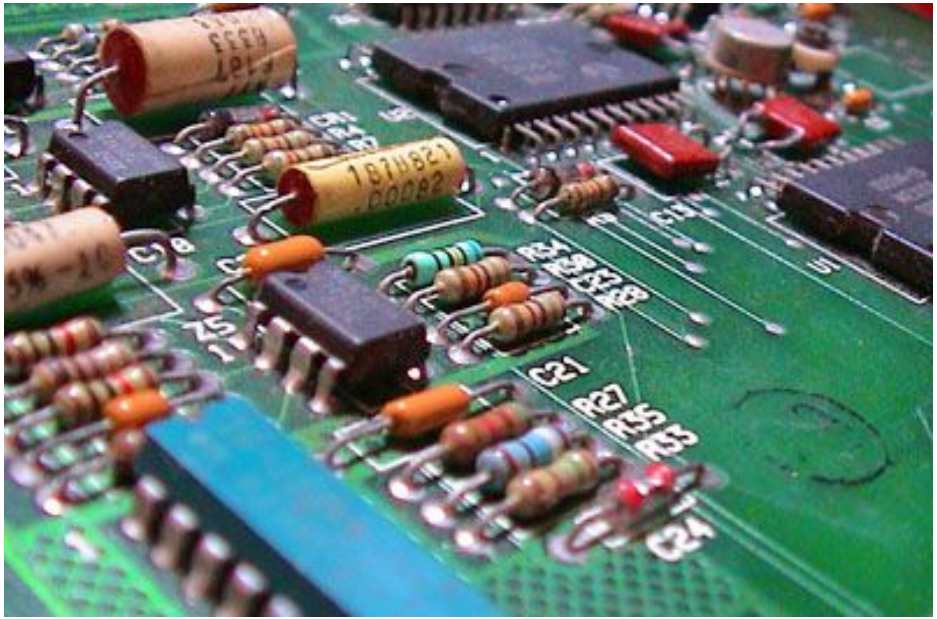


Electronics and Electricity Basics

John R. Leeman

GEARS 2023

LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: WikiPedia

A Few Safety Notes

- Never work on high voltage DC or any AC systems unless qualified
- This class doesn't qualify you
- Don't work on live systems if possible
- Don't work alone
- Unsure? Stop
- Did I mention this course doesn't make you an electrician?

Image: FieldVibe

“Anything can be a fuse” - A Mechanical Engineer

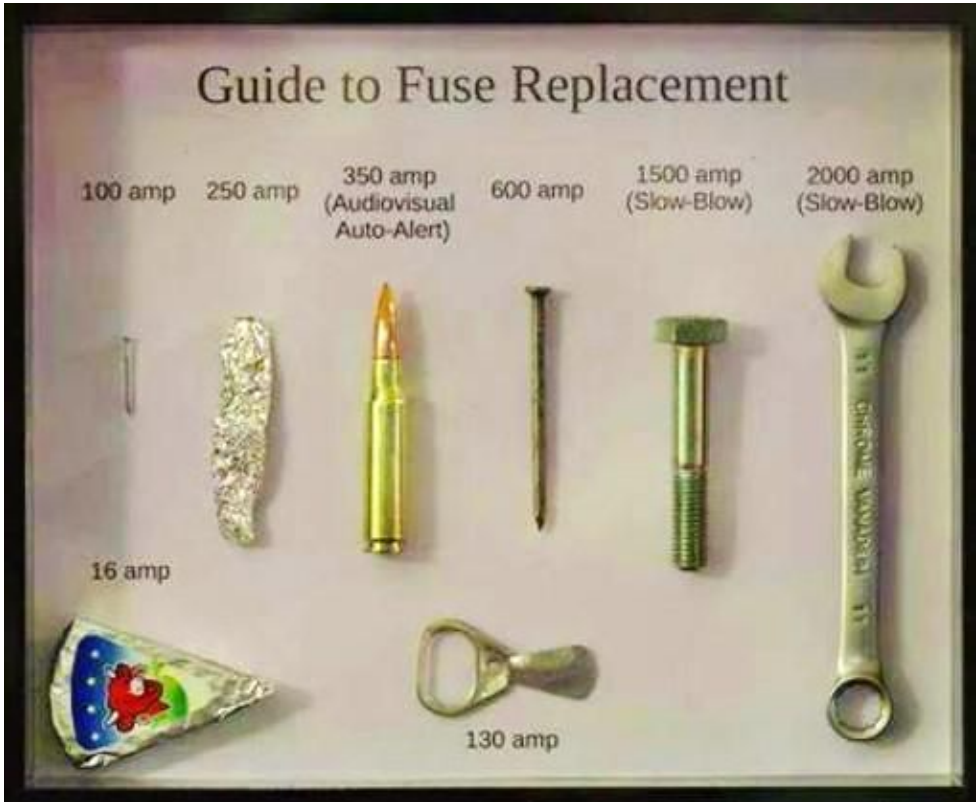
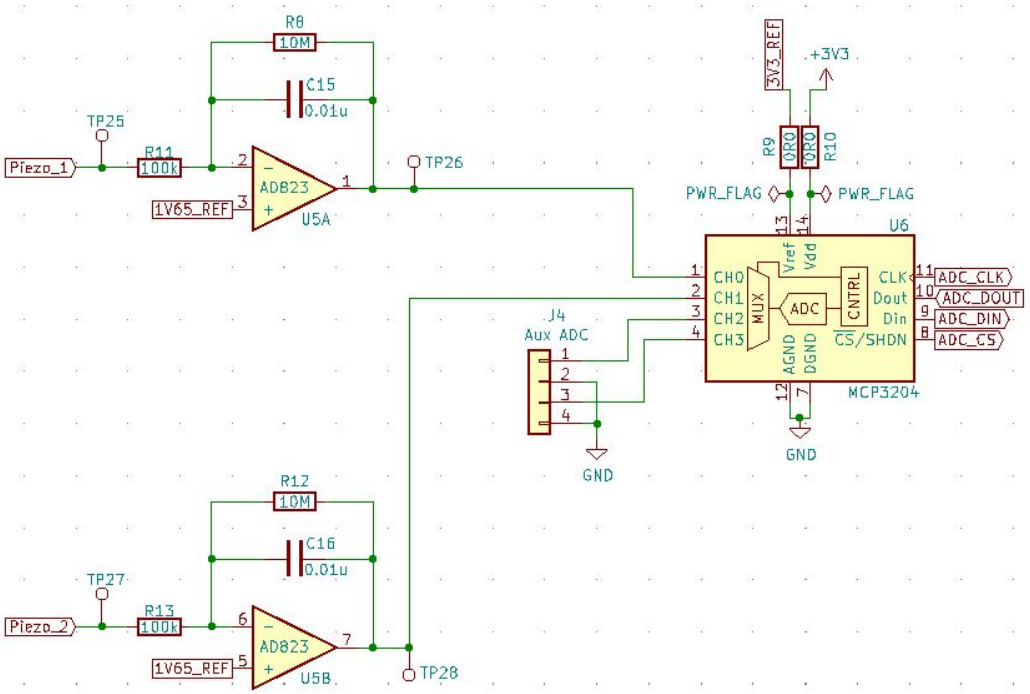


Image: Twitter

We draw circuits in schematic diagrams with symbols to represent parts and connections



LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

The symbols are “standard” for many components

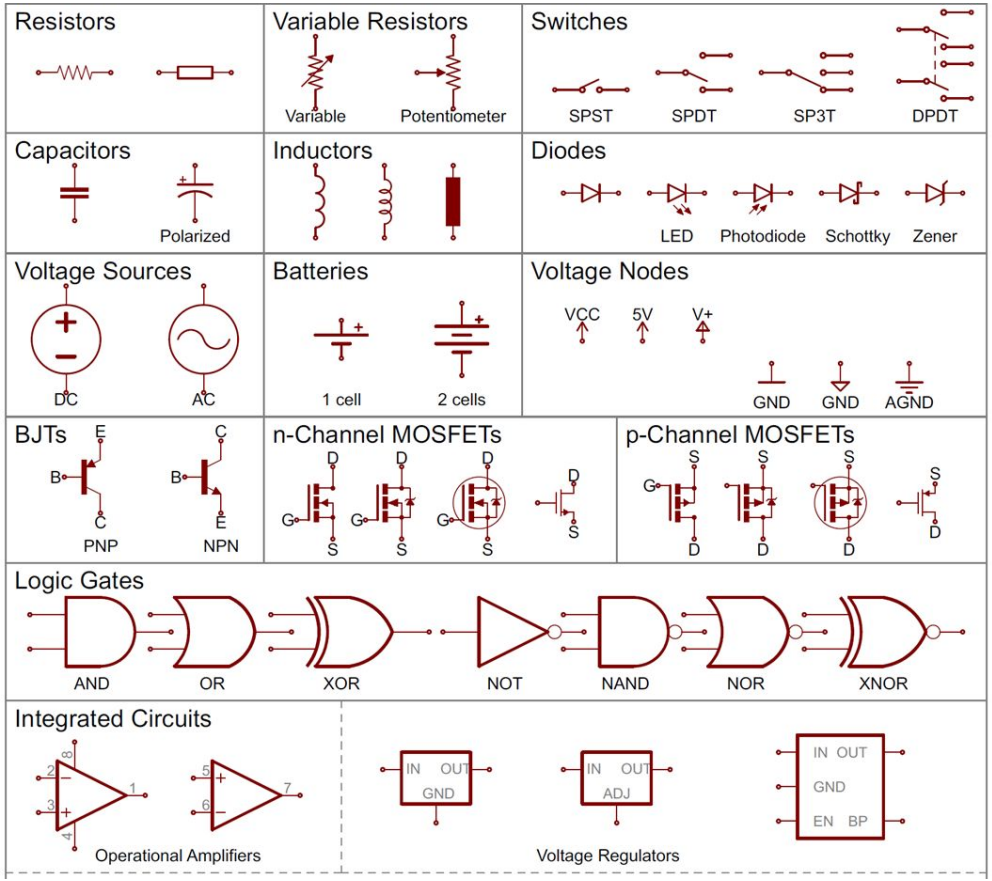


Image: Sparkfun

Junctions mark there connections are made

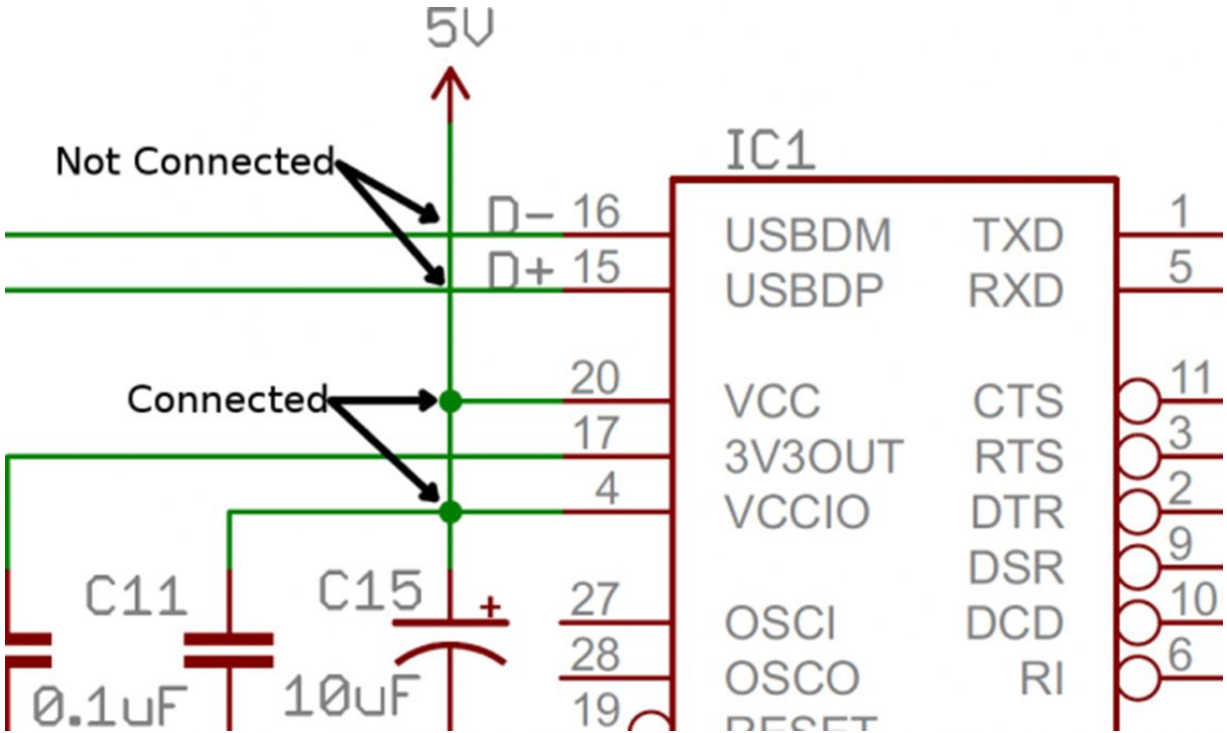


Image: Sparkfun

We also use net name labels to reduce schematic clutter

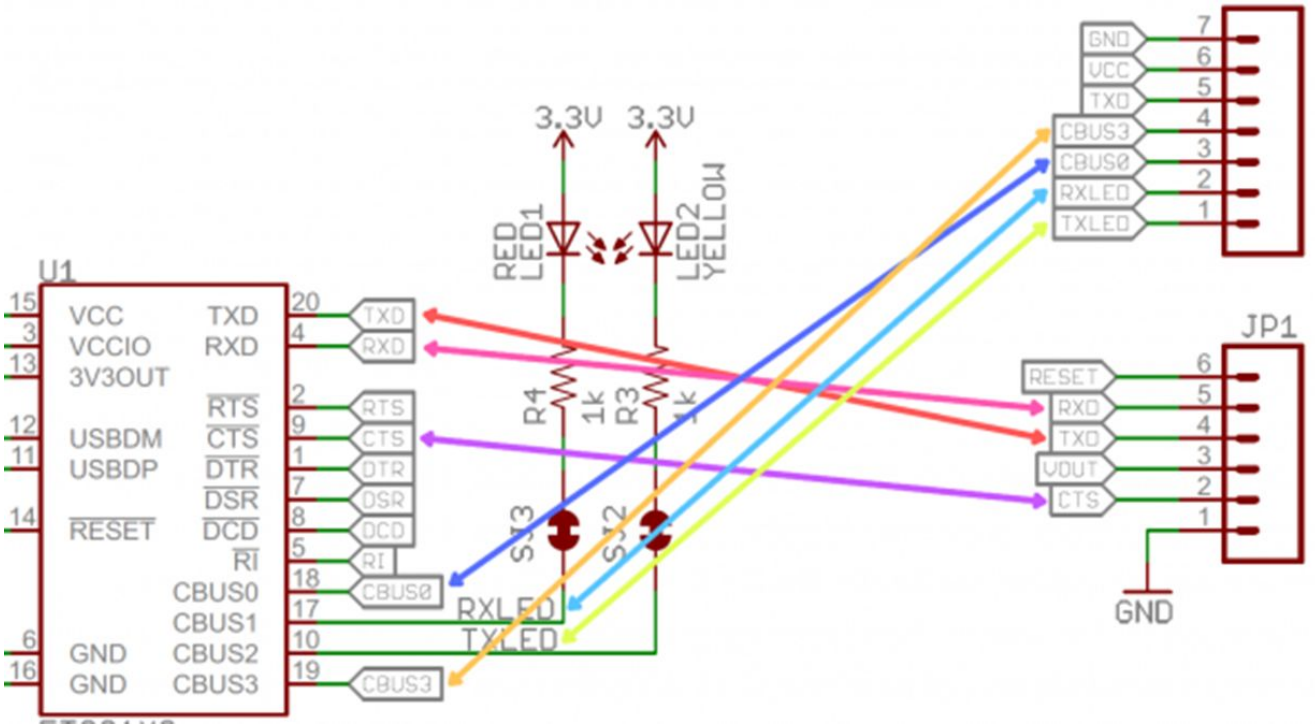
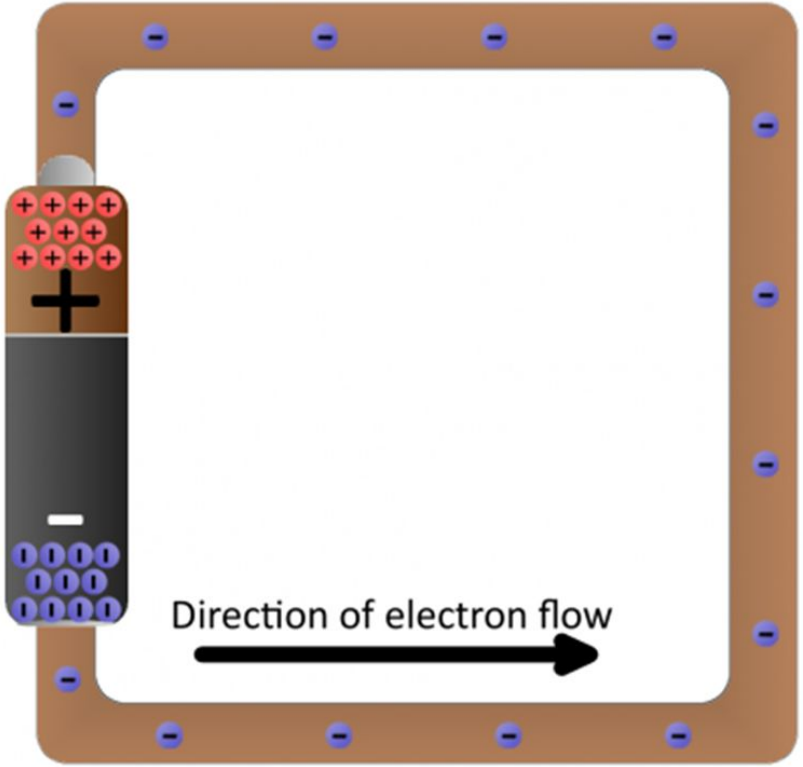


Image: Sparkfun

Electric circuits are closed loops that electrons flow through. Electrical energy is stored electrical potential difference.



LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

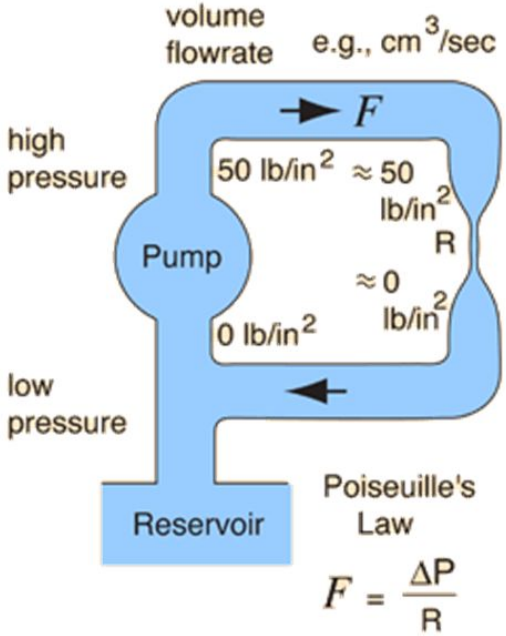
Image: Sparkfun

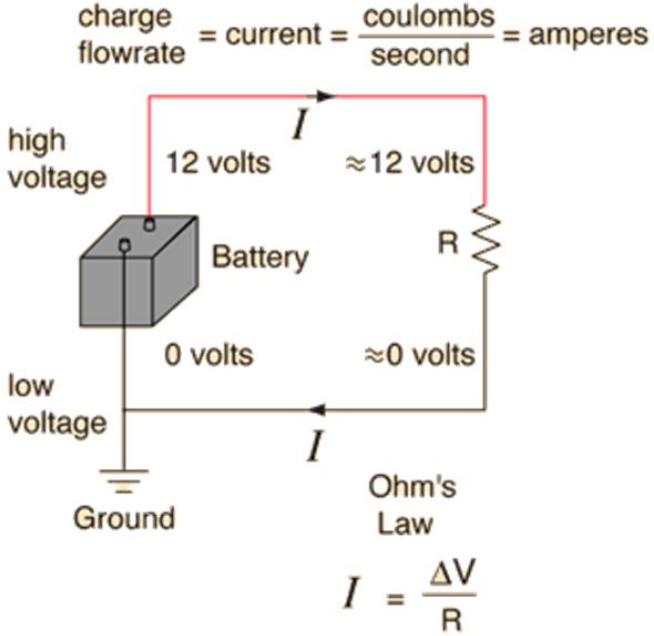
We generally think in conventional current flow, not electron flow

Image: XKCD

In electronics we generally only have to consider a few fundamental quantities

- **Voltage**
- **Current**
- **Resistance**
- Capacitance
- Inductance
- Reactance

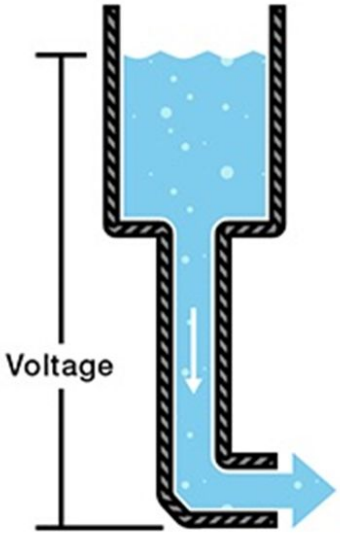


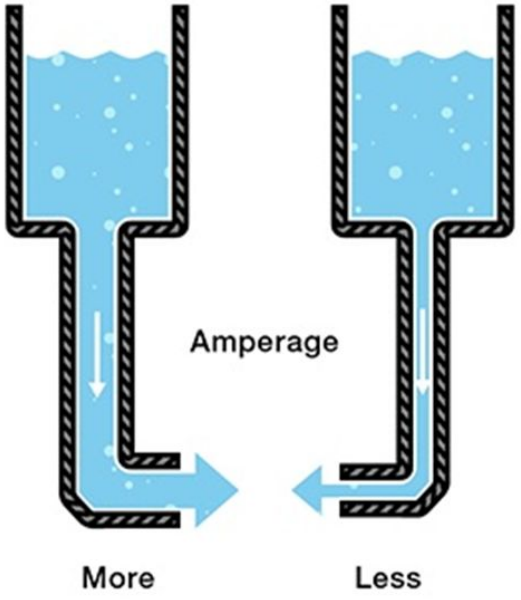


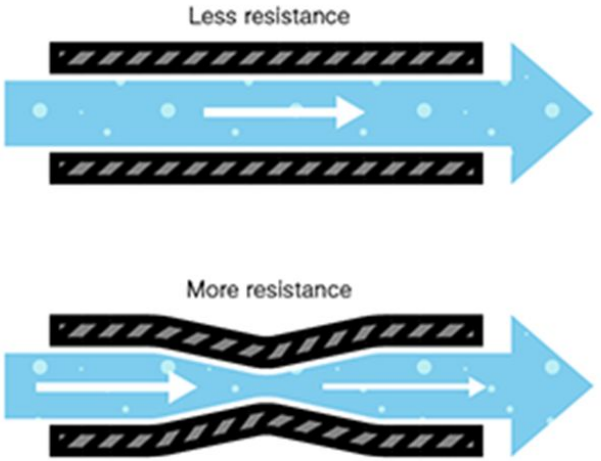
LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: Hyperphysics

We can use the water analogy for voltage, current, and resistance



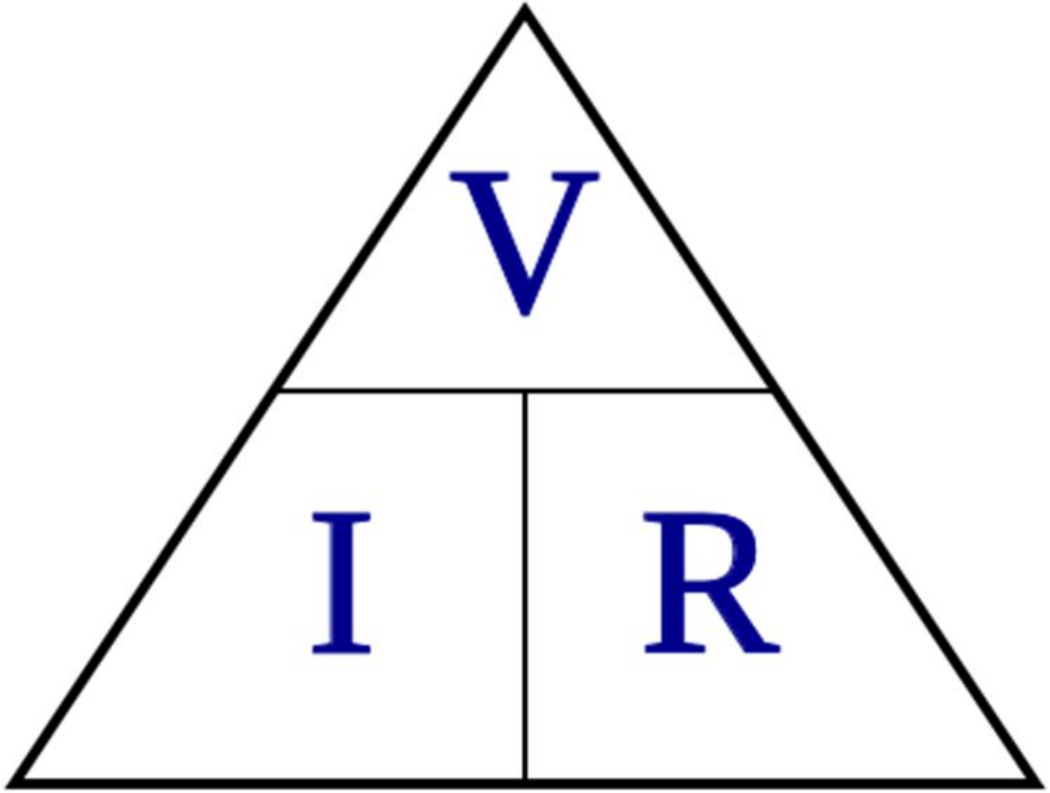




LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Images: Sparkfun

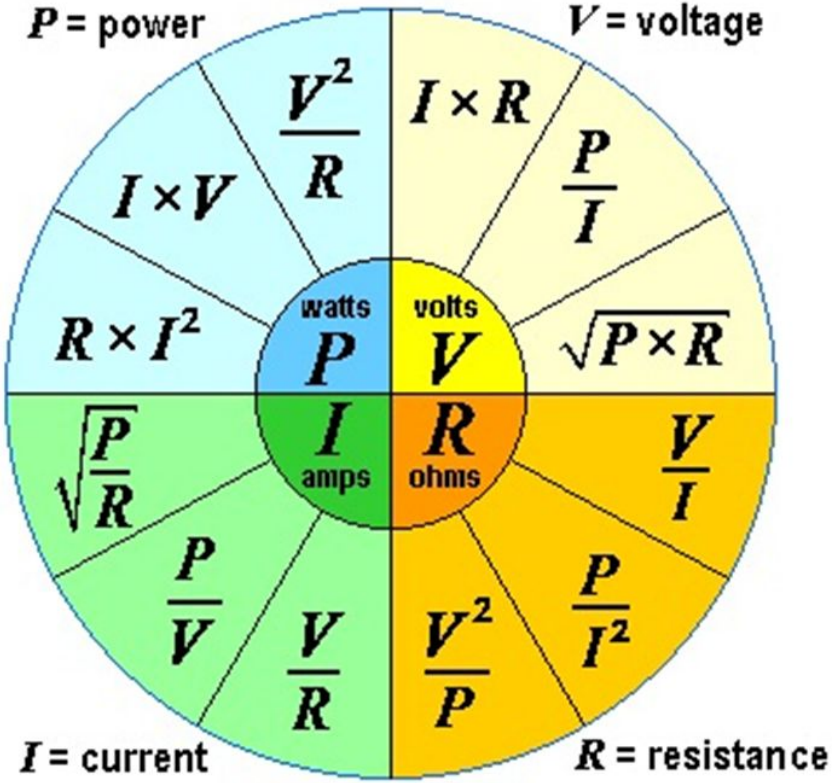
Ohm’s Law relates these quantities



LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: Wikipedia

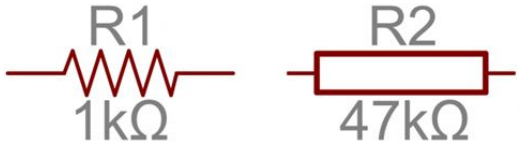
Ohm's Law relates all of these quantities



LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: sengpielaudio.com

Resistors



Images: Sparkfun

There are common values, we recommend 1% or better

	Colour	Band 1 First digit	Band 2 Second digit	Band 3 Multiplier	Band 4 Tolerance
	Black	0	0	x 1 (x 1)	-
	Brown	1	1	x 10 (x 10)	1%
	Red	2	2	x 100 (x 100)	2%
	Orange	3	3	x 1 000 (x 1k)	not used
	Yellow	4	4	x 10 000 (x 10k)	not used
	Green	5	5	x 100 000 (x 100k)	not used
	Blue	6	6	x 1 000 000 (x 1M)	not used
	Violet	7	7	-	not used
	Grey	8	8	-	not used
	White	9	9	-	not used
	Gold	-	-	-	5%
	Silver	-	-	-	10%

Table J.1 Standard Resistance Values

	1% Resistor Values (kΩ)			
5% Resistor Values (kΩ)	100–174	178–309	316–549	562–976
10	100	178	316	562
11	102	182	324	576
12	105	187	332	590
13	107	191	340	604
15	110	196	348	619
16	113	200	357	634
18	115	205	365	649
20	118	210	374	665
22	121	215	383	681
24	124	221	392	698
27	127	226	402	715
30	130	232	412	732
33	133	237	422	750
36	137	243	432	768
39	140	249	442	787
43	143	255	453	806
47	147	261	464	825
51	150	267	475	845
56	154	274	487	866
62	158	280	499	887
68	162	287	511	909
75	165	294	523	931
82	169	301	536	953
91	174	309	549	976

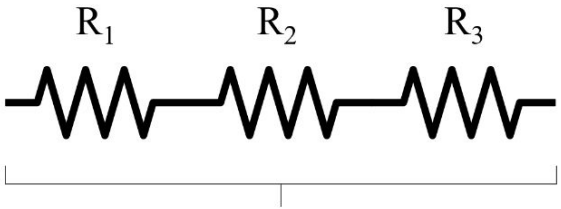
Images: Open Univeristy, Chegg

Find the current flowing through the following circuit

Resistors in parallel and sum in different ways

Series Resistors

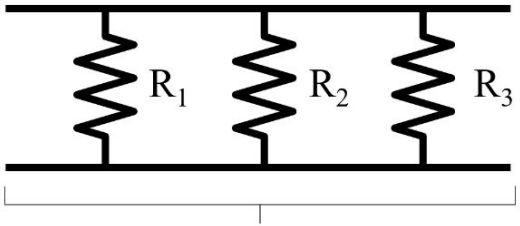
Current is the same across each resistor. Voltage is divided.



$$R_{Equivalent} = R_1 + R_2 + \ldots + R_{N-1} + R_N$$

Parallel Resistors

Voltage is the same across each resistor. Current is divided.

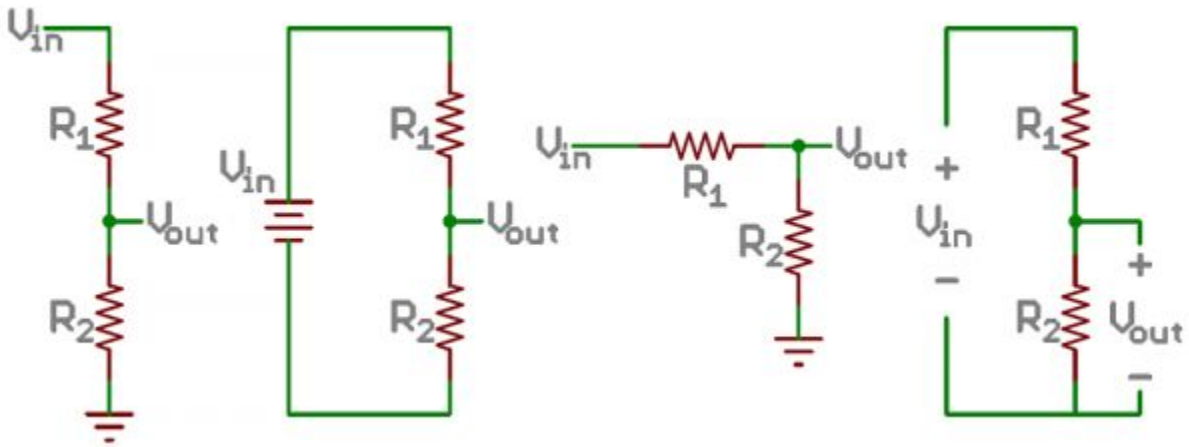


$$R_{Equivalent} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_{N-1}} + \frac{1}{R_N}}$$

Image: makeabiltylab

Now, find the current limiting resistor required for this circuit

Voltage dividers are a building block you'll find over and over



$$V_{out} = V_{in} \cdot \frac{R_2}{R_1 + R_2}$$

LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Wire - it is a component too!

LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: Simkan Cable

Connectors







LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: Wikipedia, topflitecomponents, EBay, Amphenol, renhotecrf

Common Circuits You May Encounter

Start/Stop Circuit

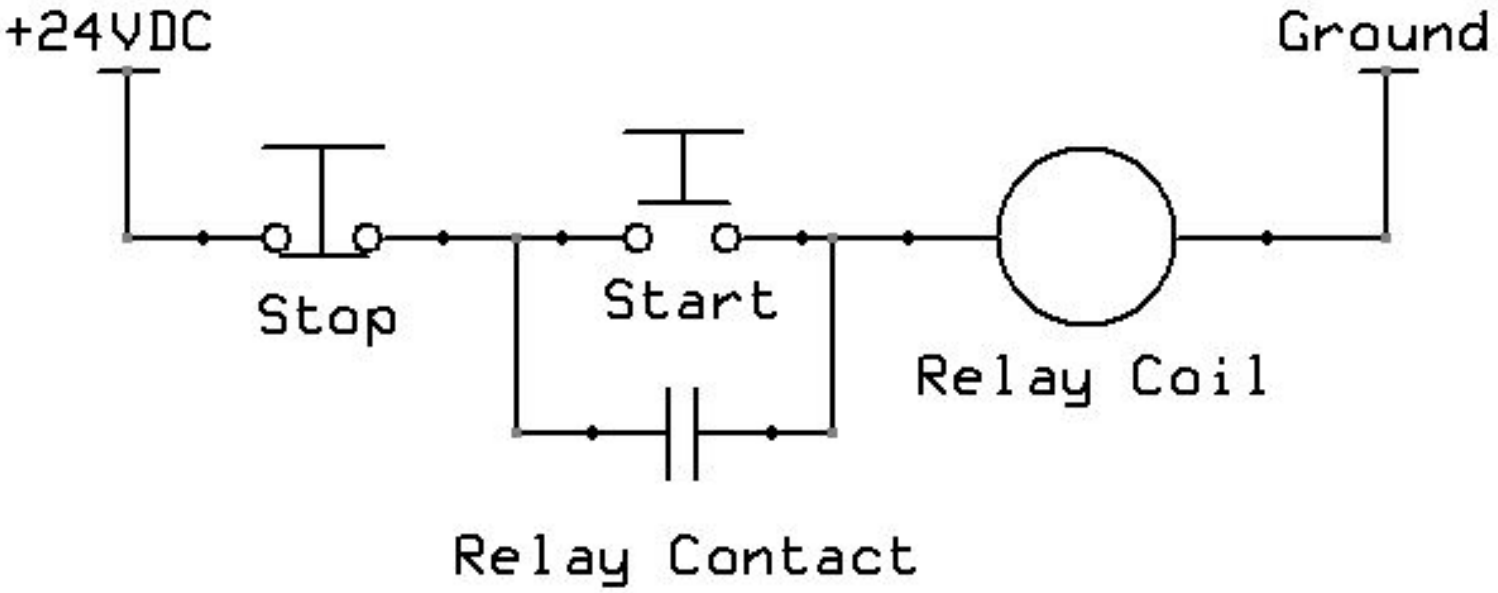
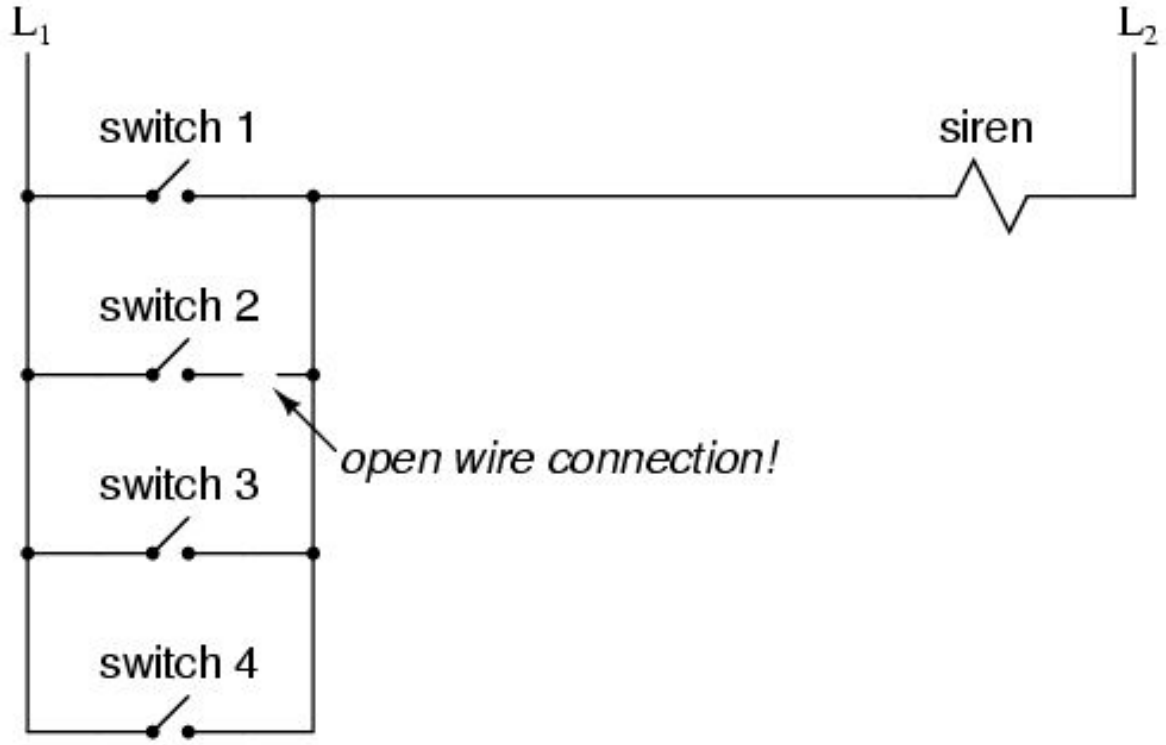


Image: drstienecker.com

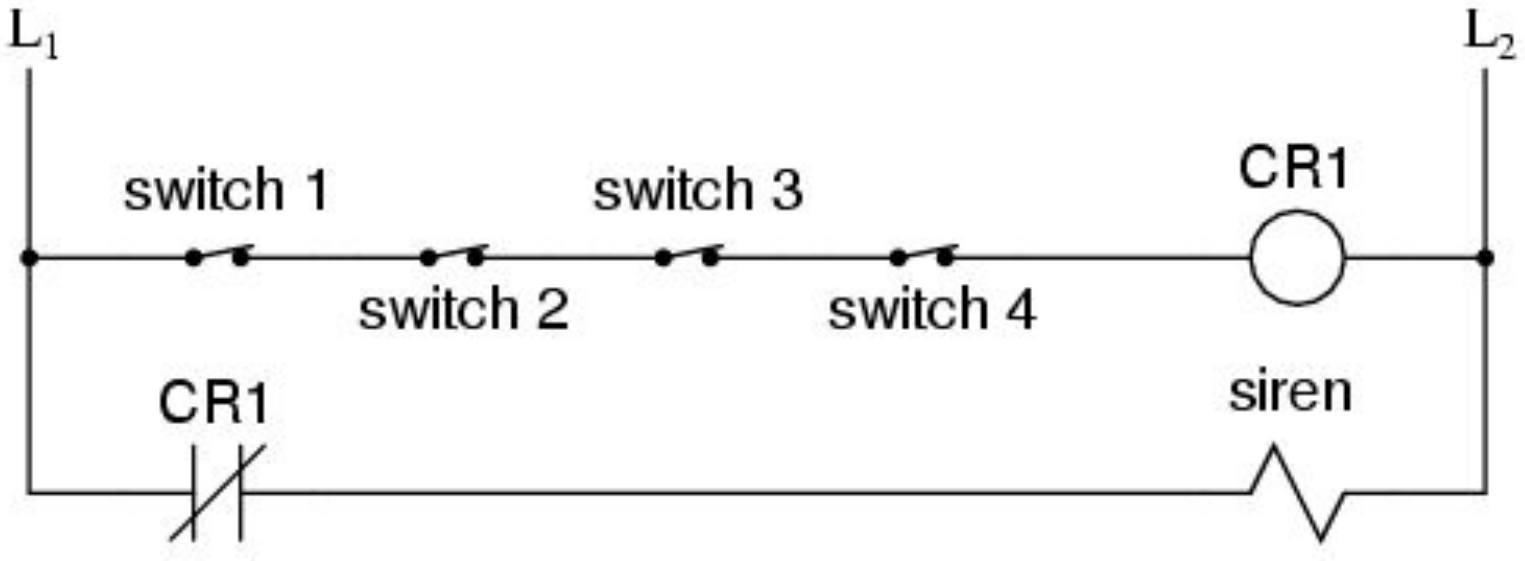
Failsafe Circuit



LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: instrumentationtools.com

Failsafe Circuit



LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: instrumentationtools.com

Common Equipment

LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Images: Test Equipment Depot, tequipment.net, Tektronix