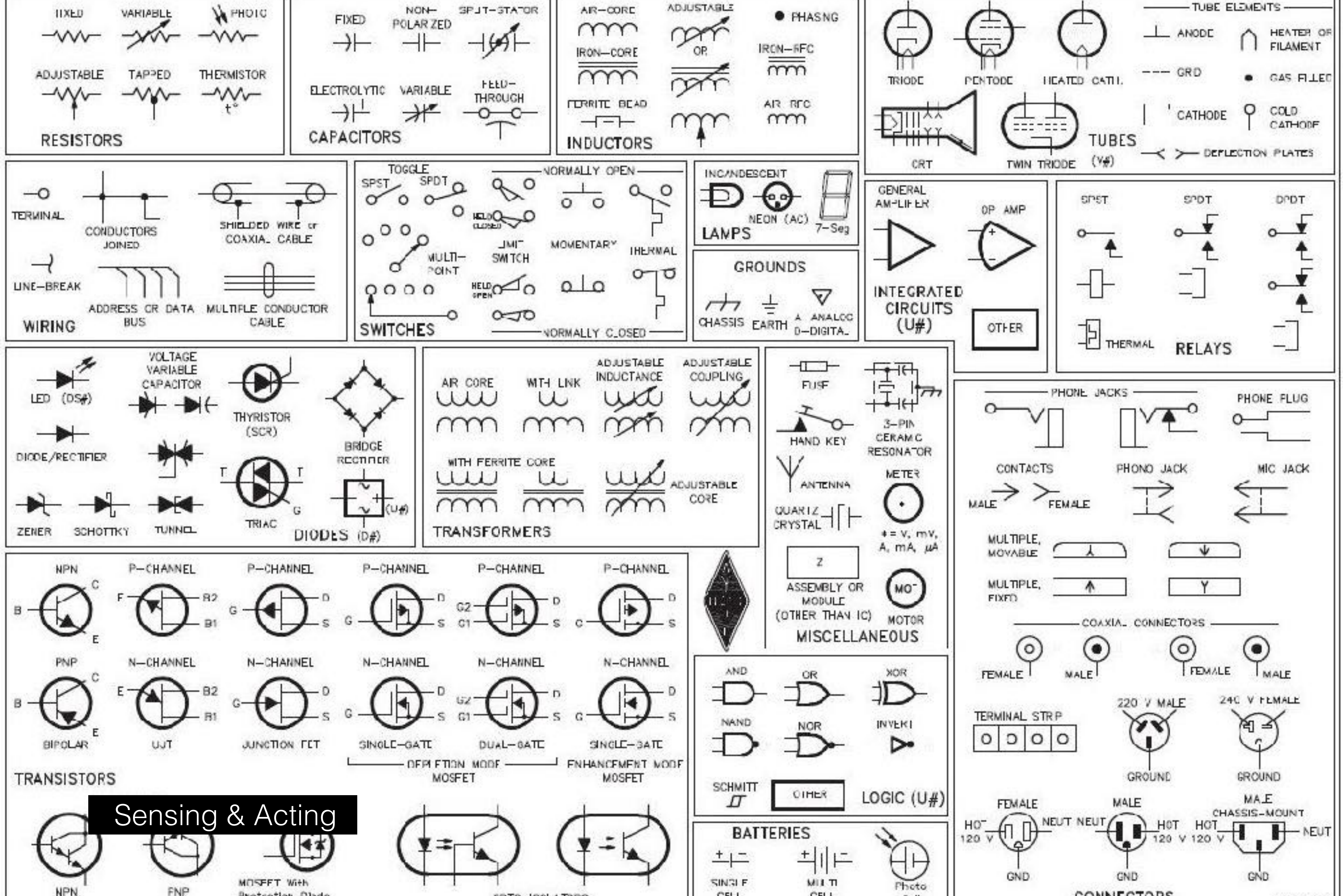
Sensing & Acting
RESISTORS
FIXED
VARIABLE
PHOTO
ADJUSTABLE
TAPPED
THERMISTOR
CAPACITORS
FIXED
NON-POLARIZED
SPLIT-STATOR
ELECTROLYTIC
VARIABLE
FEED-THROUGH
INDUCTORS
AIR-CORE
IRON-CORE
FERRITE BEAD
ADJUSTABLE
OR
PHASING
IRON-RFC
AIR RFC
TUBES (V#)
TRIODE
PENTODE
HEATED CATH.
CRT
TWIN TRIODE
TUBE ELEMENTS
ANODE
HEATER OR FILAMENT
GRID
GAS FILLED
CATHODE
COLD CATHODE
DEFLECTION PLATES
WIRING
TERMINAL
CONDUCTORS JOINED
SHIELDED WIRE or COAXIAL CABLE
LINE-BREAK
ADDRESS OR DATA BUS
MULTIPLE CONDUCTOR CABLE
SWITCHES
TOGGLE
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MULTI-POINT
NORMALLY OPEN
HELD CLOSED
LIMIT SWITCH
MOMENTARY
THERMAL
HELD OPEN
NORMALLY CLOSED
LAMPS
INCANDESCENT
NEON (AC)
7-Seg
GROUNDS
CHASSIS
EARTH
A-ANALOG
D-DIGITAL
INTEGRATED CIRCUITS (U#)
GENERAL AMPLIFIER
OP AMP
OTHER
RELAYS
SPST
SPDT
DPDT
THERMAL
DIODES (D#)
LED (DS#)
VOLTAGE VARIABLE CAPACITOR
THYRISTOR (SCR)
BRIDGE RECTIFIER
DIODE/RECTIFIER
TRIAC
ZENER
SCHOTTKY
TUNNEL
(U#)
TRANSFORMERS
AIR CORE
WITH LINK
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WITH FERRITE CORE
ADJUSTABLE CORE
MISCELLANEOUS
FUSE
3-PIN CERAMIC RESONATOR
HAND KEY
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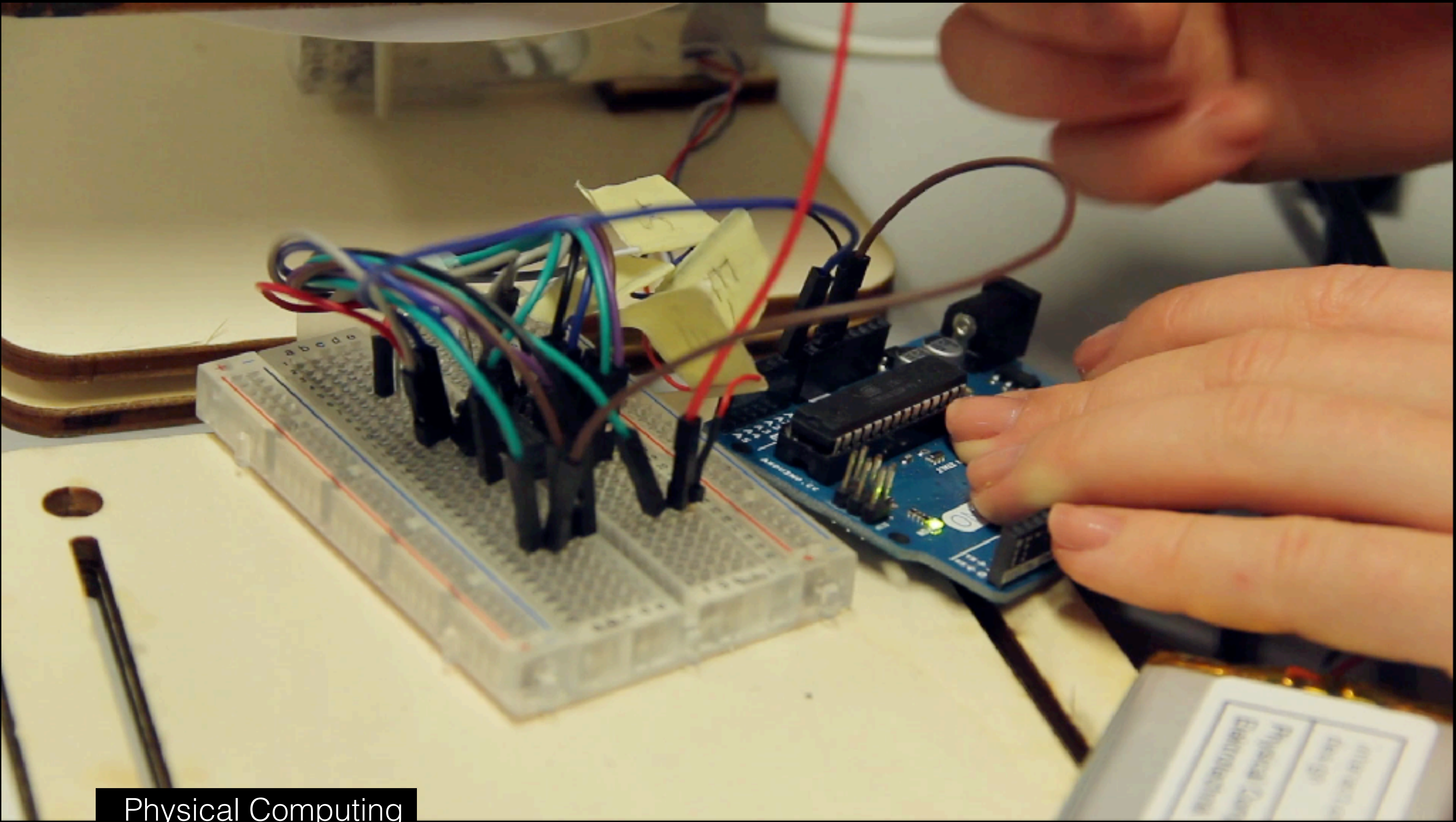
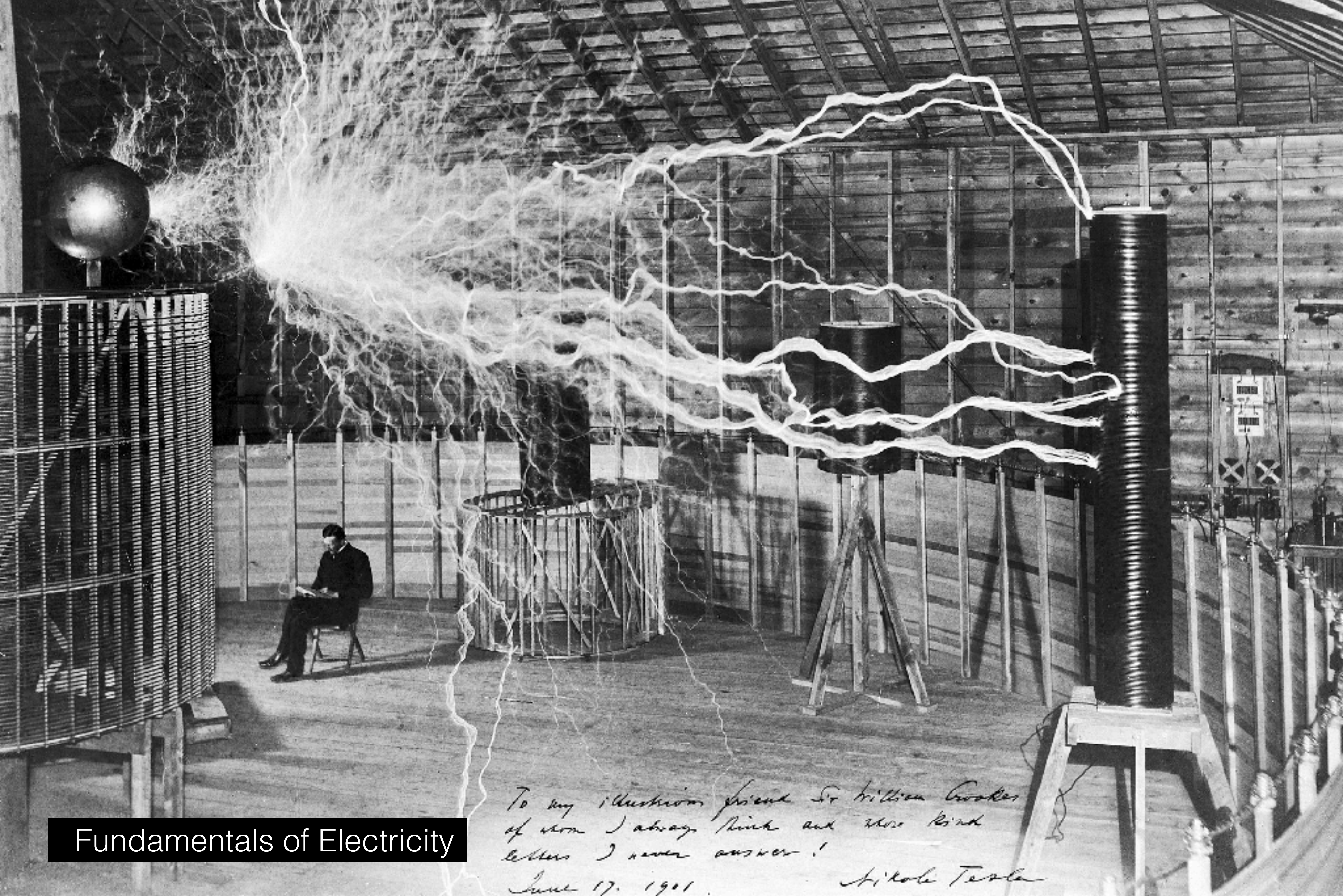
* = V, mV, A, mA, μA
ASSEMBLY OR MODULE (OTHER THAN IC)
MOTOR
MOT
PHONE JACKS
PHONE PLUG
CONTACTS
PHONO JACK
MIC JACK
MALE
FEMALE
MULTIPLE, MOVABLE
MULTIPLE, FIXED
COAXIAL CONNECTORS
FEMALE
MALE
TERMINAL STRIP
220 V MALE
240 V FEMALE
GROUND
FEMALE
MALE
MALE CHASSIS-MOUNT
HOT 120 V
NEUT
GND
CONNECTORS
TRANSISTORS
NPN
PNP
BIPOLAR
P-CHANNEL
N-CHANNEL
UJT
JUNCTION FET
SINGLE-GATE
DUAL-GATE
DEPLETION MODE MOSFET
ENHANCEMENT MODE MOSFET
MOSFET With Protection Diode
LOGIC (U#)
AND
OR
XOR
NAND
NOR
INVERT
SCHMITT
OTHER
BATTERIES
SINGLE CELL
MULTI CELL
Photo

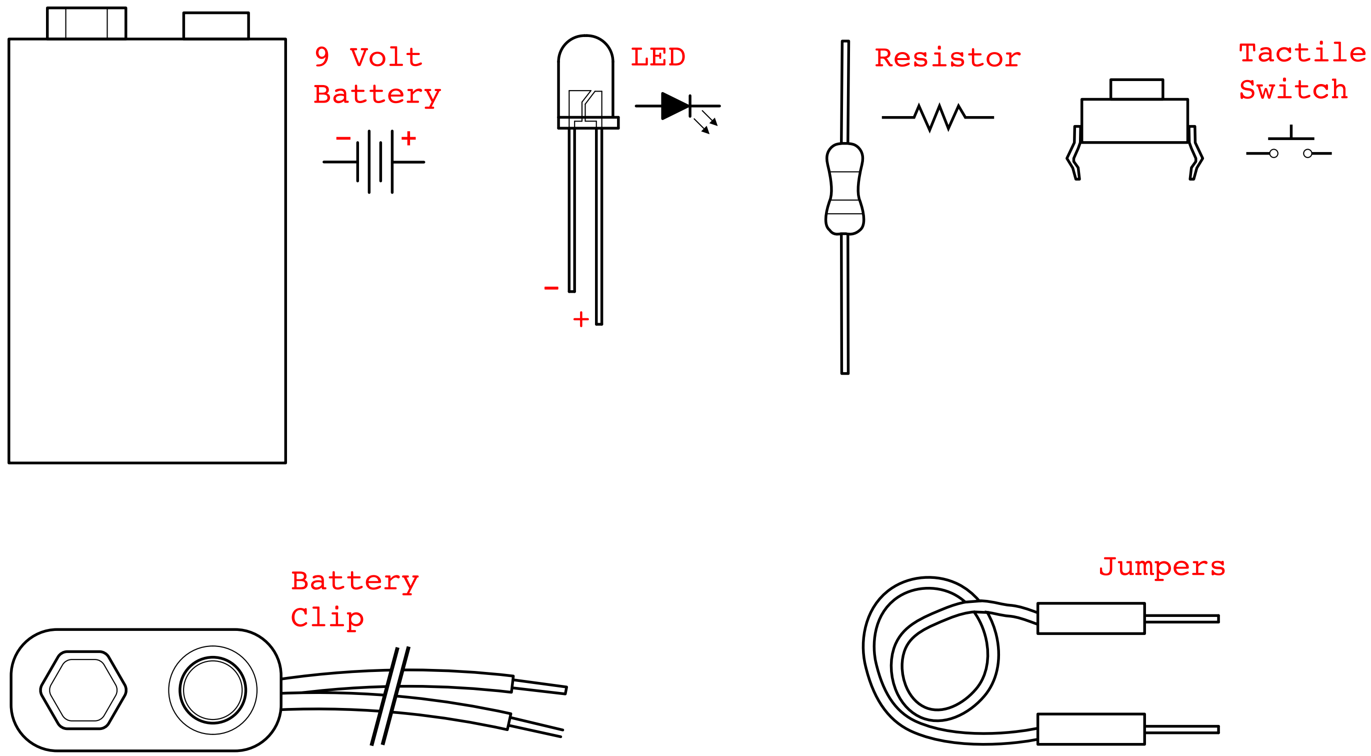


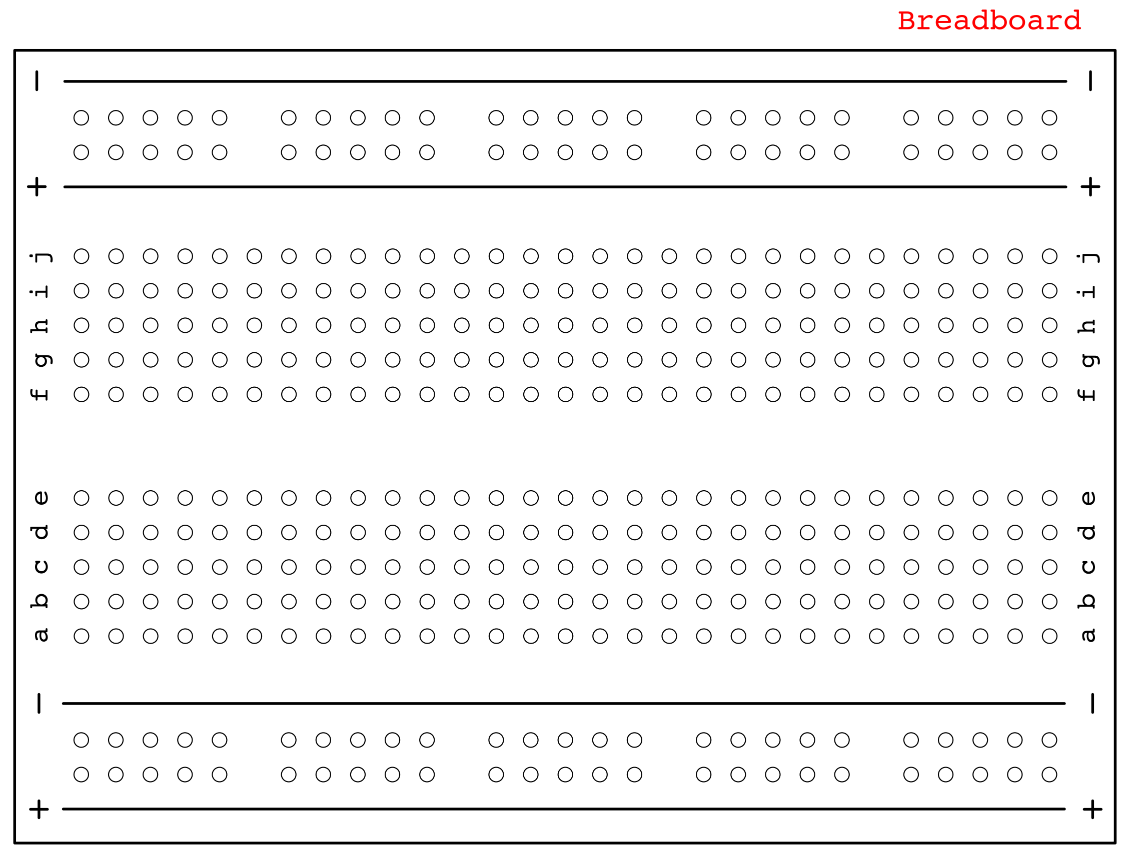
Physical Computing

Physical computing: sensing and controlling the physical world with computers

Dan O'Sullivan and Tom Igoe

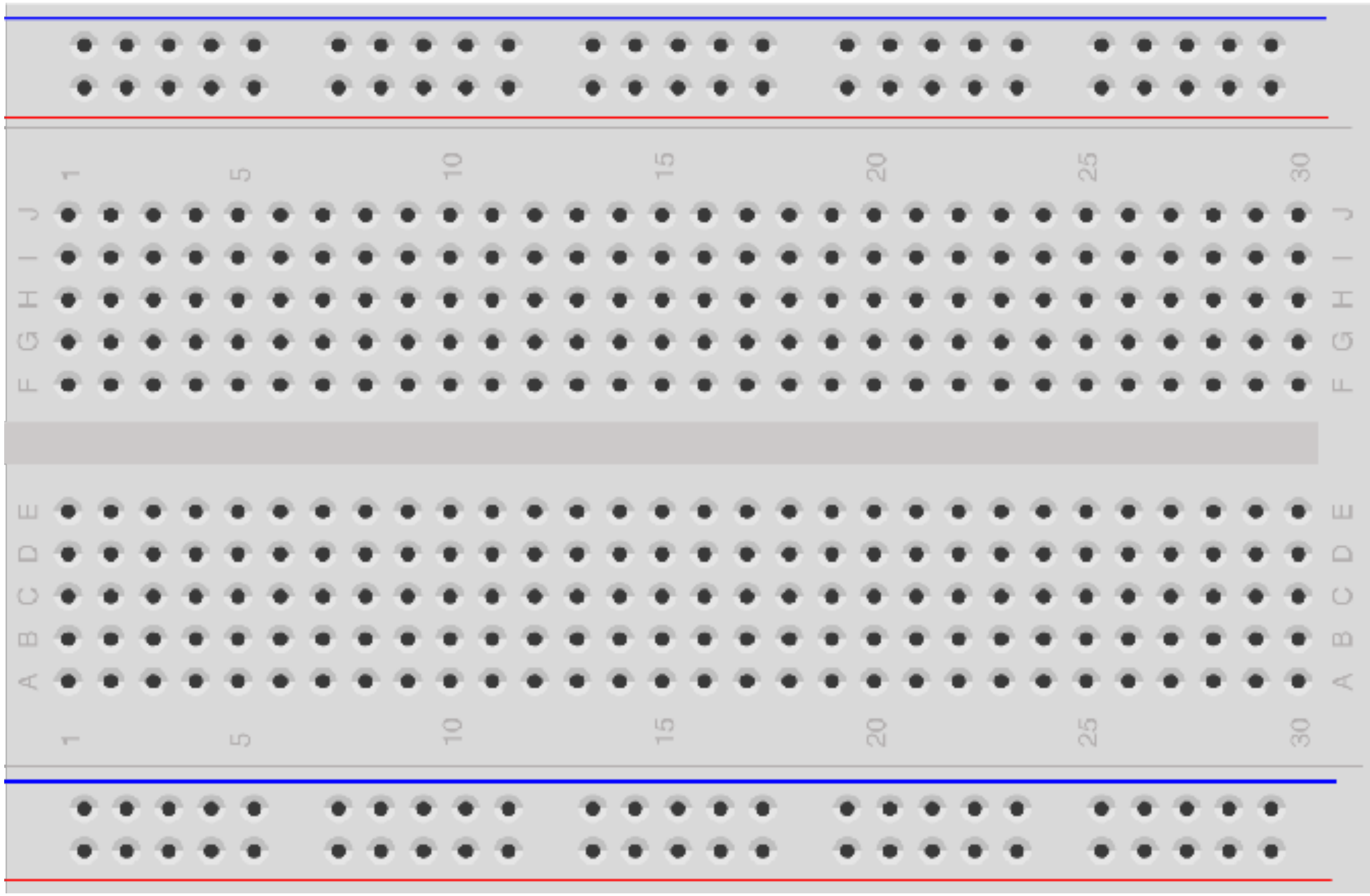

Fundamentals of Electricity
To my illustrious friend Sir William Crookes
of whom I always think and whose kind
letters I never answer!
June 17. 1901
Nikola Tesla



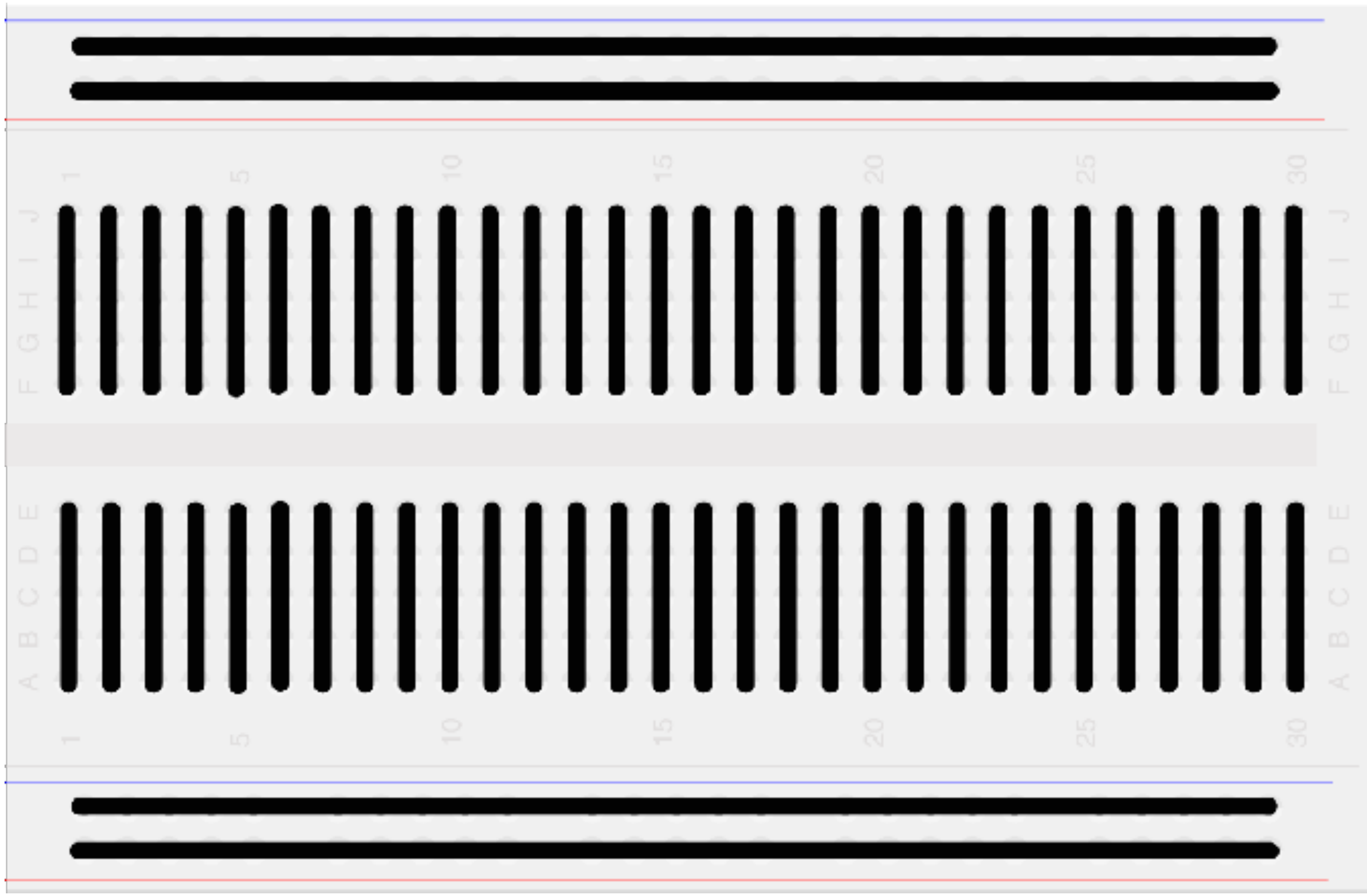


Exercise 1: Electricity

Using the materials shown, create a circuit with an LED can be switched on and off.



Bread Board



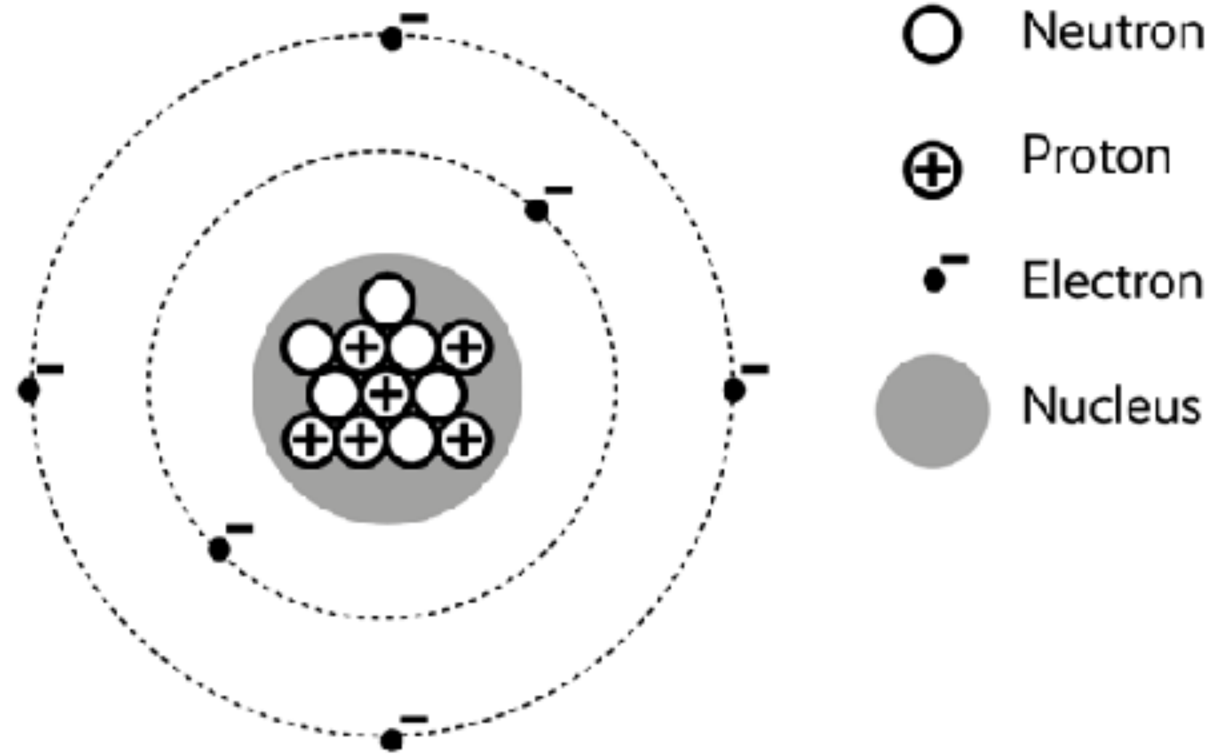
Bread Board

- Electricity is the interaction and movement of positive and negativity charged sub atomic particles.

- Negatively charged **Electrons** are attracted to positively charged **Protons** (electromagnetic force)

- Protons are strongly held in the nucleus of an atom, but electrons are more mobile.

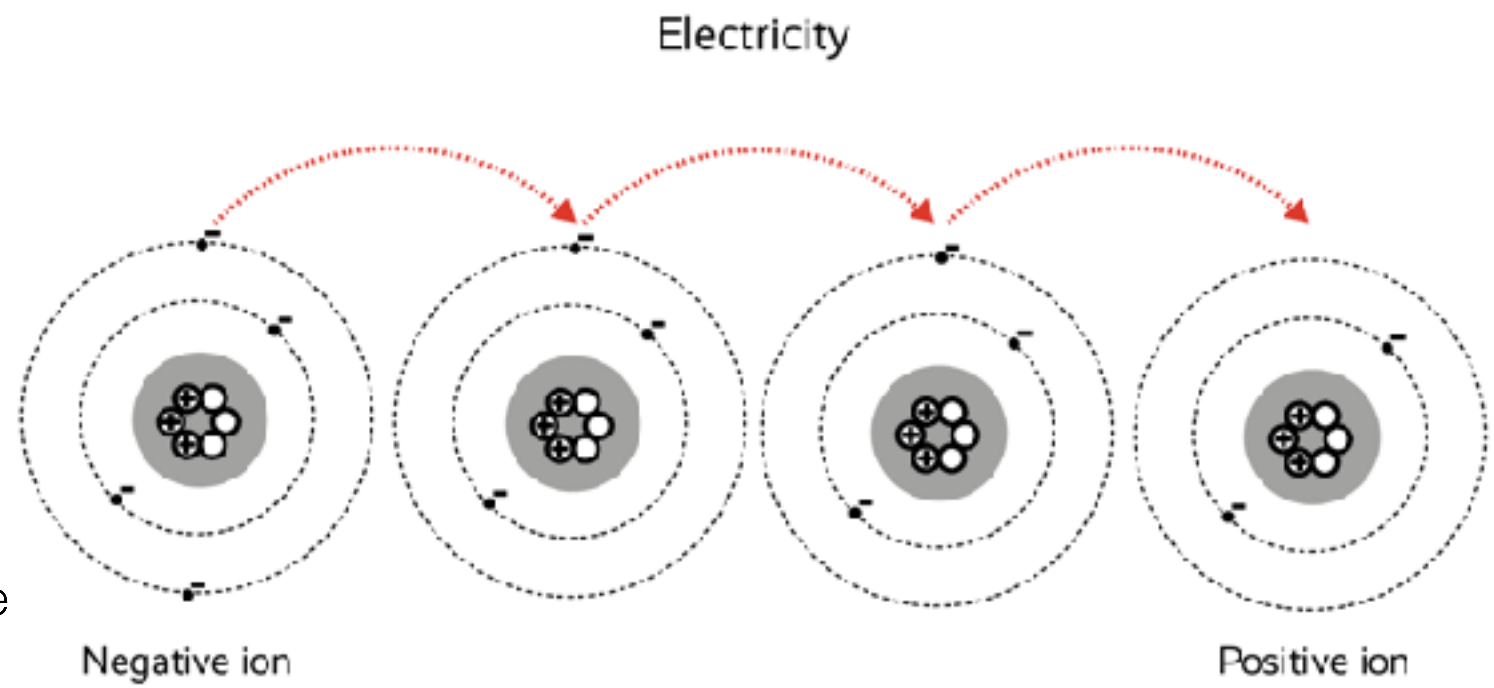
Carbon Atom

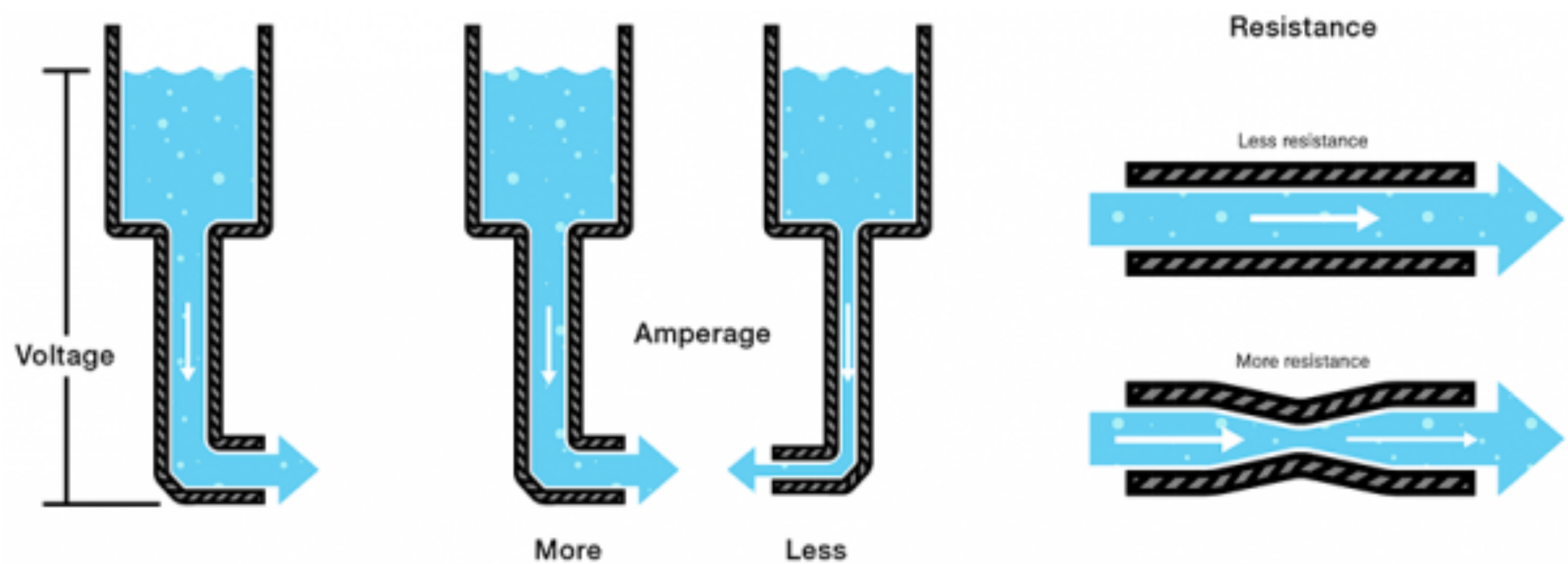


Atoms and Electromagnetic force

- The attraction (and repulsion) between subatomic particles can cause electrons to flow though conductive materials to reach positively charged atoms.

- The difference in charge left to right in this diagram can be measured in **volts.** The amount of electrons flowing can be measured in **amp** and the resistance to flow from the atoms can be measured in **ohms.**





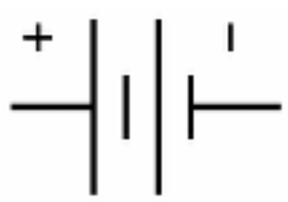
Water Analogy

UNITS: Volt

(mili) mV	V	(kilo) kV
1000	1	0.001

Volts are measure of difference in electrical charge between two points. Voltage can exists in a system even if there is no circuit, as it refers to **potential difference.**

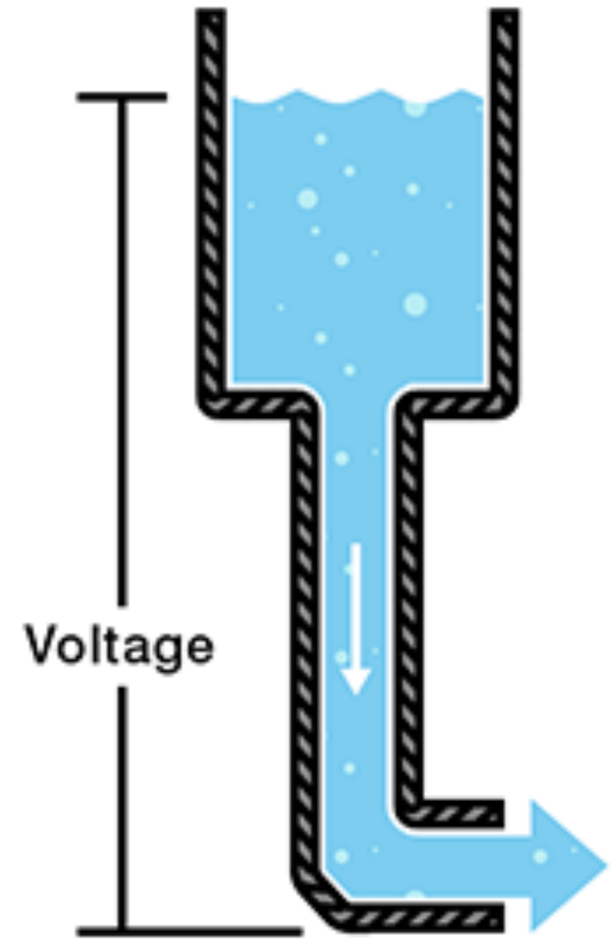
Power Supply Symbol



When current passes through a component, there is a **voltage drop.**

Voltage (volts)

Water Analogy: Pressure (or pressure difference)



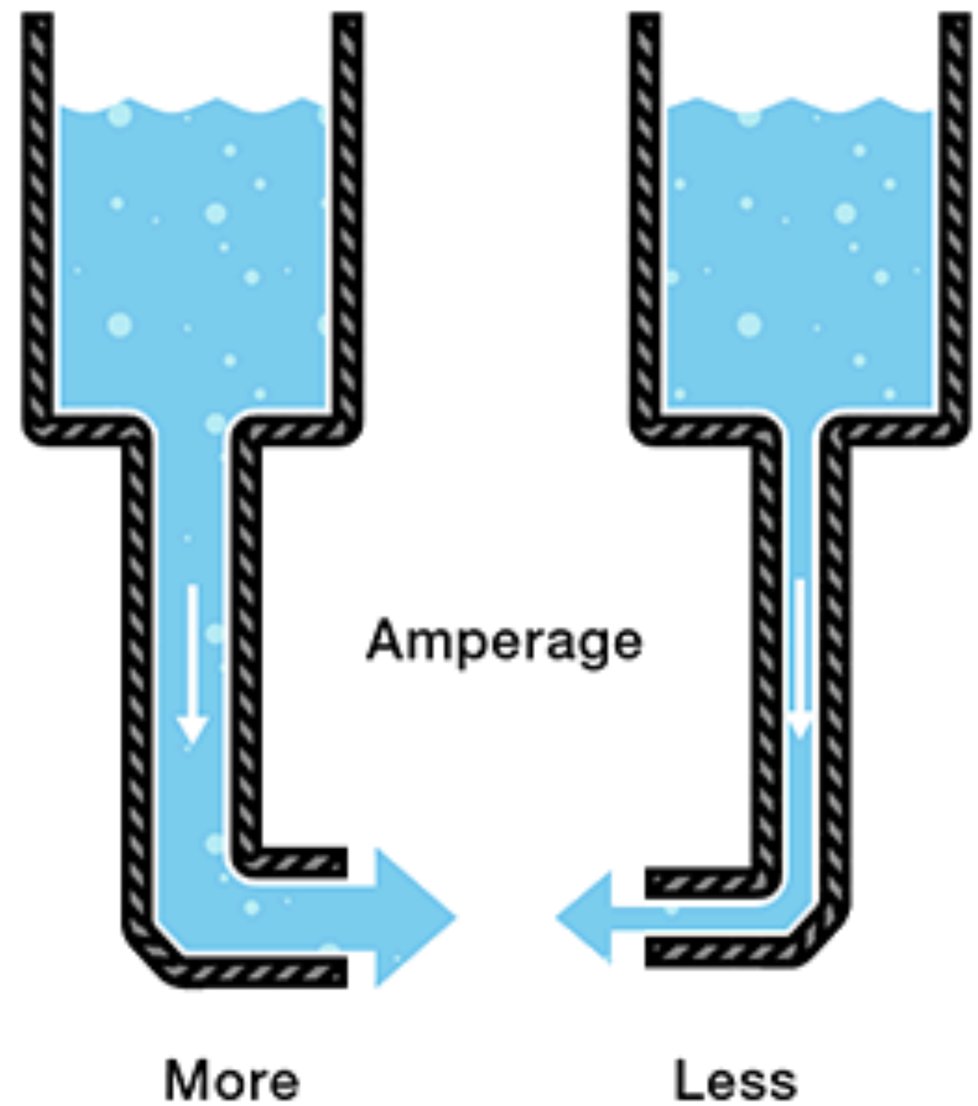
UNITS: Amps

(micro) µA	(Mili) mA	A
10000	1000	1

Current is the amount of electrons moving through material per unit of time (flow). A circuit needs to be closed before electrons can flow, so we can only observe current in a working circuit.

In a simple circuit, same amount of current will be moving through every point (and every component).

Water Analogy: Flow



Current (amps)

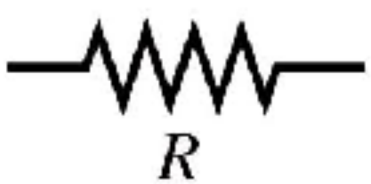
UNITS: ohms (Ω)

Ω	(kilo) kΩ	(mega) mΩ
1	0.001	0.000001

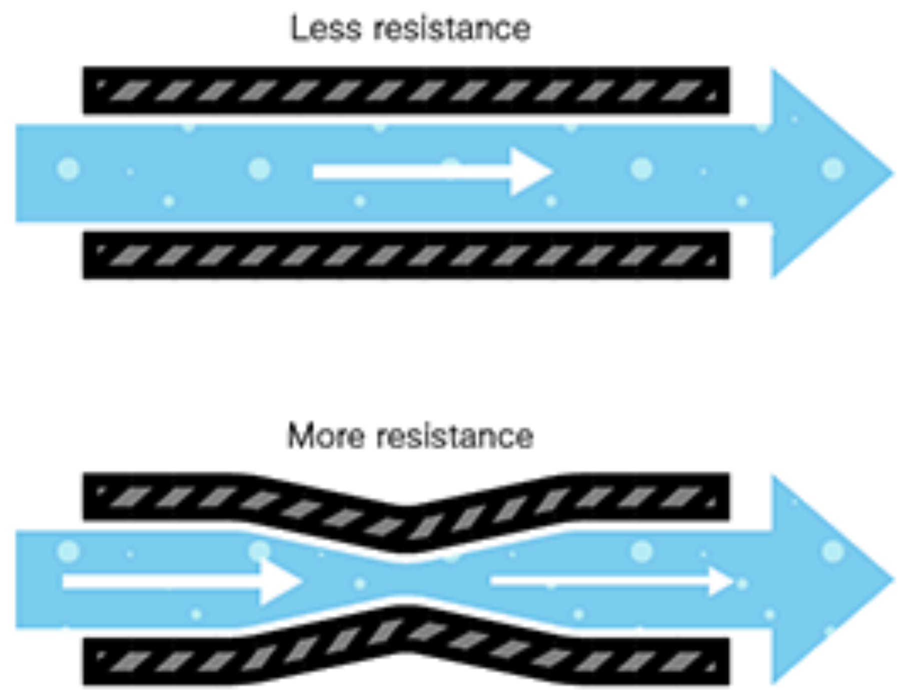
Resistance is the measure of restriction in a material to the flow of electrons.

All electronic components (including wires and batteries) have a resistance. However we mostly control this explicitly with a component called a resistor.

Symbol



Water Analogy: Restriction of Flow



Resistance (ohms)

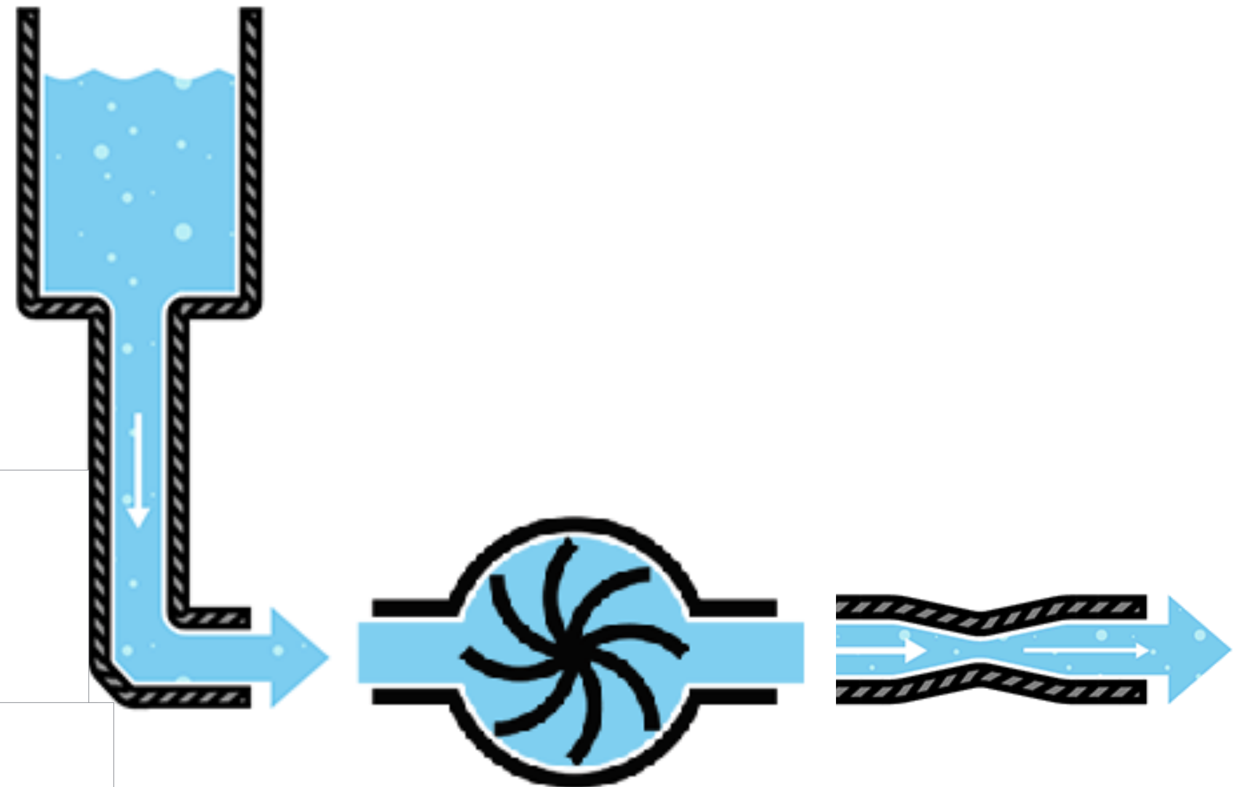
UNITS: Watt

(mili) mW	W	(Kilo) kW
1000	1	0.001

Watts are measure of power (or energy transfer)

Watts can be found by multiplying the current and the voltage in a circuit

Water Analogy: The power of the water flow to move a load is both the pressure, and the rate of flow. Note how the restriction, here would limit the rate of flow even if it is after the water wheel!

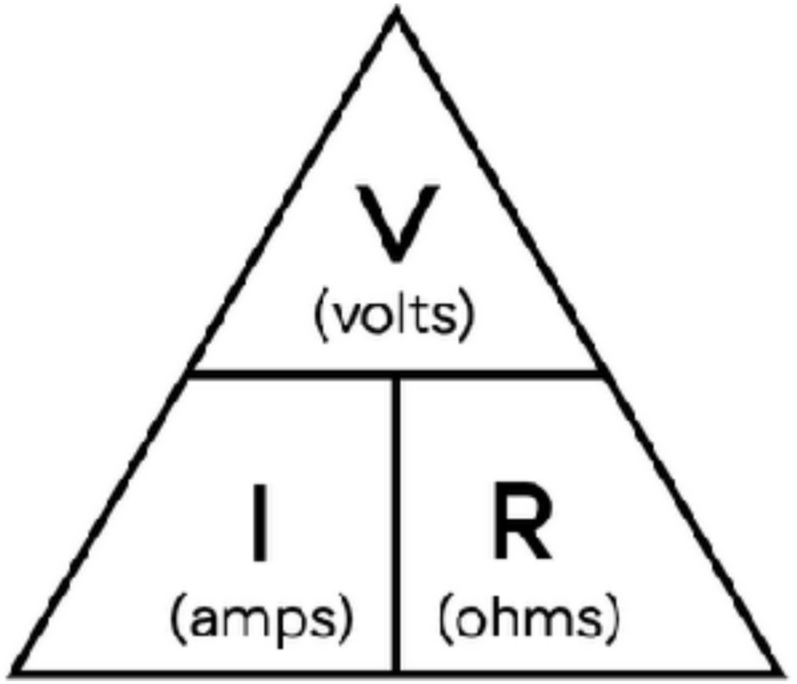


Power (watts)

Watts = V (volts) x I (amps)

Power (watts)

There is an intrinsic relationship between voltage, current and resistance, expressed as ohms Law. We can use this formula to deduct the values in many situations



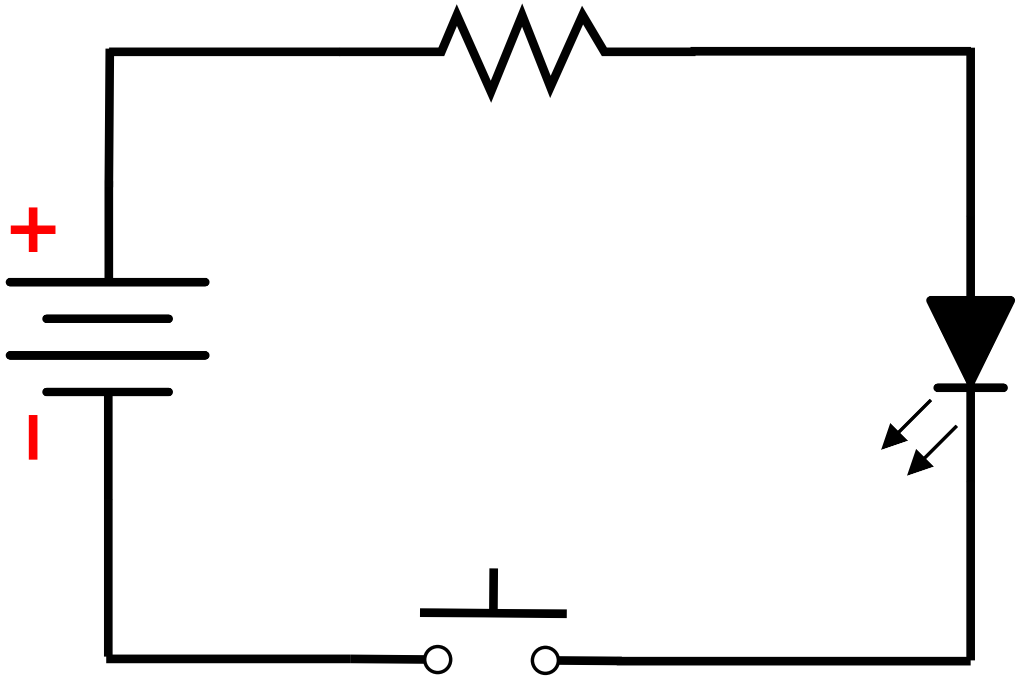
$$V = I \times R$$

$$I = \frac{V}{R}$$

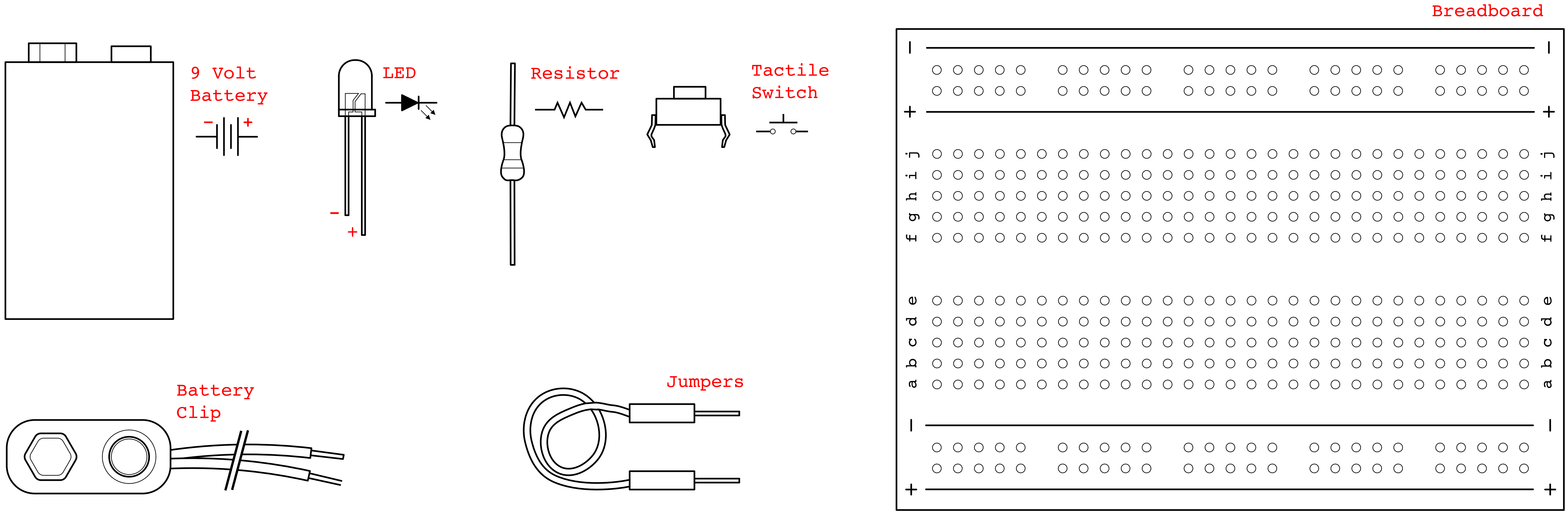
$$R = \frac{V}{I}$$

Ohms LAW

In a series circuit, the same current runs through all wires and components. Voltage can vary, depending on where we measure it in the circuit.



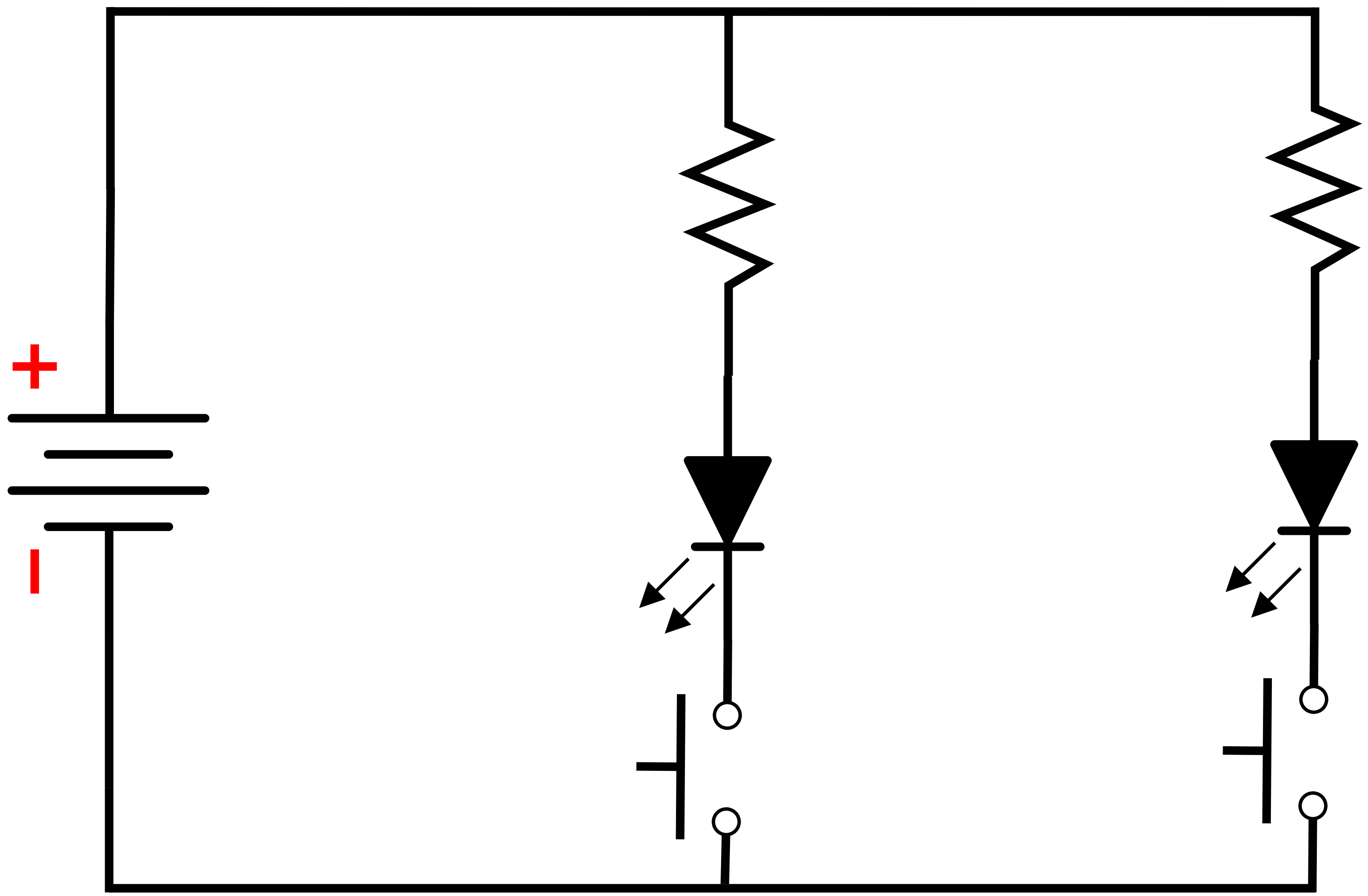
Series Circuit



Exercise 1.2: Electricity

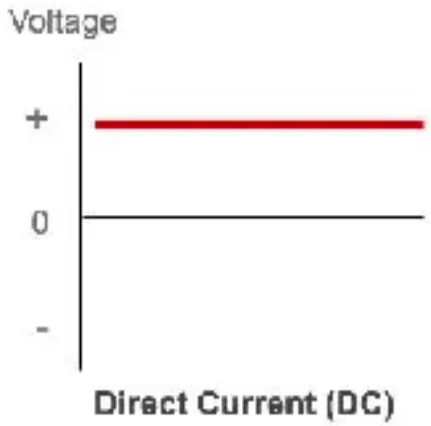
Add **another LED** to your circuit, that can be controlled by it's **own button**.

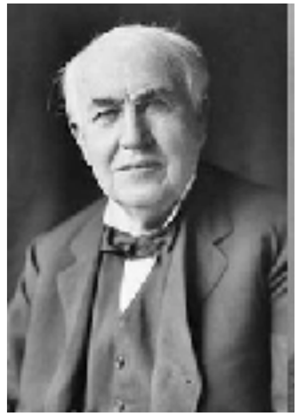
In a parallel circuit, the total current is the sum of each circuit.

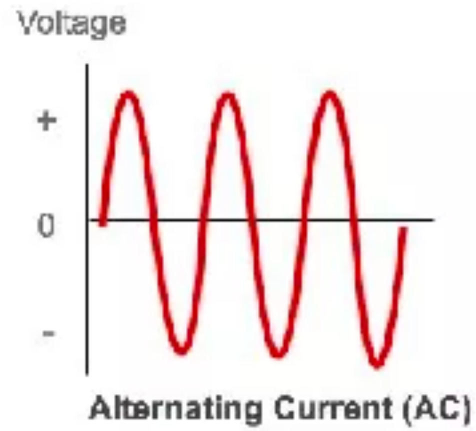


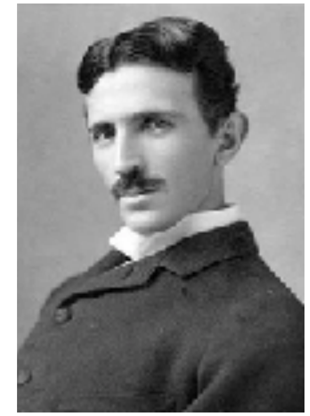
Parallel Circuit

AC vs DC



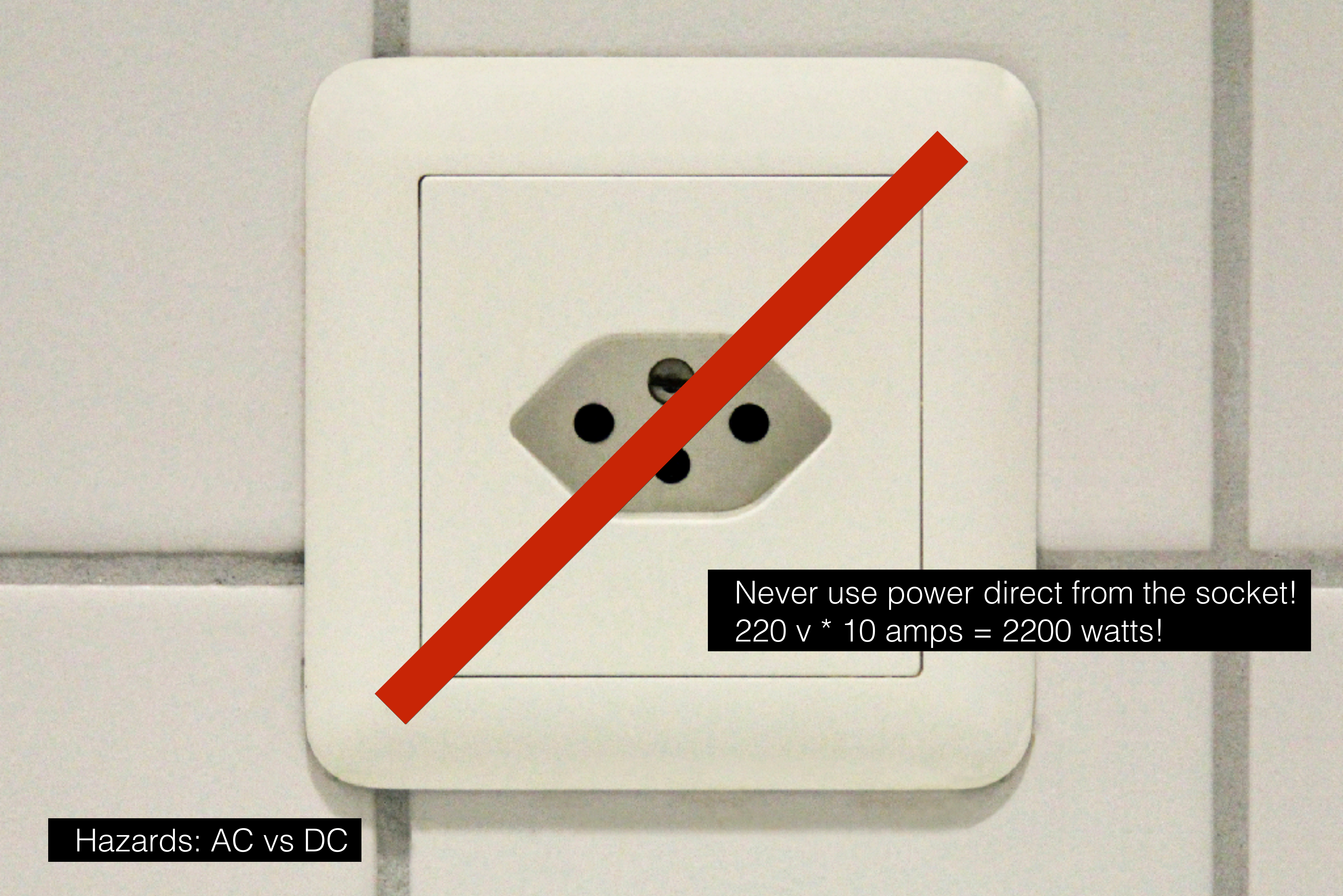

Thomas Edison



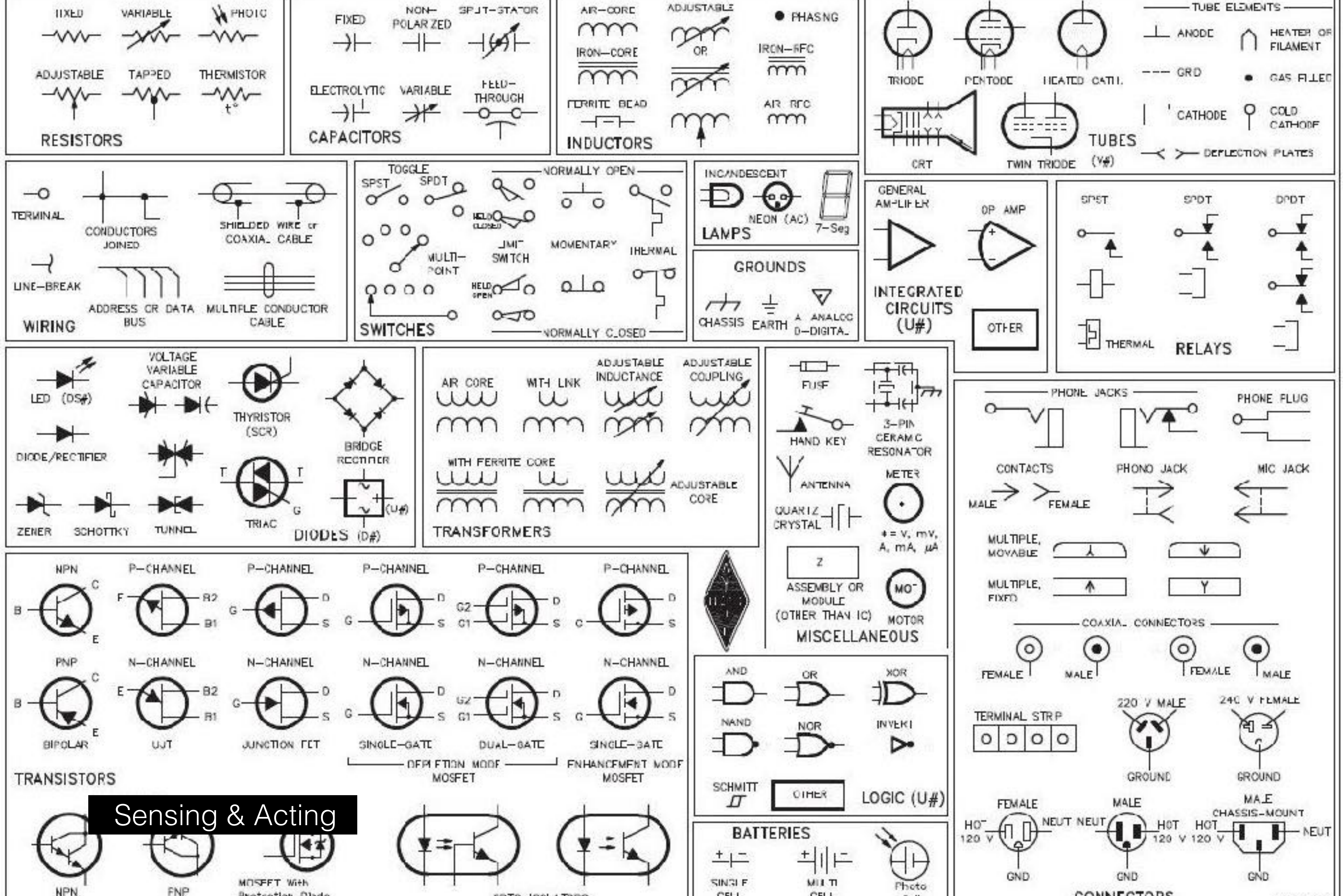

Nikola Tesla

- Direct current is easier to store (batteries and capacitors)
- DC is required for many components and devices (LEDs, Computers, Sensors)
- DC is easy to work with in low voltage applications

- Alternating current can be easily converted up or down in voltage
- Higher voltages can be transmitted with less energy loss over long distances, and easily converted down
- Many energy sources output AC
- Some devices can be driven directly by AC (motors, refrigerators, traditional lightbulbs)


Never use power direct from the socket!
220 v * 10 amps = 2200 watts!
Hazards: AC vs DC

Hazards: LIPO Batteries



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