TERRAPIN WORKS

Introduction to Basic Electronics

Students please sign in for the TW Workshop!

https://go.umd.edu/TWSP25

Part 1

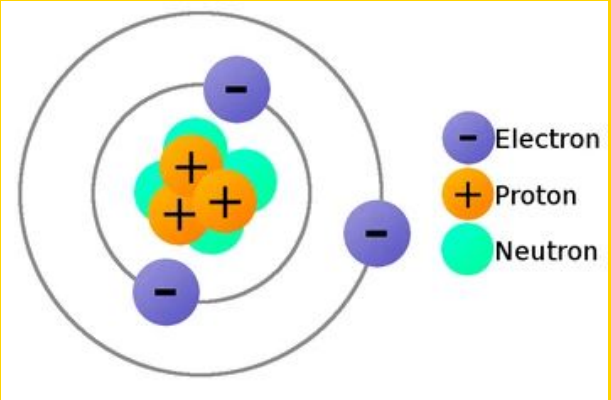
The Physics

What are Electronics?

Devices that **move electrons around** to accomplish something

- Remote control cars
- Phones
- Robots
- House lighting

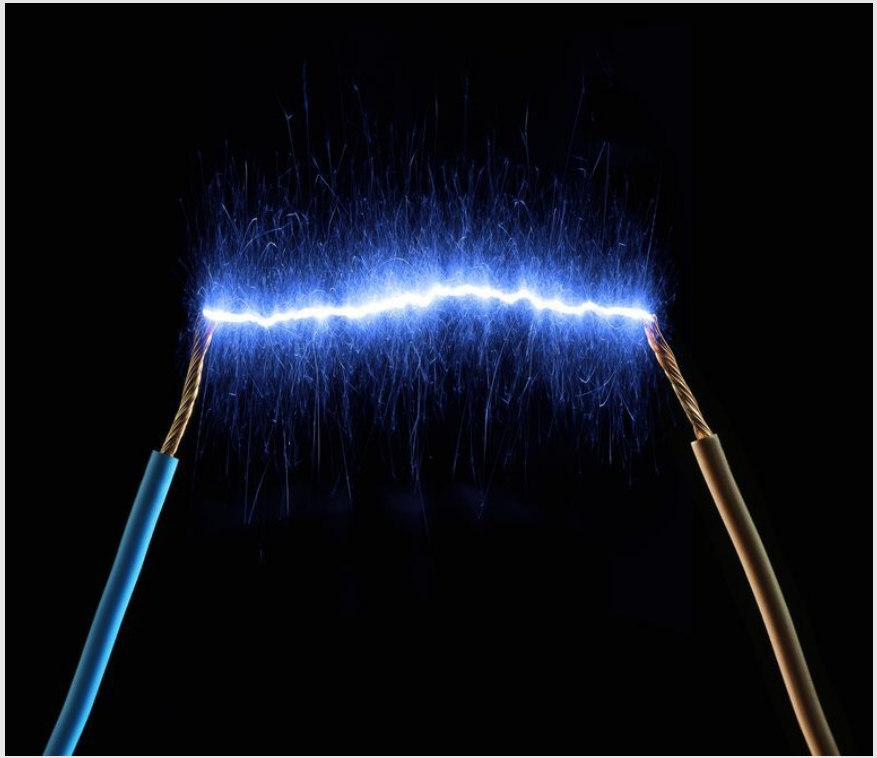
Electrons are tiny particles in matter that carry **built-in electric charge**.



Current

The **speed** with which electric charge moves

- Formally, the amount of charge moving past a point per second
- Current is the **agent of change** in circuits; no current, no change!

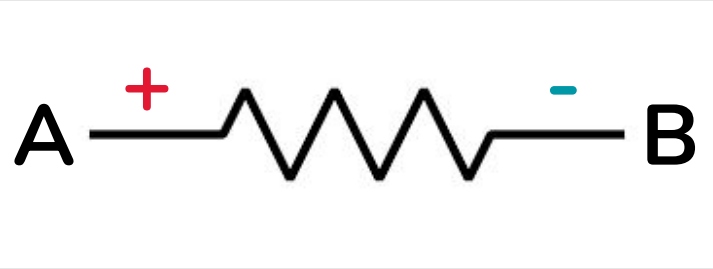


Symbol: I **Unit: Ampere**

Voltage

Symbol: V Unit: Volt

The energy **used** (or **gained**!) by moving charge from one point to another

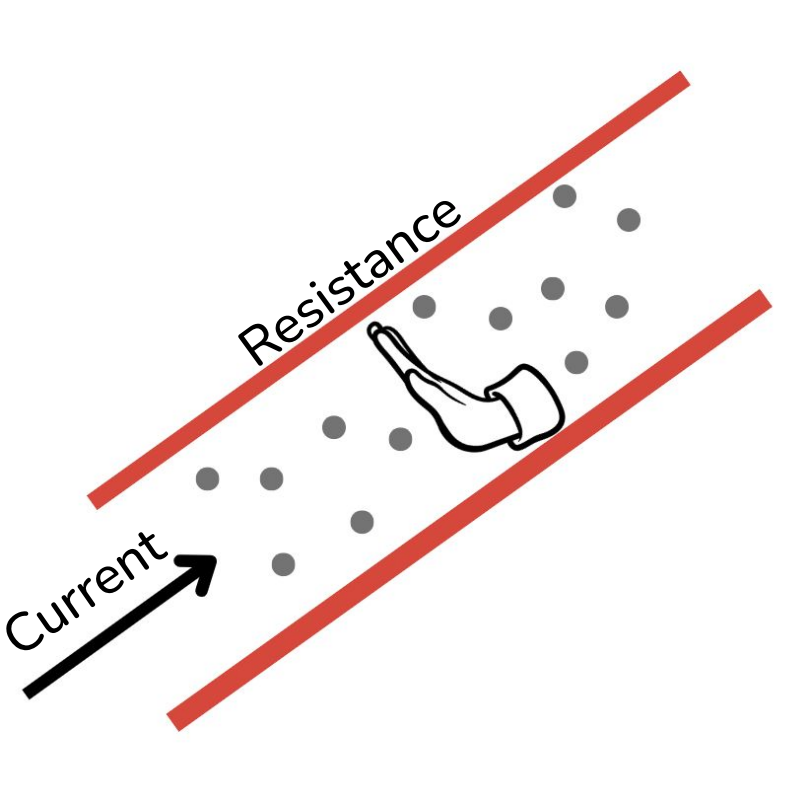


$$V_{AB} = V_A - V_B$$

- Charge is lazy, so current likes to **flow down voltage "drops"** from higher to lower voltage
- Voltage is a **relative potential energy** between two points
- We often assign a reference point that all voltages in a circuit are measured relative to. This is **ground**

Resistance

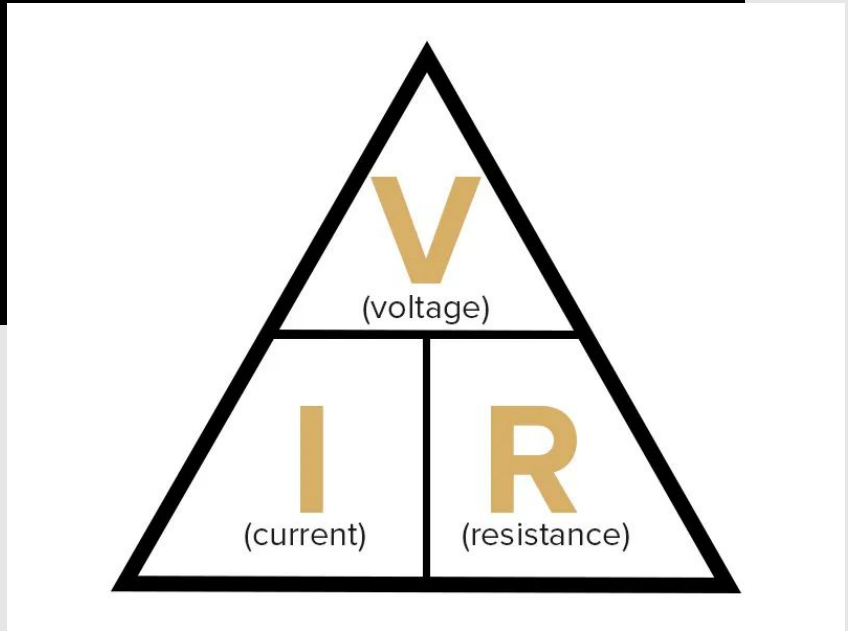
- All materials steal kinetic energy from charge flowing through them and dispel it as heat - **resistance is the rate of theft**
- TLDR: resistance slows current flow!



Symbol: R **Unit: Ohms**

Ohm's Law

Quantifies the relationship between current, voltage, and resistance

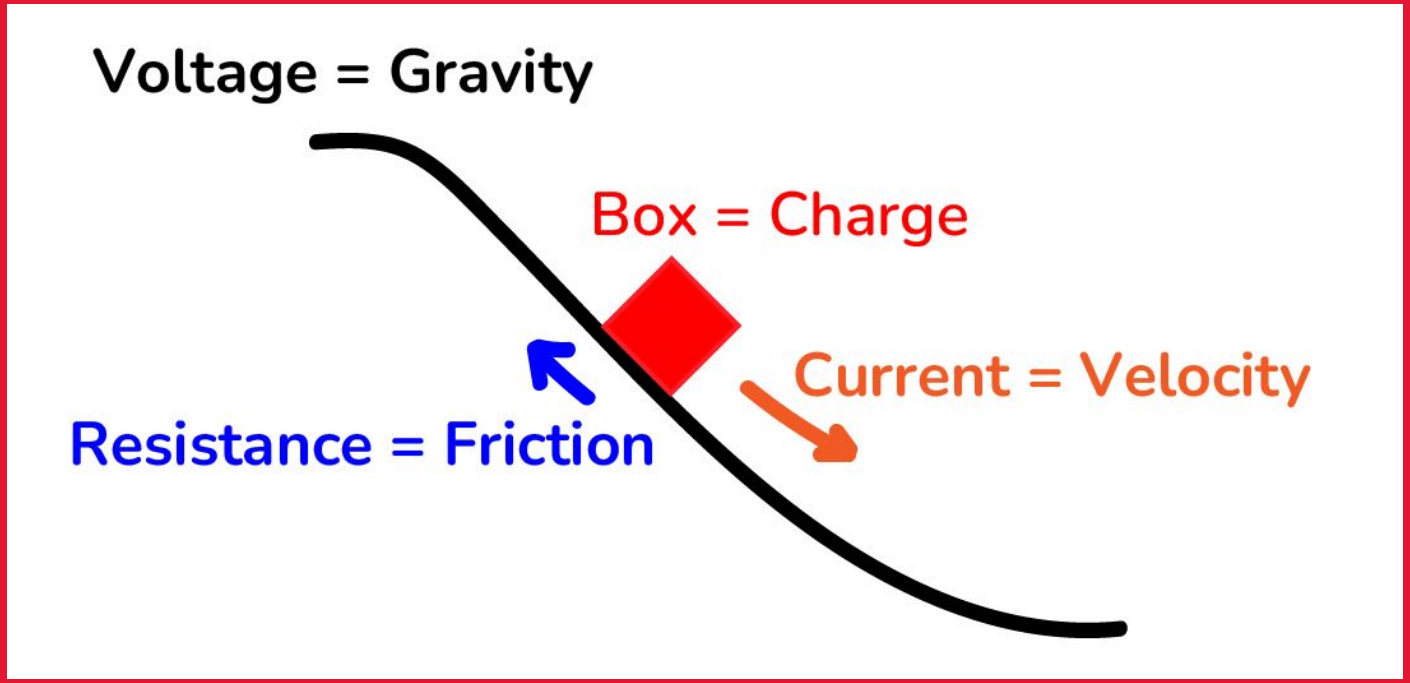


$$V = IR$$

Voltage = Current · Resistance

Devices which obey Ohm's law (eg. resistors, wires) are called **ohmic**!

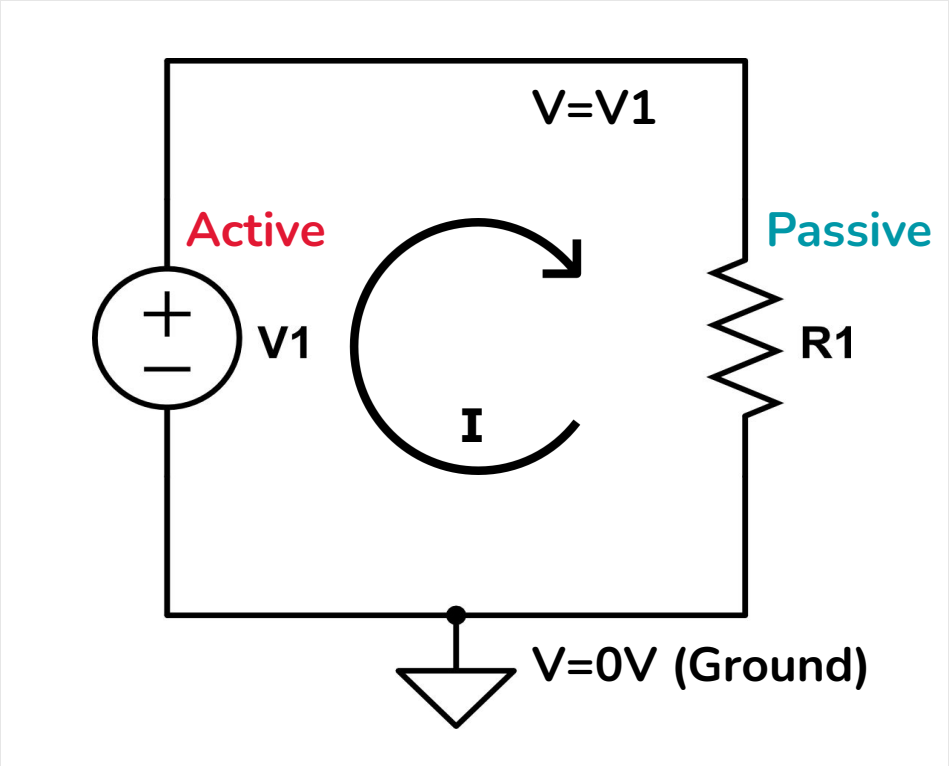
The Hill Analogy



What is a Circuit?

Current only flows through **closed loops** called circuits.

- Active parts supply power, so current flows along voltage rises
- Passive parts consume power, so current flows along voltage drops



Power

- Power=Voltage*Current
- **Energy used per second**
- Measured in Watts
- Most components and devices have max power rating

Part 2

Basic Components

Power Supplies

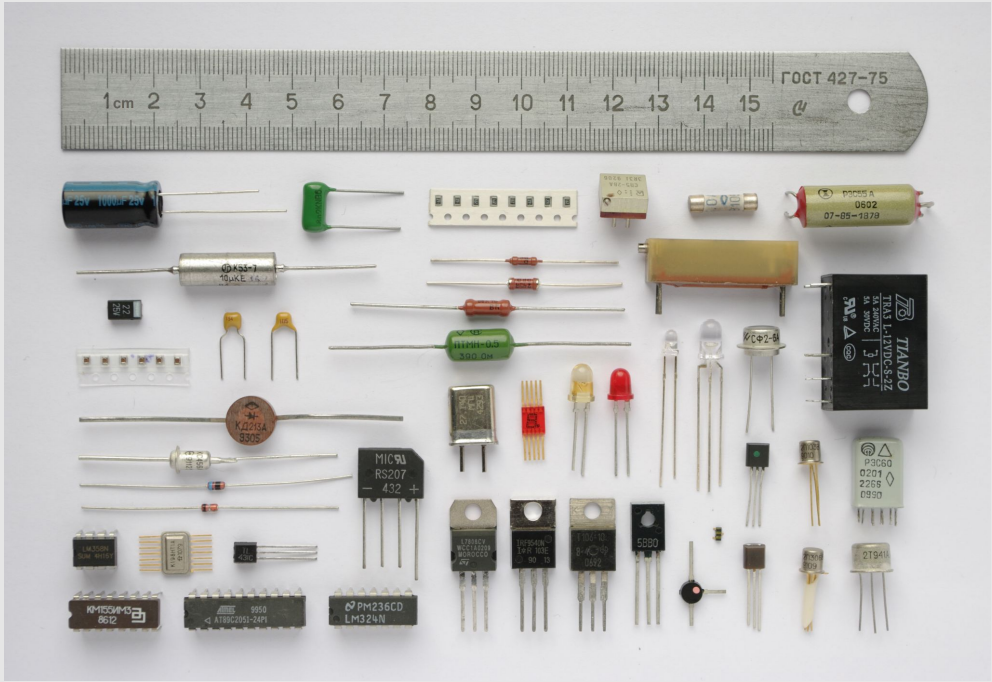
- **Sources** of power
- Use an outlet connection to convert power
- Safe, reliable, and versatile

Batteries

- Store their own energy (measured typically in mWh) that is limited in quantity
- Can either be rechargeable (Li, NiCd, NiMH) or single use (alkaline)
- Portable
- Harder to use than benchtop power supplies (voltage varies across lifetime, limited current delivery/high ESR)

Basic Electronic Components

- Resistors
- Capacitors
- Inductors
- Diodes
- Transistors
- Buttons

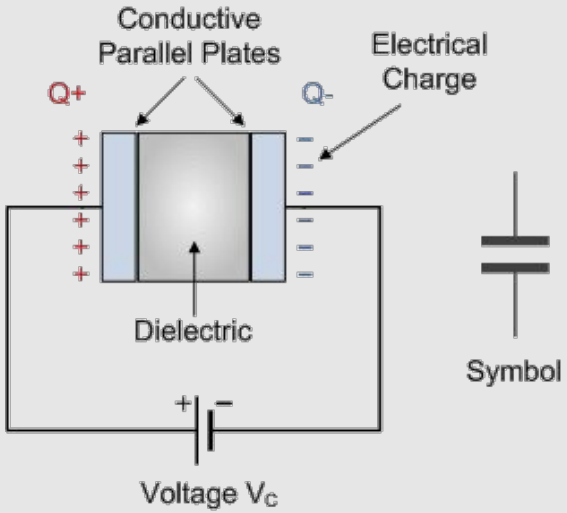


Resistors

- Component with designed **resistance**
- Follows Ohm’s law
- V=IR
- Resists the flow of current

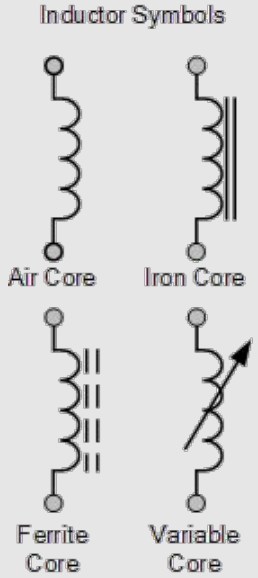
Capacitors

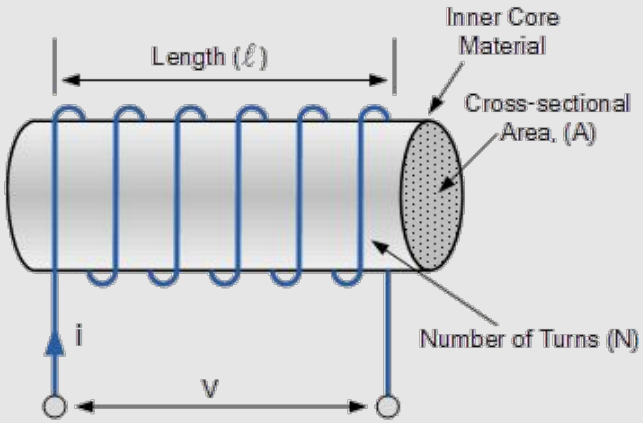
- **Stores electric energy**
- Metal plates separated by gap
- When **voltage increases**, **charge accumulates** on plates
- When **voltage decreases**, **charge flows** from plates



Inductors

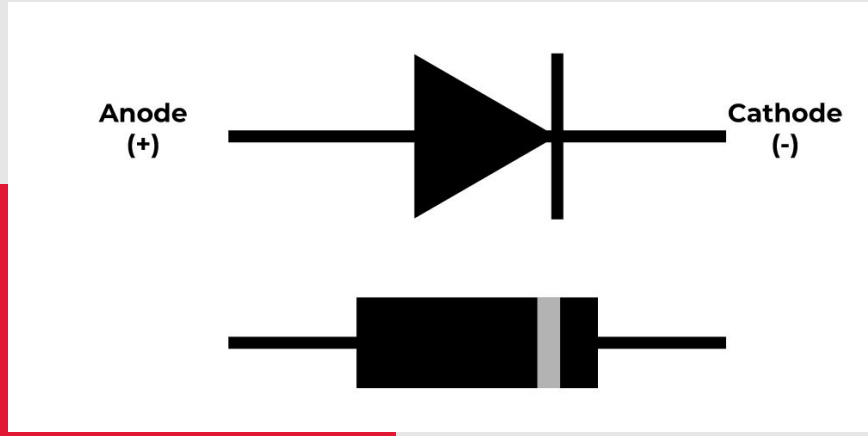
- **Stores magnetic energy**
- Coil of wire
- Current causes a magnetic field around coil
- **Opposes a change** in current

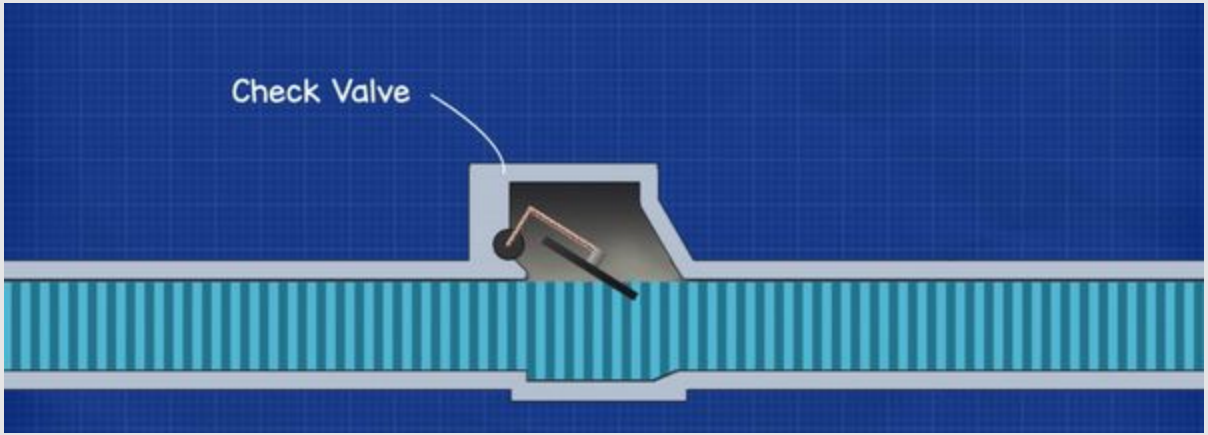




Diodes

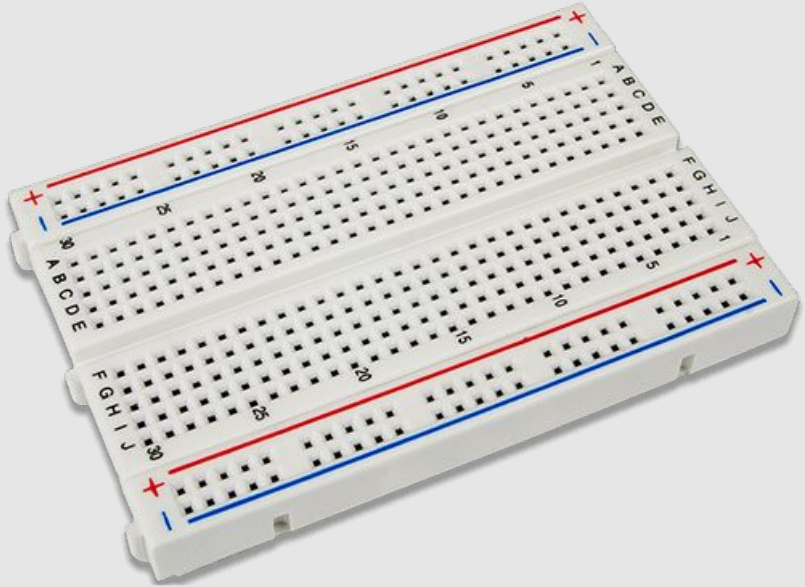
- Allow current to flow in **one direction**
- Electrical check valves



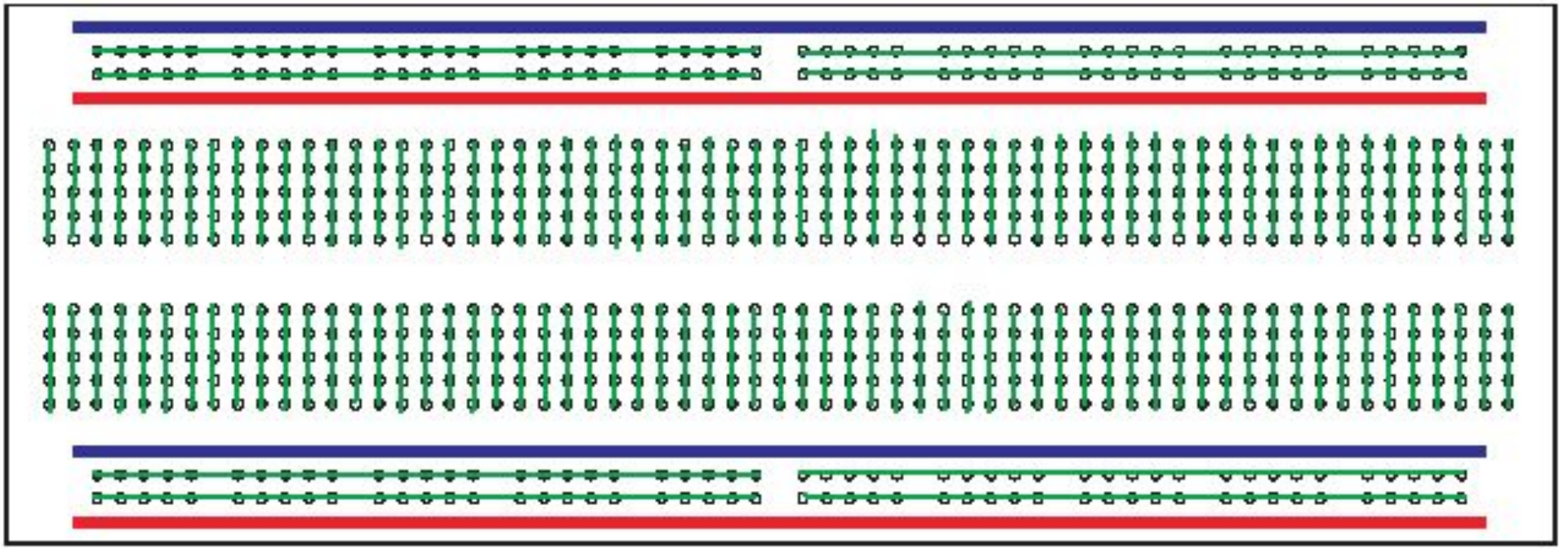


Breadboard

- Used to make temporary connections to test circuits
- Rows are connected together with a jump in the middle
- Column bars used for power and voltage levels



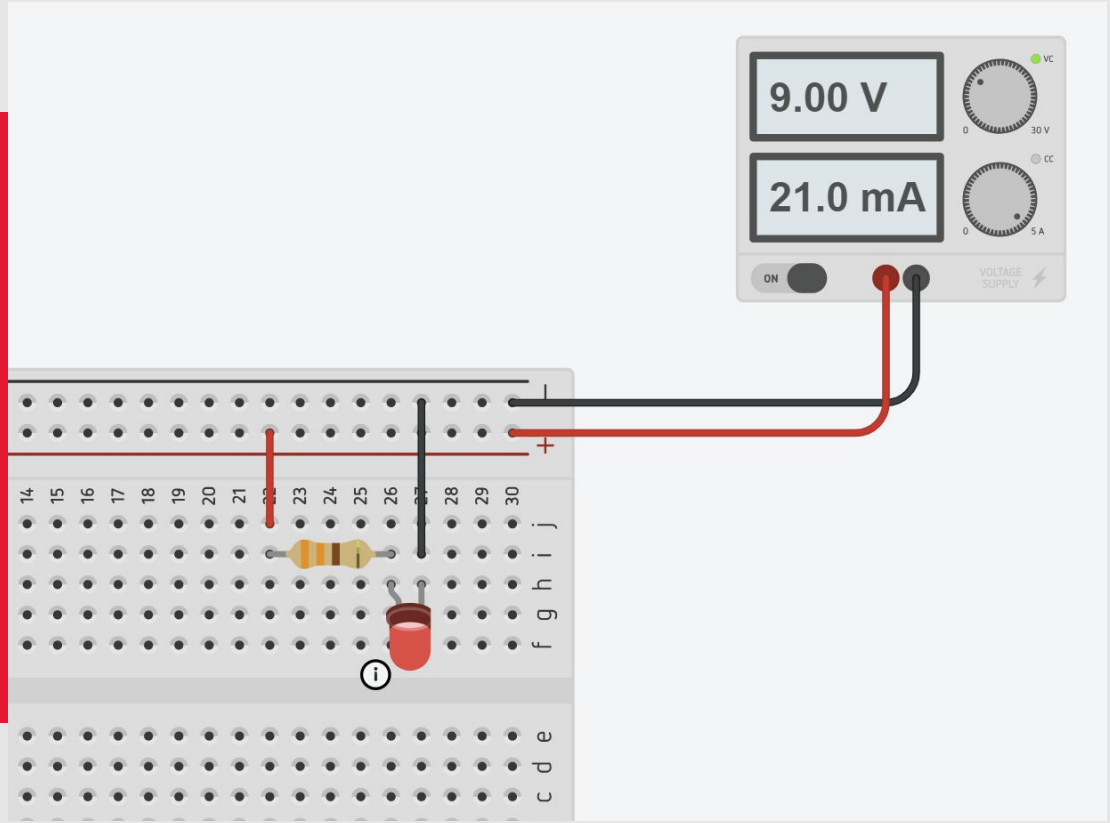
Breadboard Connections



LED Circuit

- Construct this circuit
- Power supply will be 9V
- Calculate Resistance needed
- LED needs 20mA and 2V

$$V = I \times R$$

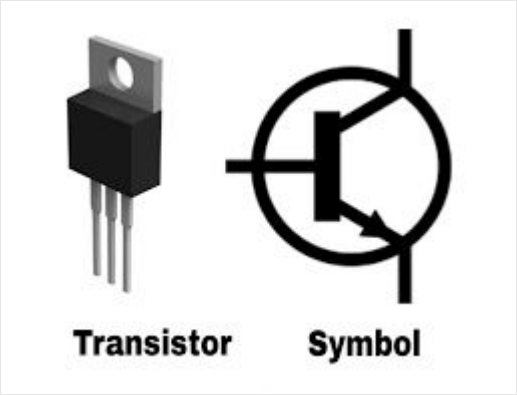


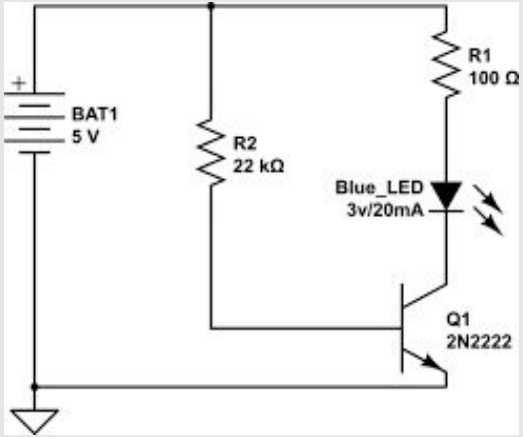
Part 3

Controlling Circuits

Transistor

- **Electrical Switch**
- One terminal impacts current flow between the other two terminals

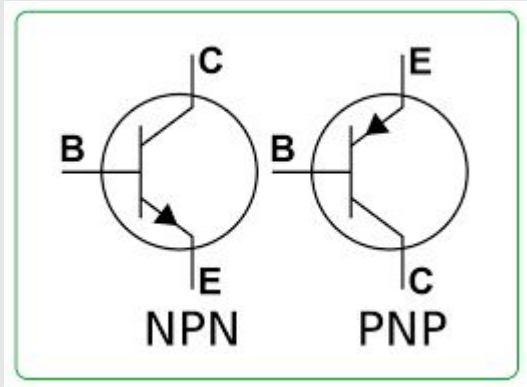


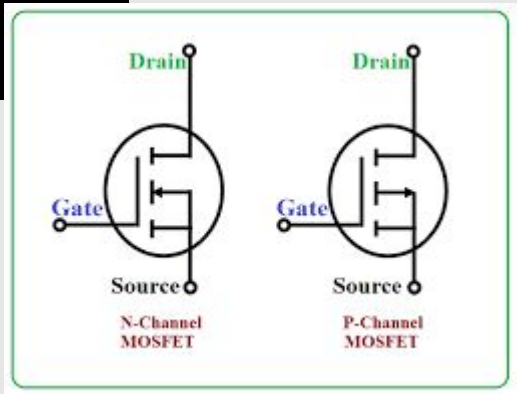


MOSFET vs. BJT

MOSFET

- Voltage Dependent
- Gate control pin





BJT

- Current Dependent
- Base control pin

Buttons

- **Temporary** electrical connection
- Connection formed when pressed
- **Physical** Switch

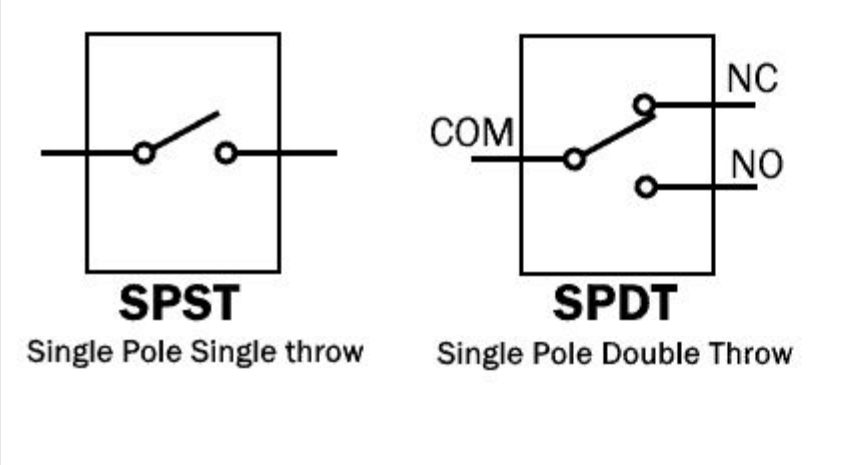
Pole and Throw

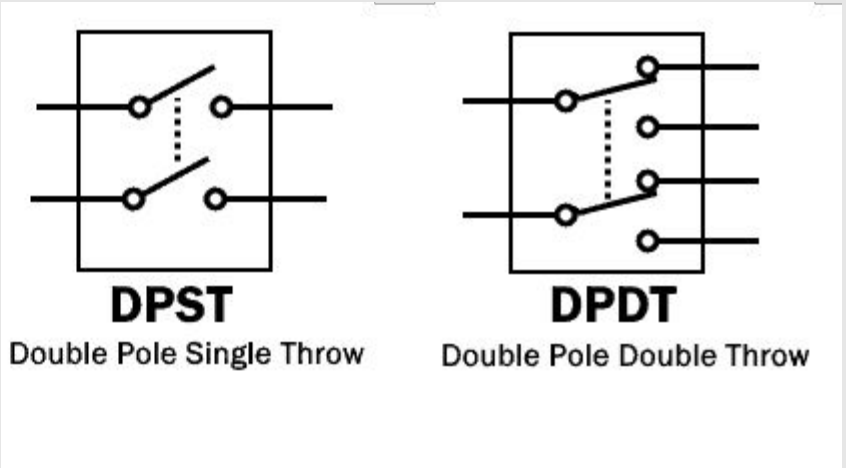
Pole

- Number of switches

Throw

- Number of connections





Momentary vs Latching

Momentary Switch

- The state of the switch is **directly set** by depression (pressed = on, idle = off)

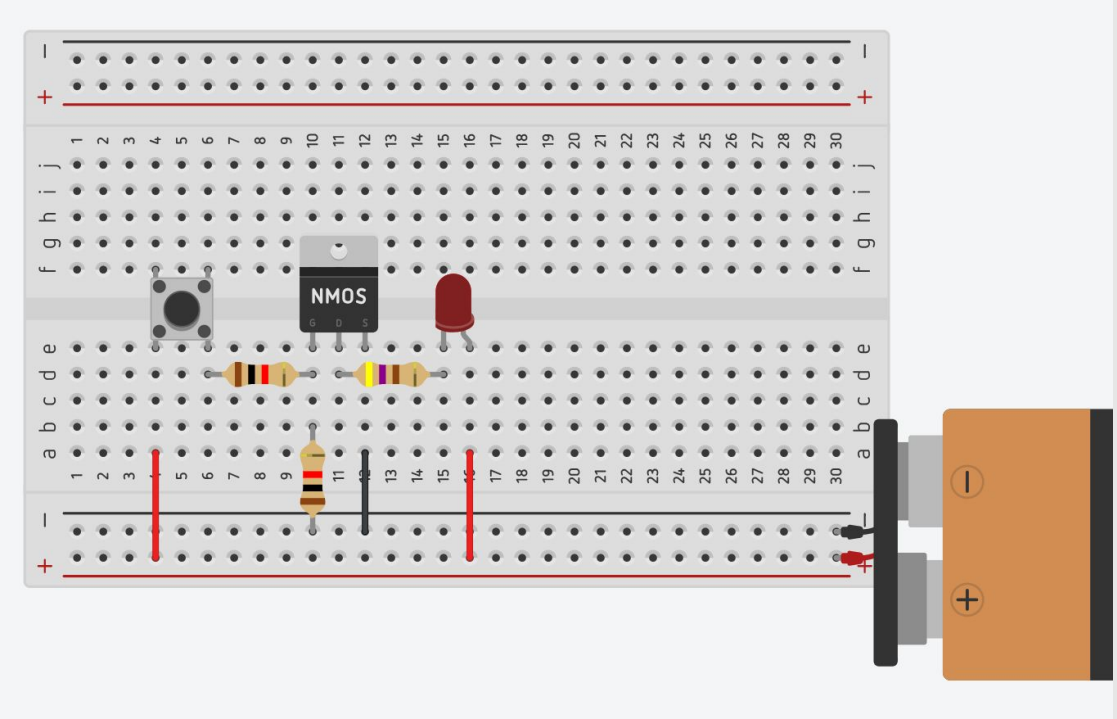
Latching Switch

- A state transition is **initiated** by depression (it remembers)

Example Project

Is this too much? Idrk

It showcases momentary pushbuttons and the switching functionality of transistors which I think we need to do if we mention both



Part 4

Measuring Circuits

Multimeter

- Measures many different quantities
- DC and AC voltage, current, resistance, frequency, capacitance, inductance, etc
- Measurements are done with two probes

https://www.amazon.com/Fluke-115-Compact-True-RMS-Multimeter/dp/B000OCFFMW

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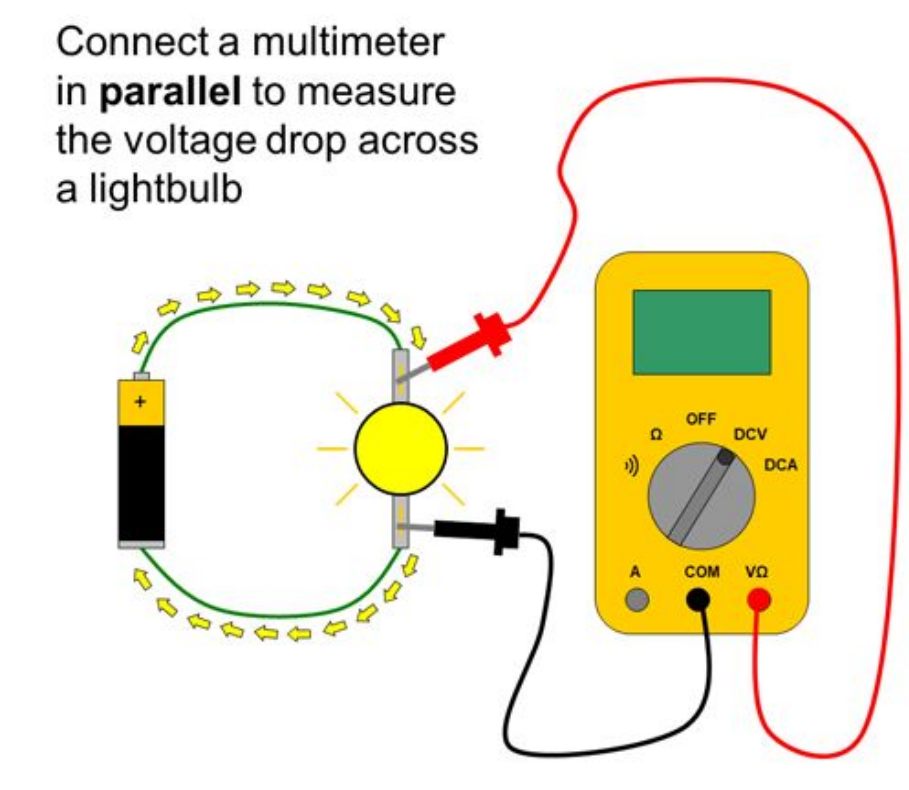
Probes

- Wires that **connect measurement tool** to circuit
- Red goes to positive side of measurement
- Black goes to negative side of measurement

Measuring Voltage

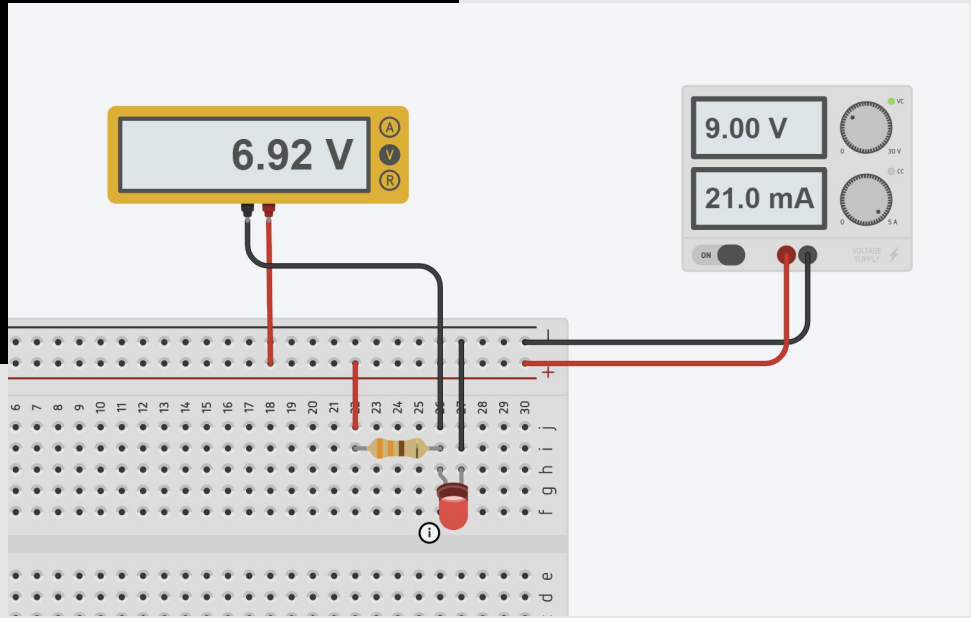
- Voltage is measured between two points on the circuit
- Make sure red probe is on the voltage side
- Set multimeter to measure voltage
- Place probes at the two locations to measure across



https://www.sciencebuddies.org/science-fair-projects/references/how-to-use-a-multimeter

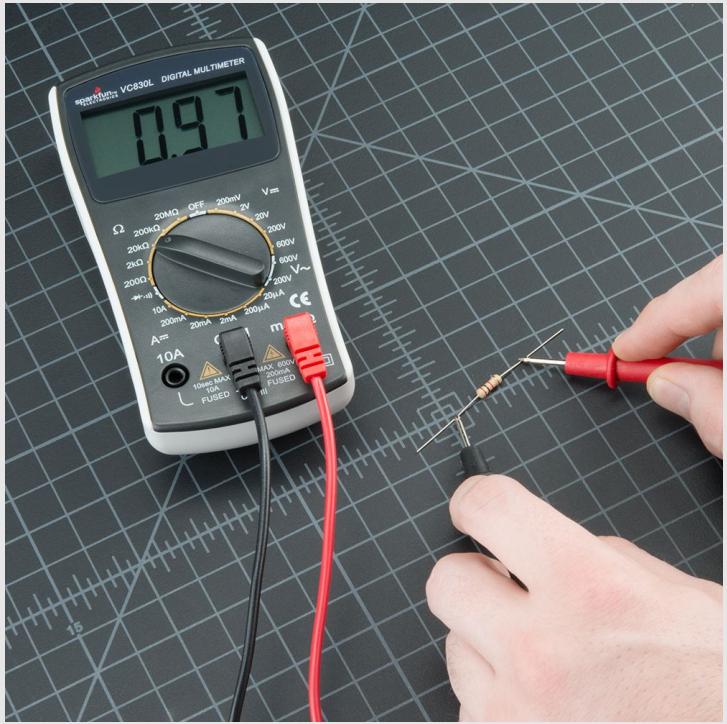
Practice Measuring Voltage

- Turn on the power supply
- Measure the voltages across the resistor and LED



Measuring Other Values

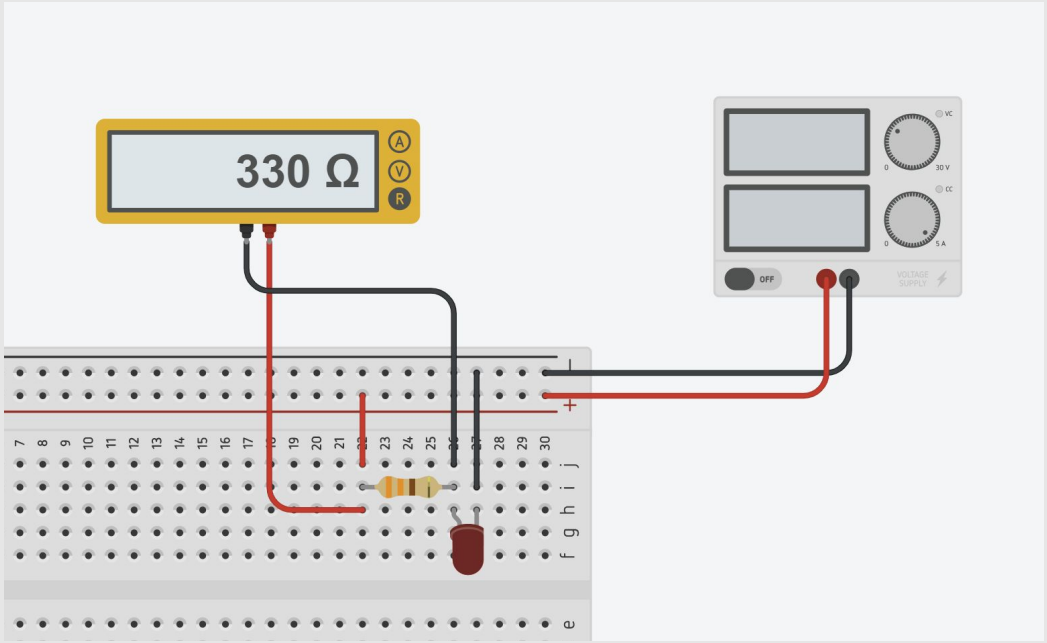
- Resistance, frequencies, capacitance, continuity, etc
- Measured using the same port as voltage
- Except for frequency your circuit should be off for these measurements



https://learn.sparkfun.com/tutorials/how-to-use-a-multimeter/measuring-resistance

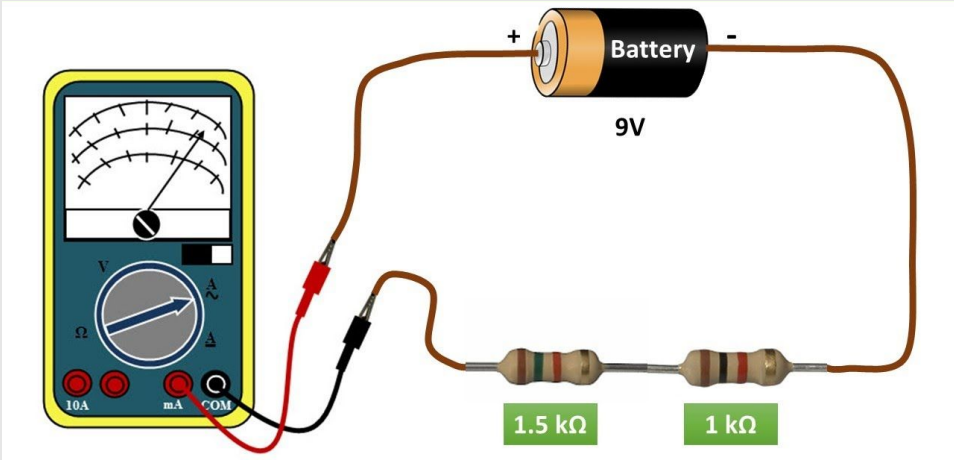
Practice Measuring Resistance

- Turn off power supply
- Measure the actual resistance of the resistor
- Using your previous voltage measurement calculate the current



Measuring Current

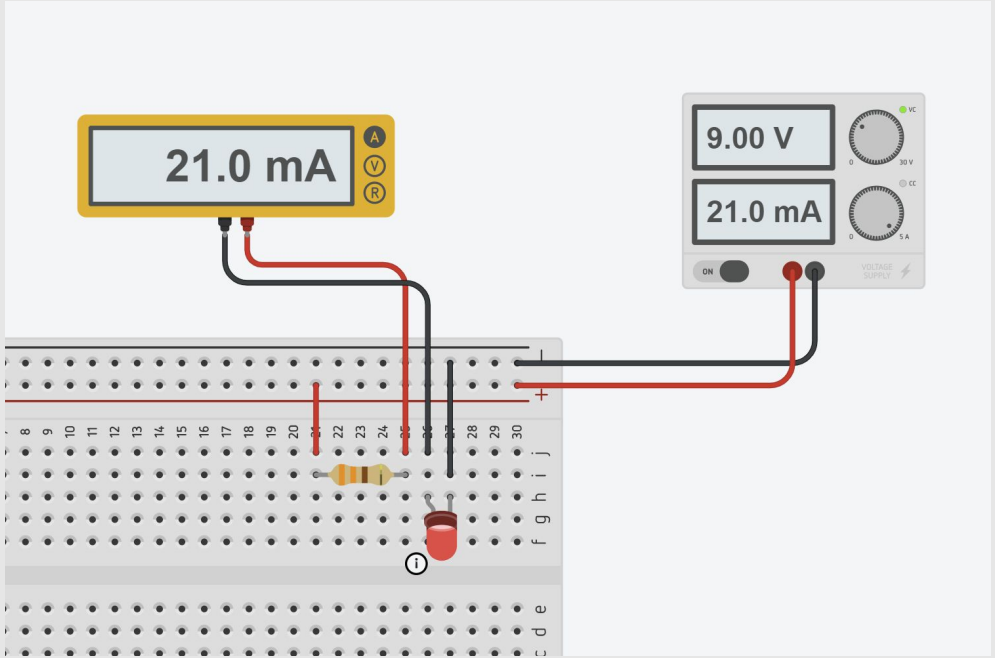
- Current is measured differently than voltage
- Need to break open the circuit and measure between the points you broke open
- This is a **single-point measurement**
- Use the current port instead of the voltage port



https://www.youtube.com/watch?app=desktop&v=b3DMqGiWLeg

Practice Measuring Current

- Rearrange circuit to measure current
- Turn power supply back on
- Measure current
- Use measured current and voltage measurements to determine power

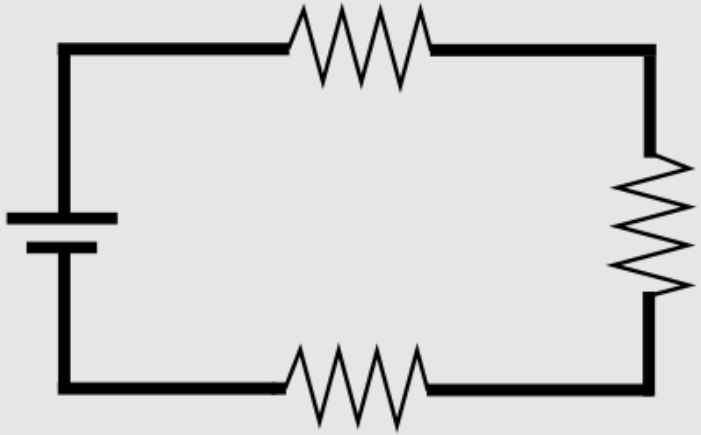


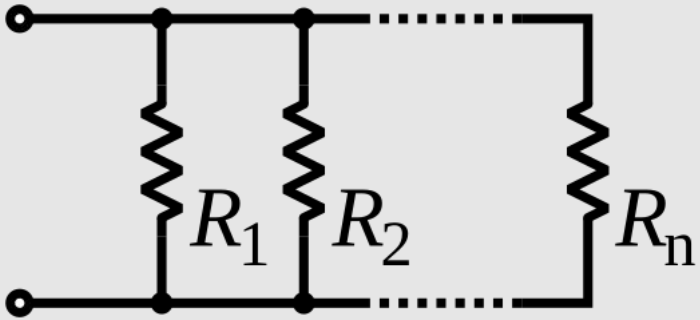
Part 5

Building Circuits

Types of connections

- It is possible to connect the same set of components in different ways.
- The different orientations drastically affect the electrical performance.



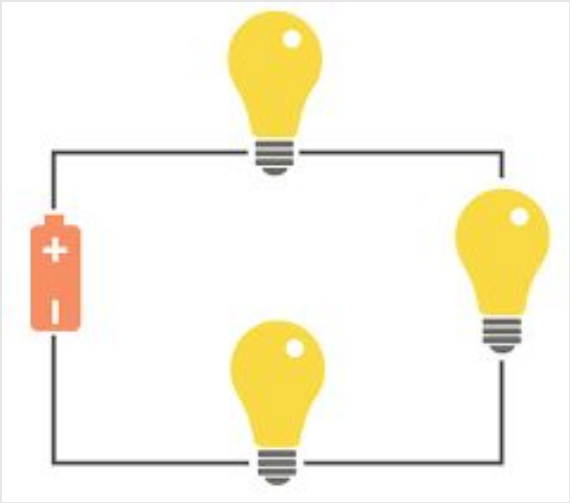


Series connection - Theory

- **Singular path** for current
- Current is **constant** through all components
- Voltage is used up **crossing** each component.
- Voltage is **summed** across the connection.

$$Vt = V1 + V2 + V3$$

$$It = I1 = I2 = I3$$

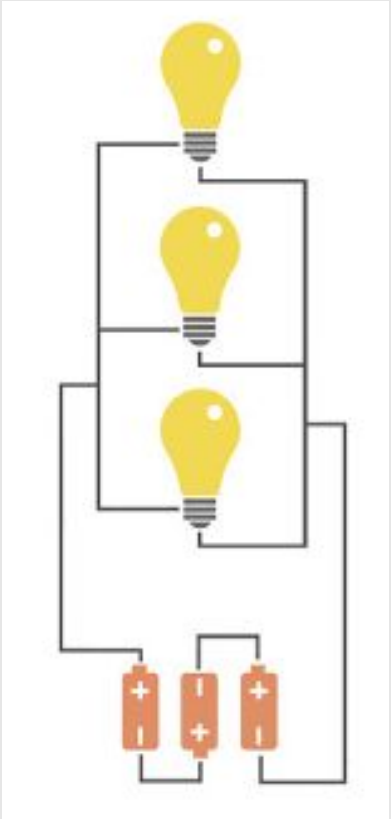


Parallel connection - Theory

- **Multiple paths** for current
- Current is **divided** among each branch.
- Each component is place **across** voltage source
- Voltage is the **same** across all components.

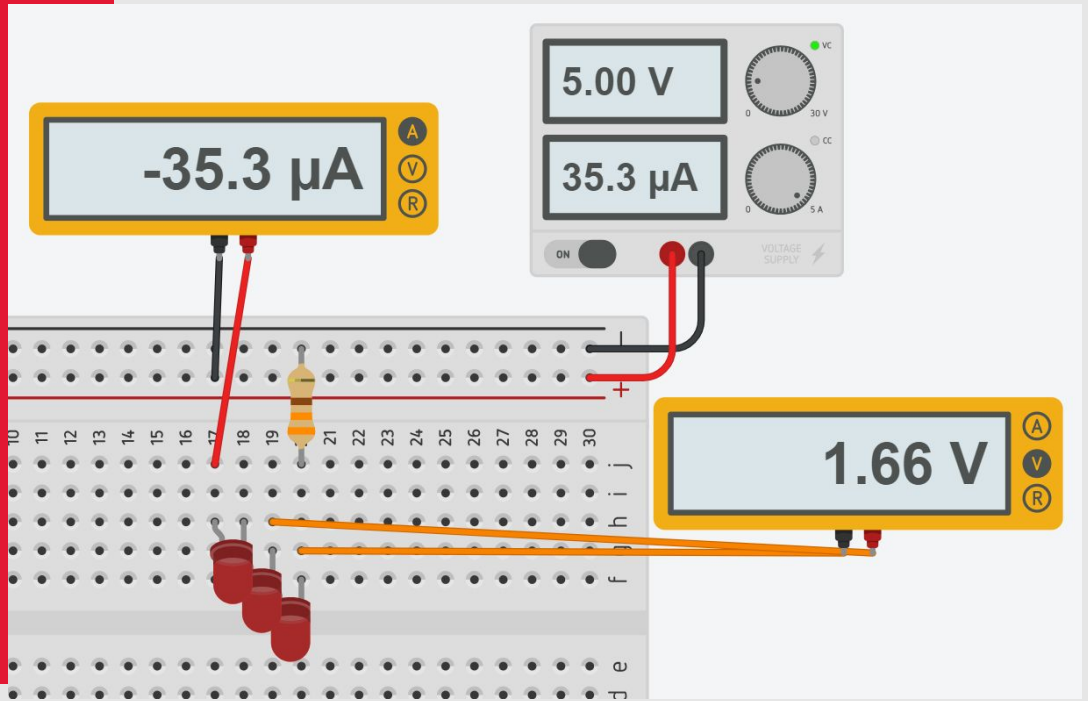
$$V_t = V_1 = V_2 = V_3$$

$$I_t = I_1 + I_2 + I_3$$



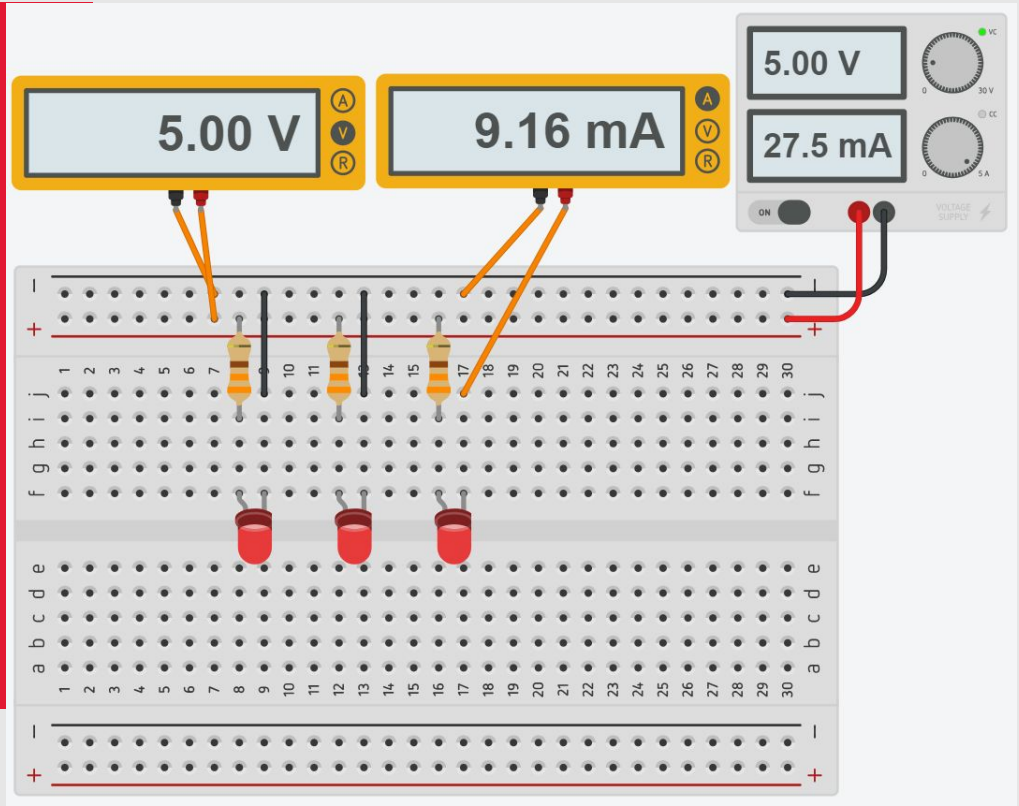
Series connection - Practice

- Note how each LED has **voltage drop** across it and how this affects brightness.
- Note how current is the **same** at all parts of the circuit
- Experiment! See how adding or removing LED's changes voltage.



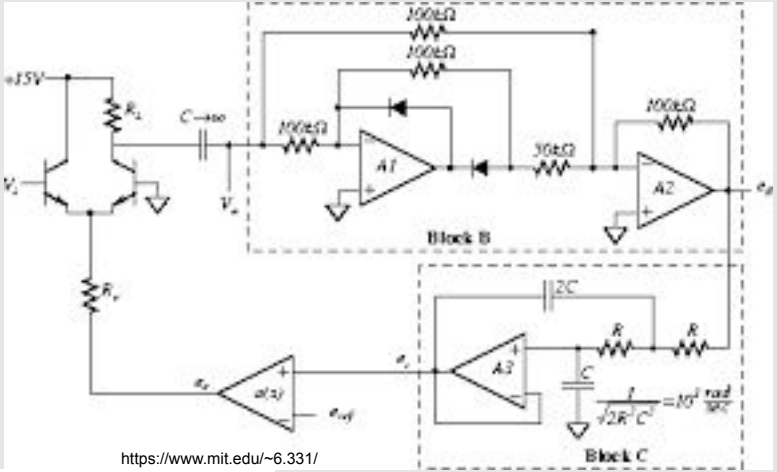
Parallel connection - Practice

- Since each branch has the same resistance current in each branch is identical.
- Voltage across each branch is **identical**.
- Experiment! See how changing resistances changes currents.

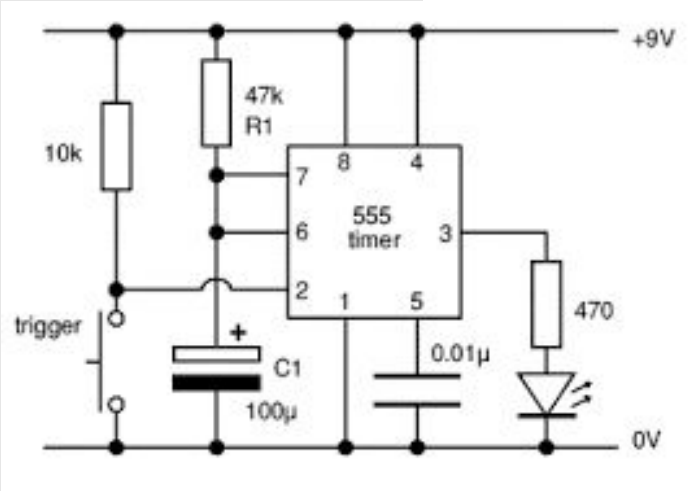


Next Workshop

- What is a circuit
- Parts of a circuit
- Basic circuit elements

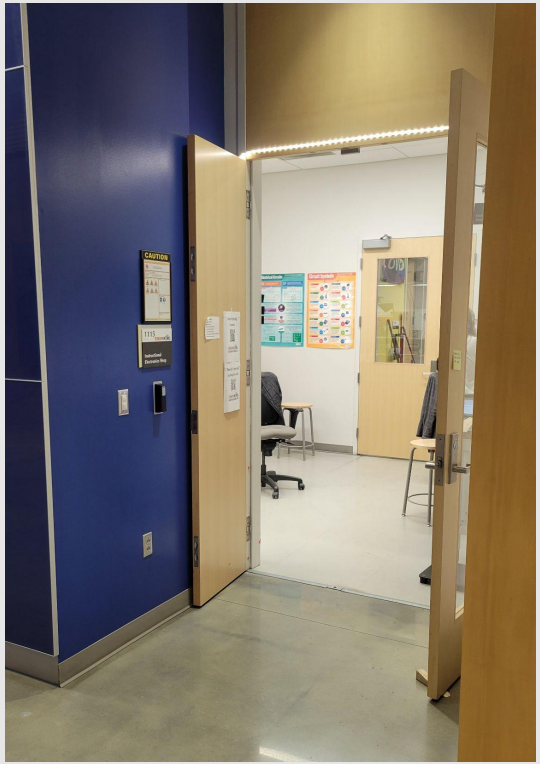


https://www.mit.edu/~6.331/



https://electronicsclub.info/circuitsymbols.htm

Come visit the IES!



1115 AJC

Open Lab 2:00- 7:00 PM Weekdays

Thank you!

Please give us your feedback!
https://tinyurl.com/6eayw8r8

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