Electrical Training

Week 1: Electricity, Voltage, Current, Resistance, Power, Breadboards, Github

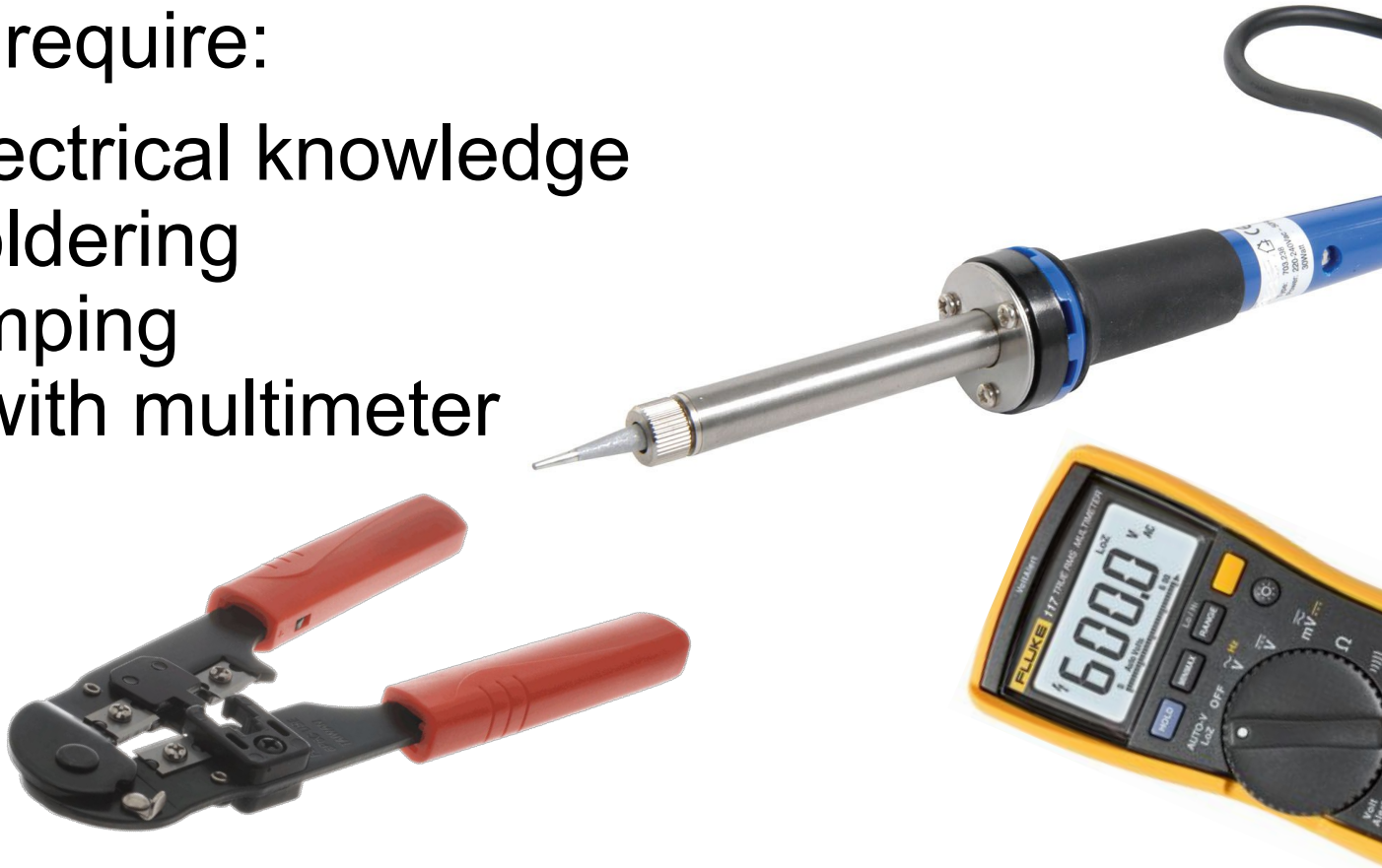
Agenda

- Electrical subteams in RoboJackets
- Electricity basics
- Ohm’s Law
- Breadboards
- Multimeters
- Github

RoboJackets Electrical

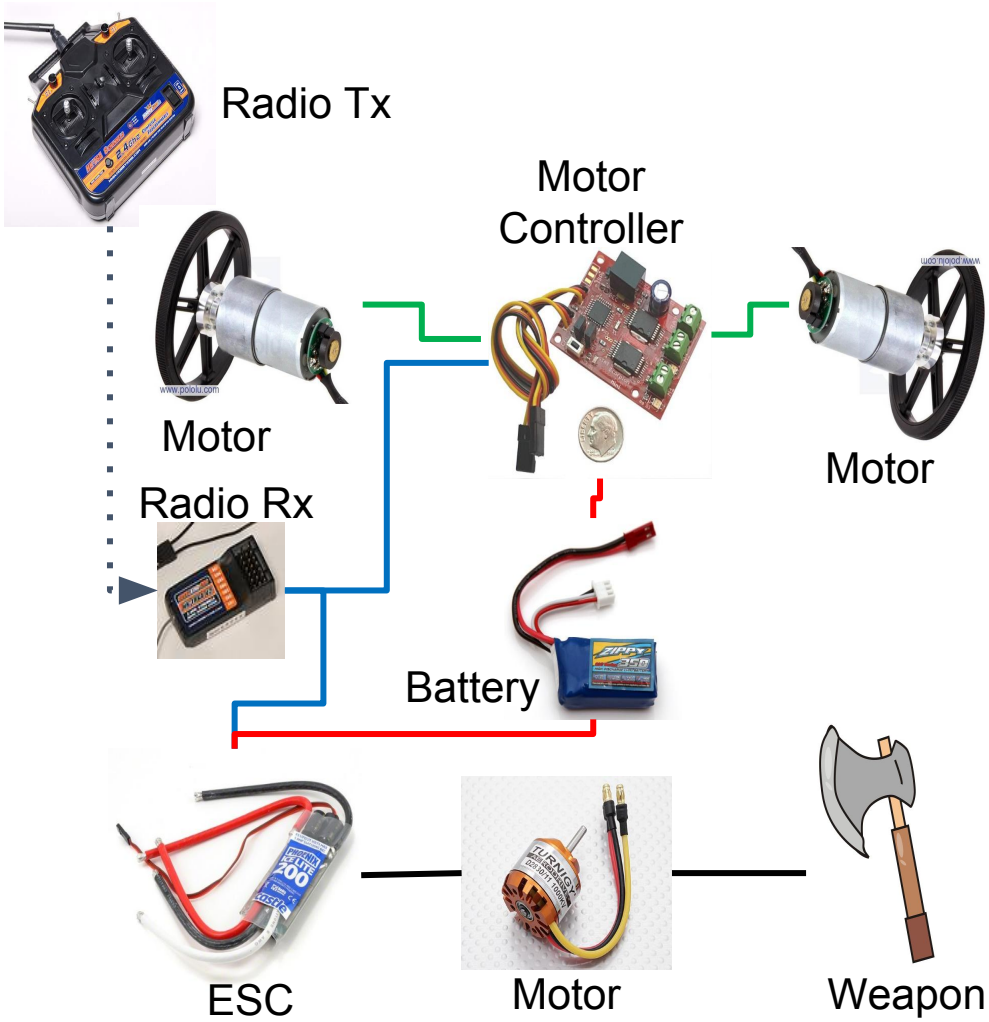
All teams require:

- basic electrical knowledge
- basic soldering
- wire crimping
- testing with multimeter



Electrical Teams:

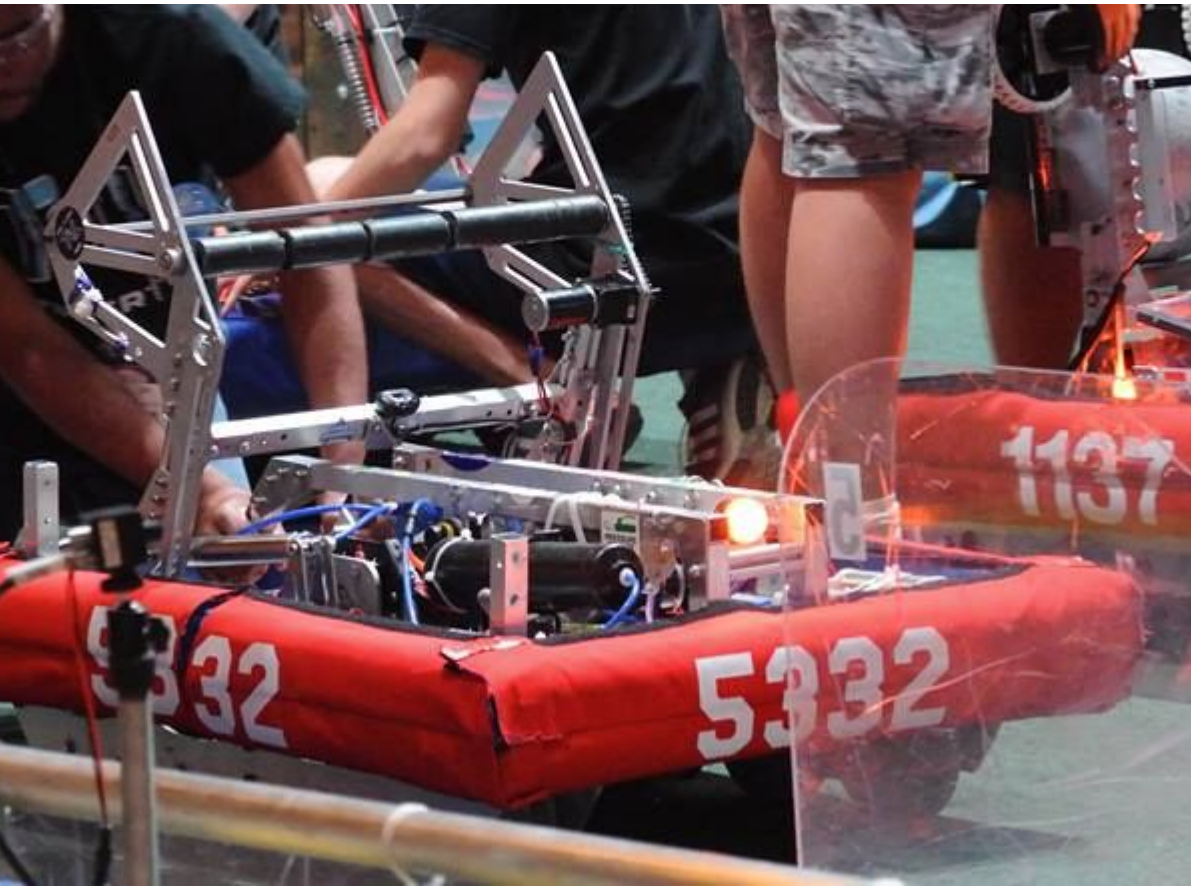
BattleBots



- Motor Operation
- Wireless control
- Power and durability
- Low focus on precision

Electrical Teams:

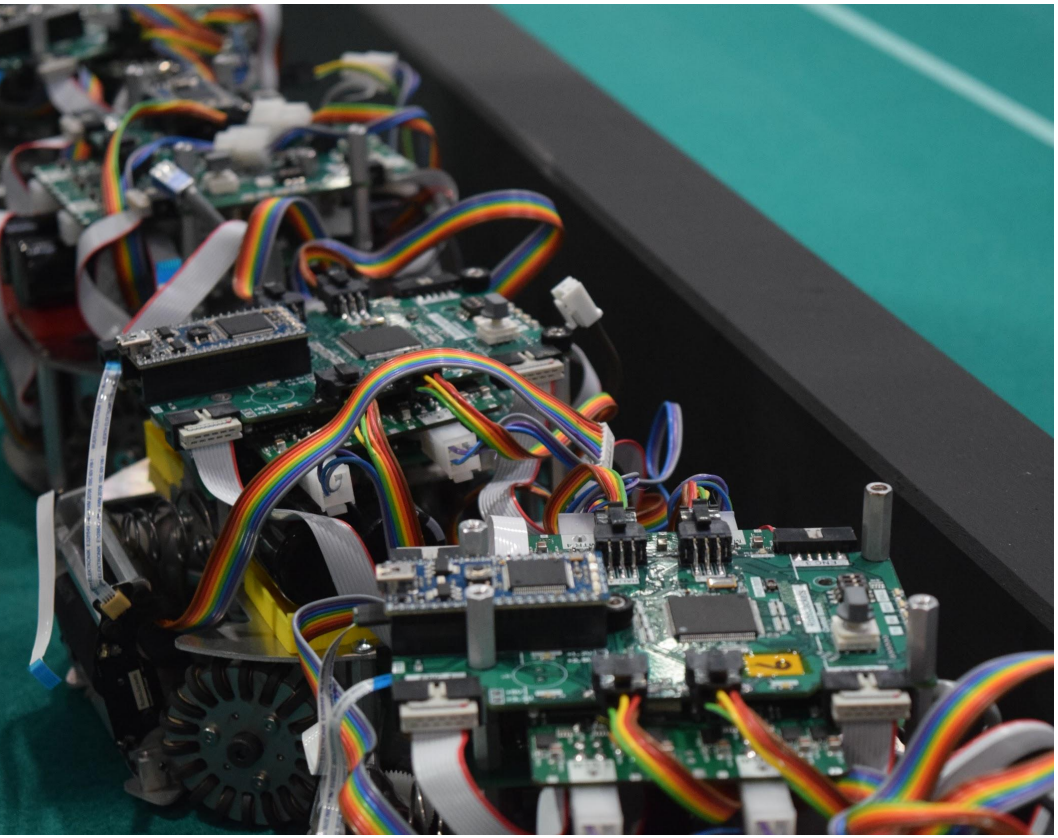
FIRST Outreach



- Standard electrical parts
- Less emphasis on durability
- more emphasis on precision

Electrical Teams:

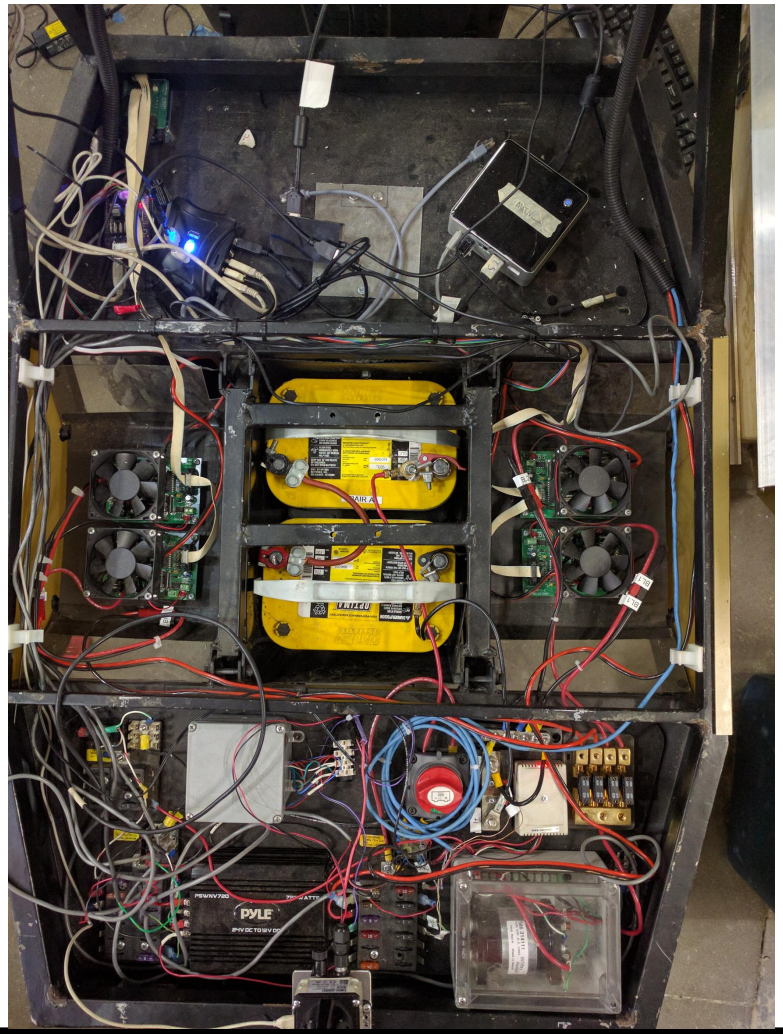
RoboCup



- Main focus on design
- Low focus on high power
- Extreme precision and accuracy
- All electrical boards custom-designed

Electrical Teams:

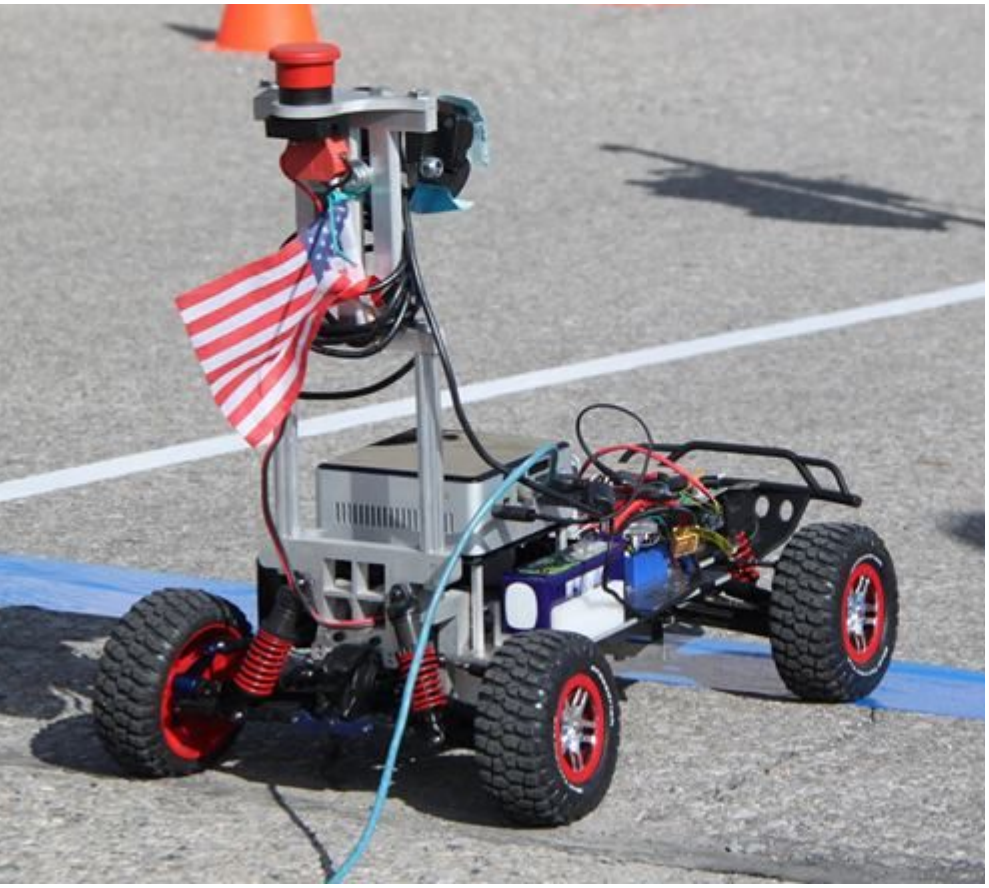
IGVC



- Combination of custom and off-the-shelf components
- Multitude of sensors
- High-power motor operation
- Focus on maintaining and testing complex system

Electrical Teams:

RoboRacing



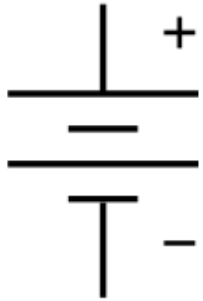
- Medium-power motor control
- System stability and durability
- Interface software and hardware with standard development board

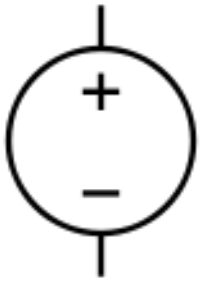
What is electricity?

- The flow of electrons through a conductor
- We can describe this flow using:
  - voltage (*V*)
  - current (*I*)
  - resistance (R)
- Relate the 3 together by using **Ohm's law**:

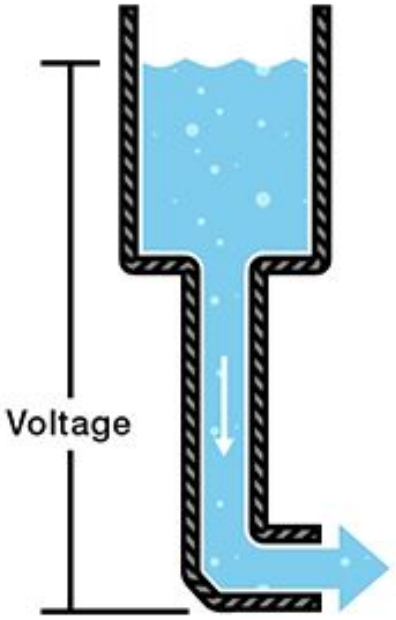
$$V = I * R$$

Voltage (*V*)



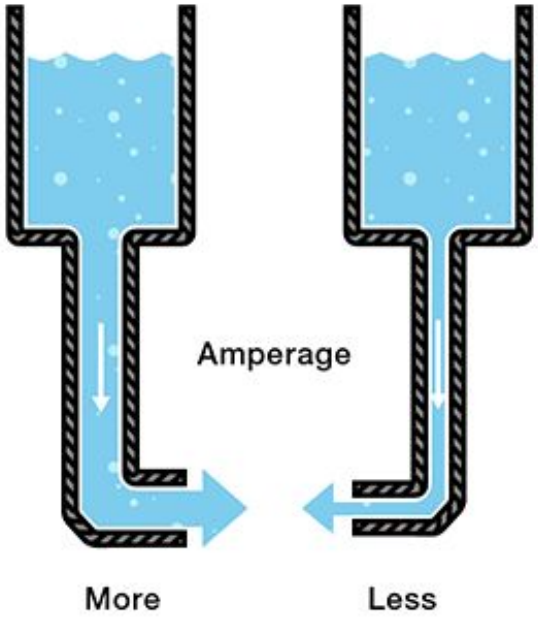


- The difference in potentials between 2 different locations
- The "*pressure*" with which electrons are thrust through a conductor
- water pipe analogy: the voltage resembles the downward pressure caused by water in a cylinder



Current (*A*)

The amount of charge flowing through a point in a conductor



Voltage and Current

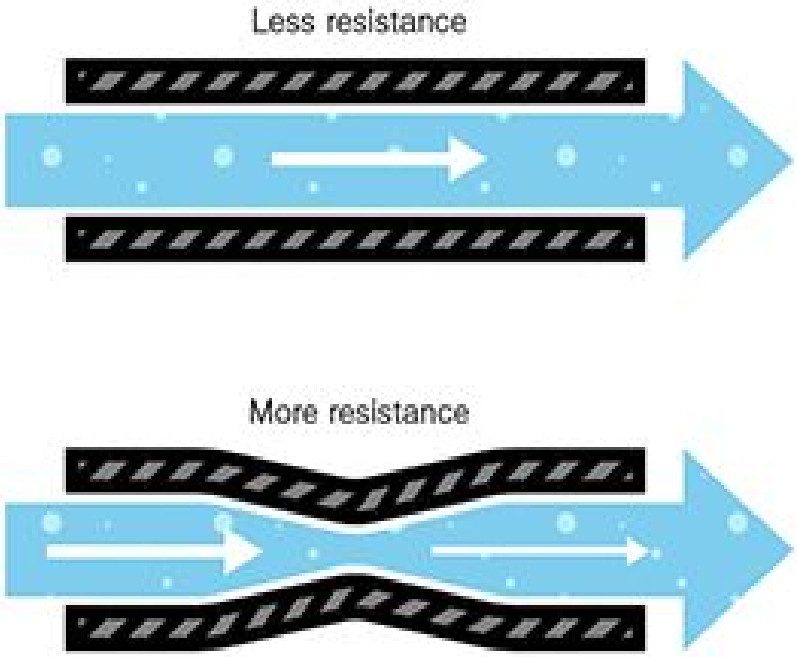
voltage

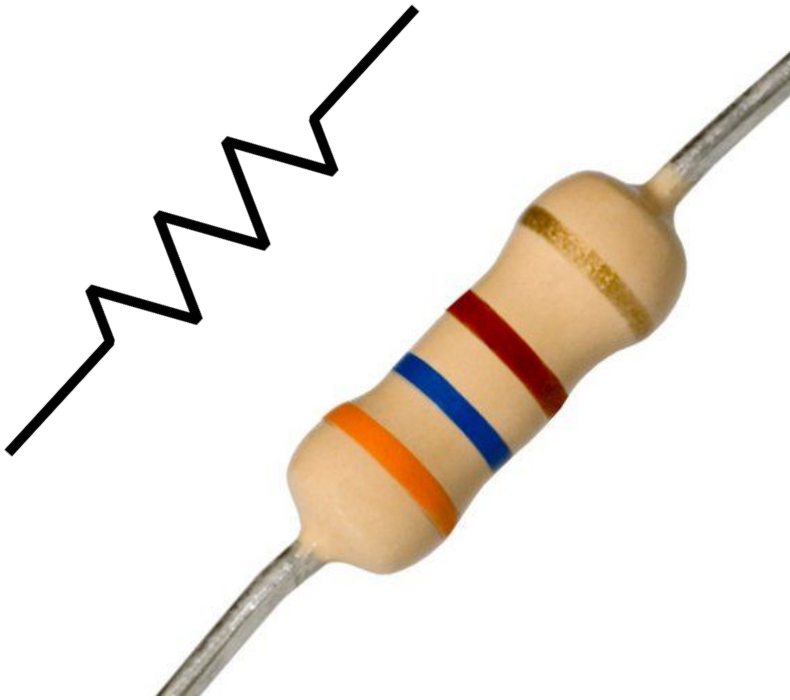
current

“Voltage shocks, current kills”

Resistance (Ω)

- Used to control the amount of flow (current)
- *Resistors* provide this functionality





Ohm's Law

- $V = I * R$
- We can use resistance to control the flow of current at a point
- Similar to squeezing a water hose
  - press down -> water goes farther (with more pressure) but less goes through

Power

- Electrical components convert electricity to other forms of energy
  - Heat
  - Light
  - Motion
  - RF (…)
- Power expended by a component is:

$$P = V * I = I^2 * R = V^2 / R$$

- Components provide specification for how much power they can safely handle

Short and Open Circuits

Open Circuit - no connection between leads; *zero current*

I = 0

No energy is expanded between leads

Short circuit - direct connection between leads; *zero voltage*

V = 0

No voltage drop across leads

Short circuit across battery

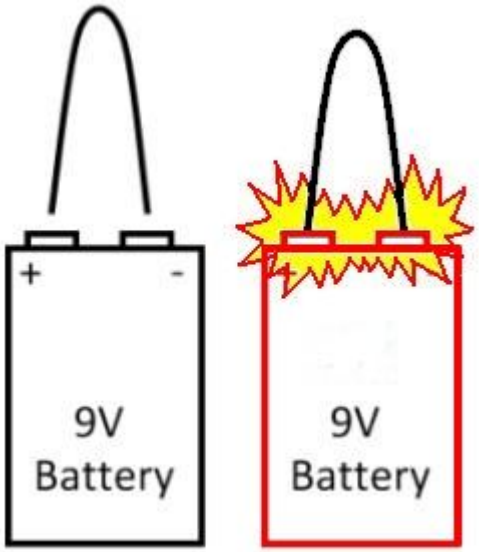
Short: $R = 0,\ V = 9V$

$I = V / R$

$I = 9V / 0 \rightarrow \infty$

$P \rightarrow \infty$

Because all wire carries a small amount of resistance, a finite, albeit large, amount of power is expanded



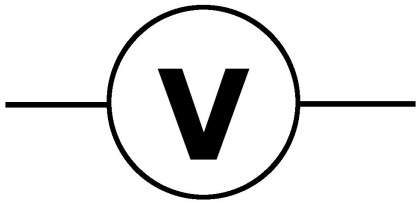
- wires burn
- batteries explode
- robots cry

Measuring *V*, *I*, *R*

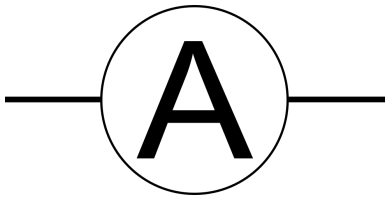
We use a **multimeter**.

Tools:

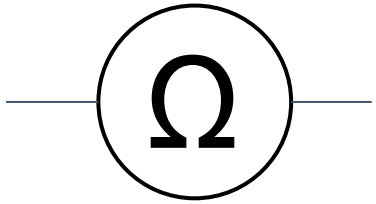
- voltmeter



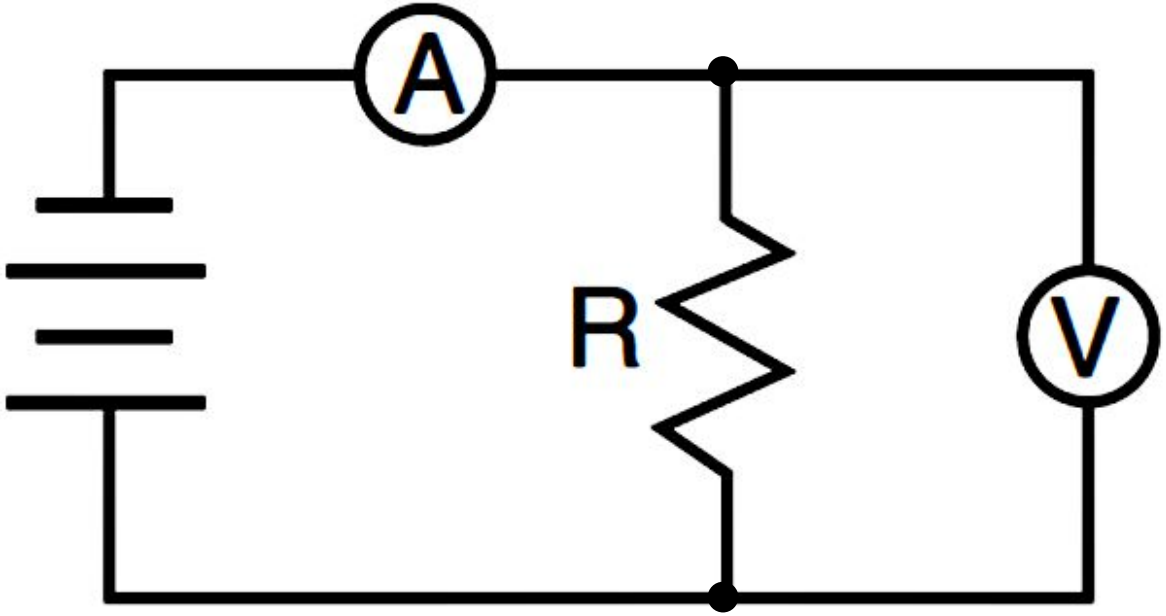
- ammeter



- ohmmeter



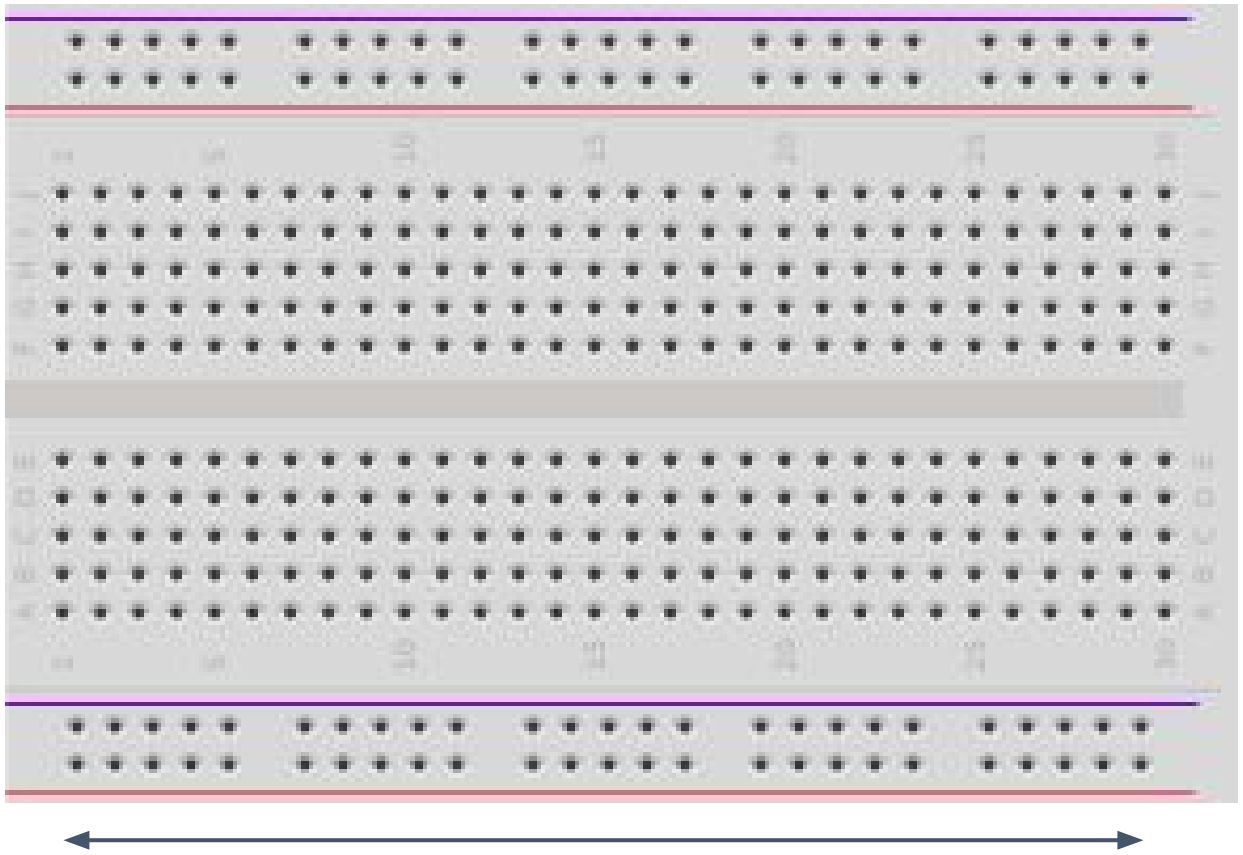
Measurements in a Circuit



Breadboards

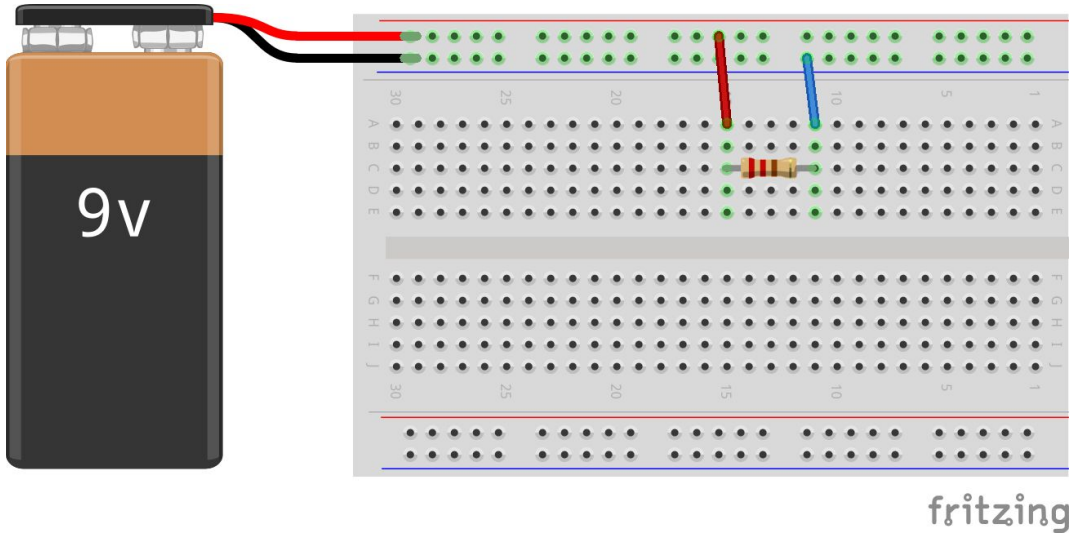
allow us to easily create and test circuits

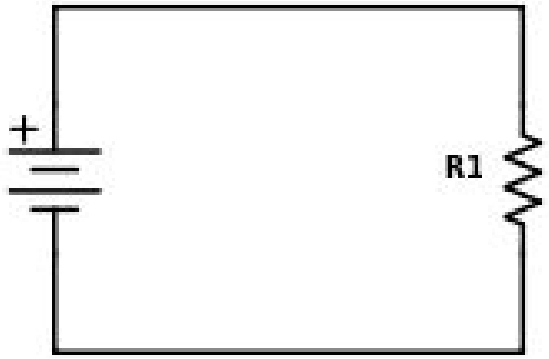
points are connected in voltage and ground columns



points are connected in a row

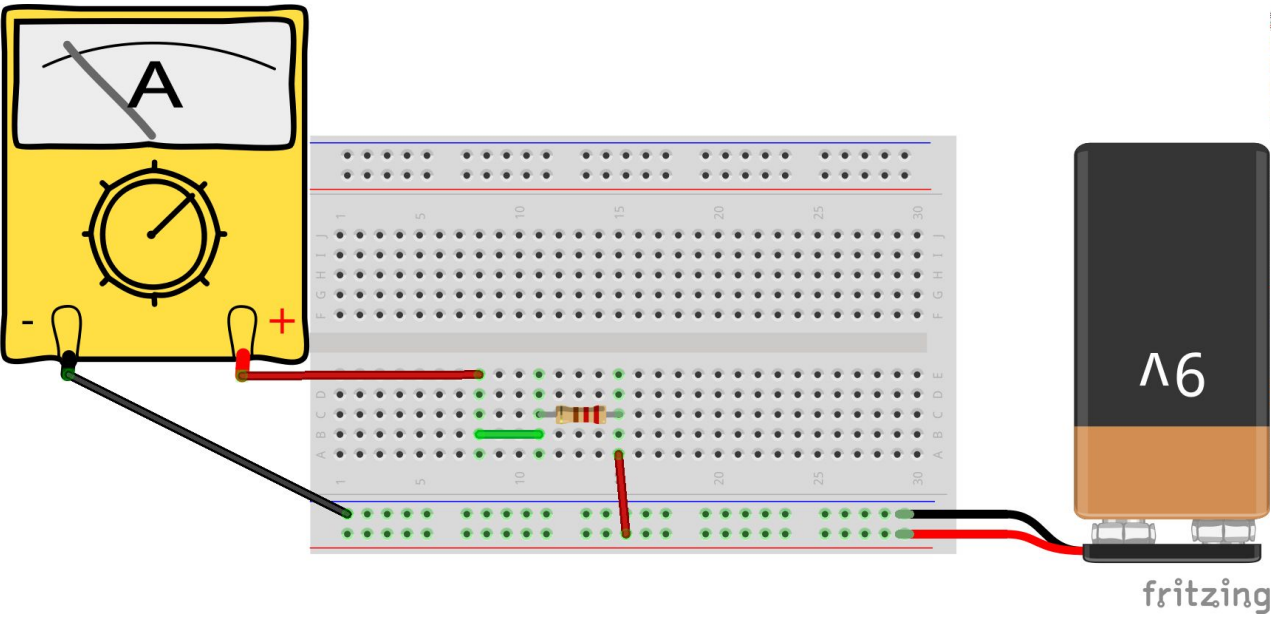
Circuit - Single Resistor

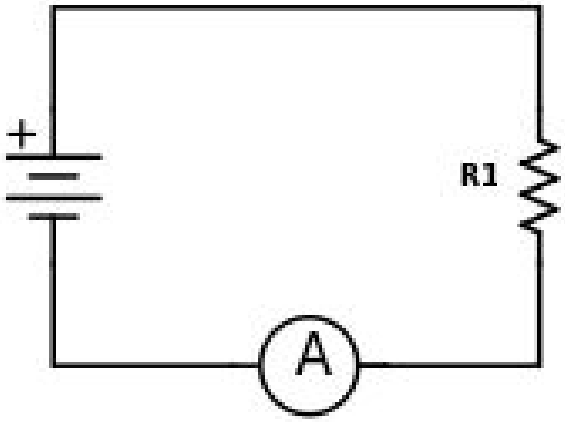




Circuit - Measure Current

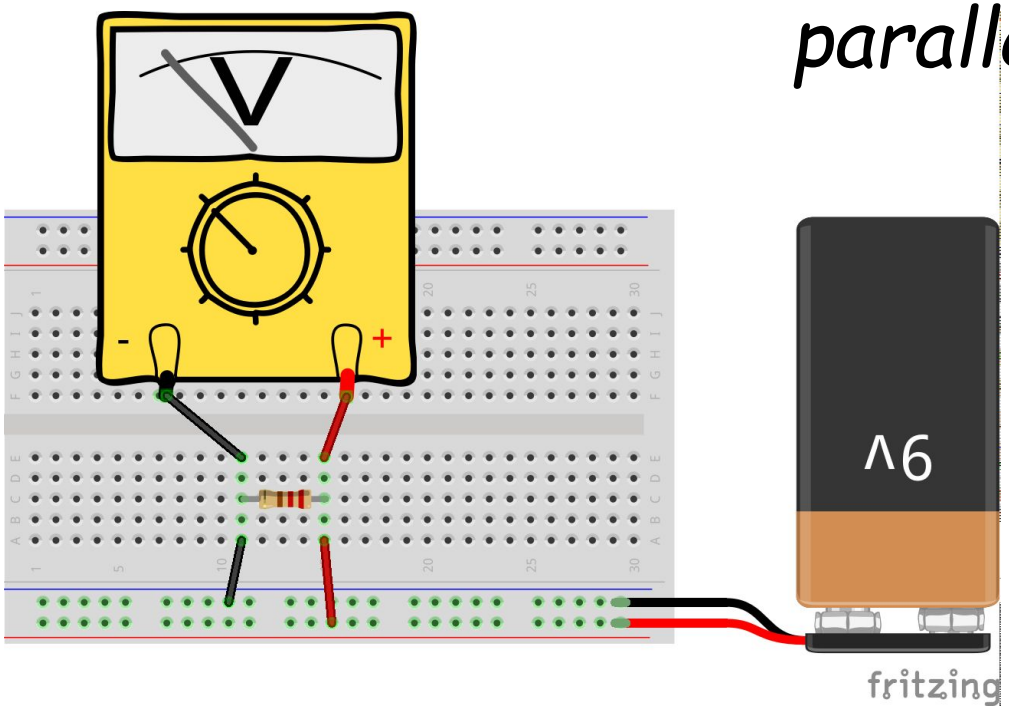
Ammeter connected in *series* with circuit

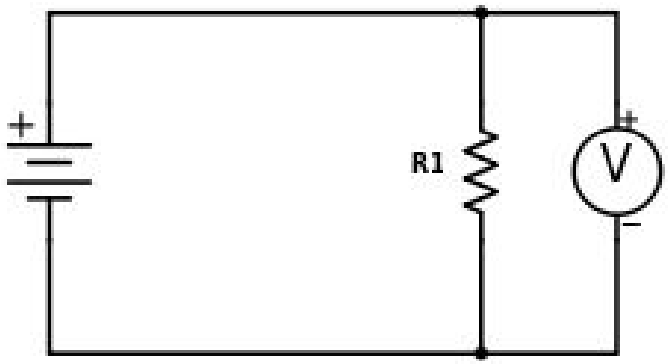


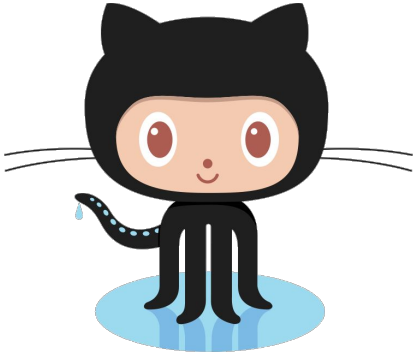


Circuit - Measure Voltage

Voltmeter connected in *parallel* with circuit







GitHub

- Version control software
- Electrical Training content (presentations, schematics, code, etc.) can be found at:

github.com/RoboJackets/electrical-training