Electronics 1

Introduction

Owen Mundy

Overview

- This lecture provides a foundation for working with DC currents and includes the following topics:
- Safety
- AC vs. DC
- Breadboards
- LEDs
- Resistors
- Anatomy of a circuit

General safety

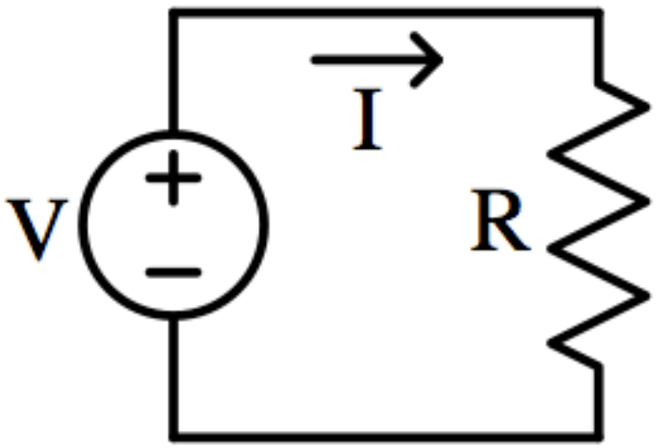
- Use common sense when handling anything that could potentially harm you.
- Maintain a sense of respect for whatever tool you work with.
- Measure twice, cut once.
- Work cautiously and safely.

Electrical hazards

- **Power:** Always power-down breadboards and micro-controllers before adding/ removing components.
- **Liquids:** Keep them away from your work area.
- **Short circuits:** If you smell something burning then remove power immediately and check your connections/electrical flow. Some electronic components are polarity-sensitive; putting them in a circuit “backwards” can damage them.
- **Static:** Touch something metal to discharge static build-up before handling components, especially integrated circuits (ICs), and especially in cold, dry weather.
- **Lead:** Many electronic components still contain lead so make sure to wash your hands after handling components. Also, it’s probably a bad idea to hold components in your mouth.
- **Soldering:** If you graduate to soldering, please have adequate ventilation and be aware that rosin-core solder (even lead-free varieties) are a common trigger for asthma.

How electricity works

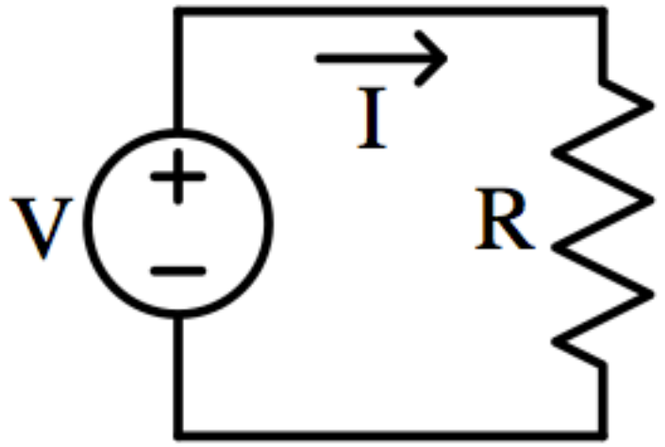
- **Electricity** is a form of energy that is converted into other energy that we use in every day life.
- **Electric current** is the flow of electric charge (a.k.a. electrons) through a conductive medium such as wires, motors or light bulbs.
- An **electric circuit** is a network of electrical components, energy sources, and switches within a closed loop.
- In the image on the right, the voltage source V drives a current around the circuit, delivering electrical energy into the resistor R. From the resistor, the current returns to the source, completing the circuit.

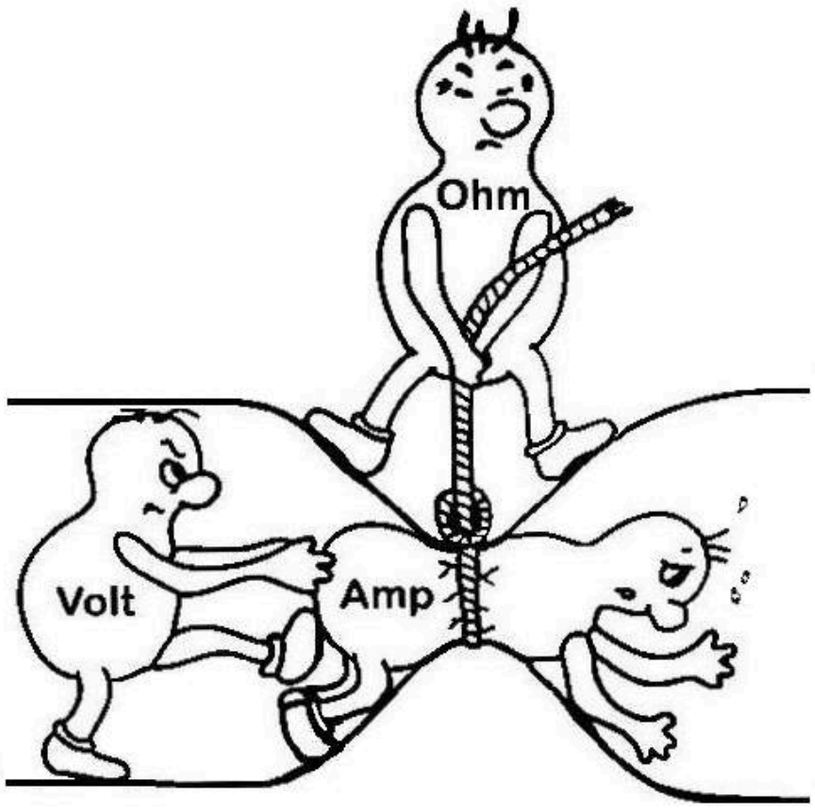


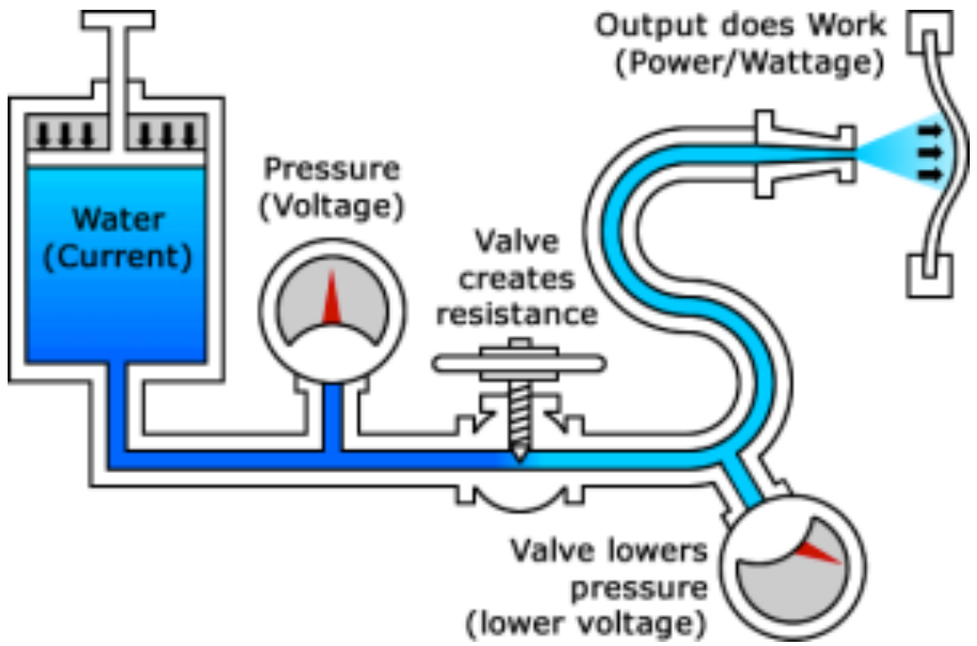
- Make presents: Ohm's Law (7:09)
- Adafruit: A is for Ampere (3:49)

How electricity works

- The “water analogy” offers another way to think about Voltage, current, and resistance.





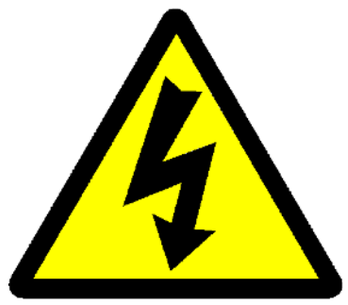


AC vs. DC

- We'll be working with **direct current (DC)** power (3.3V-9V) which is generally safe.
- All computers and small electronics run on DC power (like USB=5V). Typical sources include batteries (e.g. AAs or your laptop) and "wall warts" (AC to DC converters) that can be used to charge batteries or power your device directly.
- **Alternating current (AC)** (like the power coming from a wall outlet) is different from DC power. AC voltages are typically: 110V or 220V, both of which can hurt or even kill you.
- Please be very careful and clear-headed when using AC power, and be mindful even of DC power over 9 volts.

DC

AC



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Batteries

An electrical battery is one or more electrochemical cells that convert stored chemical energy into electrical energy.

While AAA, AA, and D batteries are all rated at 1.5V **DC**, larger batteries are capable of supplying more current for a longer duration. For example, an MP3 player might need 0.2 Amps of current (one AAA battery), but a large flashlight might require 5 Amps of current (like from two D batteries).

Adafruit: B is for Battery (7:12)

Measuring electric current

We can measure electric current, resistance, and amperes using a multimeter.

Measuring electric current

This fully-charged 9V battery measures 11.08V DC because it has no “load,” meaning, there are no electrical components through which its electrons are flowing.

Measuring electric current

If we switch the red (+) and black (-) leads on the multimeter then we get the same voltage reading but in reverse.

Measuring electric current

USB supplies 5V DC but with no load will also register higher

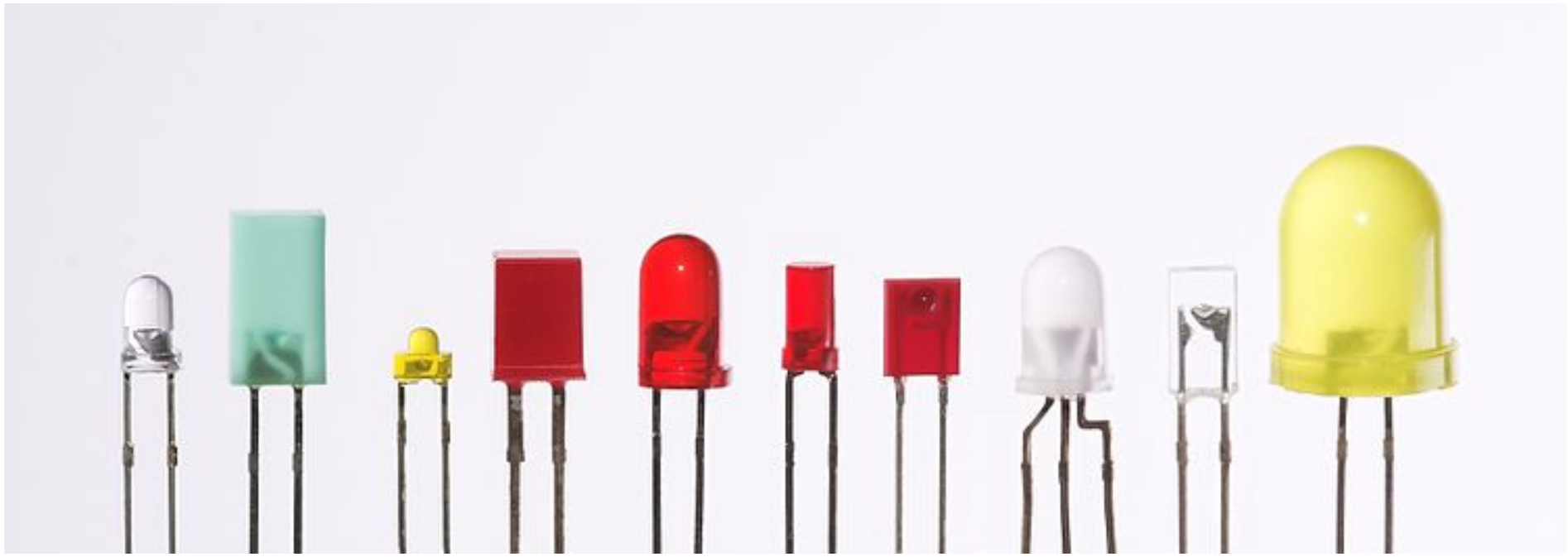
Measuring electric current

This wall wart is rated at 12V DC but again, is much higher if we test it because there is no load.

Note: the black lead (-) is fixed to the outside of the barrel plug while the red (+) lead is inserted inside the plug.

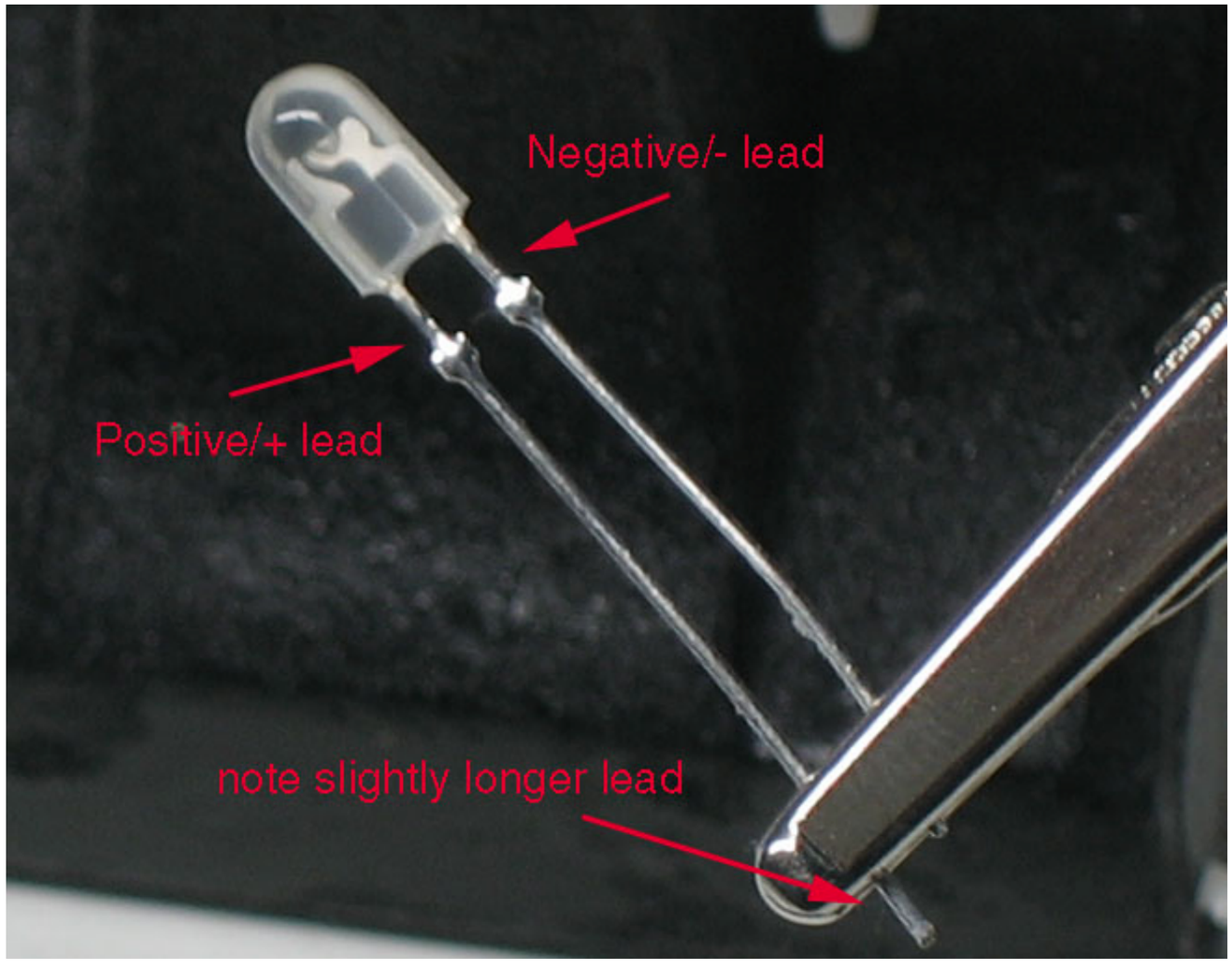
Light Emitting Diodes (LEDs)

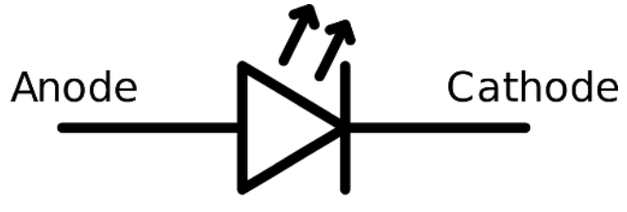
- LEDs have been around only since 1962.
- They’re smaller, cheaper, and use much less energy than incandescent or CFL bulbs you find in your home.
- They come in many varieties (colors, brightnesses, sizes, applications).
- We’ll be using through-hole LEDs in our projects (note the 2 legs below).



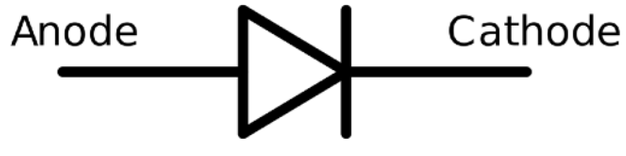
Light Emitting Diodes (LEDs)

- LEDs have two wires, the anode (positive “+”) and the cathode (negative “-”).
- The longer lead goes to the positive voltage, the other to the negative voltage.
- LEDs that are 'backwards' won't work - but they won't break either. If you are having trouble getting it to work just flip it around!
- Make Presents: The LED (5:29)





+ Light Emitting Diode –



+ Regular Diode –

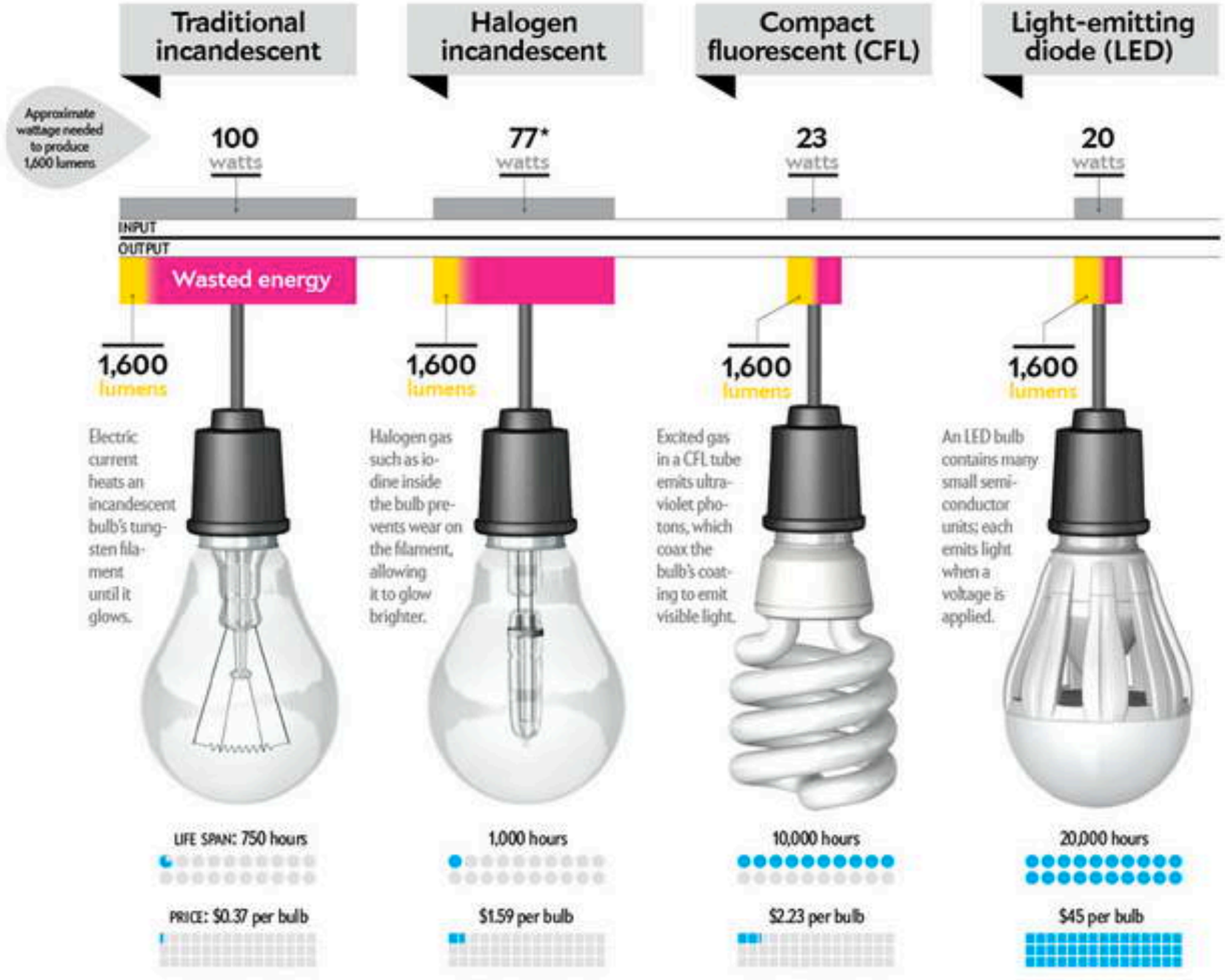
Source: ladyada.net

Anatomy of a circuit

- Our first circuit will be simple. Using a 3V watch battery and a red LED, connect the + (positive) (*I like to put a small bend in the longer side) to the + terminal of the battery, and the short end of the LED to the - (negative) terminal.
- This completes a circuit by allowing electrons to flow from the battery, through through the LED and back again.
- You might notice these aren’t very bright. That is because we aren’t giving them much electrical current.
- The more electrical current you give an LED, the more energy is consumed to produce light.

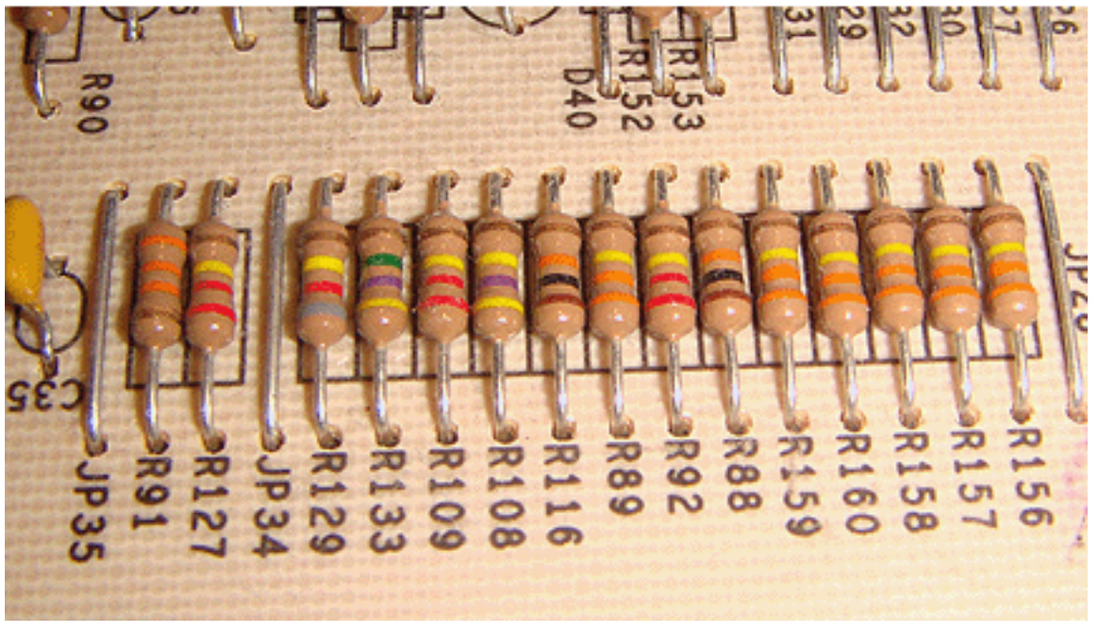
Resistance

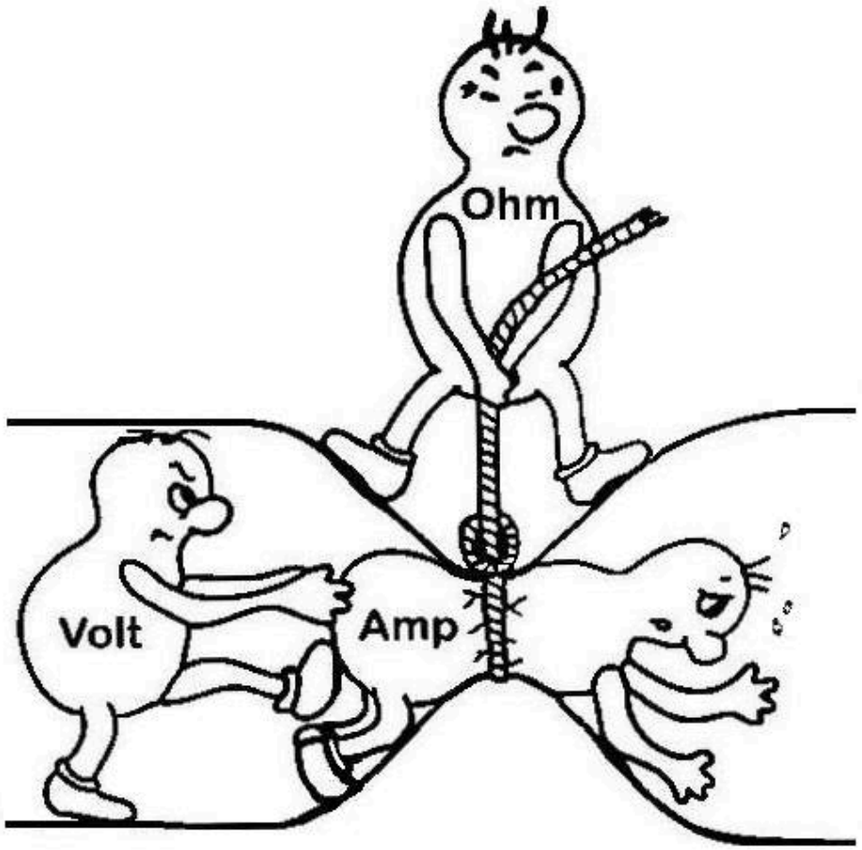
- All light bulbs produce heat in addition to light.
- LEDs convert more electrical energy to light and less to heat than all other viable options.
- This, and the fact they last much longer makes them more economical.
- Effect of heat on chocolate bunny (1:36)



Resistors

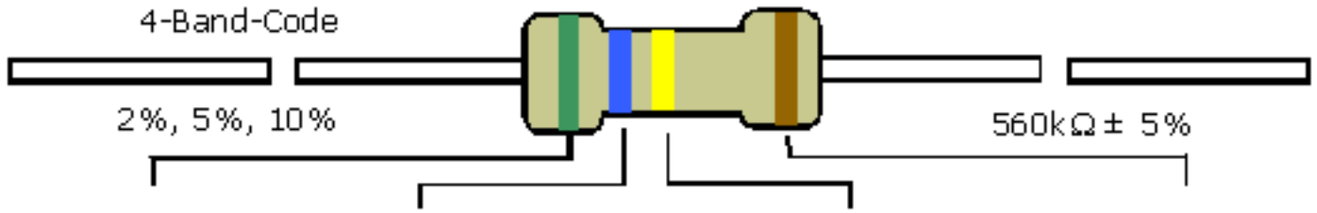
- Too much current can burn out LEDs.
- We limit current with a resistor. It literally, *resists*, current.
- Resistors are measured in Ohms Ω and come in many values.
- Can be installed in either direction.
- Make presents: The Resistor (5:08)





Resistors

- There are three ways to determine the value of your resistor: 1) read the bag (easiest!), 2) measure it with a multimeter, or 3) use the standard color chart.
- Now let us find the value of our resistors!



COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	±0.5% (D)
Blue	6	6	6	1MΩ	±0.25% (C)
Violet	7	7	7	10MΩ	±0.10% (B)
Grey	8	8	8		±0.05%
White	9	9	9		
Gold				0.1	± 5% (J)
Silver				0.01	± 10% (K)

Anatomy of a circuit

- To use LEDs properly (so they don't burn out) we need to know the resistor value to use. We can calculate if we know: 1) **forward voltage (V)** and 2) **forward current (mA).**
- Specs from the supplier might say: 3.4V @ 20 mA. Or we can use some general rules and plug these into the handy LED calculator.
- **Voltage:** Enter the rated voltage of your supply here.
- **Forward voltage:** Red LEDs typically = 2V.
- **Forward current:** For 99% of 3mm and 5mm LEDs you will encounter, the optimal current is 20mA, but don't be too scared to push it up to 30mA to make them a little brighter.

color	voltage (Volts)
IR	1.5
red	2.0
orange	2.0
yellow	2.1
green	2.2
true green	3.3
blue	3.3
white	3.3
UV	3.3
blue (430 nm)	4.6

Source: ladyada.net

Anatomy of a circuit

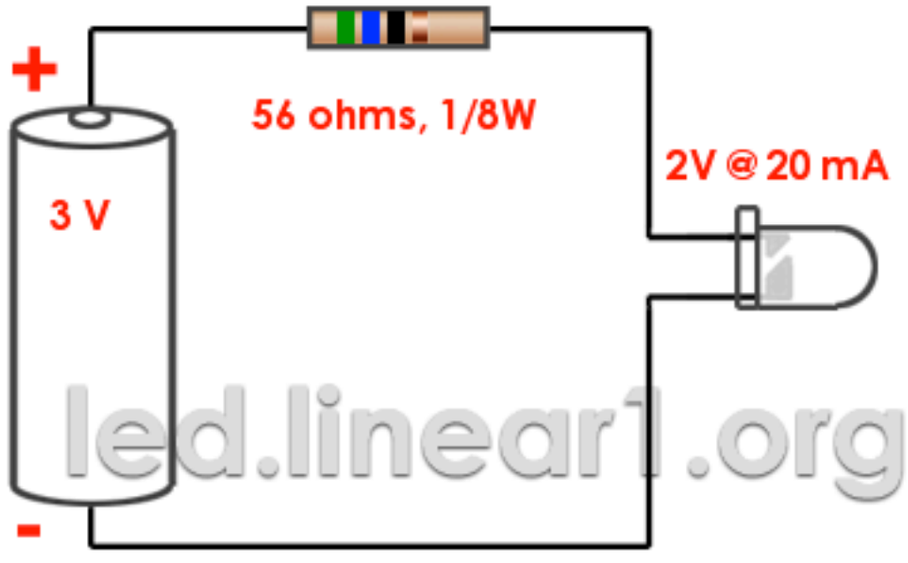
- Here is the original circuit in an LED calculator. You can see the resistor value is very small. So we didn't even bother using one.
- If I connect a 9V battery to an LED without a resistor we get to learn what a burnt component smells like. …

LED calculator: current limiting resistor value

3	Source voltage
2	diode forward voltage
20	diode forward current (mA)

Find R

The wizard recommends a 1/8W or greater 56 ohm resistor. The color code for 56 ohms is green blue black.



Link to this solution: **http://led.linear1.org/1led.wiz?VS=3;VF=2;ID=20**

Anatomy of a circuit

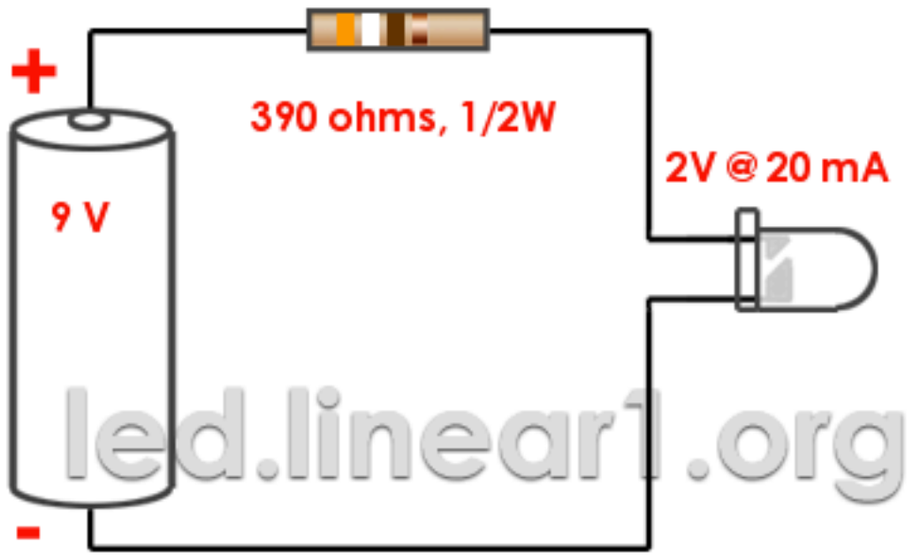
- Here is the calculator the a 9V battery as the power source.

LED calculator: current limiting resistor value

9	Source voltage
2	diode forward voltage
20	diode forward current (mA)

Find R

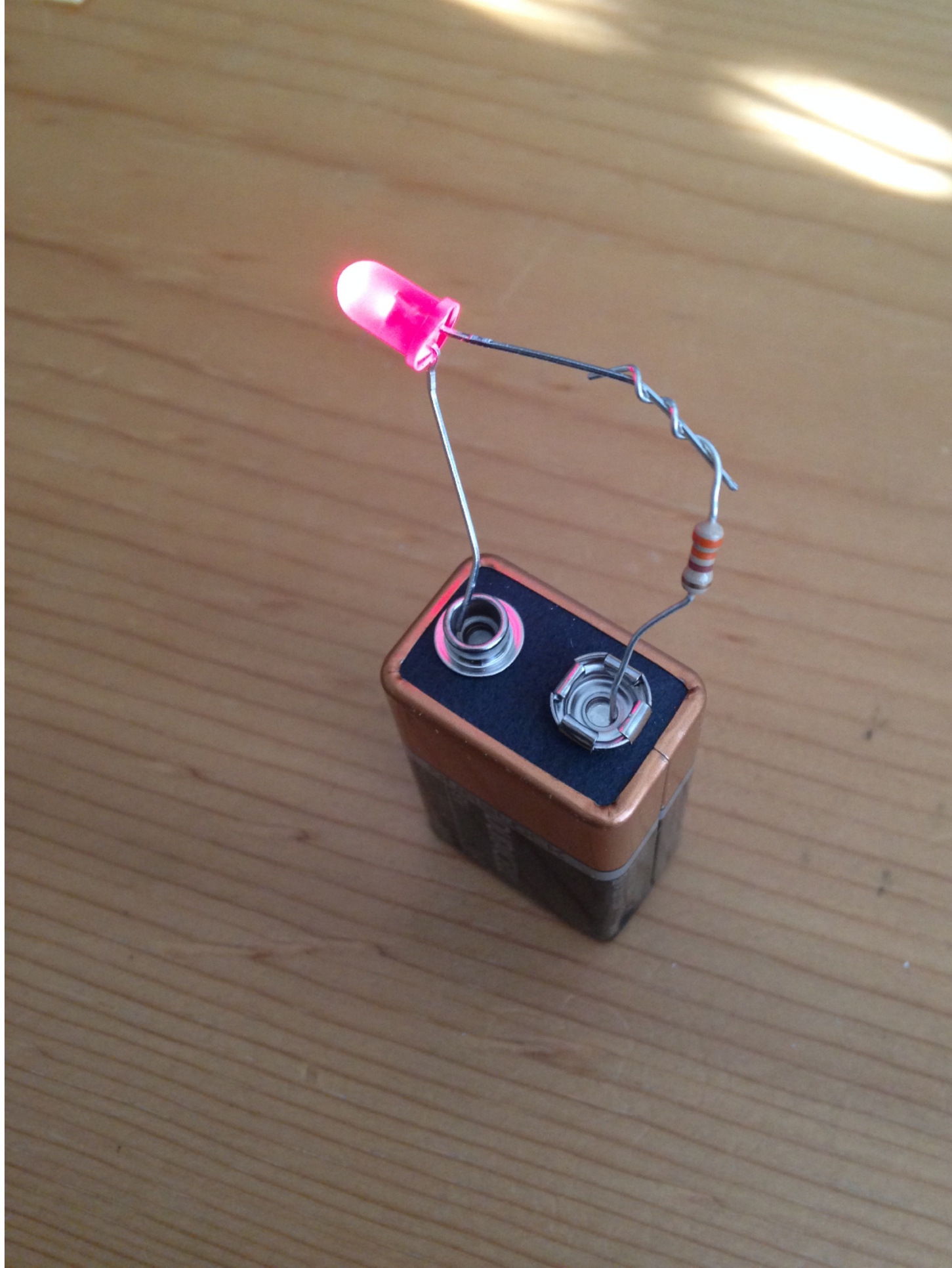
The wizard recommends a 1/2W or greater 390 ohm resistor. The color code for 390 ohms is orange white brown.



Link to this solution: **http://led.linear1.org/1led.wiz?VS=9;VF=2;ID=20**

Anatomy of a circuit

- So now we connect the LED to the 9V battery with the resistor.
- I had 330 ohm resistors handy; they are close enough.
- Careful to not touch the LED to the two battery terminals without the resistor!
- Twist the lead wires around each other to hold them together.
- We could also change out the resistor to see the brightness decrease or increase as more current is allowed through.

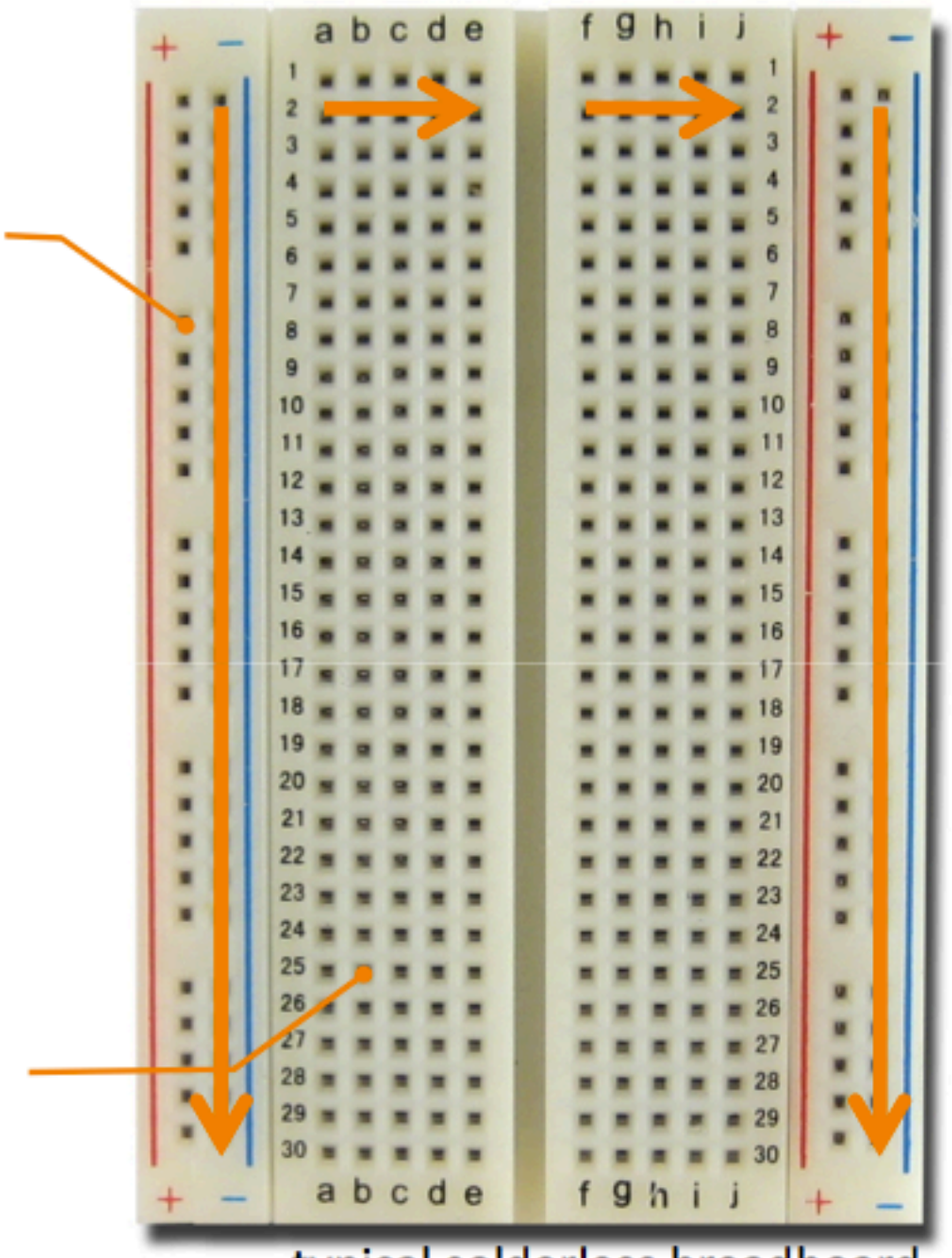


Breadboards

Next steps: Solderless breadboards allow us to create and manipulate circuits easily, without having to commit with solder.

bus strip
(connected in columns)

tie points
(connected in rows)



typical solderless breadboard

Breadboards

Next steps: Solderless breadboards allow us to create and manipulate circuits easily, without having to commit with solder.

bus strip
(connected in columns)

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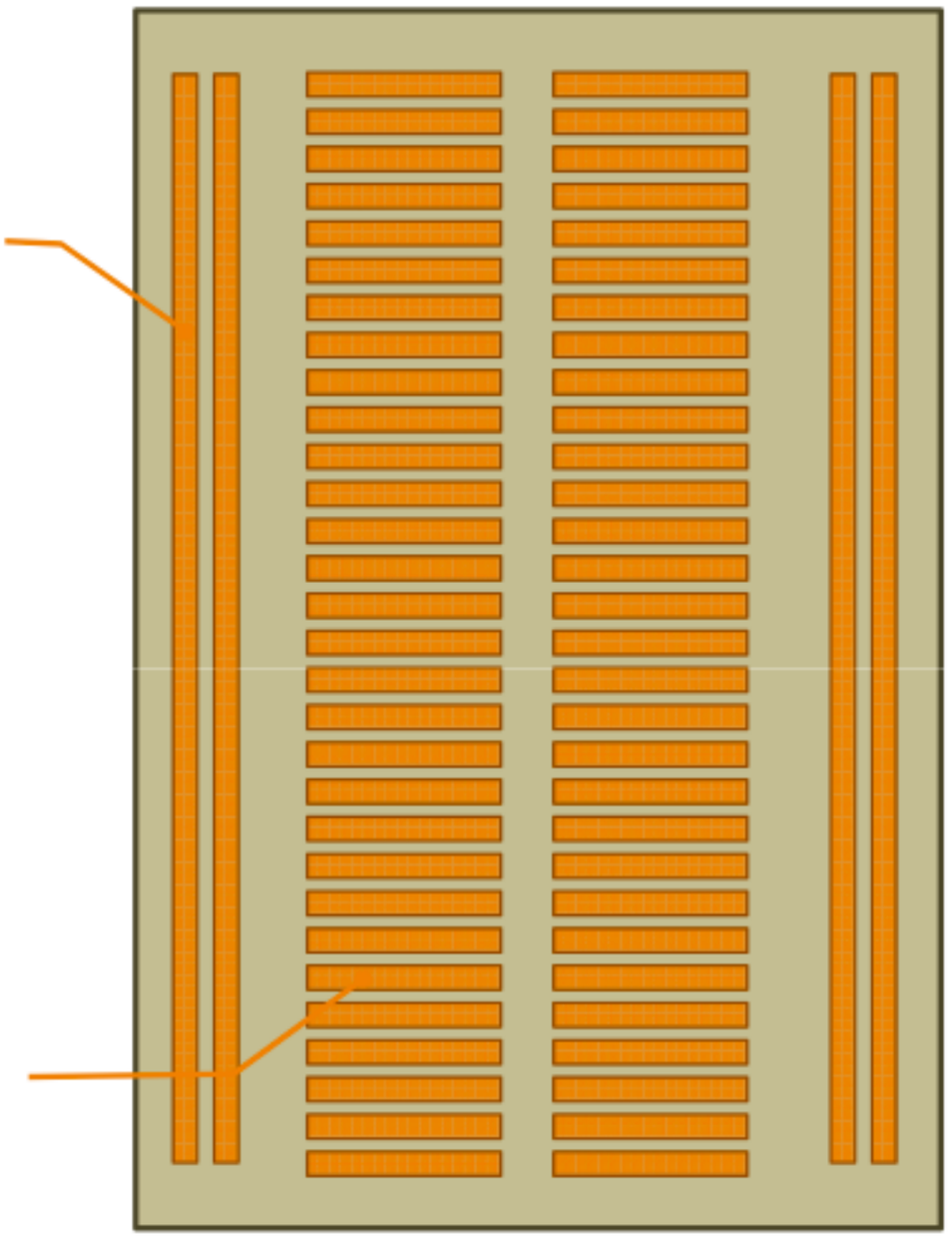
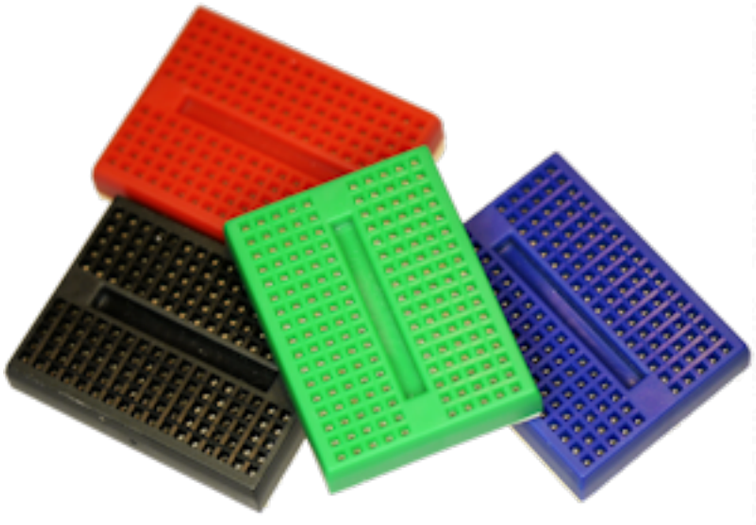
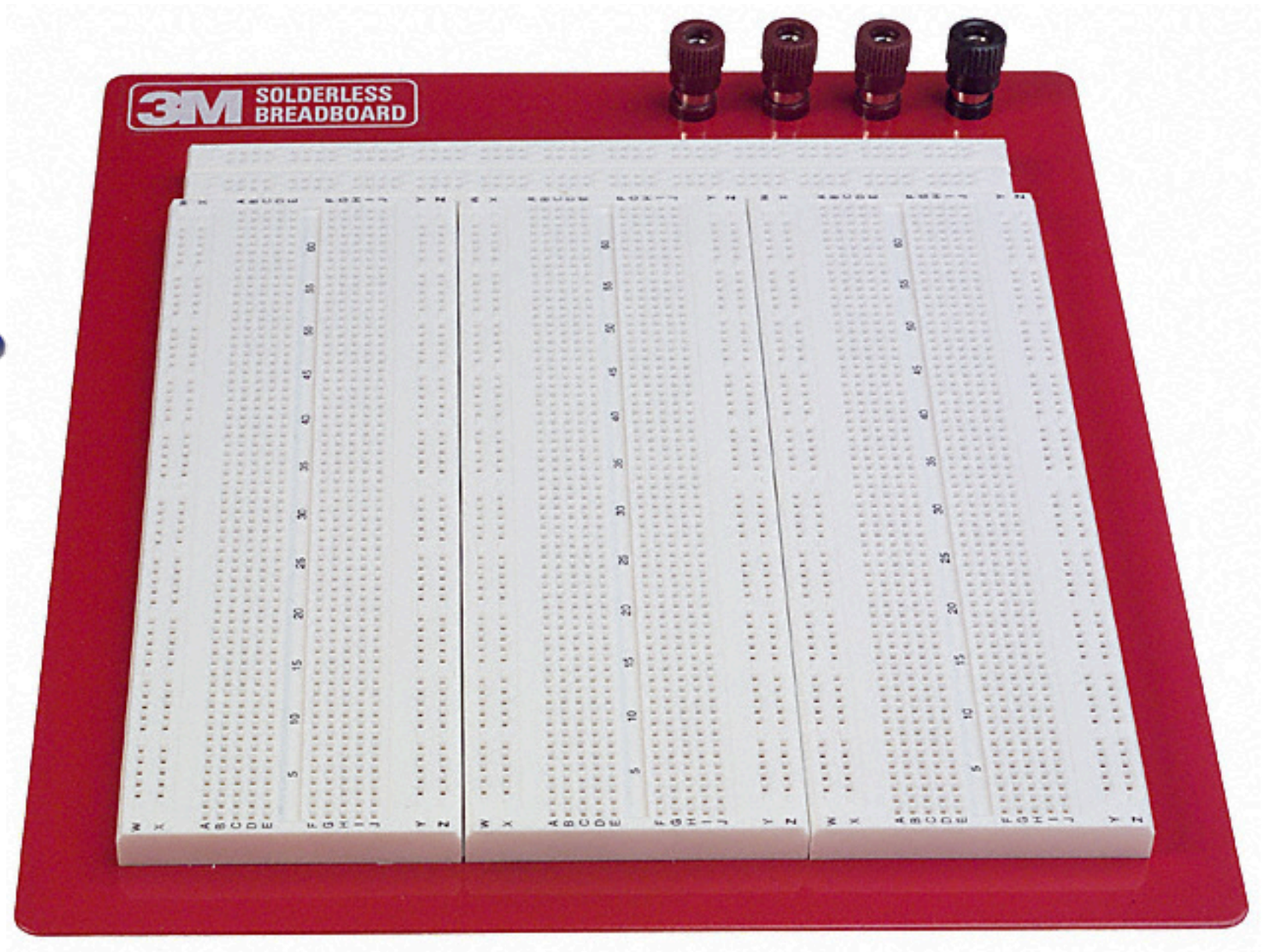


X-Ray view of the connections

Breadboards

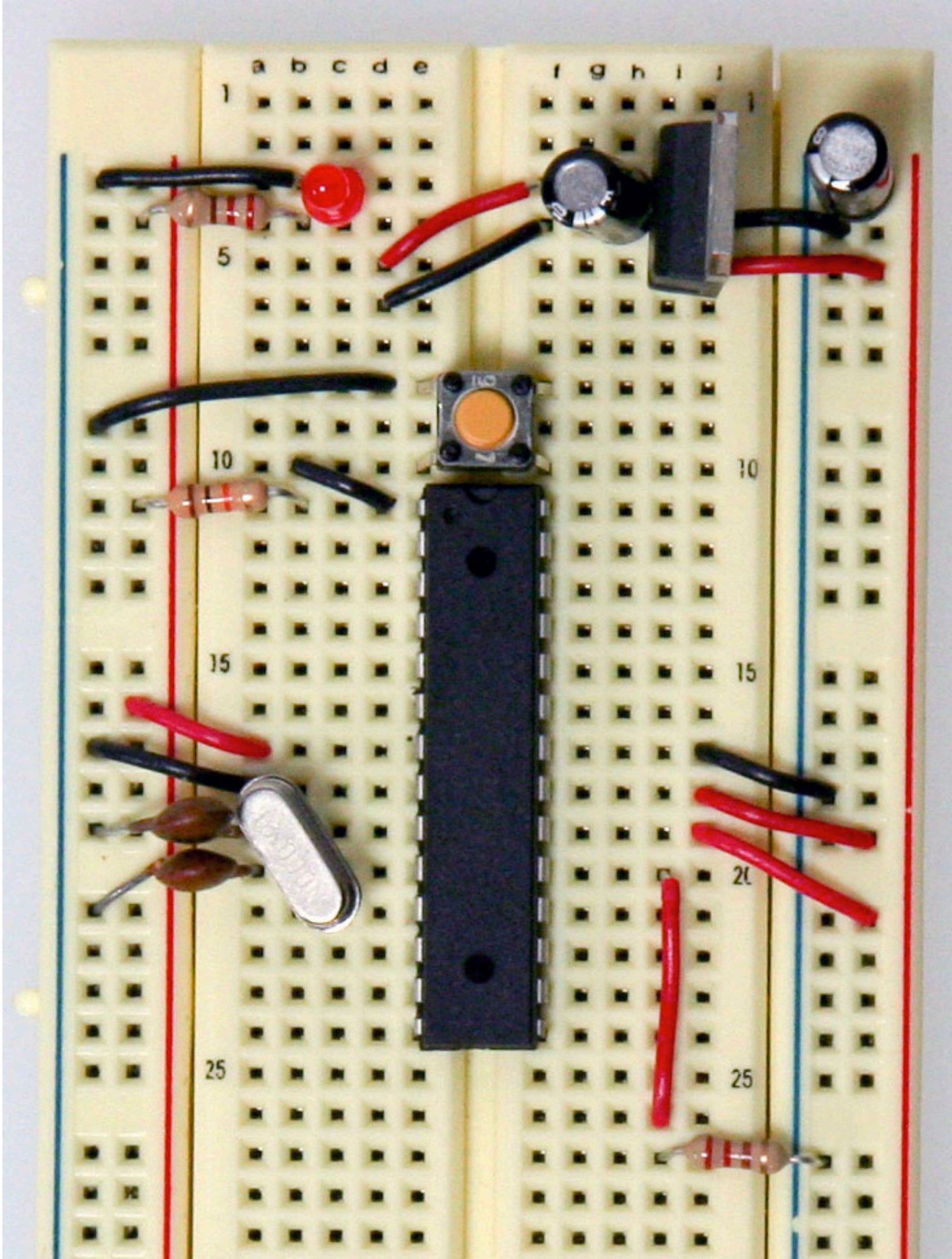
Breadboards come in many shapes and sizes.





Breadboards

One of my favorite intro projects is to build an Arduino from scratch on a solderless breadboard.



Anatomy of a circuit

- Here’s an example diagram again for reference.
- This was made using Fritzing a circuit diagramming software.