PHYSICAL COMPUTING

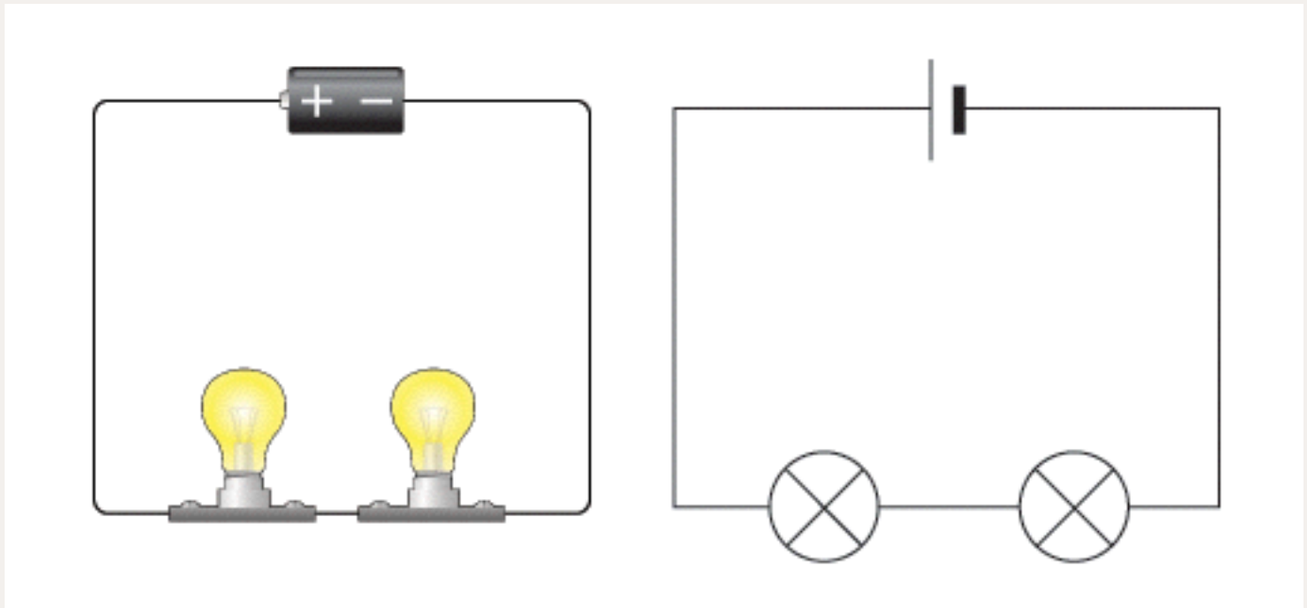
WEEK 03

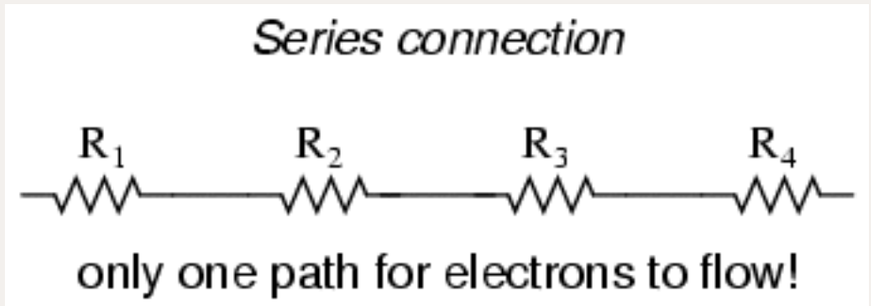
motion and impurities

MOTORS, SERVOS & SEMICONDUCTORS

Serial Circuit

Serial = One after the other in order

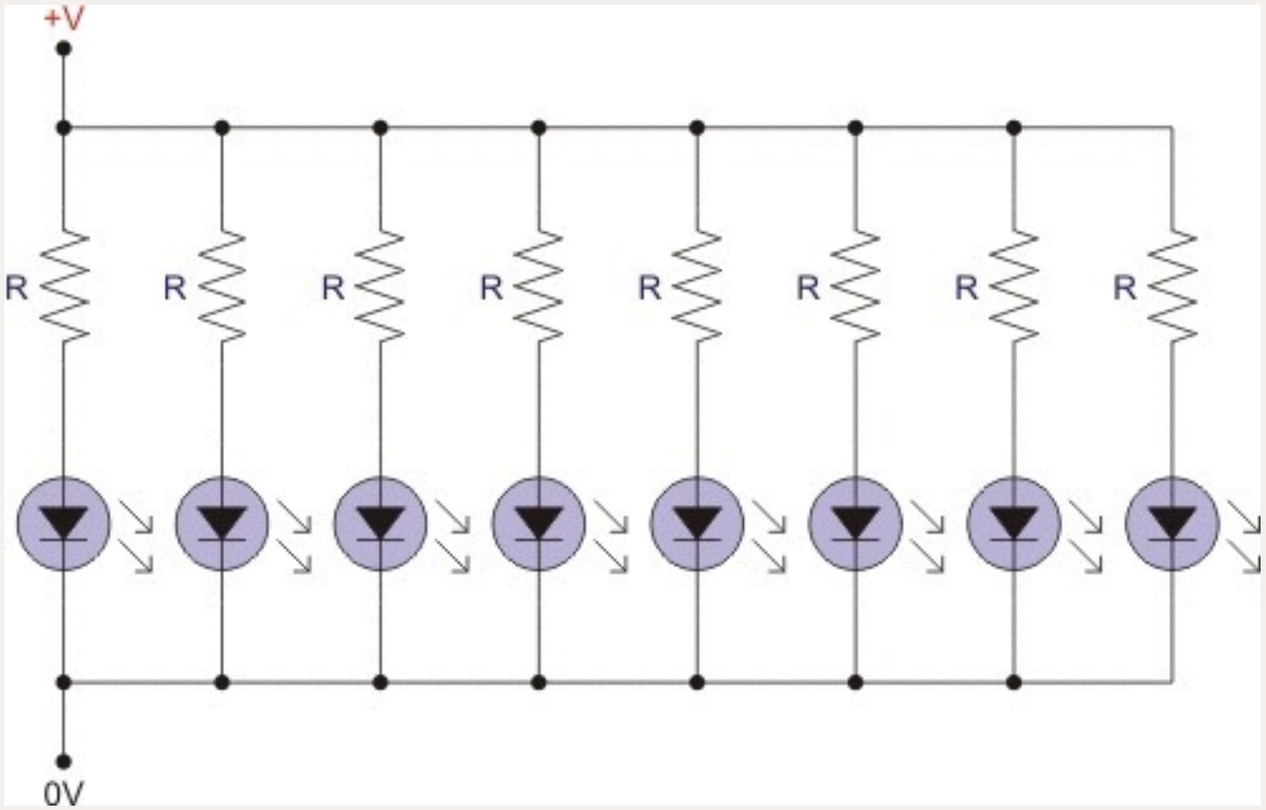




RT = R1 + R2 + R3

Parallel Circuit

All just connected to the same power and ground



R_total = 1/r1 + 1/r2 + 1/r3 + ...

R_total = 1/r1 + 1/r2 + 1/r3 + ...

For example, suppose we have a parallel circuit with resistors of 30 Ohms, 60 Ohms, 20 Ohms and 10 Ohms. Then the total resistance is:

$$\frac{1}{R_t} = \frac{1}{30} + \frac{1}{60} + \frac{1}{20} + \frac{1}{10}$$

$$= \frac{2}{60} + \frac{1}{60} + \frac{3}{60} + \frac{6}{60}$$

$$= \frac{12}{60} = \frac{1}{5}$$

Thus

$$R_t = \frac{1}{1/5} = 5 \text{ Ohms}$$

How you hook it up changes the **amount of current you have**

Eventually, you’re going to run **out of pins, voltage or current.**

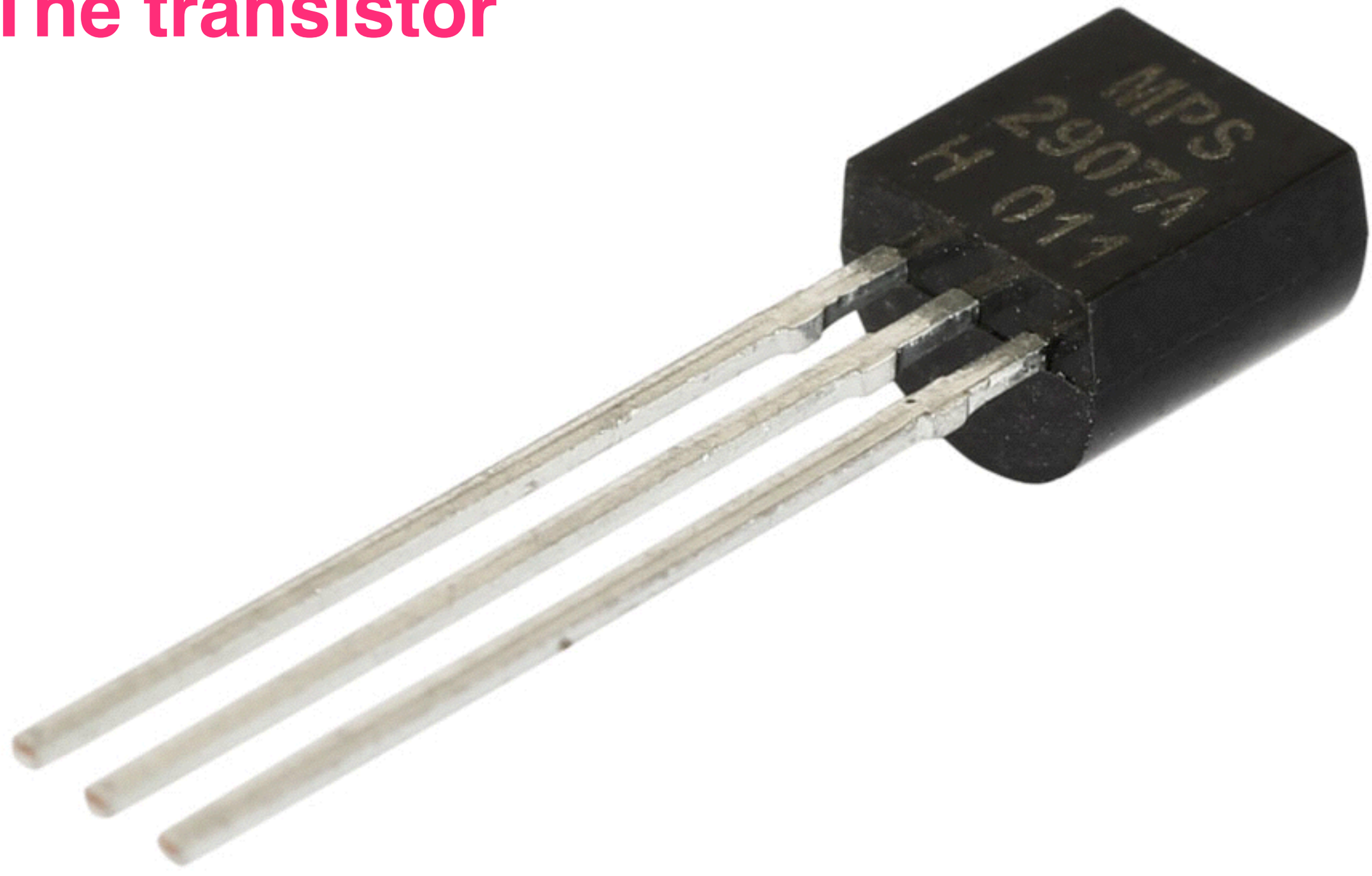
The solution is multiplexing

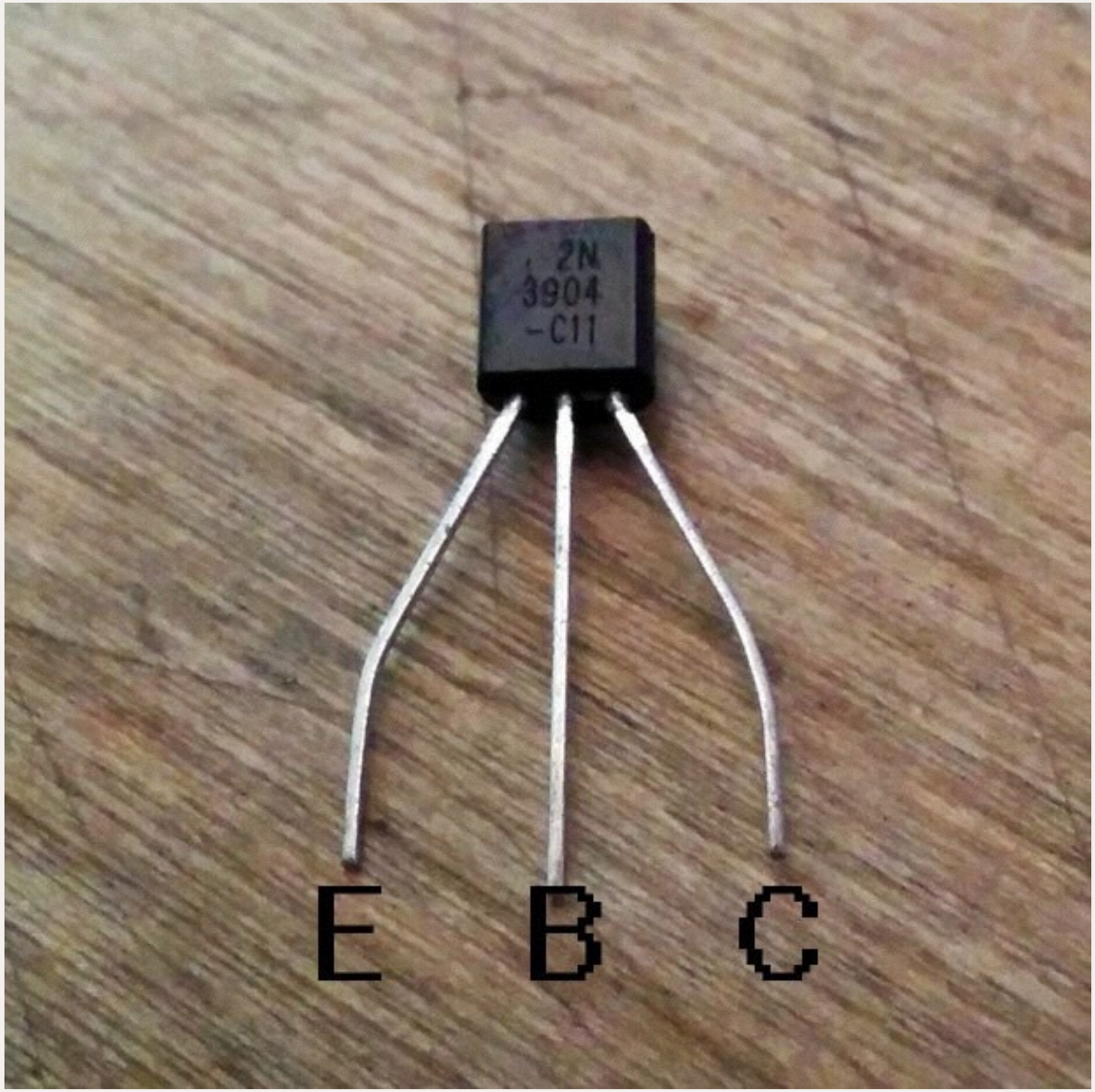
but to do it we will want to learn a few things first.... (so next week more to see here)

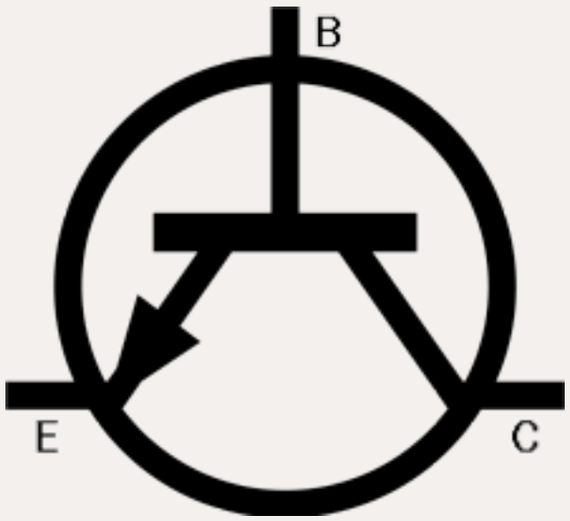
The Transistor

They key to our first multiplexing experiment next week. This week? We'll use it to learn to drive a motor and make a night light.

The transistor



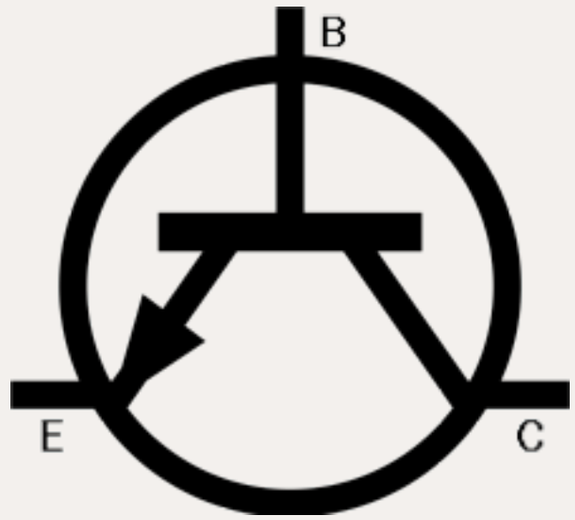




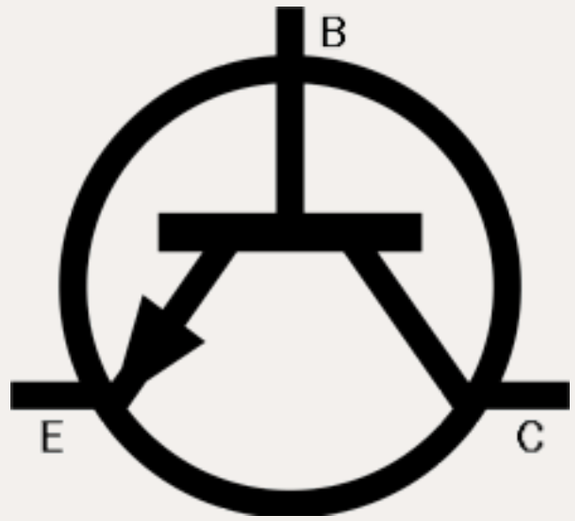
E = Emitter
B = Base
C = Collector

Doping

Adding impurities to an extremely conductive semiconductor to change how the current will flow



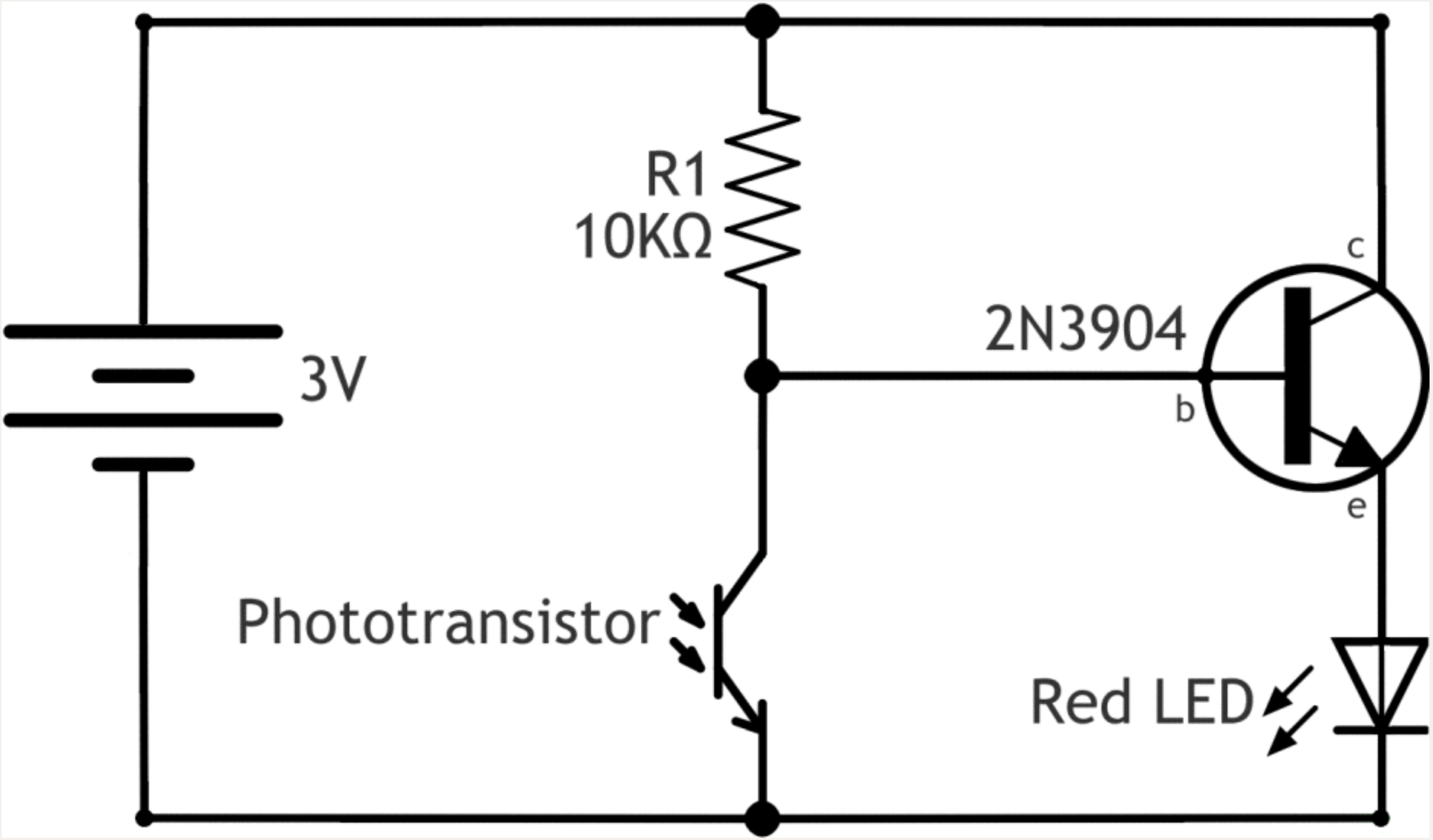
NPN
Not **P**ointing i**N**;
The collector goes to ground
and when the base gets the right voltage
it allows current to flow from the Emitter to the
Collector, completing the circuit

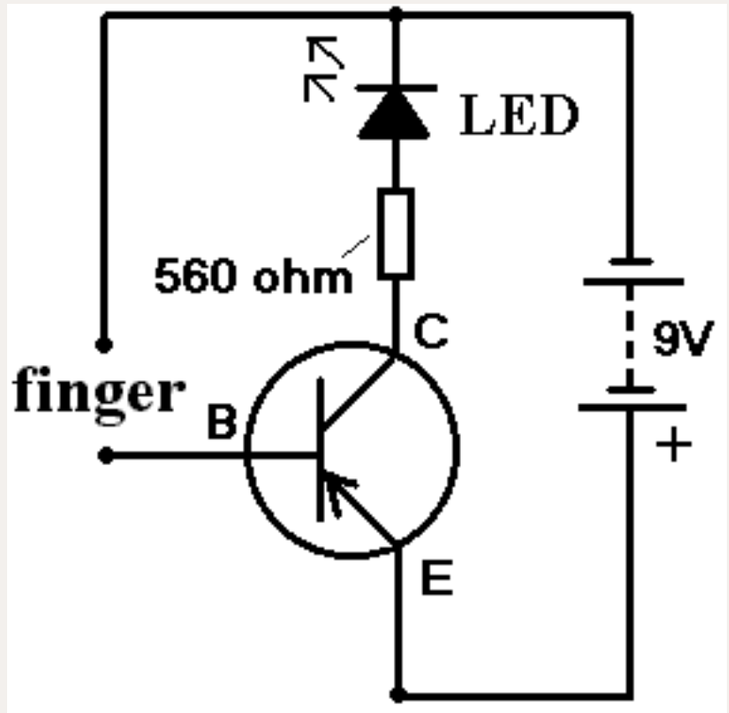


NPN
Not **P**ointing i**N**
This Semiconductor is P-doped between two N-doped layers.

N-doped = spare electrons
P-doped = spare electron holes

This allows a very small amount of current to trigger the flow of a larger amount of current


R1
10KΩ
3V
2N3904
c
b
e
Phototransistor
Red LED



PNP

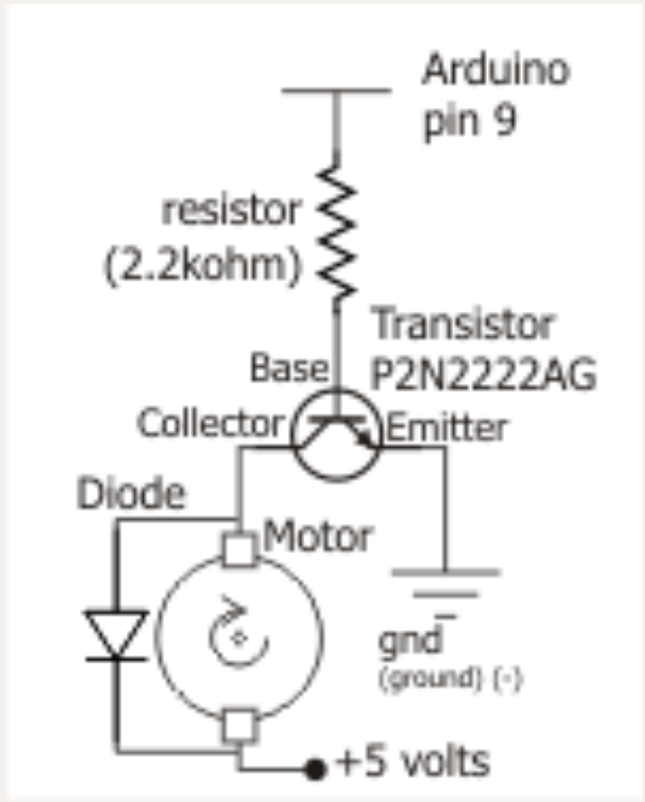
Points i**N** **P**roudly

PNP transistors use a small base current and a negative base voltage to control a much larger emitter-collector current.

In other words for a PNP transistor, the Emitter is more positive with respect to the Base and also with respect to the Collector.

PNP transistor are reversed which means that it “sinks” current into its Base as opposed to the NPN Transistor which “sources” current through its Base.

In our kit we have an **NPN** Transistor (P2N2222) and we'll use it to control current flow to a motor. (CIRC-03)



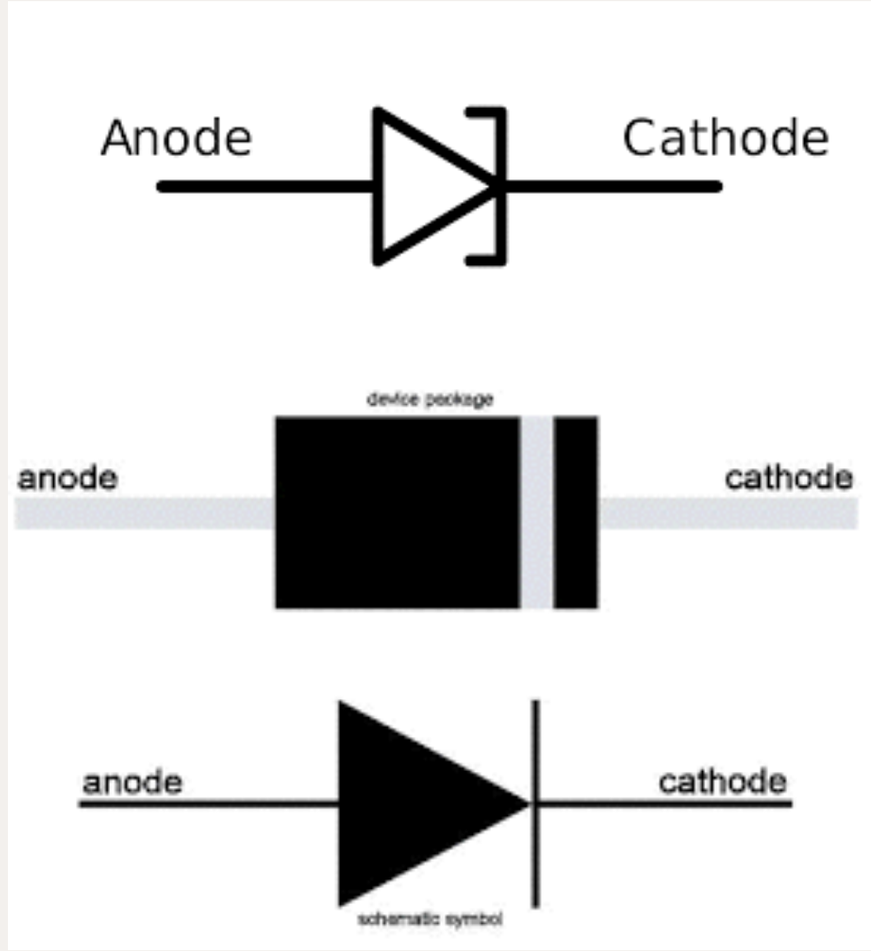
http://oomlout.com/a/products/ardx/circ-03/

The Diode

A component that allows current to flow in only one direction. Most diodes are semi-conductor diodes with p-n junctions.

In a device which consumes power, the **cathode** is **negative**, and in a device which provides power, the **cathode** is **positive**:

N-doped = spare electrons
P-doped = spare electron holes



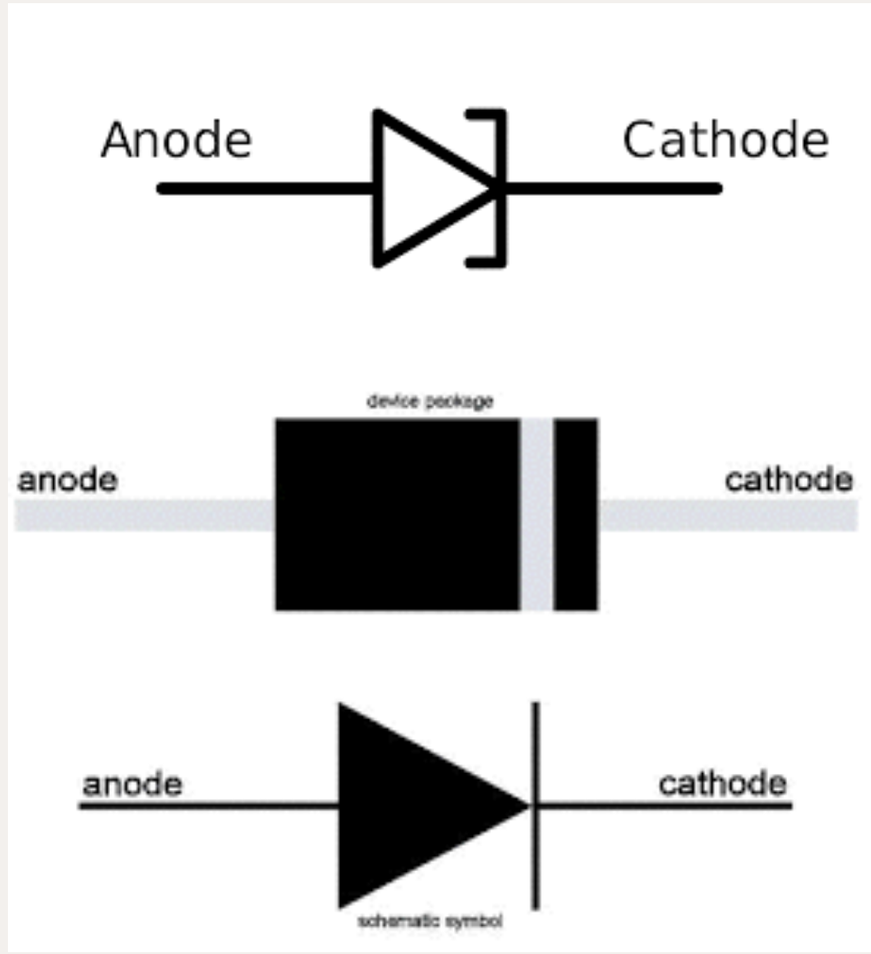
Hint: Put the grey line to +5


I HAVE
NO TIME
FOR YOUR
NEGATIVE
BULLSHIT.

The Diode

Provides some protection for your circuit. Keeps current from flowing in the opposite direction.

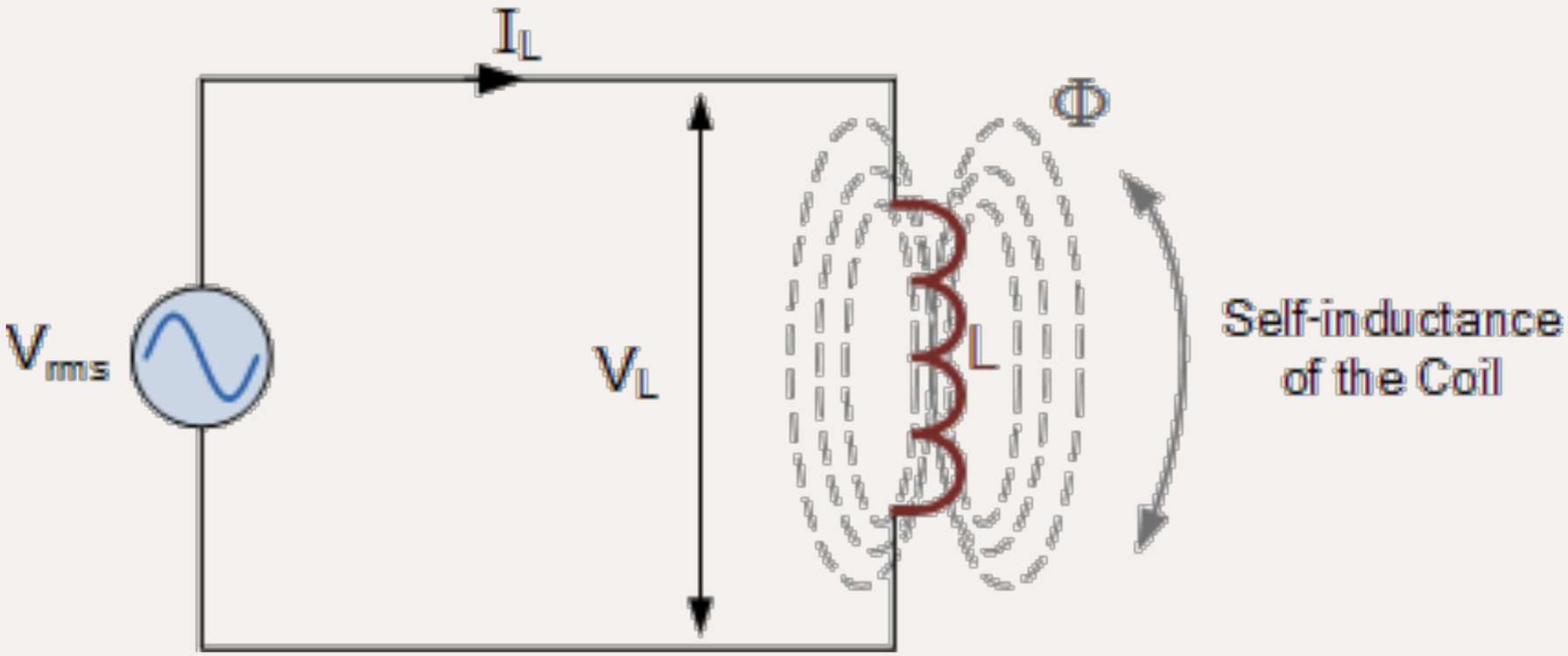
This can save your Arduino or raspberry pi.



Hint: Put the grey line to +5

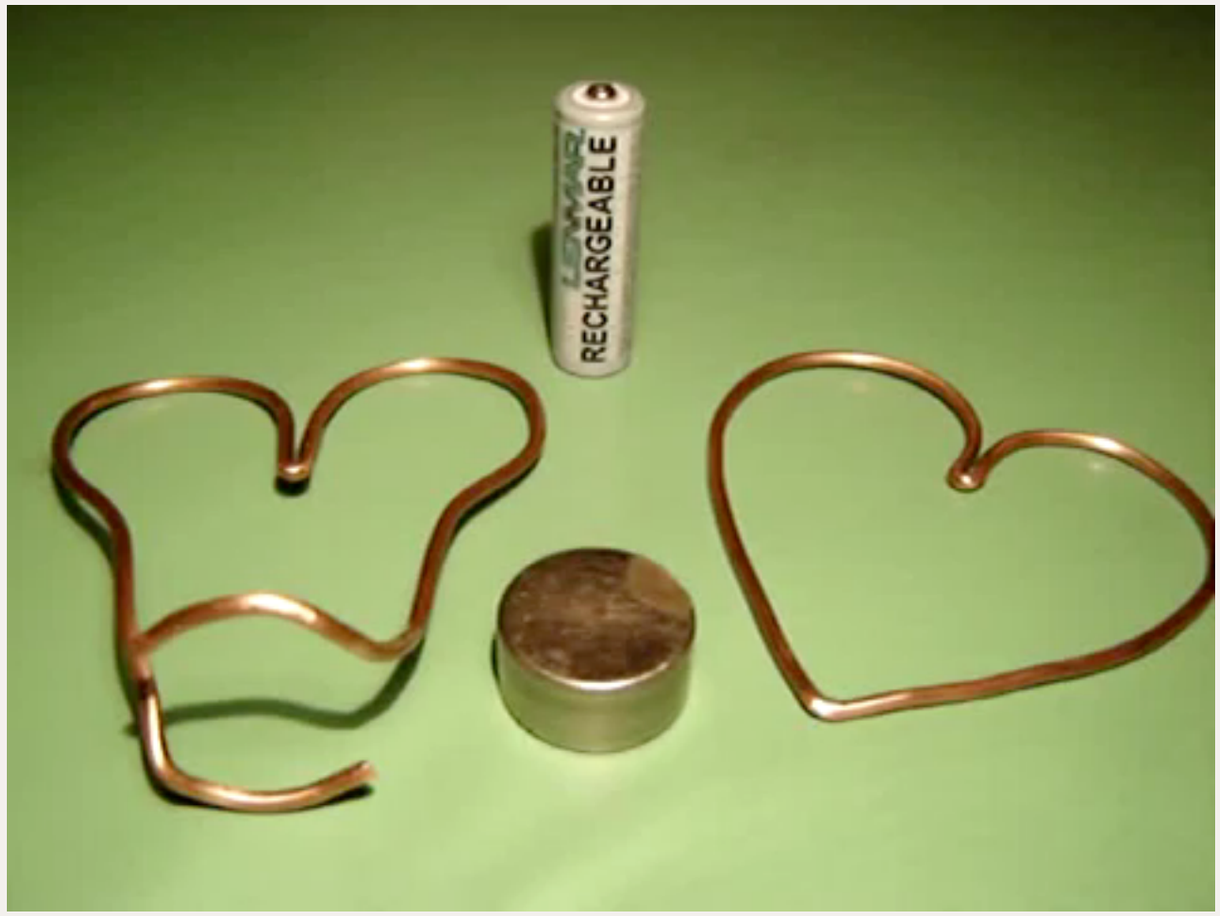
Inductor

When you run voltage through a cooper wire you create a magnetic field. Manipulating this simple fact of nature gives us speakers, microphones and motors

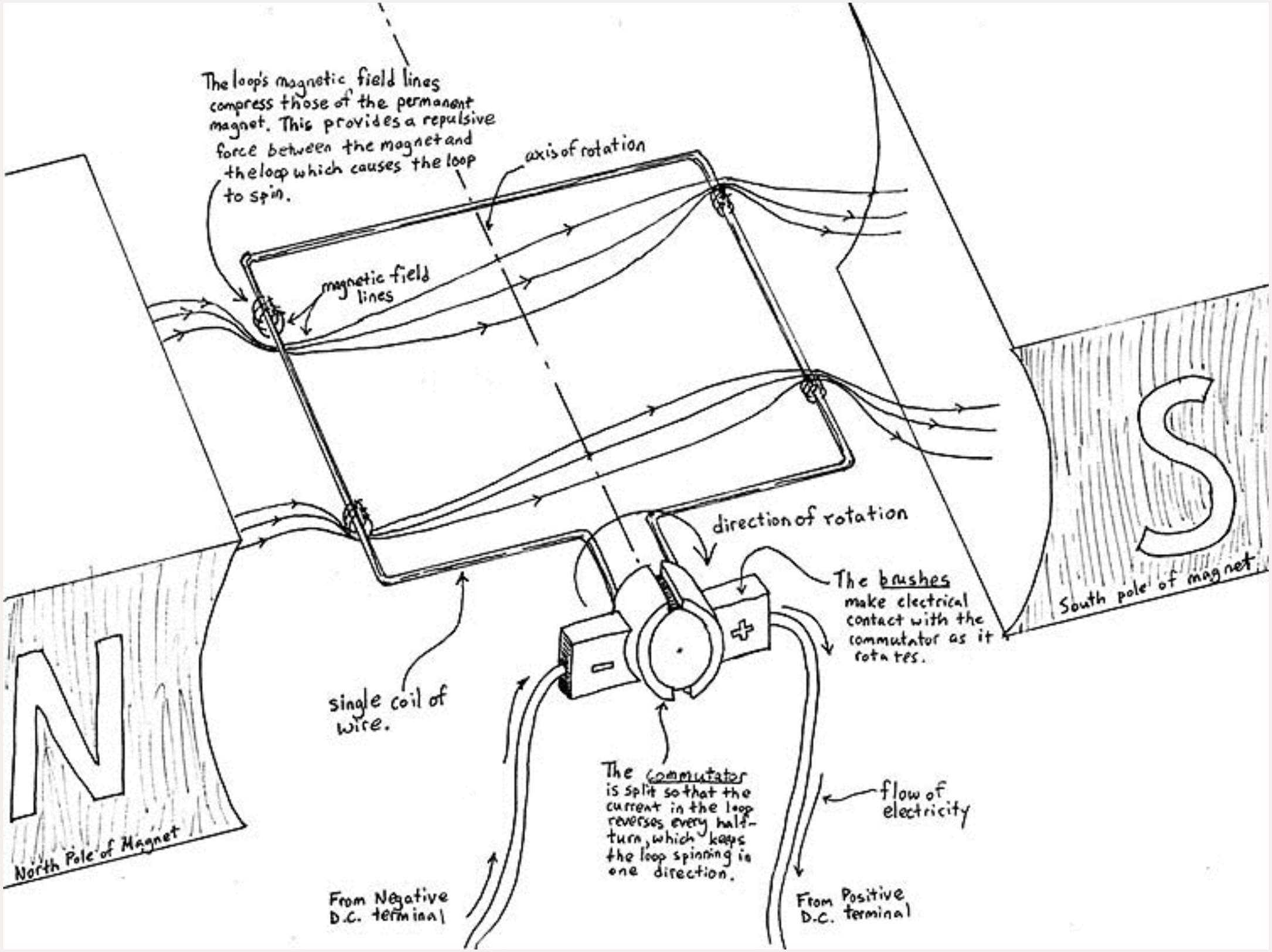


How to make a motor

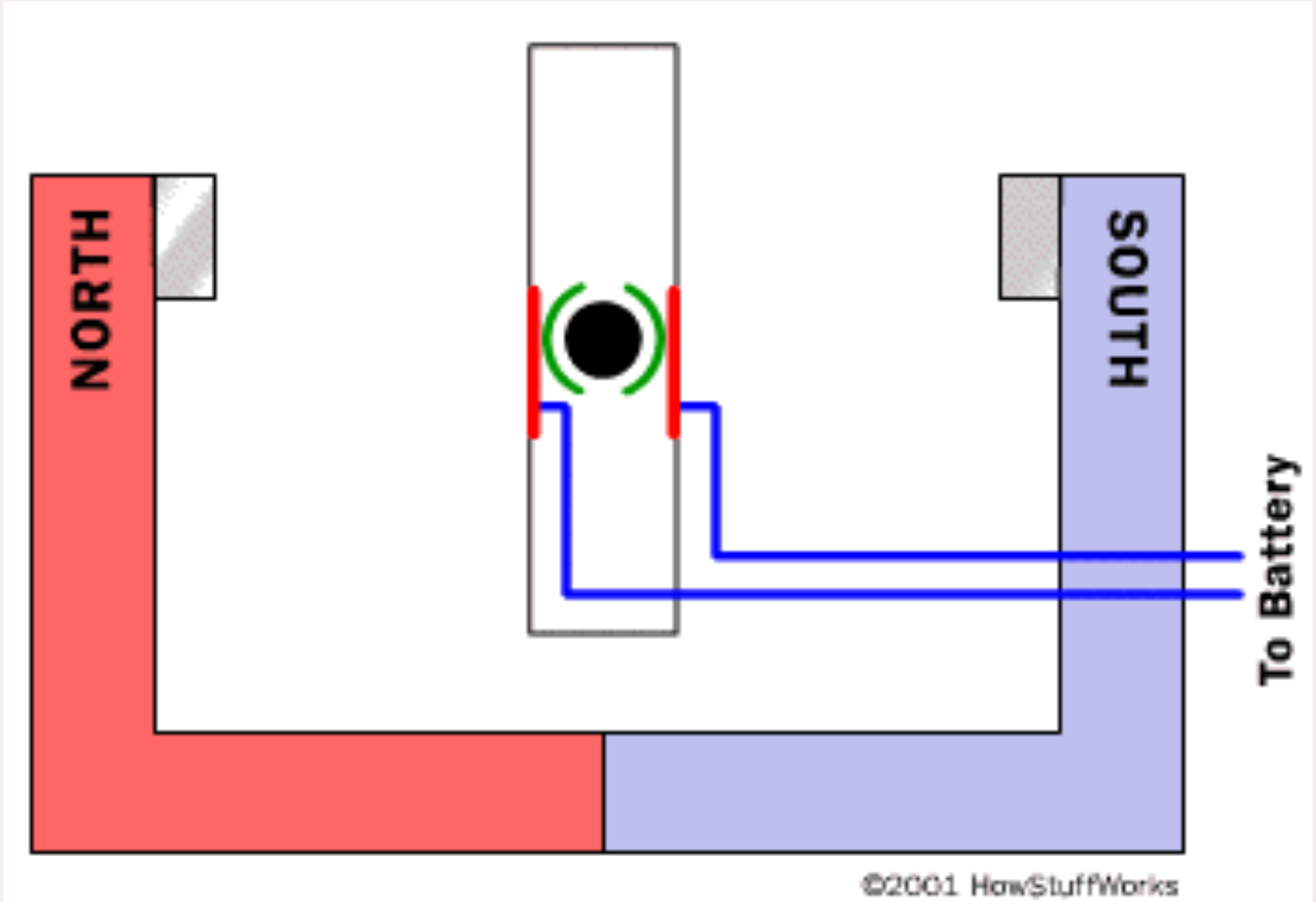
https://www.youtube.com/watch?v=iG0pzGcy4xU



Your DC Motor

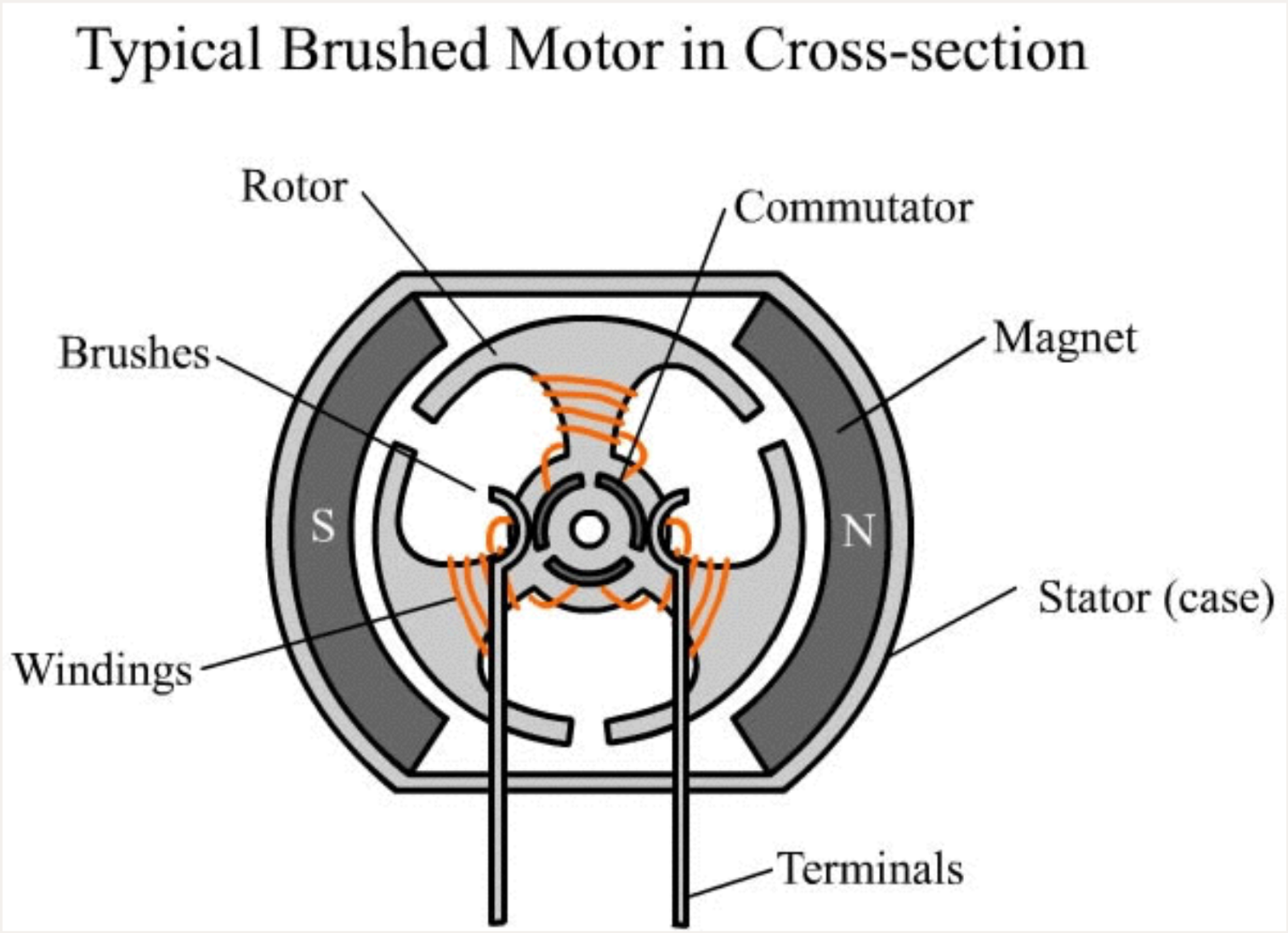


Your DC Motor

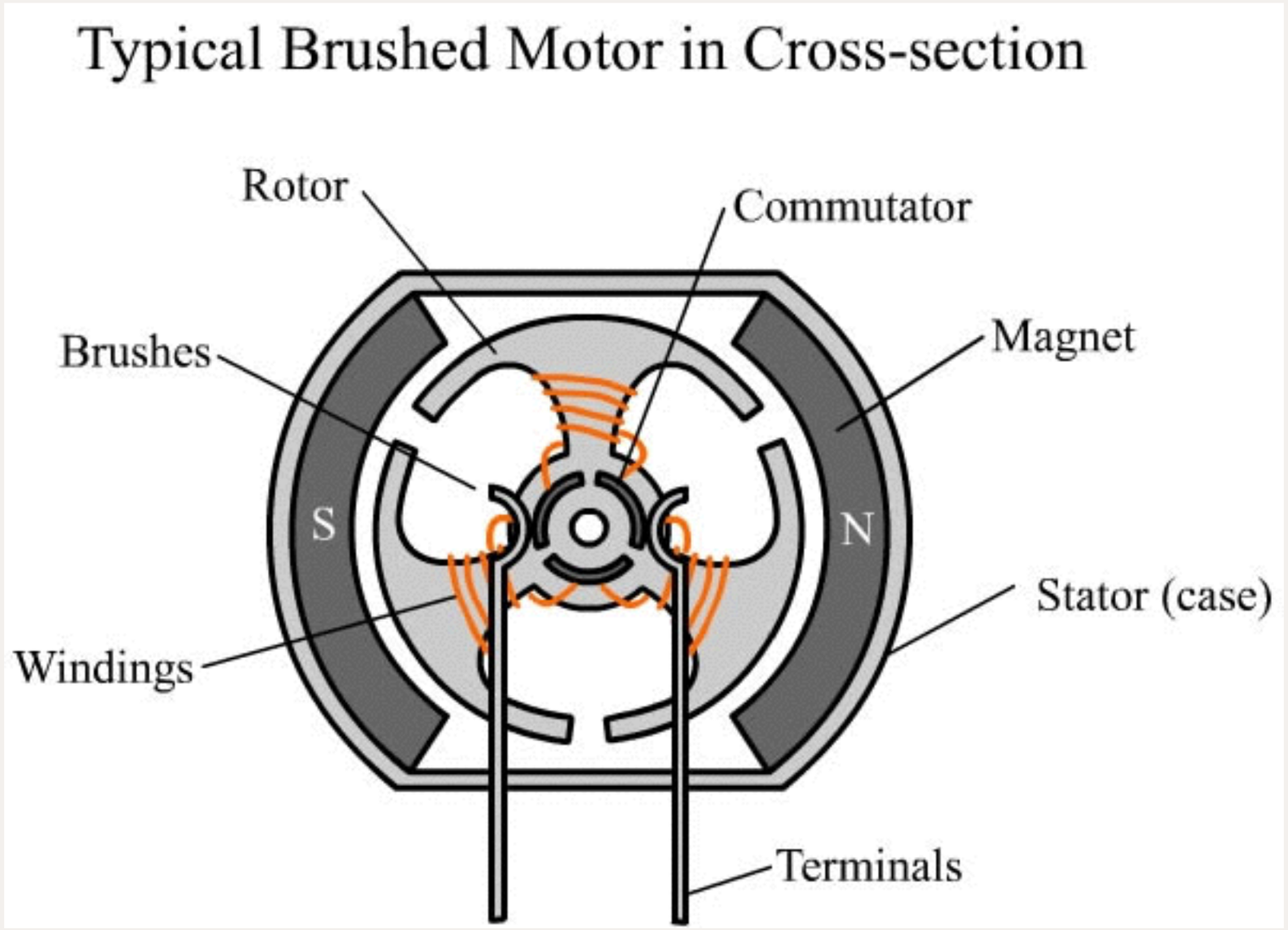


Want to flip the direction a motor spins?
Reverse the leads

Your DC Motor

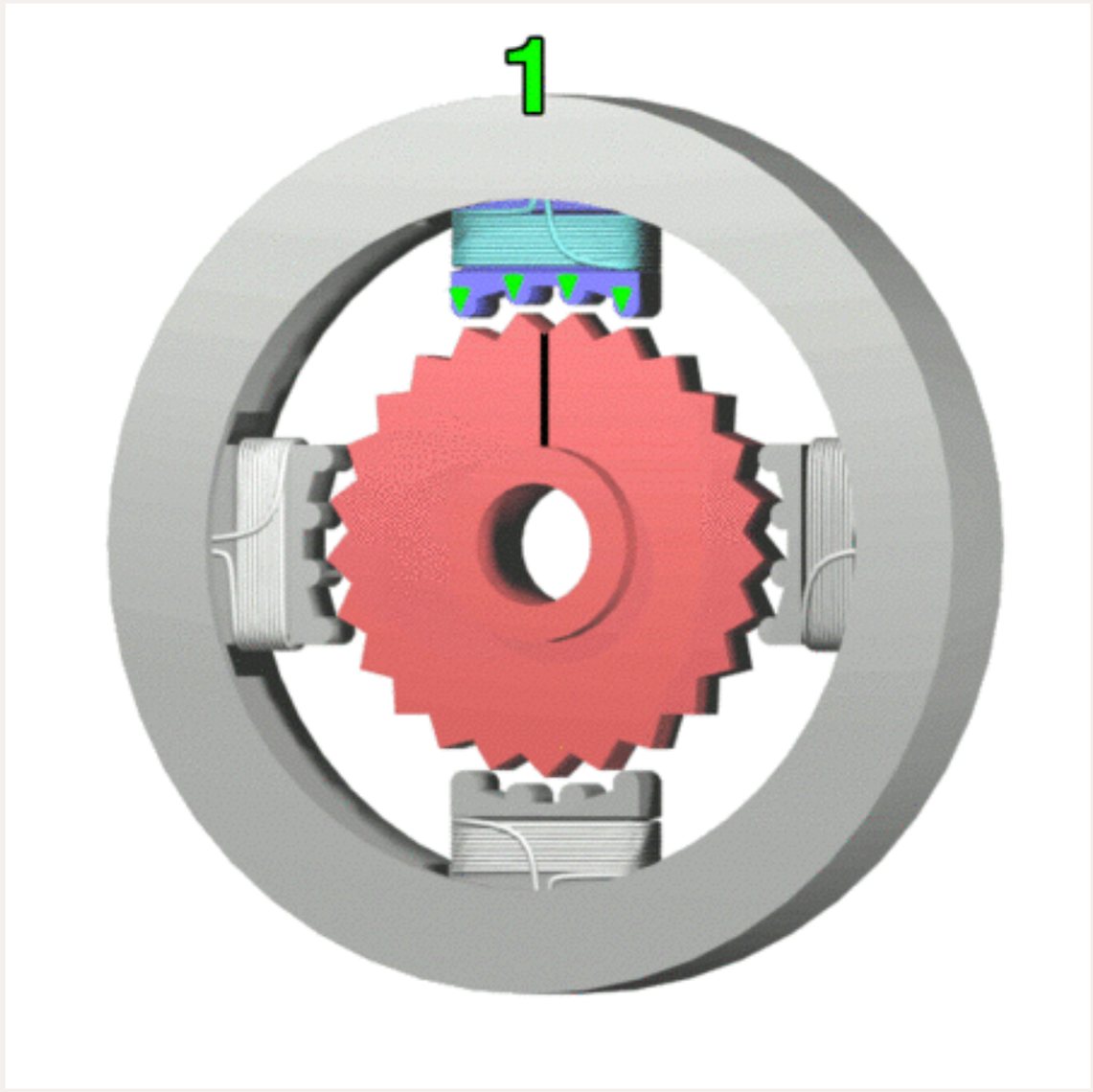


Your DC Motor



Lots of rotation very little torque
If you slow the rotation by adding gears you get more torque
You can turn it on and off in code.
More voltage? Faster motor (up until a point)

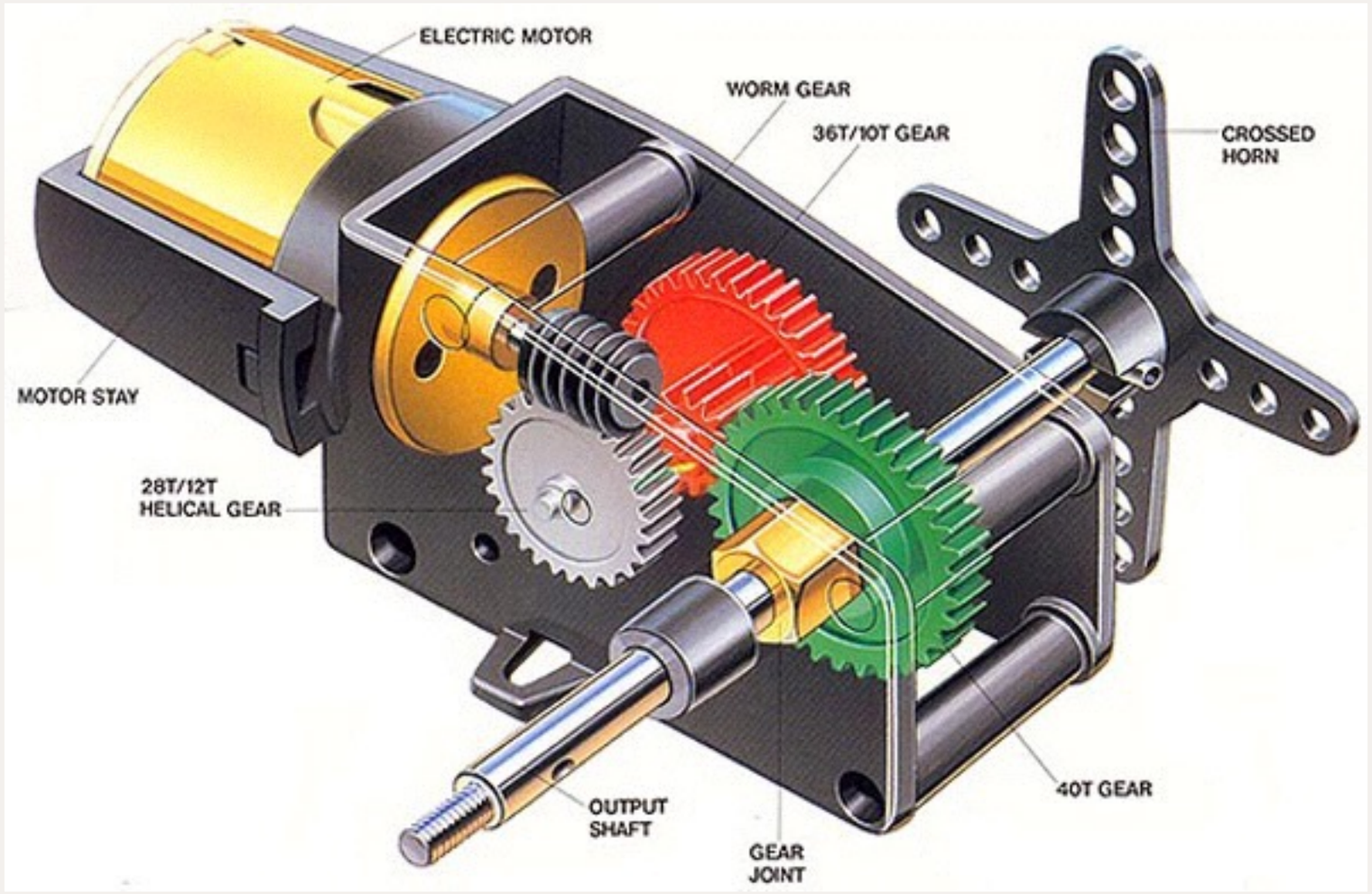
A Stepper motor



* divides a full rotation into a number of equal steps.
* Position commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller)

http://www.wired.com/2012/02/arduino-powered-etch-a-sketch/#slide-2

Your Servo Motor

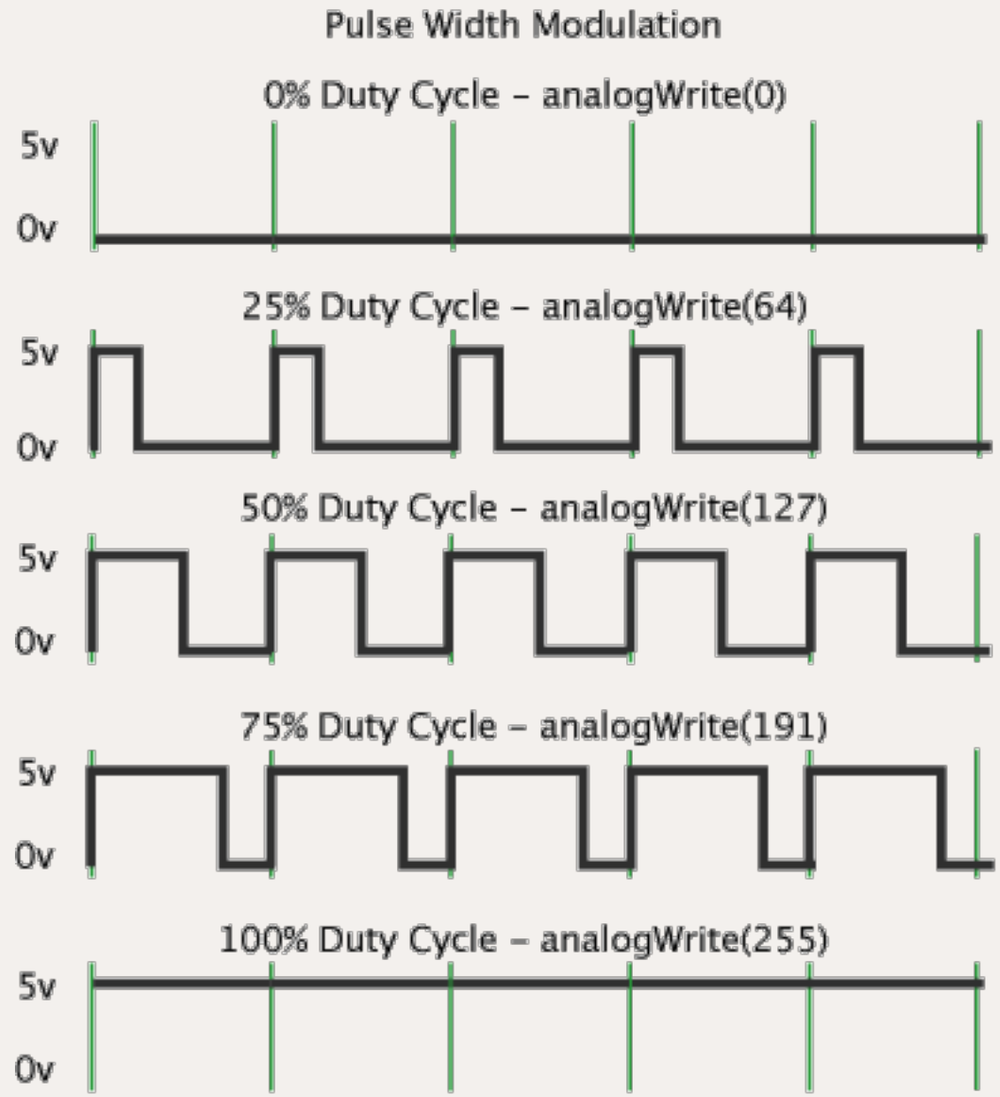


More complex gears.
Turns from 0 - 180 degrees (almost)
Sensor on gear shaft provides feedback on positioning
Allows you to control it via PMW

https://www.youtube.com/watch?v=VufMgHvaoG0

PWM (0-255)

* makes a digital pin act analogish
* sends a little pulse every 20ms
* the length of the pulse indicates the value
* longer the value the higher the value and the more voltage sent
* they are indicated on the Arduino by a ~
* use it to turn a servo by a certain angle using the Arduino built in servo library

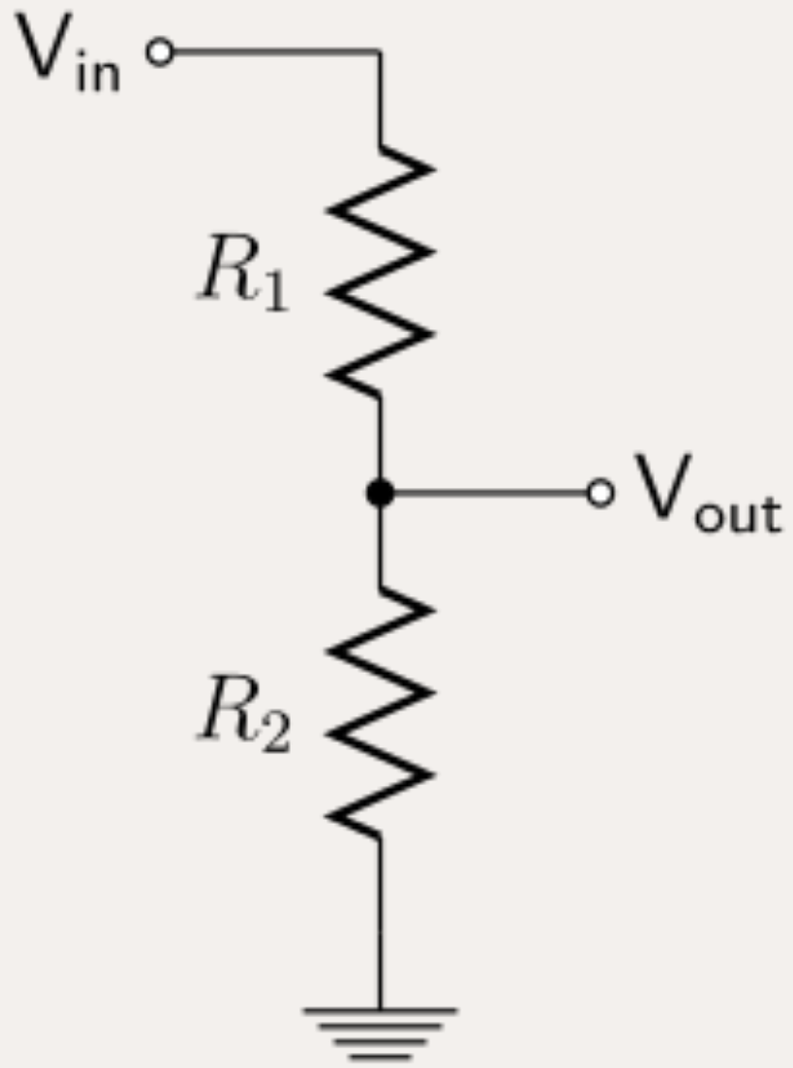


The voltage divider

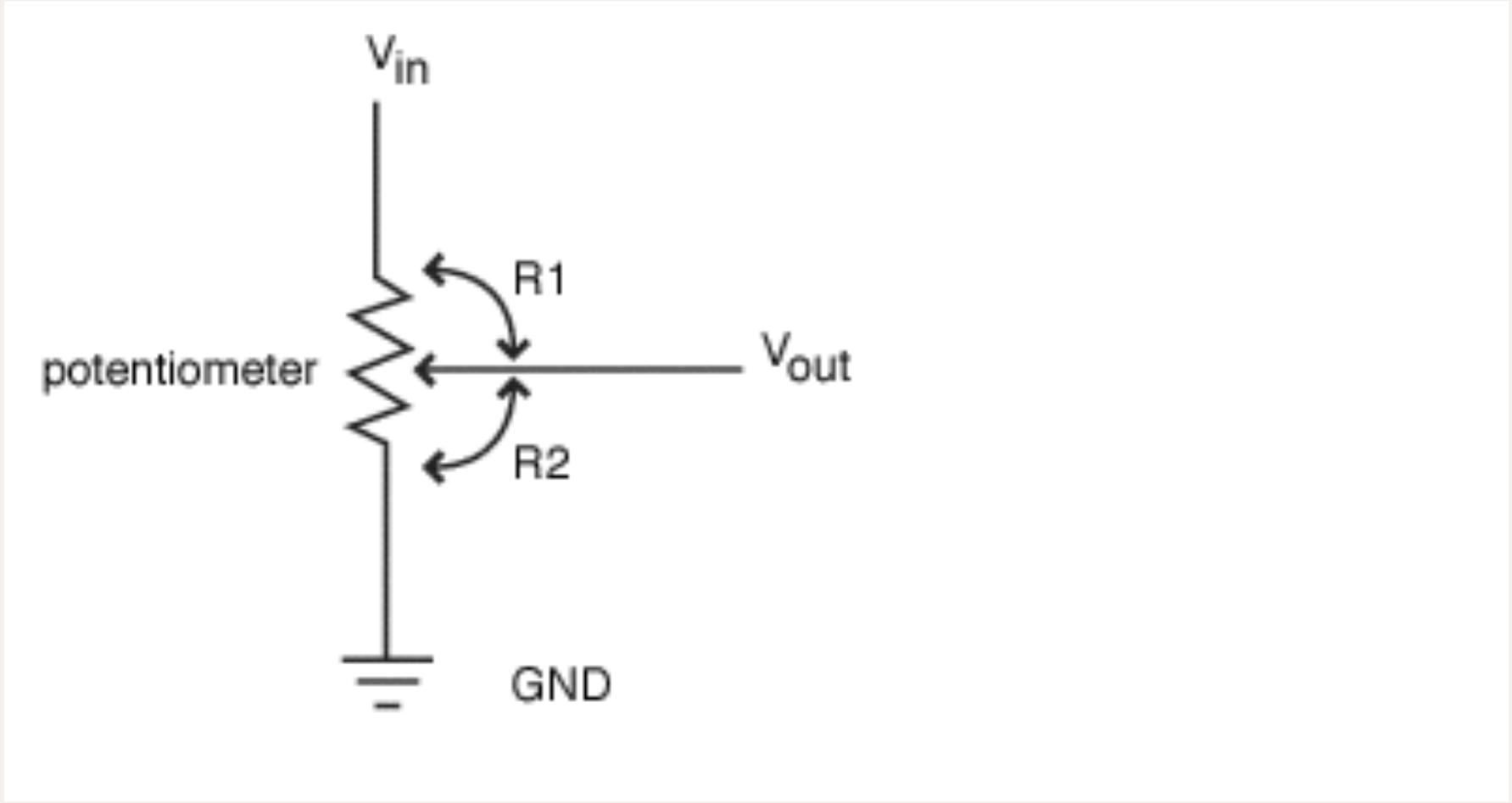
* What if you want less voltage going to a component to slow a motor?

* Where have we seen this already?

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



The voltage divider



* Potentiometer can act like the R2 or R1 resistor and allow you to vary an LED's brightness, a servo's angle, or the speed of a motor using PWM