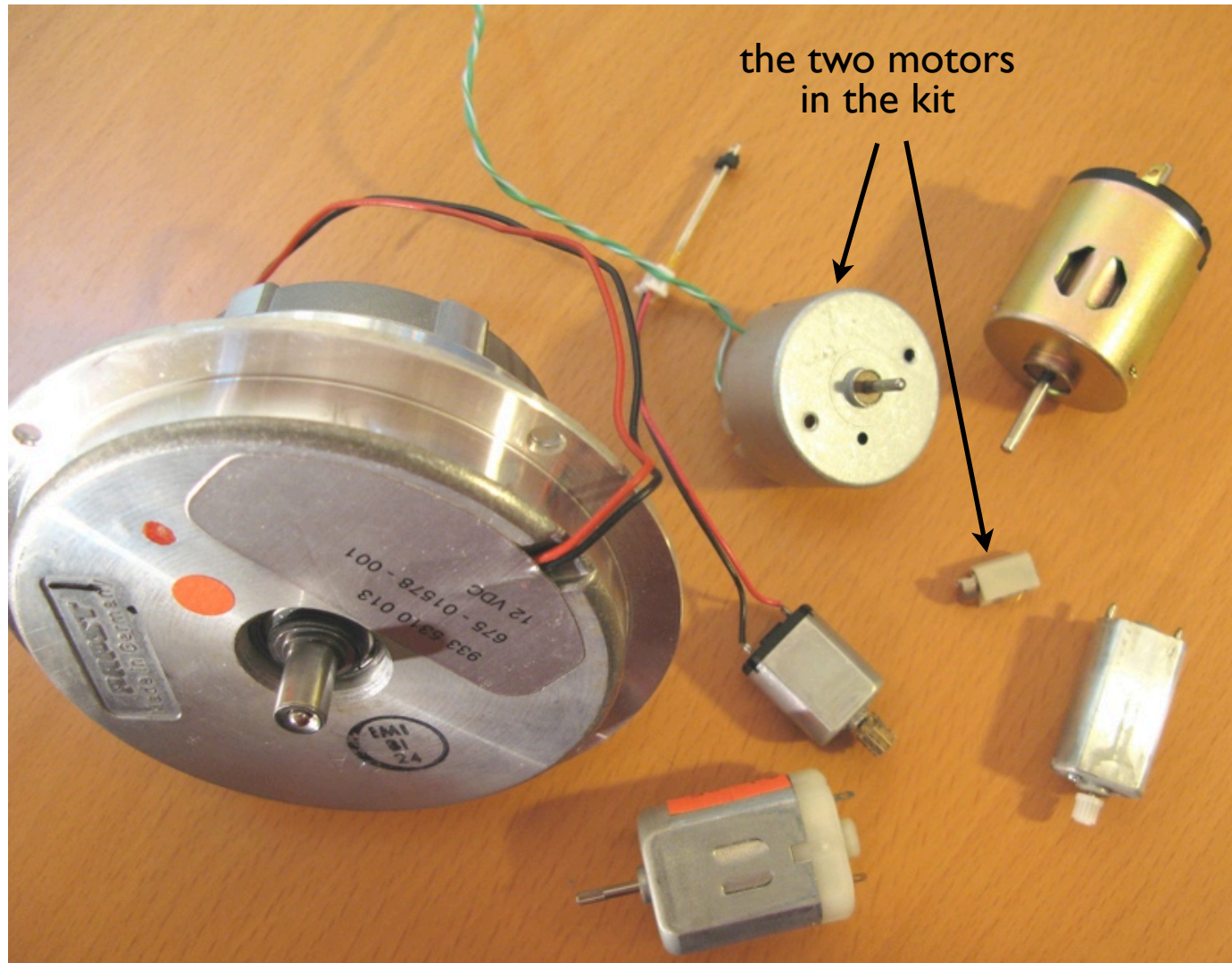


# DC Motors

come in all  
shapes and sizes

You probably have  
3-4 on you right now

(cell vibrate, laptop fan, laptop dvd drive)



When motors first came out, people thought we'd just have one for the house. The household motor. Various attachments for vacuuming, meat grinding, ceiling fan were available, and some houses had intricate mazes of belts and gears routed through the house to supply this rotational power.

# DC Motors

A dizzying array of parameters specify a motor

- direct-drive vs. gearhead – built-in gears or not
- voltage – what voltage it best operates at
- current (efficiency) – how much current it needs to spin
- speed – how fast it spins
- torque – how strong it spins
- oh, and also: size, shaft diameter, shaft length, etc.

The two motors you have are small direct-drive,  
high-efficiency motors that work at 5 volts

Gearhead motors are the best.

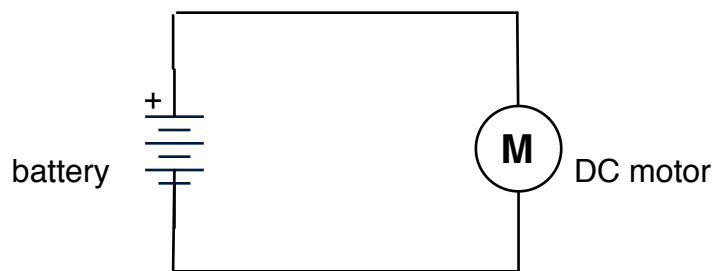
# DC Motors

## Characteristics

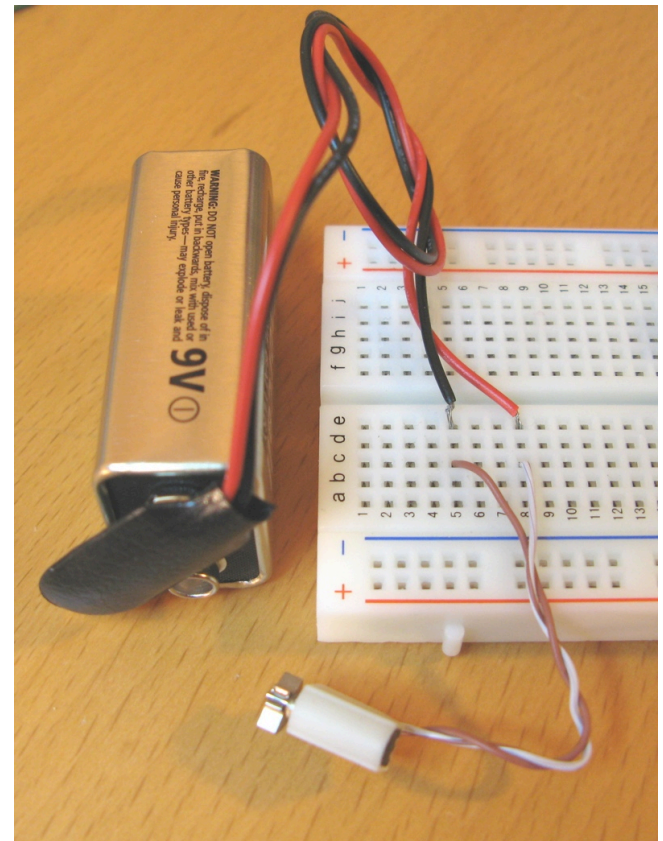
- When the first start up, they draw a *lot* more current, up to 10x more.
- If you “stall” them (make it so they can’t turn), they also draw a lot of current
- They can operate in either direction, by switching voltage polarity
- Usually spin very fast: > 1000 RPM
- To get slower spinning, need gearing

# DC Motors

To drive them, apply a voltage  
The higher the voltage, the faster the spinning



polarity determines which way it rotates

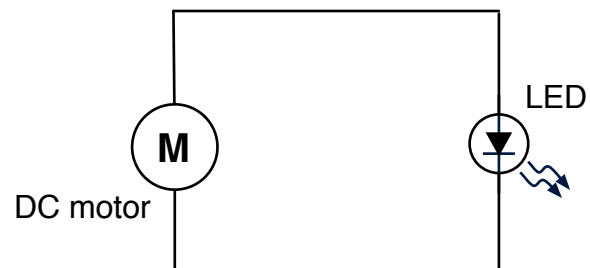


Try this out real quick.  
Then swap polarity

Don't let it go to long. These motors will work at 9V for awhile, but aren't made to continuously run at that voltage.

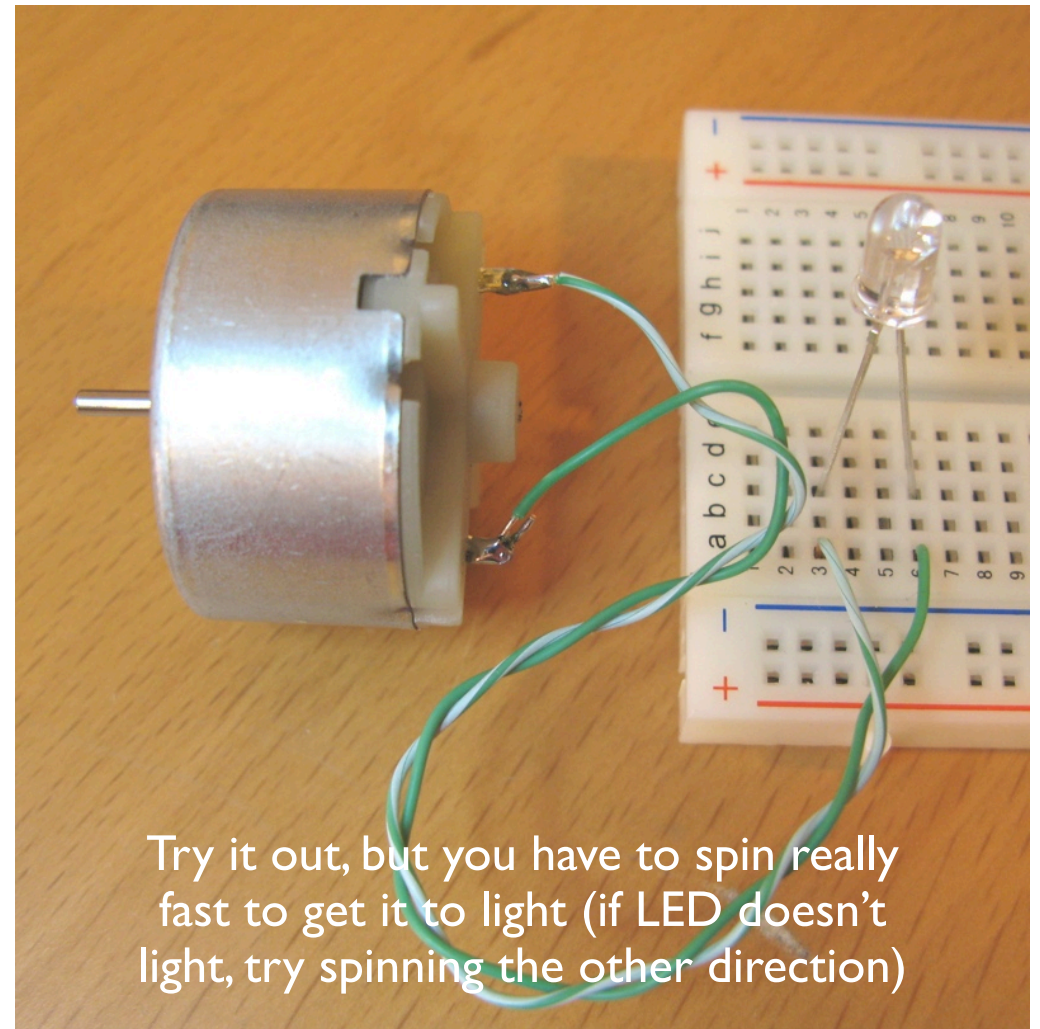
# DC Motors as Generators

Just as voltage causes rotation...



...rotation causes voltage

This is used for “regenerative braking” in electric & hybrid cars



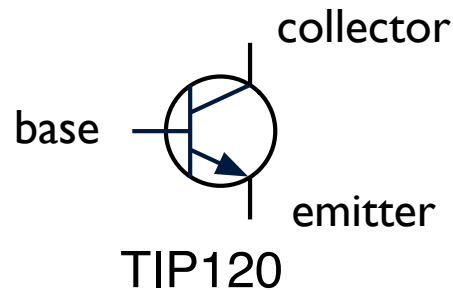
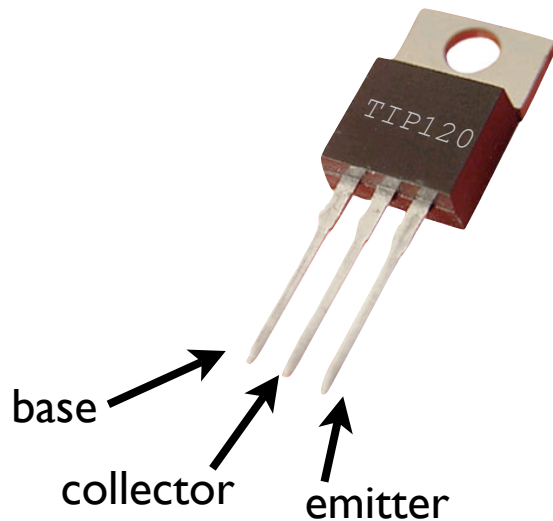
Try it out, but you have to spin really fast to get it to light (if LED doesn't light, try spinning the other direction)

These high-efficiency motors I gave you don't generate much current (because they don't use much current). I have a cheapy motor that lights LEDs better that I can show you.

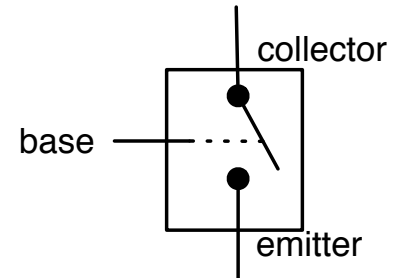
# Transistors

Act like switches

electricity flicks the switch instead of your finger



schematic symbol



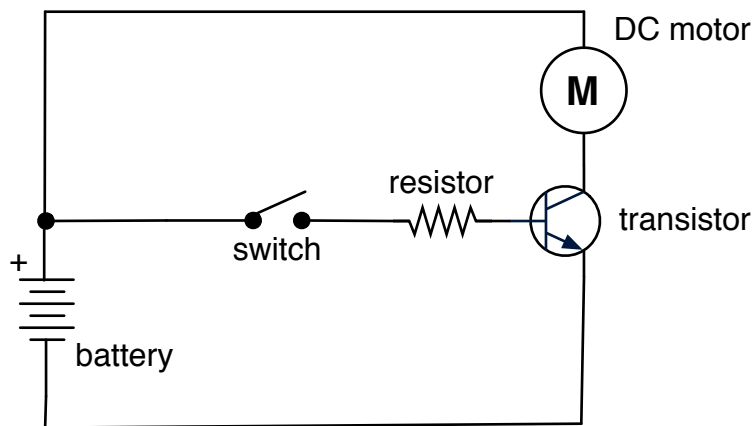
how it kind of works

Turning on the “base” connects the “collector” & “emitter” together

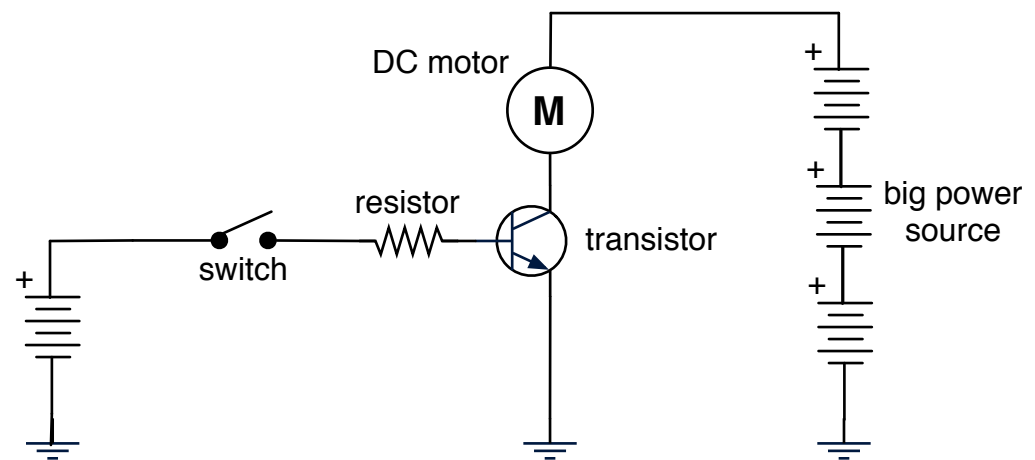
The differences between the pins are very important. The names aren't that important, but their functions are. The “base” is the input that you use to open and close the “switch” across the “collector” and “emitter”. On this type of transistor (called an NPN), you need to make sure the collector is always more positive than the emitter. Generally you do this by connecting the emitter to ground.

# Switching Motors with Transistors

little motor



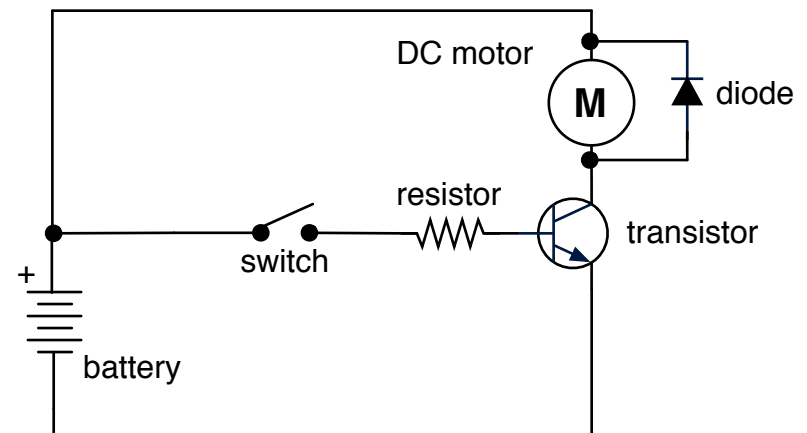
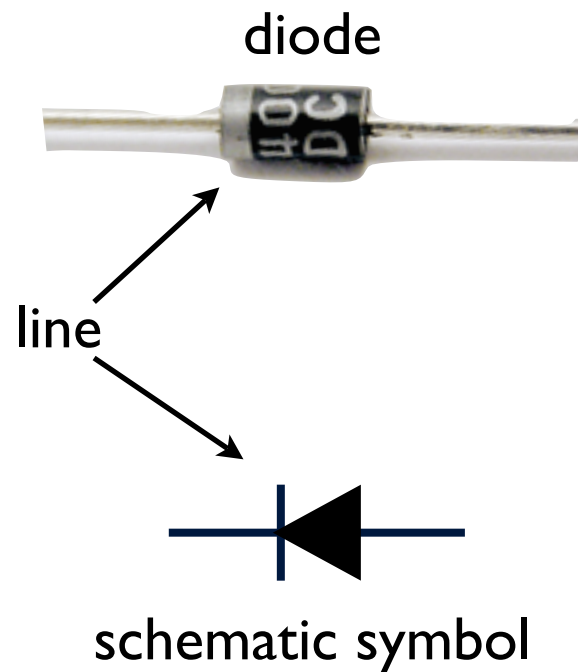
big motor



switching a different power source

transistors switch big signals with little signals

# Need a “Kickback” Diode



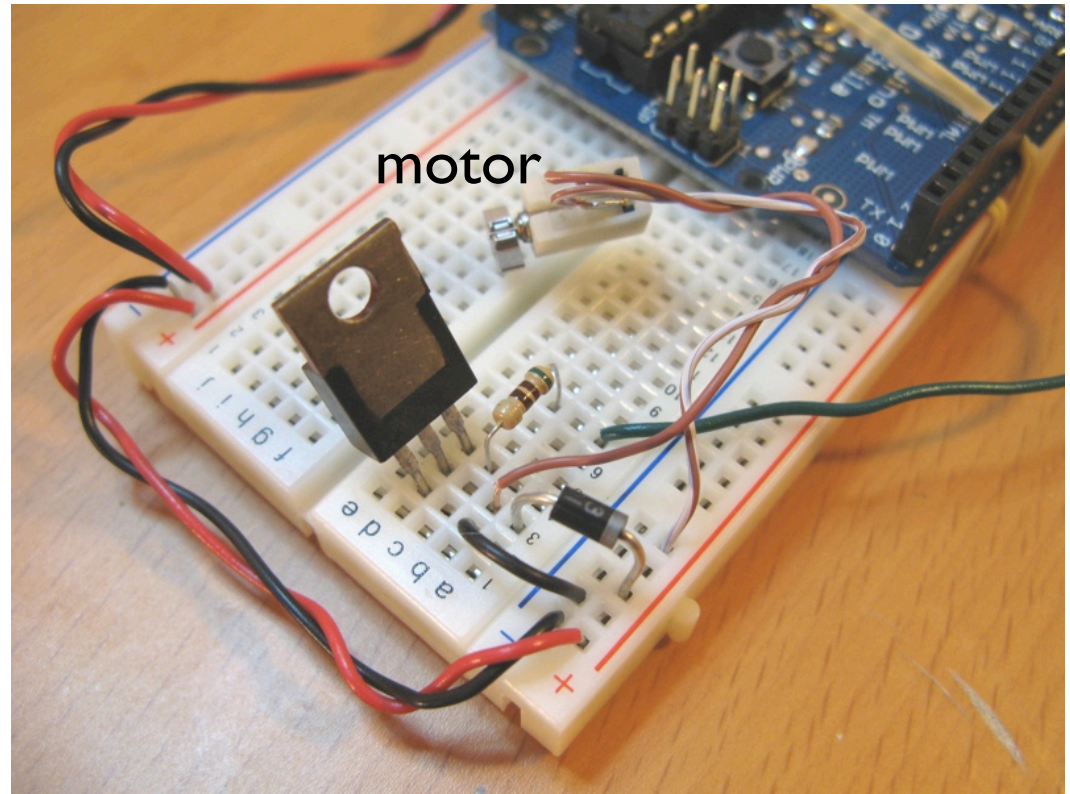
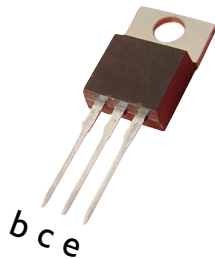
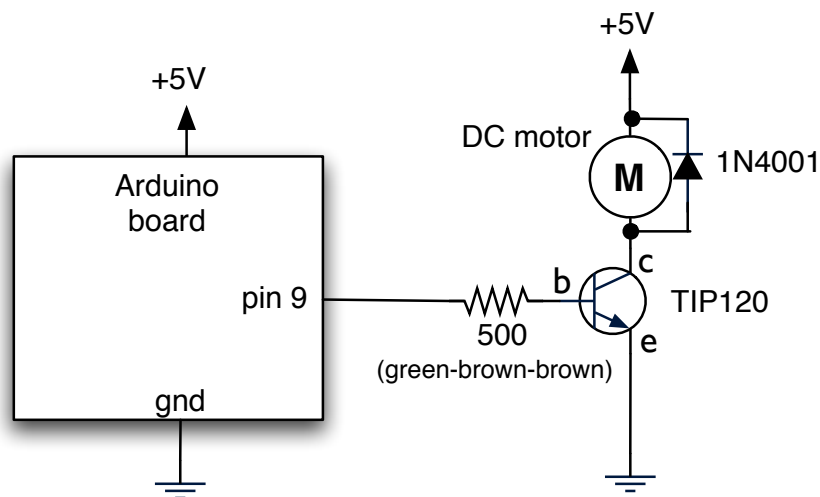
since motors can act like generators,  
need to prevent them from generating “kickback” into the circuit

Once a motor starts spinning, its inertia keeps it spinning, this turns it into a generator and thus can generate a “kickback” voltage. The kickback diode routes that voltage harmlessly back into the motor so it can’t damage the rest of the circuit.

Kickback is also called “back EMF” (EMF == electromotive force == voltage)



# Controlling a Motor

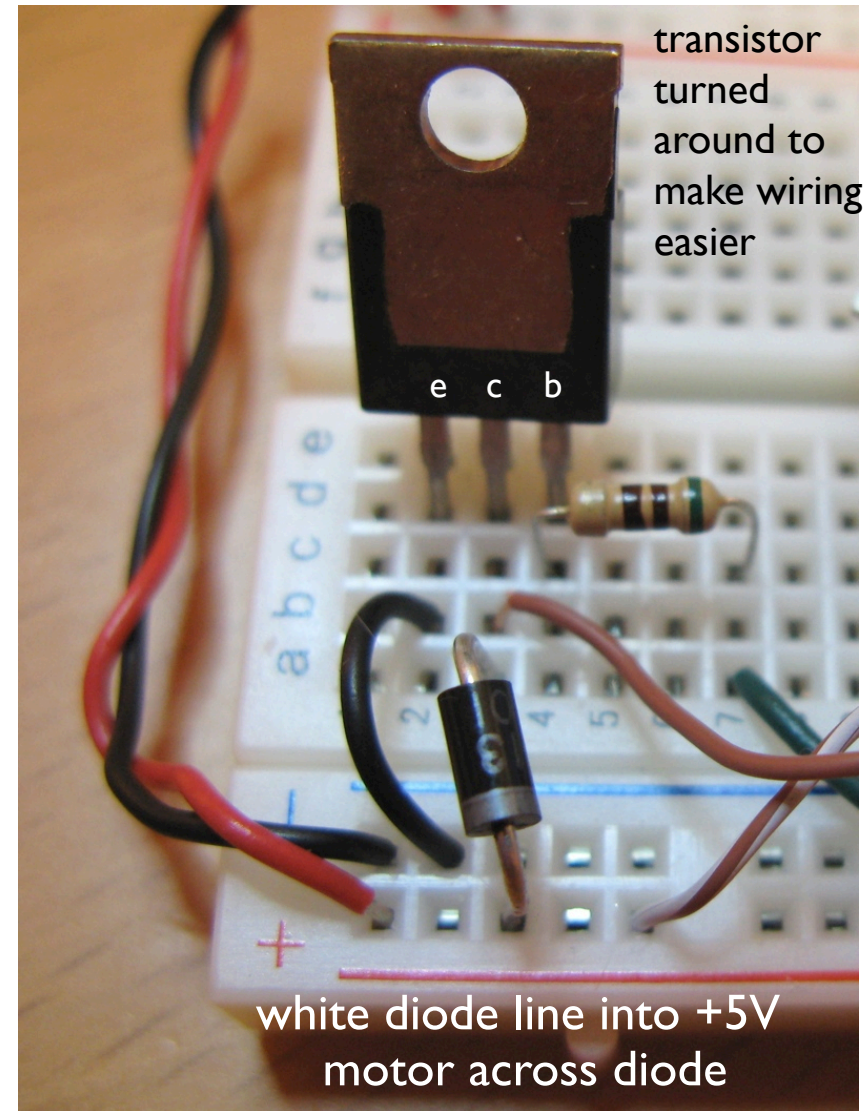
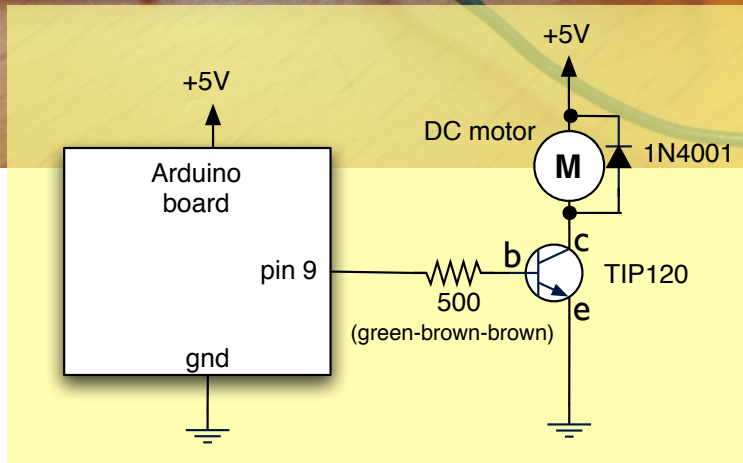
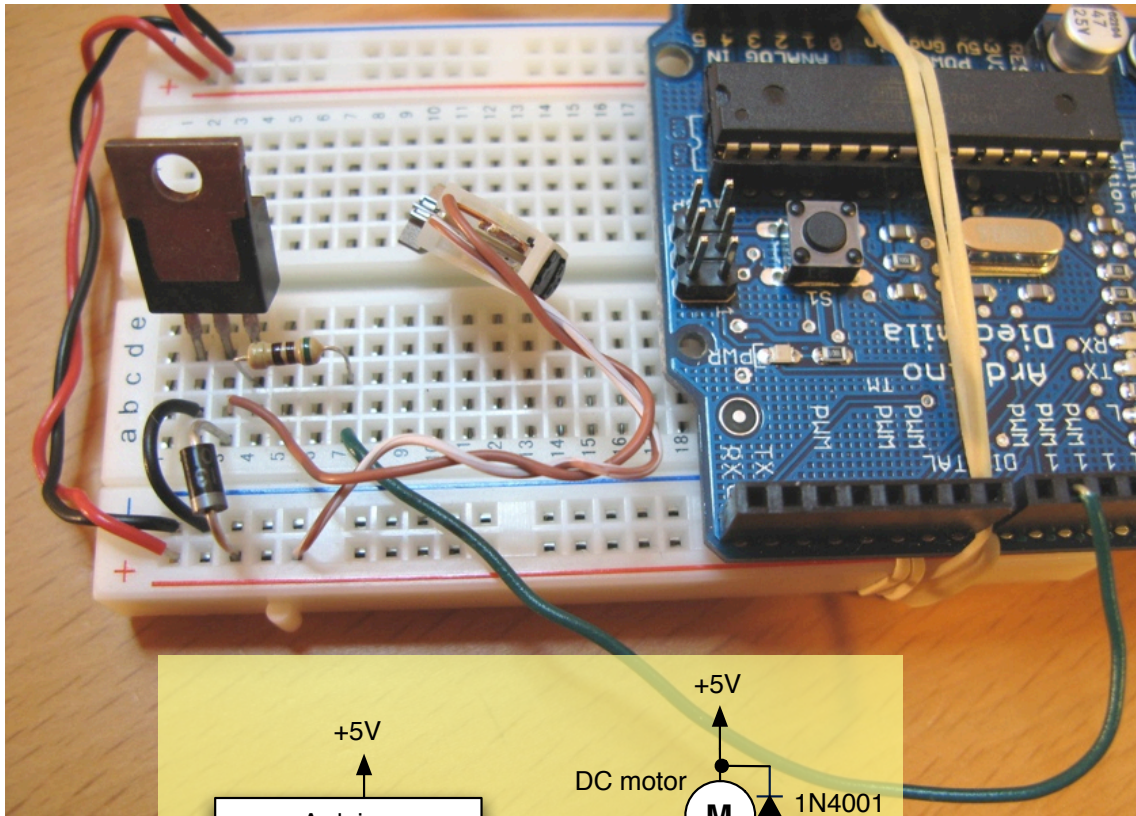


start with the tiny motor

Can control speed of motor with `analogWrite()`  
just like controlling brightness of LED

Why 500 ohms? Because I have a lot of 500 ohm resistors. Typically you see 1k ohms. Anything 1k or below will work. The lower the value, the more current you're "wasting" to turn on the transistor.

# Wiring up Motor Circuit



transistor  
turned  
around to  
make wiring  
easier

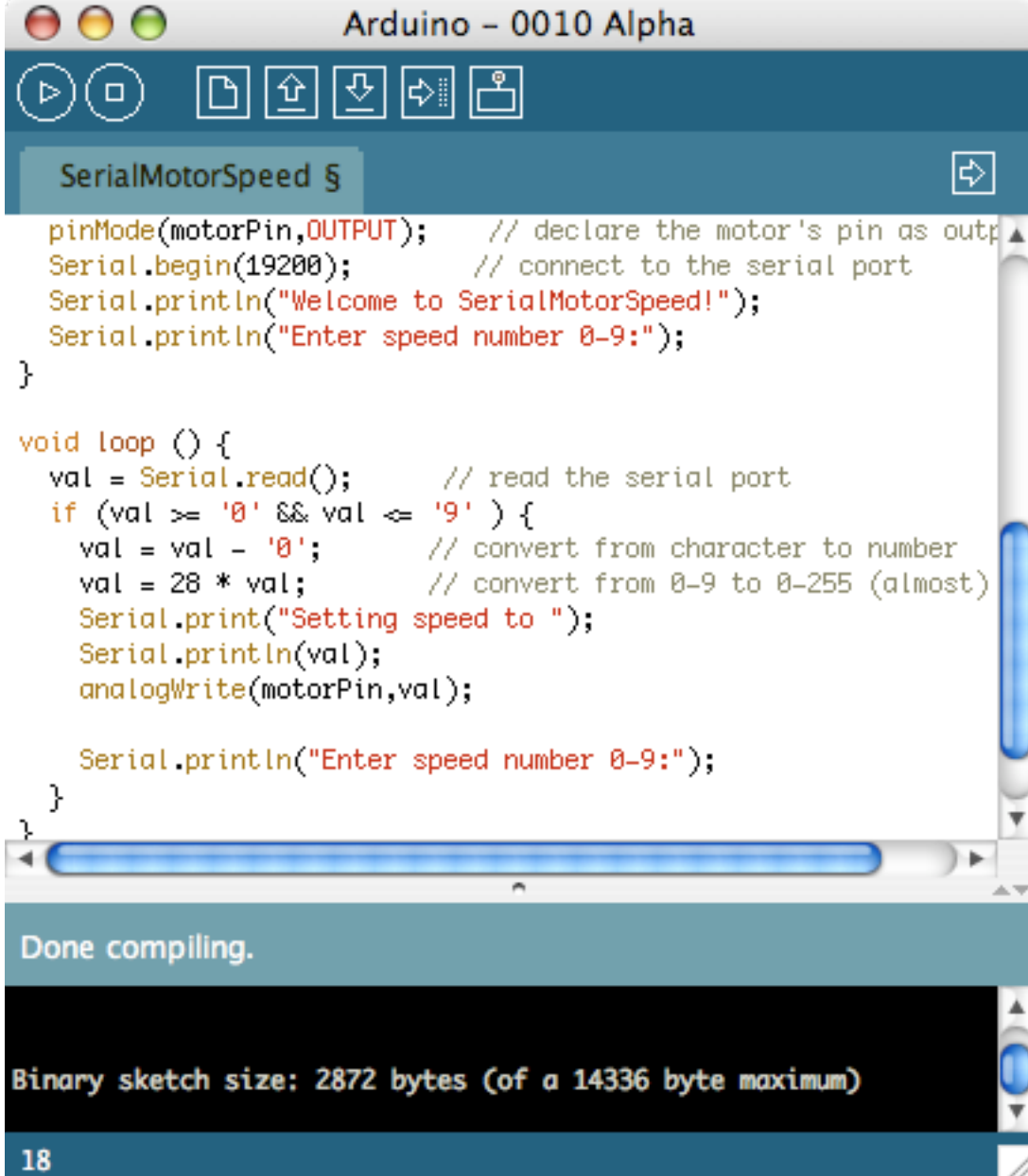
white diode line into +5V  
motor across diode

# Sketch

“SerialMotorSpeed”

Type a number 0-9  
in Serial Monitor to  
control the speed of  
the motor

How would you change this  
to control the motor speed  
with the potentiometer?



```
Arduino - 0010 Alpha

SerialMotorSpeed 5

pinMode(motorPin,OUTPUT); // declare the motor's pin as output
Serial.begin(19200); // connect to the serial port
Serial.println("Welcome to SerialMotorSpeed!");
Serial.println("Enter speed number 0-9:");
}

void loop () {
  val = Serial.read(); // read the serial port
  if (val >= '0' && val <= '9' ) {
    val = val - '0'; // convert from character to number
    val = 28 * val; // convert from 0-9 to 0-255 (almost)
    Serial.print("Setting speed to ");
    Serial.println(val);
    analogWrite(motorPin,val);

    Serial.println("Enter speed number 0-9:");
  }
}

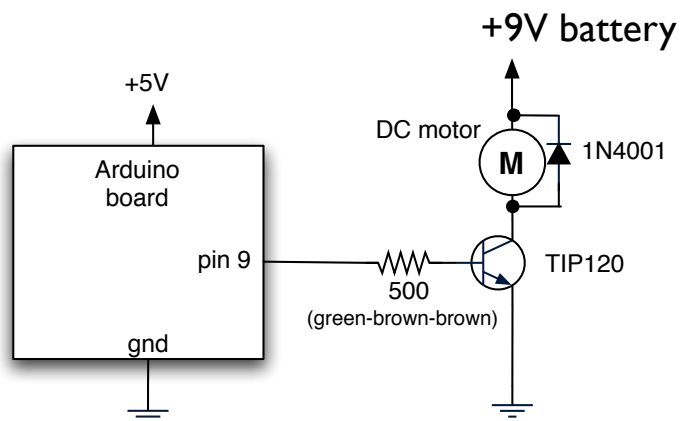
Done compiling.

Binary sketch size: 2872 bytes (of a 14336 byte maximum)

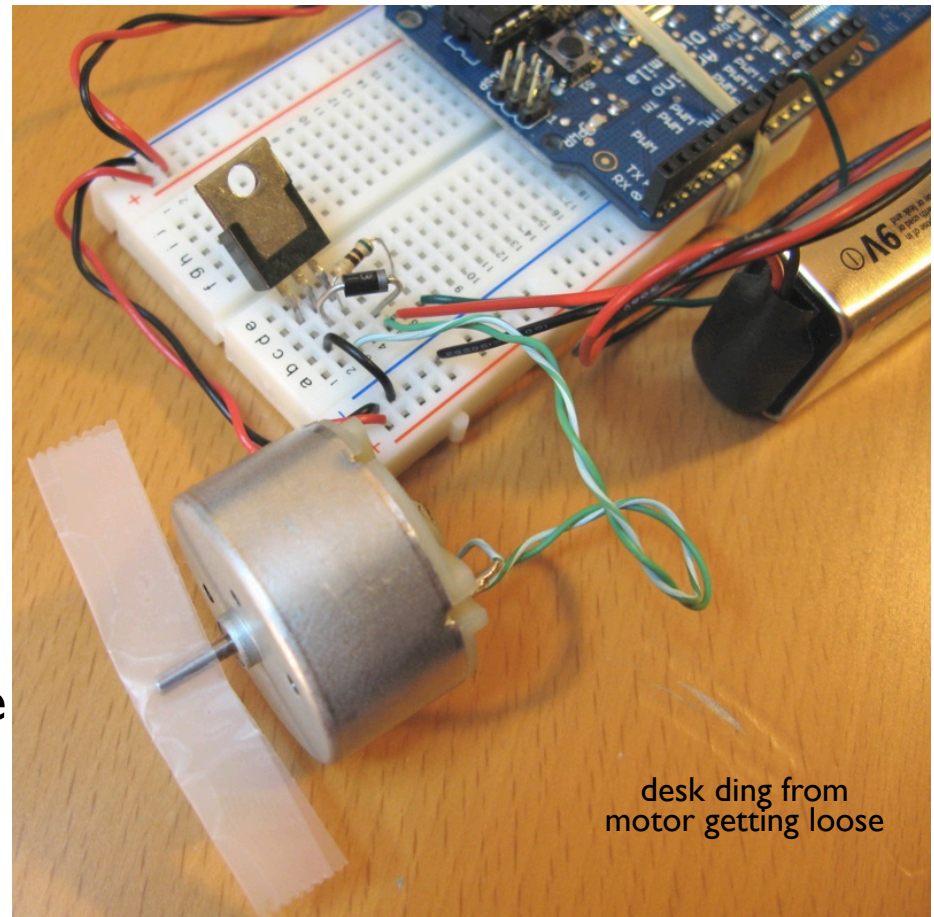
18
```

# Controlling a Bigger Motor

Same circuit as before, different voltage source



motor w/ tape propellor



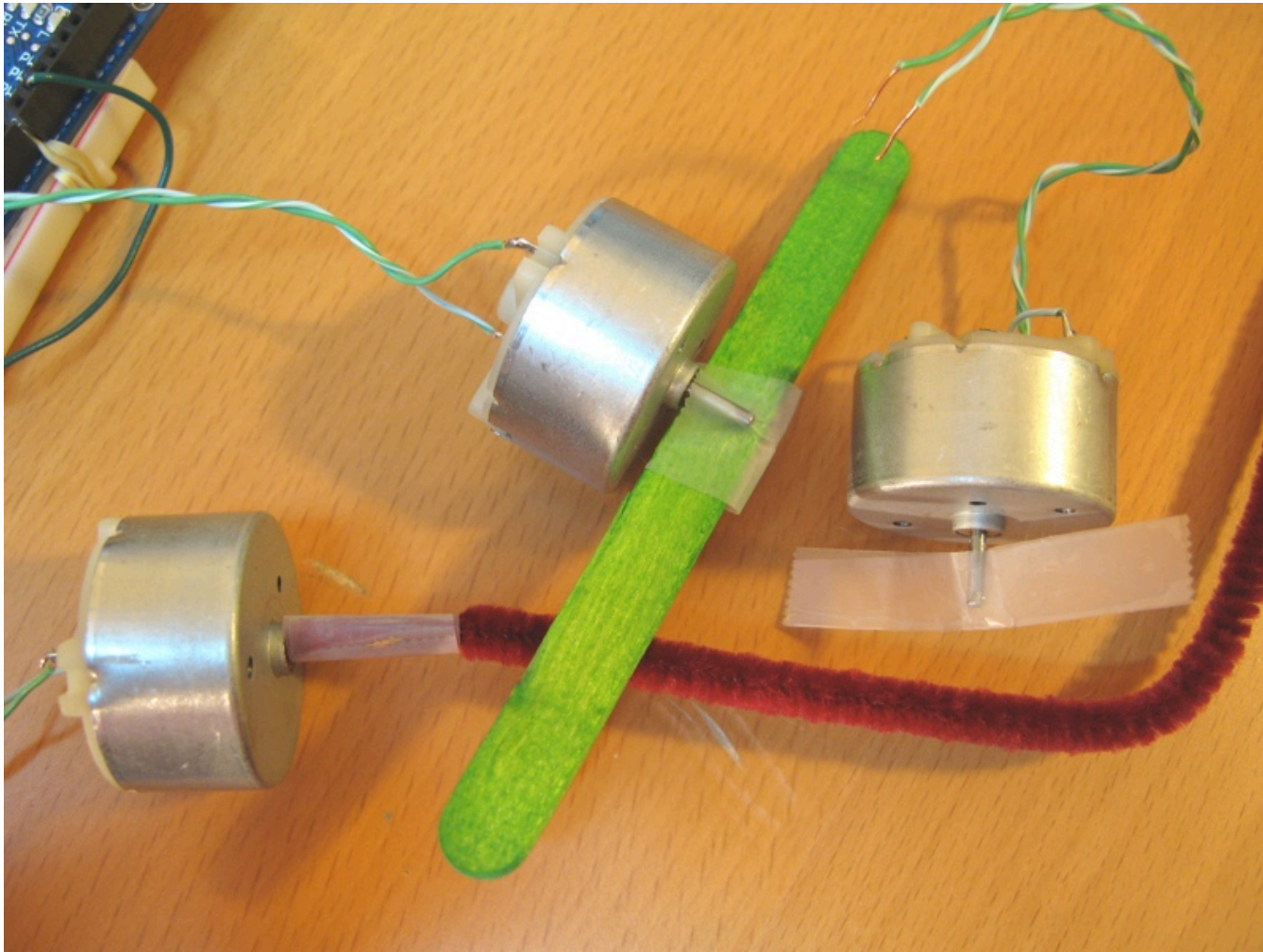
9V battery

desk ding from motor getting loose

Motor will spin faster for a given `analogWrite()` value

Actually with both of the motors you have, you can run off the Arduino power supply. But many motors cannot because they either draw too much current or they need a voltage higher than 5 volts.

# Fun Motor Attachments



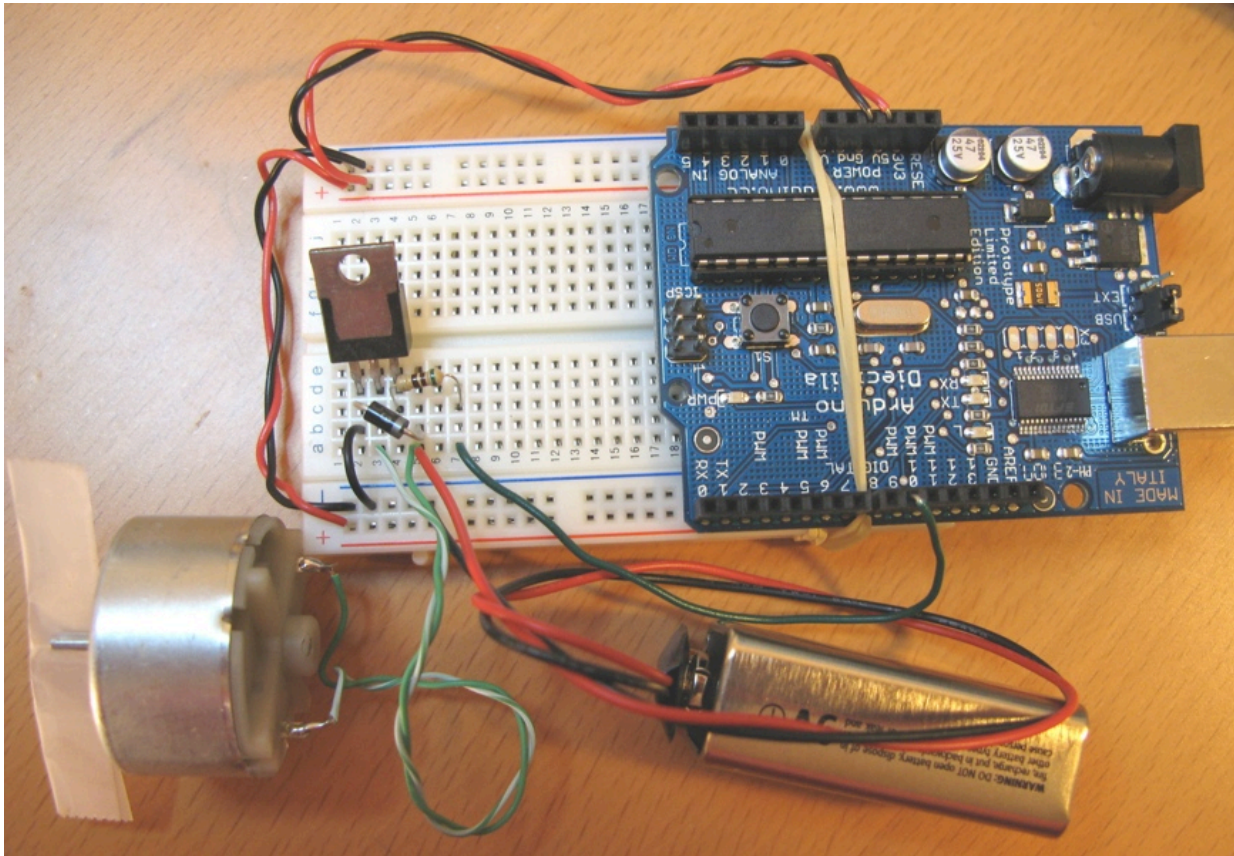
pipe cleaner squiggler

tape propeller

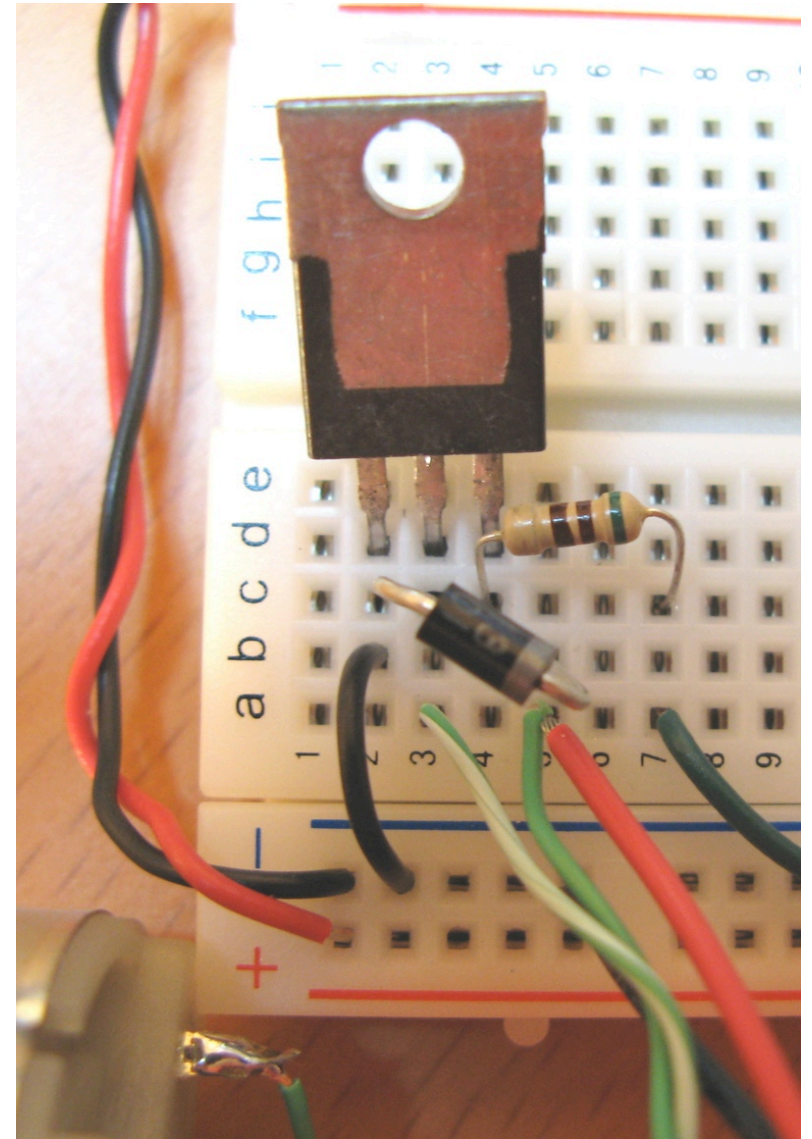
popsicle stick beater

I'm terrible at mechanical engineering. If anyone has good ways of mounting things to motors, let me know. :-)

# Wiring Up Bigger Motor

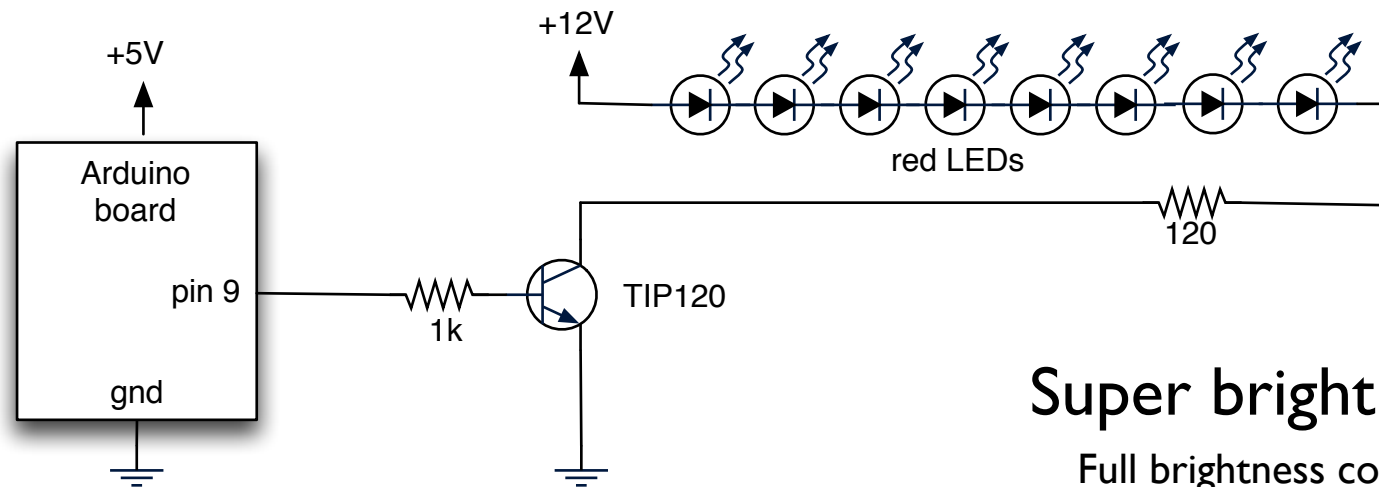


Don't just add 9V to +5v bus!  
Move the diode from +5 to another row  
Add red 9V wire to that row,  
Add black 9V wire to Gnd

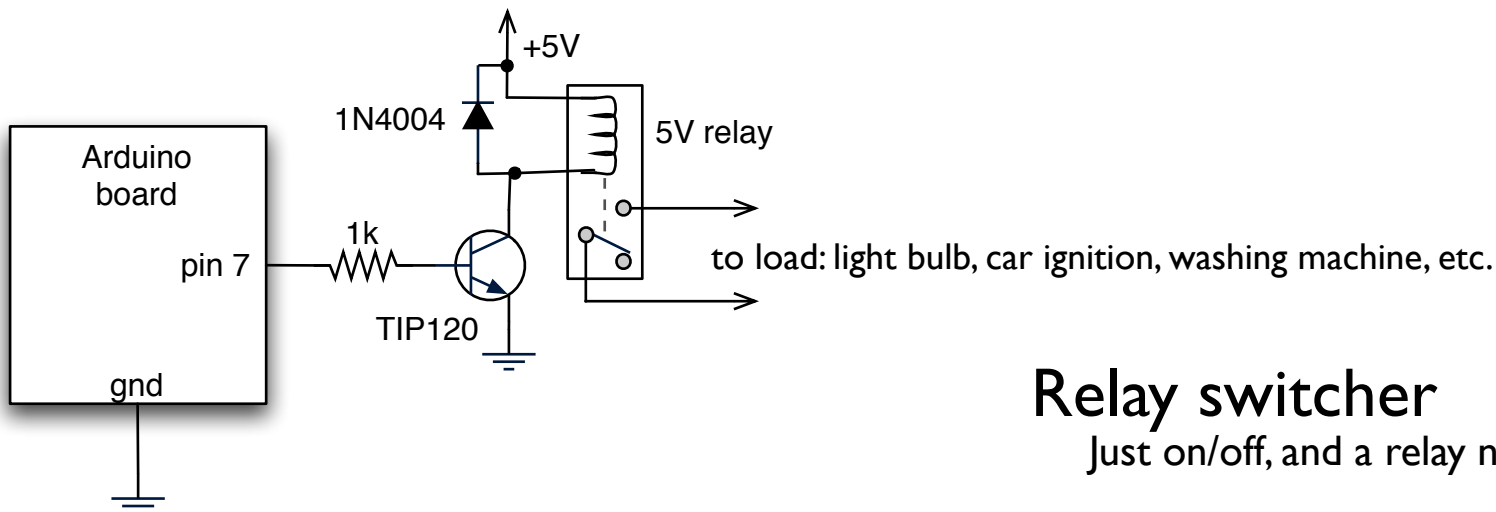


You might find it easier to push the red 9V wire in with the motor wire.

# Can Switch Anything\*



**Super bright LED light**  
Full brightness control with PWM



**Relay switcher**  
Just on/off, and a relay needs a diode too

\*Anything up to about 1 amp. Need a bigger transistor or a relay after that