

Inventing...

3

with Software and
Electronics







PWM

Loops & Motors & Amps

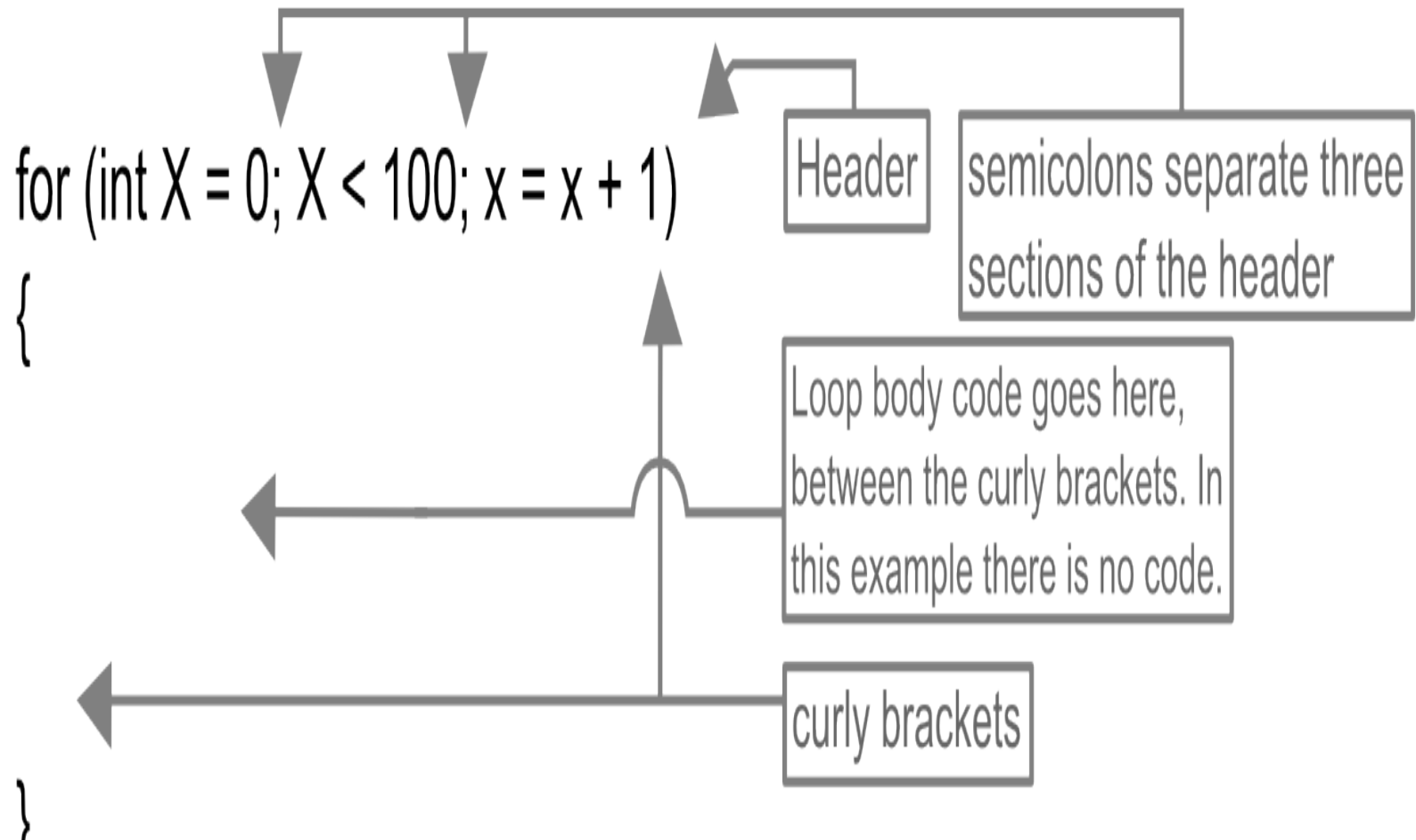
(Oh, Boy!)



KEY FACT: Software can be simplified with loops



Lazy Programmer
(K I S S)



For Loop

- But what if I don't know how many iterations there will be?



```
variableN = 0;
```

This is not a part of the while loop, it just sets variableN equal to zero before the while loop happens.

```
while (variableN < 10)
```

```
{
```

Header

```
variableN = variableN + 1;
```

Loop body code goes here, between the curly brackets. In this example it changes variableN so you're not stuck in the while loop forever.

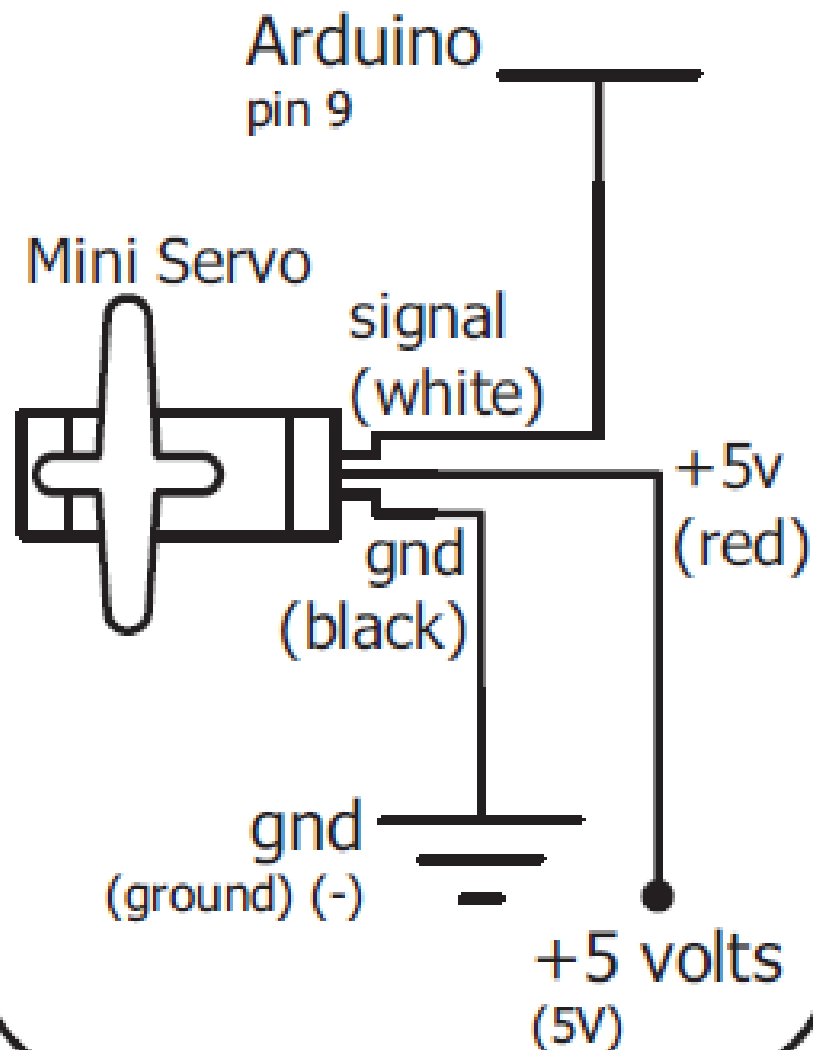
```
}
```

curly brackets



The while loop

Schematic



Includes another file which “declares”
a class called Servo.

```
#include <Servo.h>  
Servo myservo; // create servo object to control a servo
```



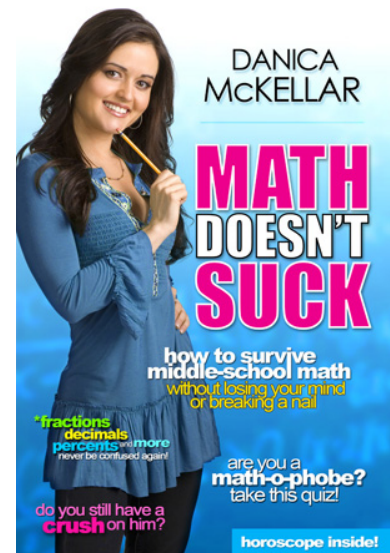
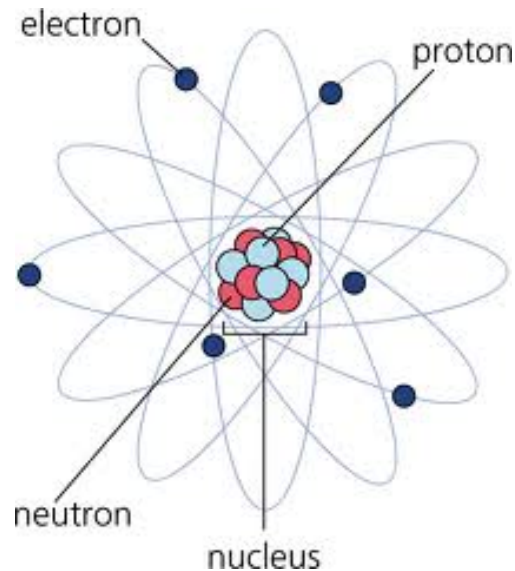


KEY FACT: Each Arduino pin
can source 40mA of current



KEY FACT: Some actuators in
our kit require more than
40mA

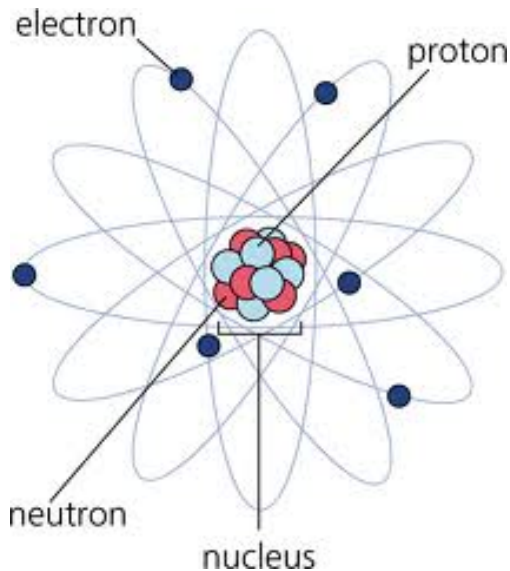
So, in 1 second how many electrons are flowing through our 20mA LEDs?



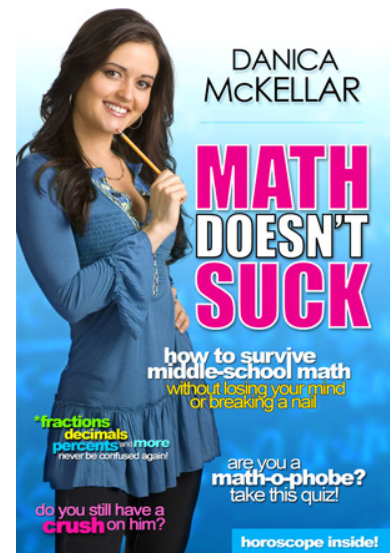
$$1 \text{ Amp} = 6.2 \times 10^{18} \text{ e- /second}$$

$$20 \text{ mA} = 1 \text{ Amp} / 500$$

$$20 \text{ mA} = 1.24 \times 10^{16} \text{ e- /second}$$



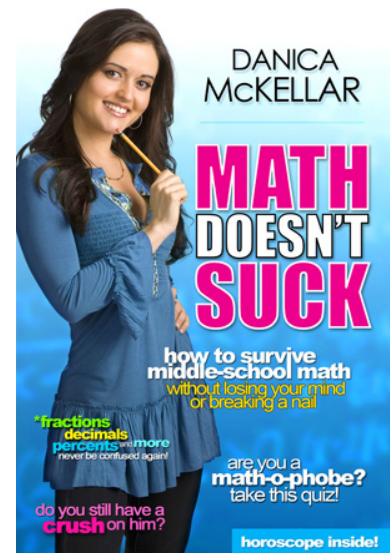
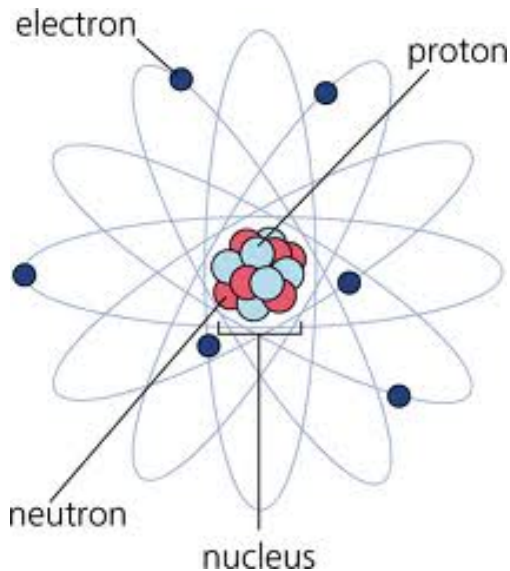
ANSWER



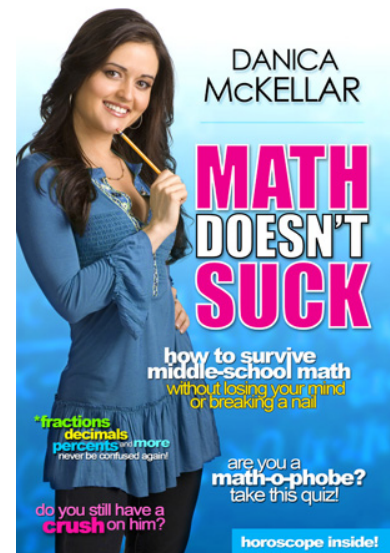
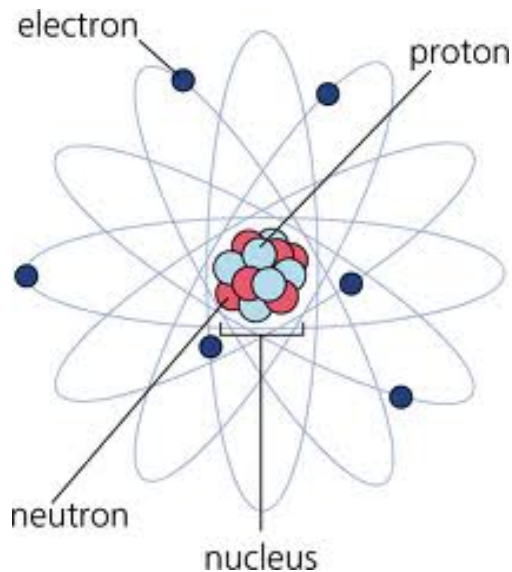
14 zeroes!

12,400,000,000,000,000

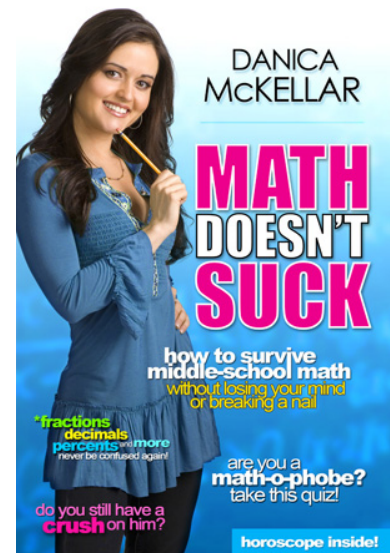
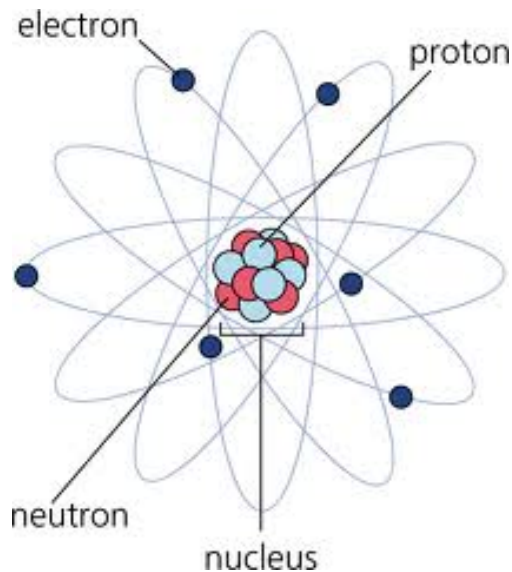
e-/second



> 12 Quadrillion
e-/second



> 12 Million Billion
e-/second



Analogy /ə'naləjē/: *n.*

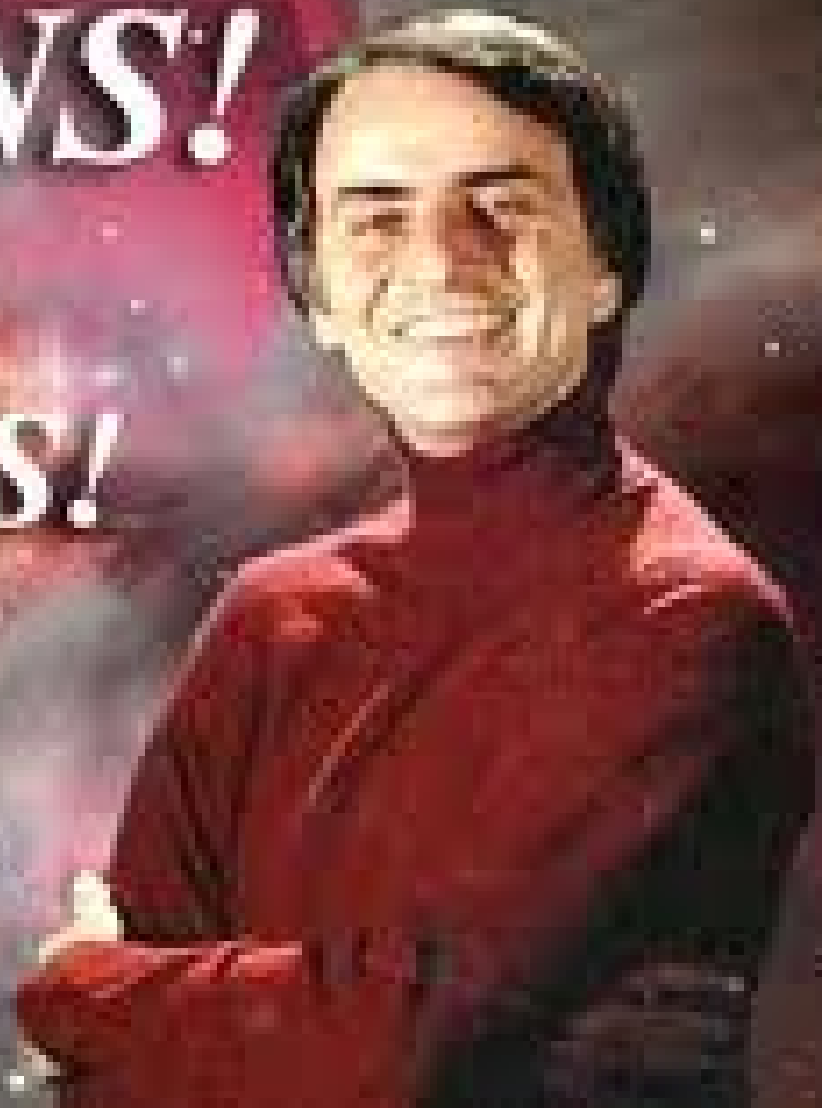
[Origin: Middle English analogie, from Old French, from Latin analogia, from Greek analogi, from analogos, *proportionate*;]

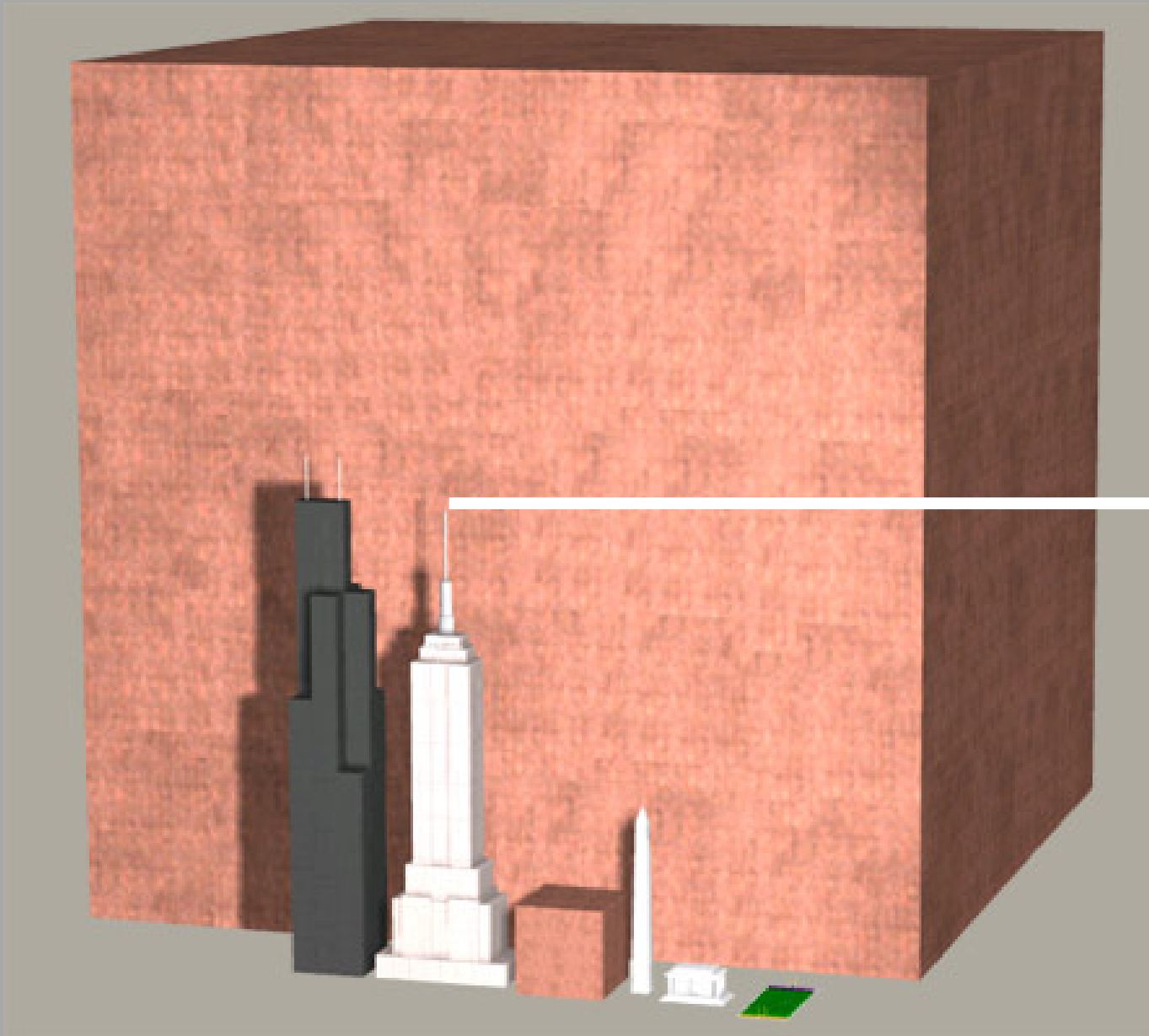
A comparison between two things, typically on the basis of their structure and for the purpose of explanation or clarification.

BILLIONS!

and

BILLIONS!





Empire State Building
102 Stories

Or – a pile of pennies
986,426,768 Miles
High....

A
N
A
L
O
G
Y

A
L
E
R
T

Conductor (Wire)



A
N
A
L
O
G
Y

A
L
E
R
T

Electrons



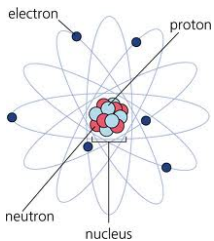
**A
N
A
L
O
G
Y

A
L
E
R
T**



Flow Rate (Gallons/Hour)

ANALOGY ALERT



Current (Amps)

Arduino Uno Datasheet

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)



“The absolute max
should be avoided - it is
dangerous to approach
it. “



EARLY GRAVE

Circuit Happiness



Dead



Stressed



Healthy



Underpowered



Asleep

A
N
A
L
O
G
Y

A
L
E
R
T

What happens if there's not enough current?

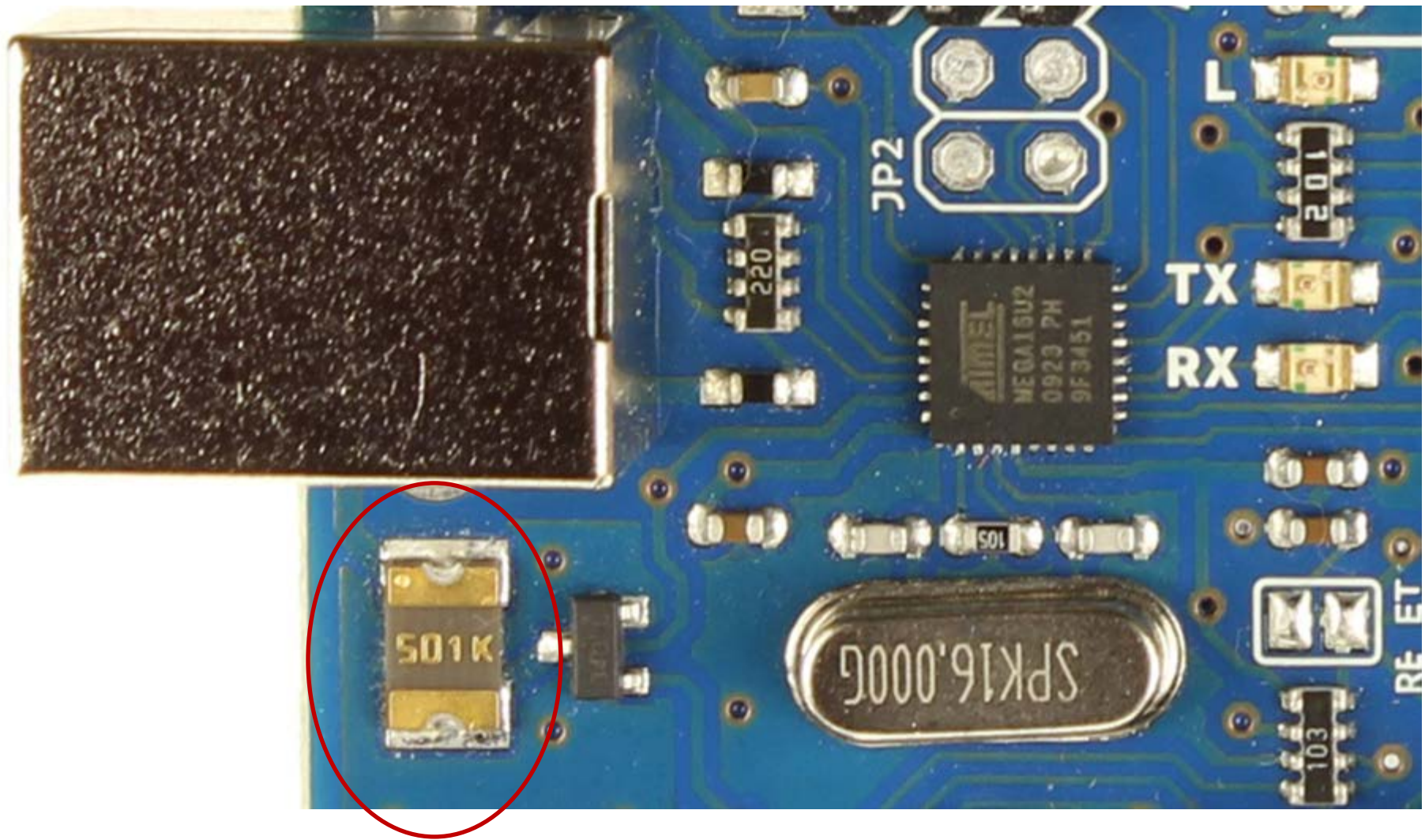




What happens if the current rating is exceeded?







Polyfuse (500mA)



Ways to Kill an Arduino



Easily Possible

Shorting I/O Pins to Ground

Apply Overvoltage to I/O Pins

Shorting I/O Pins to Each Other

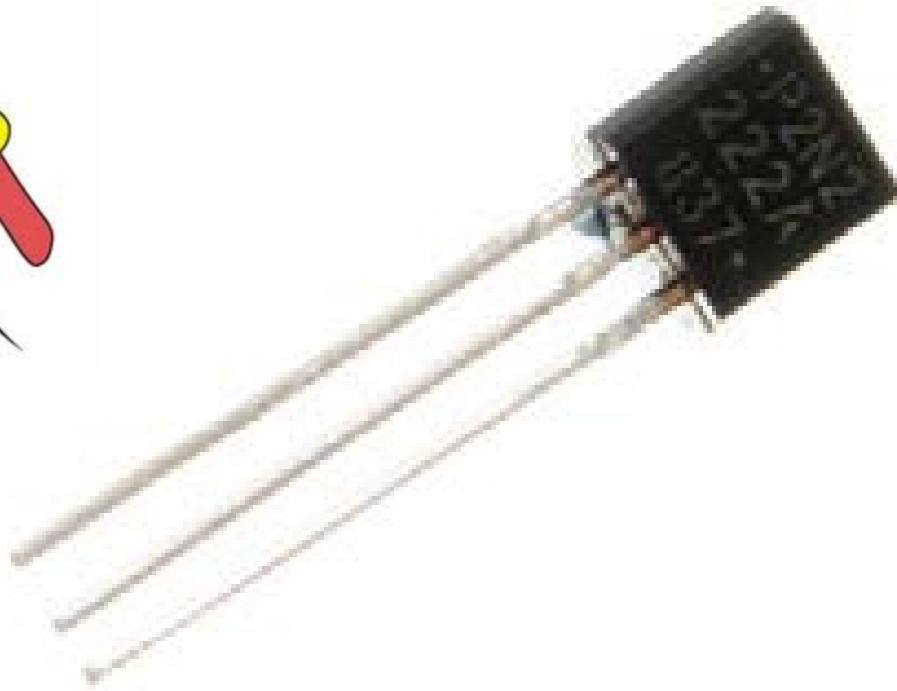
Exceed Total Microcontroller Current (200mA)



NO SMOKING



“the most important invention of the 20th century”



Transistor

A
N
A
L
O
G
Y

A
L
E
R
T



Valve

-
Battery
Terminal

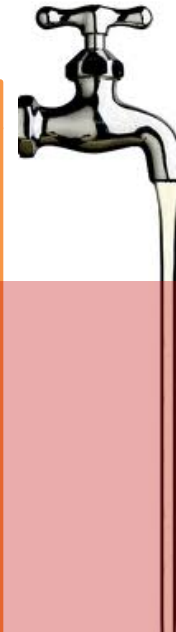
+
Battery
Terminal

Arduino
5V/Gnd
(.2A)

Pin (.04A)

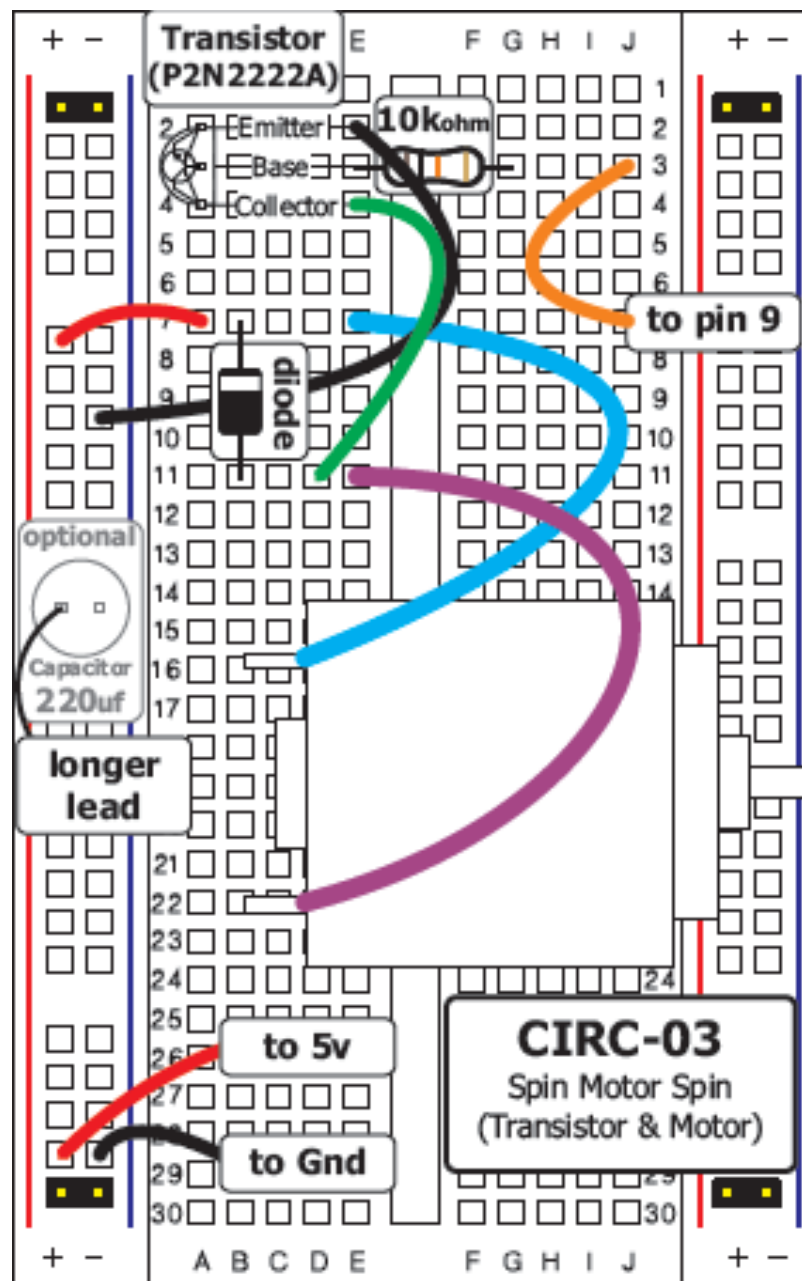
Transistor
Collector/
Emitter
(.6A)

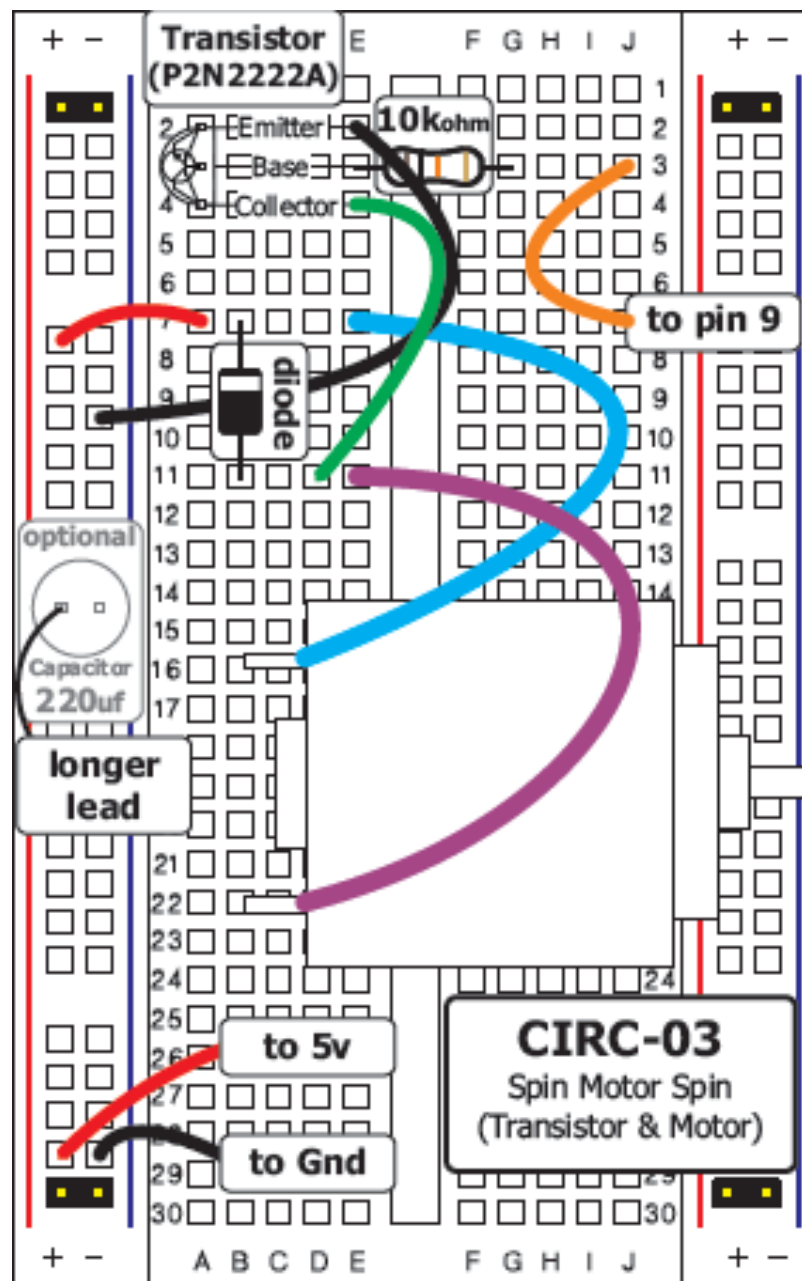
Fuse
(.5A)



Idle Motor(.32A)







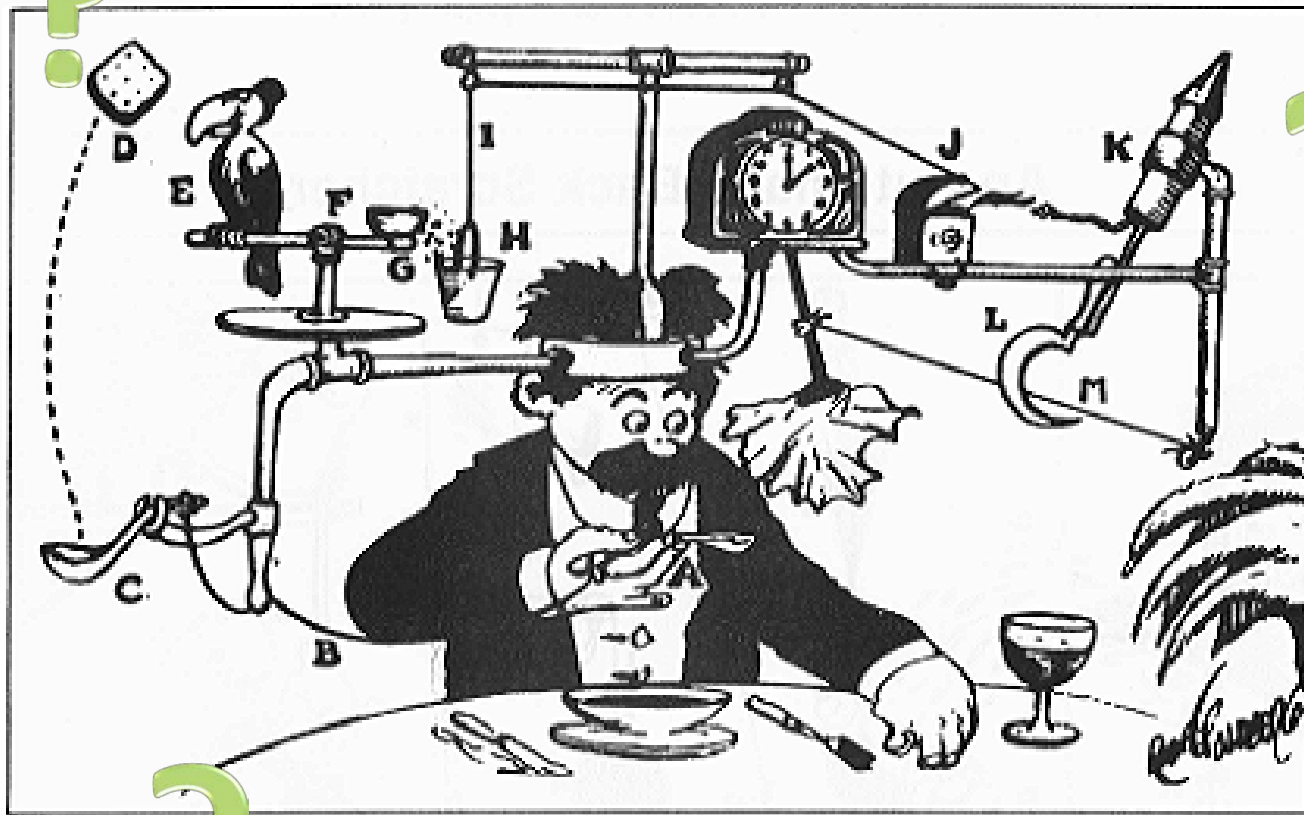


Makey Makey (thanks, Ava!)

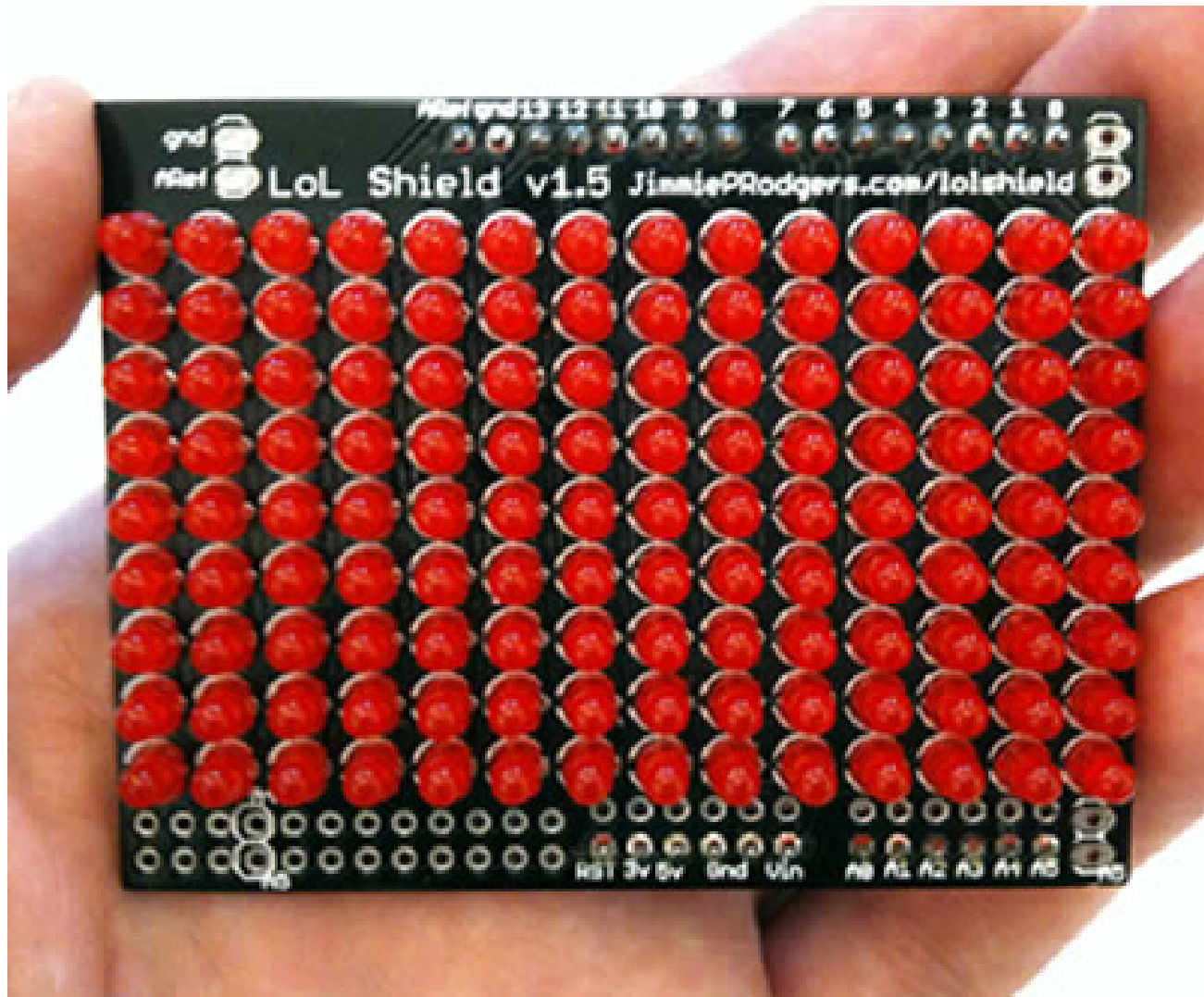
Resistance & Ohms
&
Sound
&
Color
&
ICs

But first.....

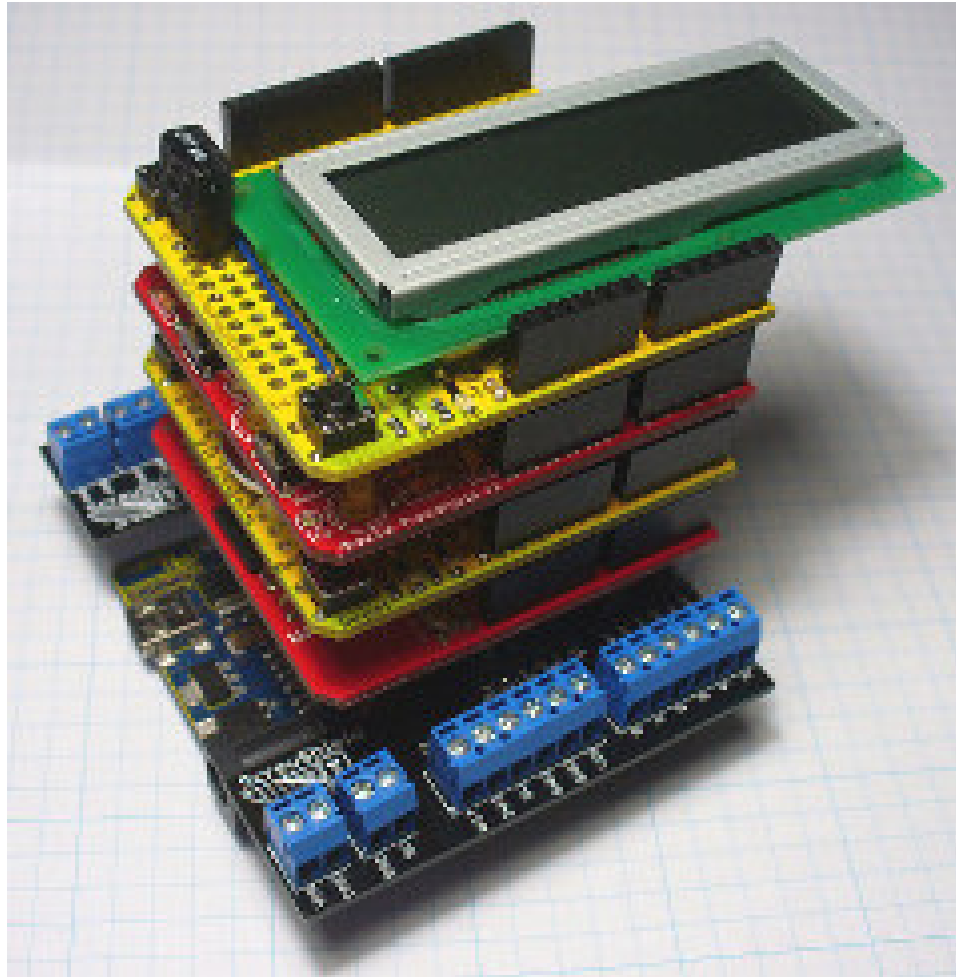
Self-Operating Napkin



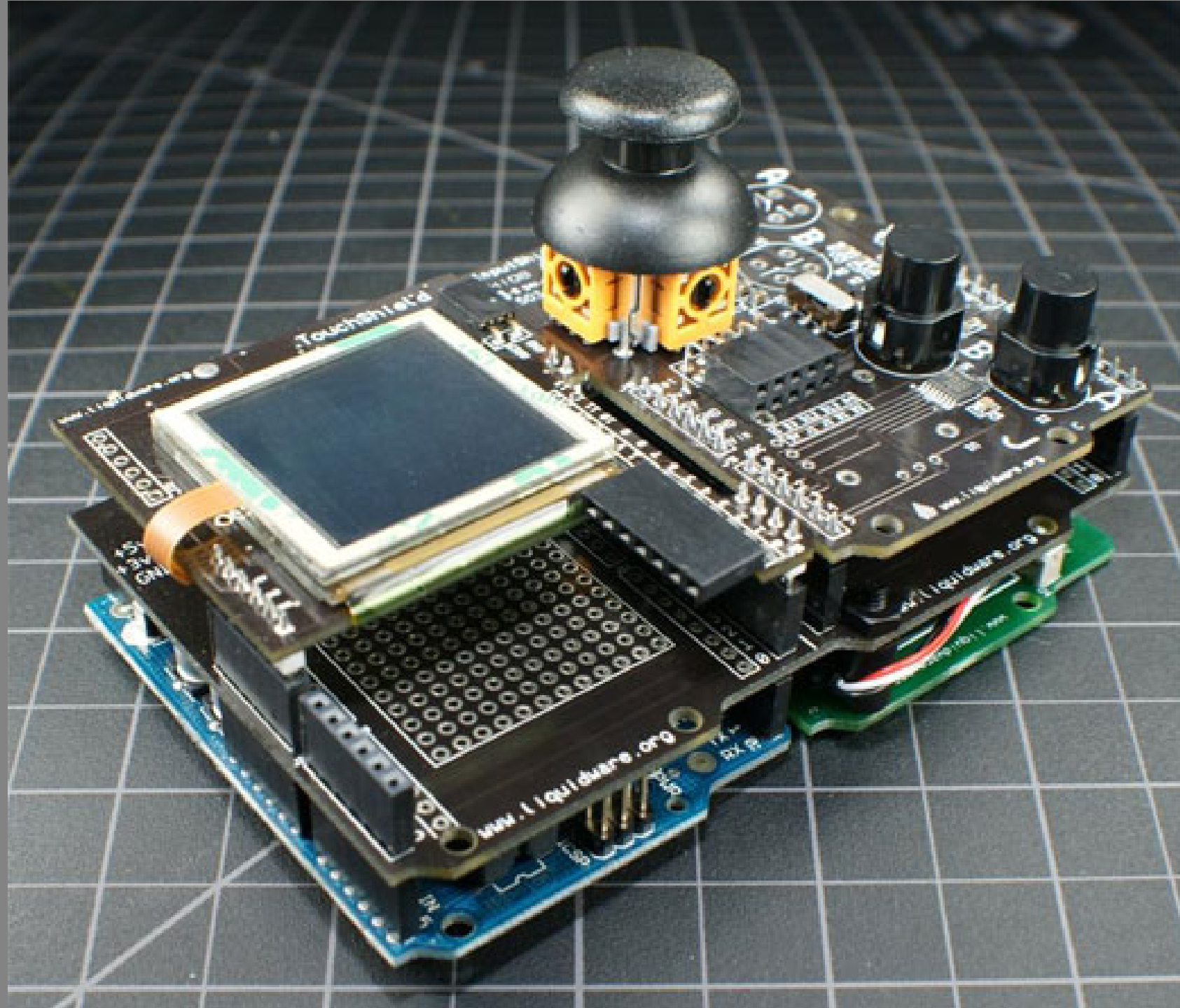
Your Project Goes Here



LED Array Shield

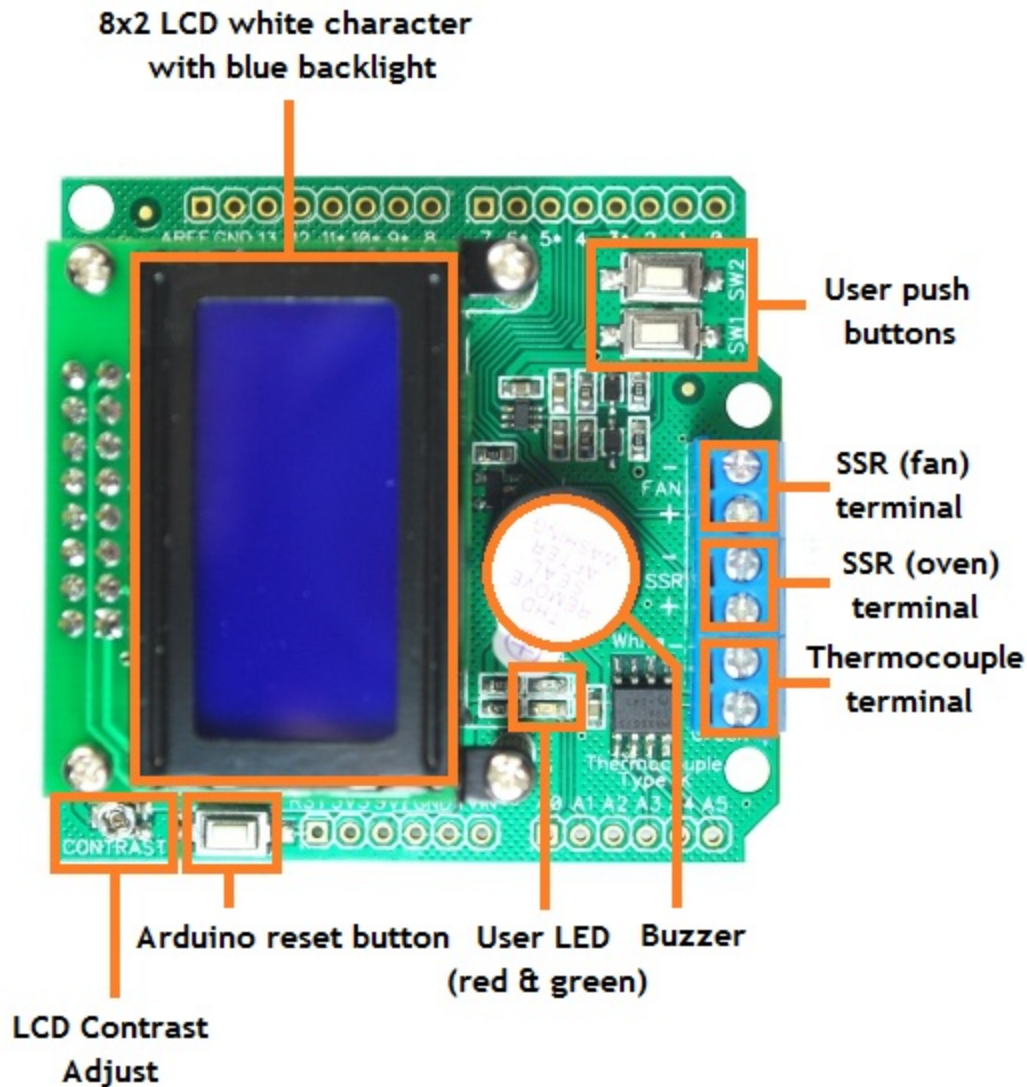


Arduino Shields

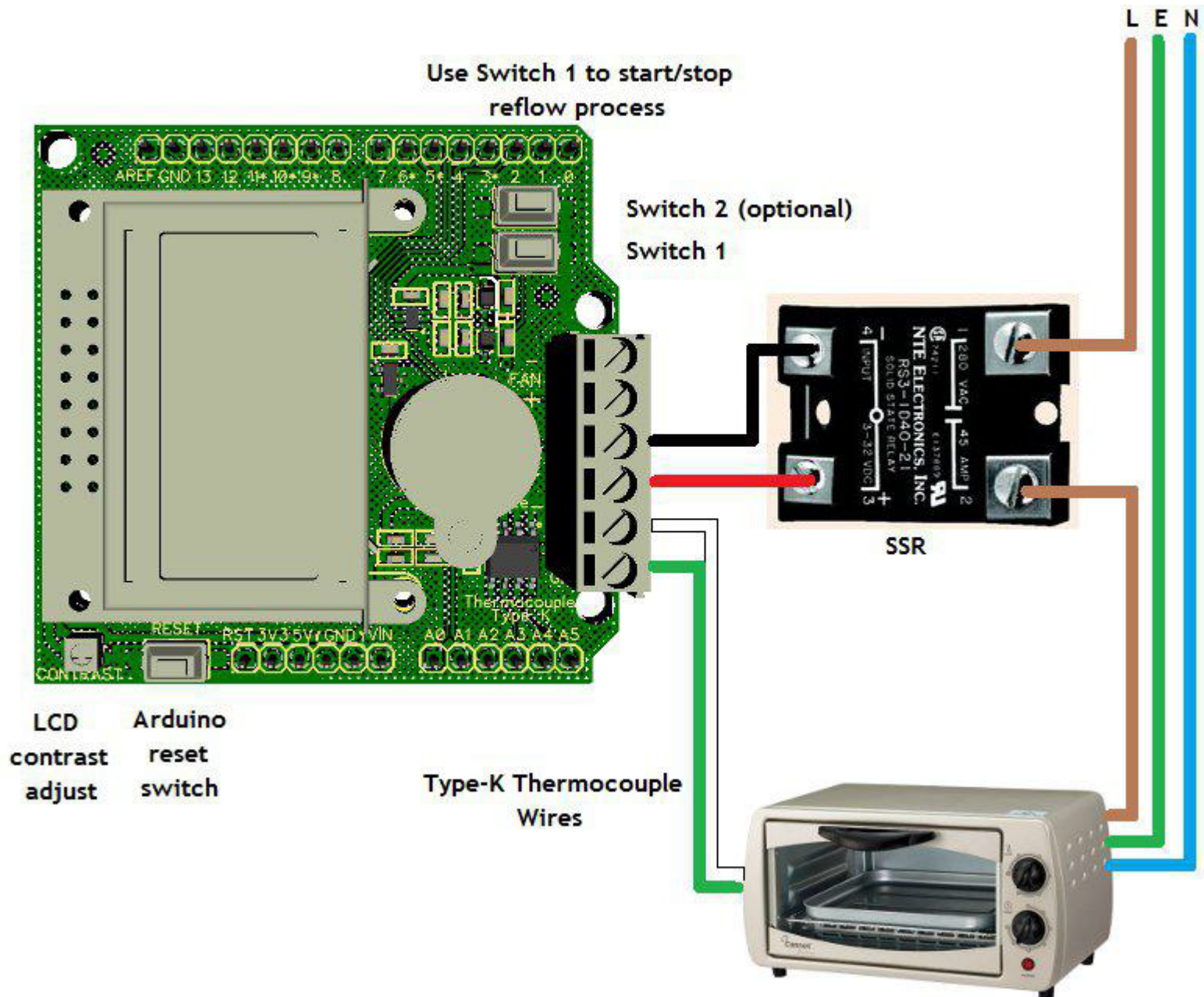


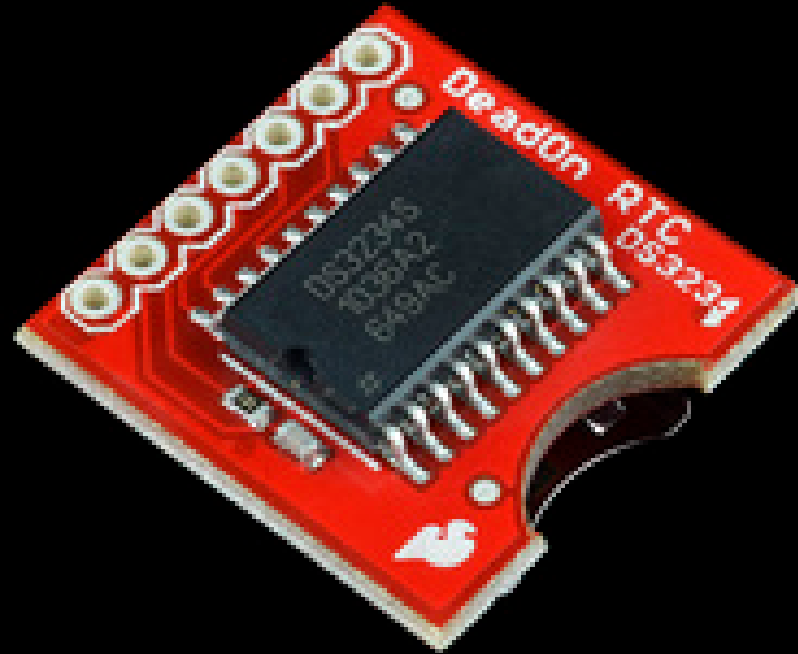


LOVE PID Controller



Reflow Oven Controller Shield

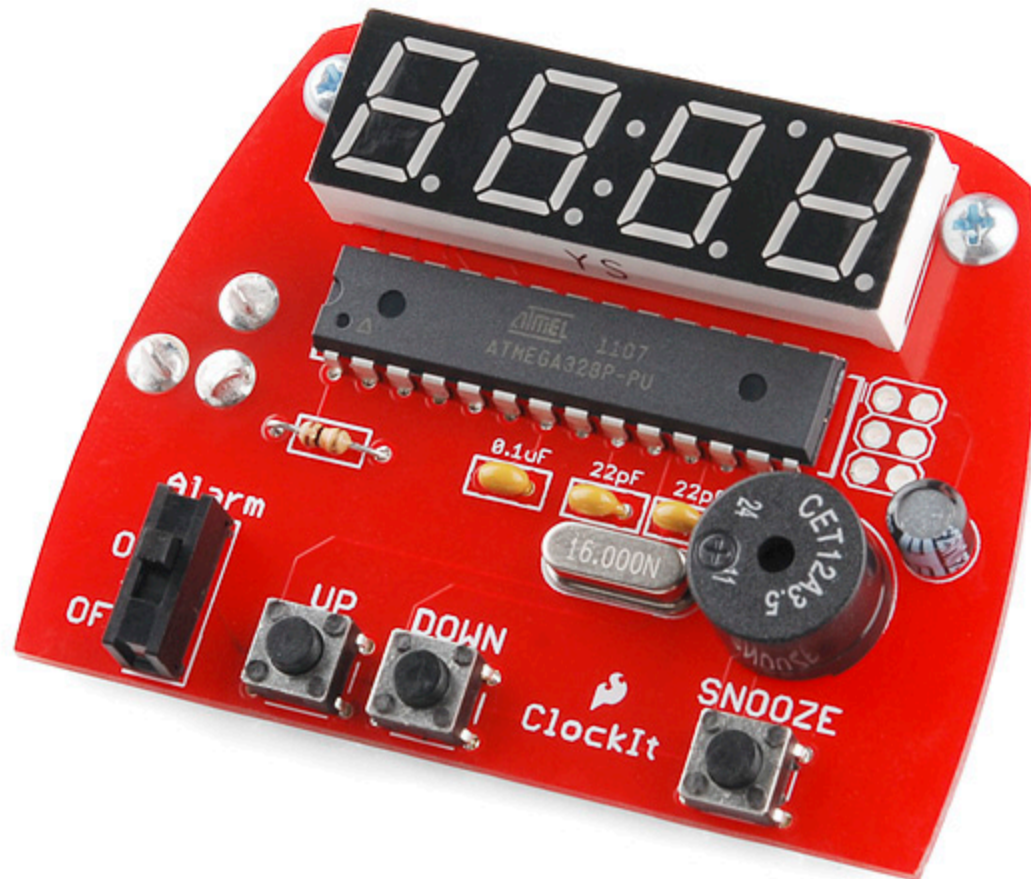




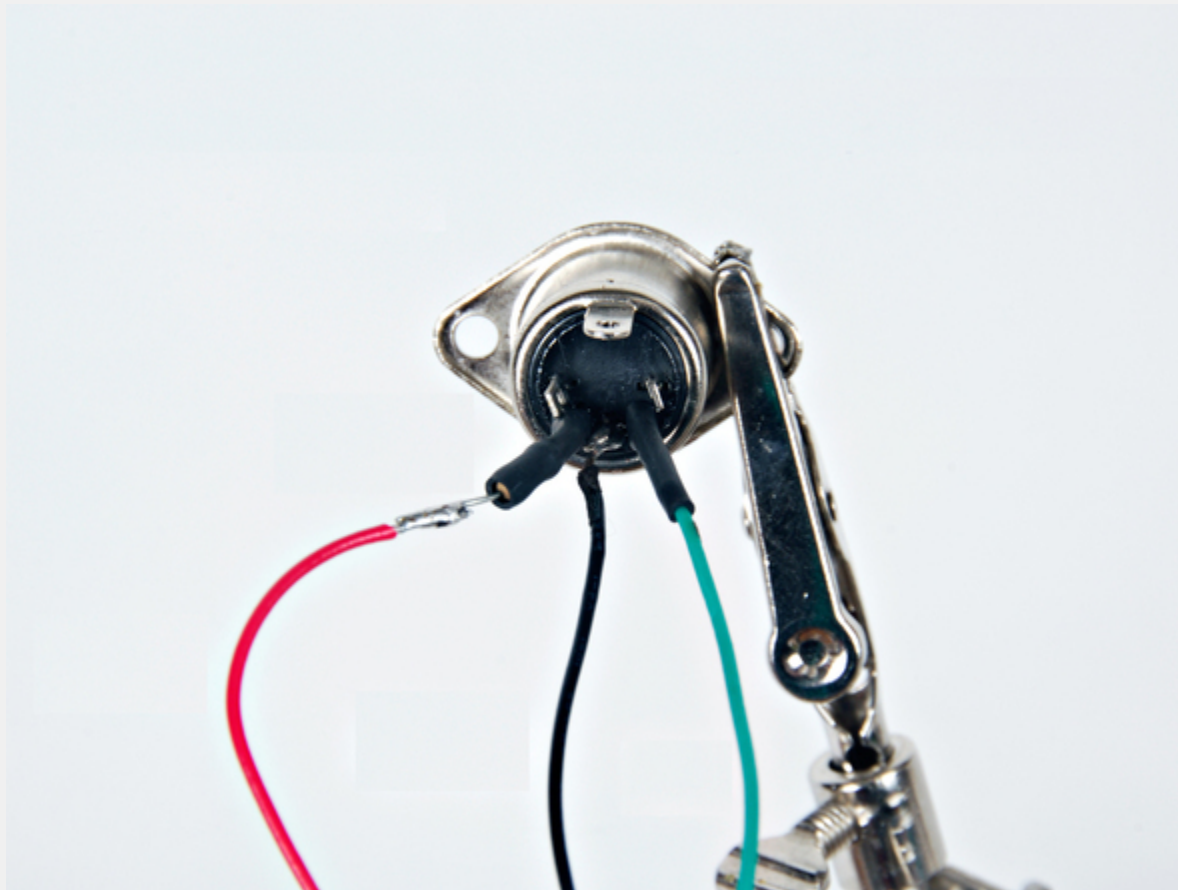
Real-time Clock Chip

Serial Communication

Next Week!



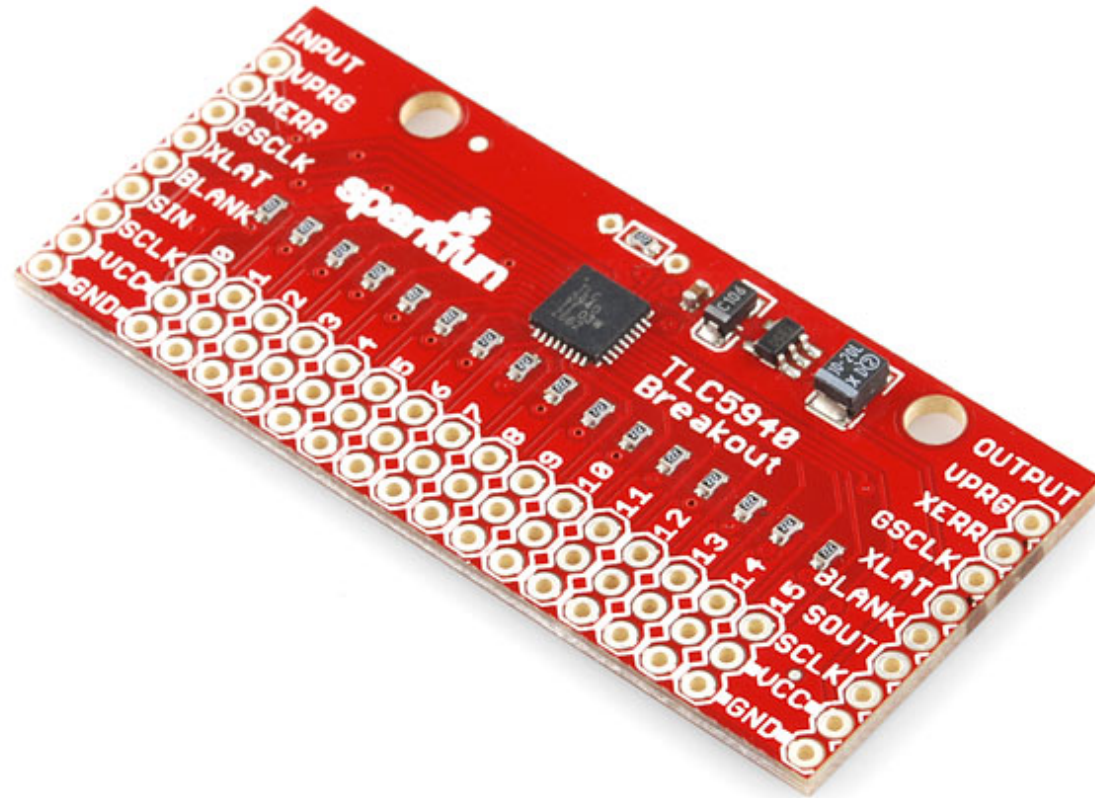
Clock Kit



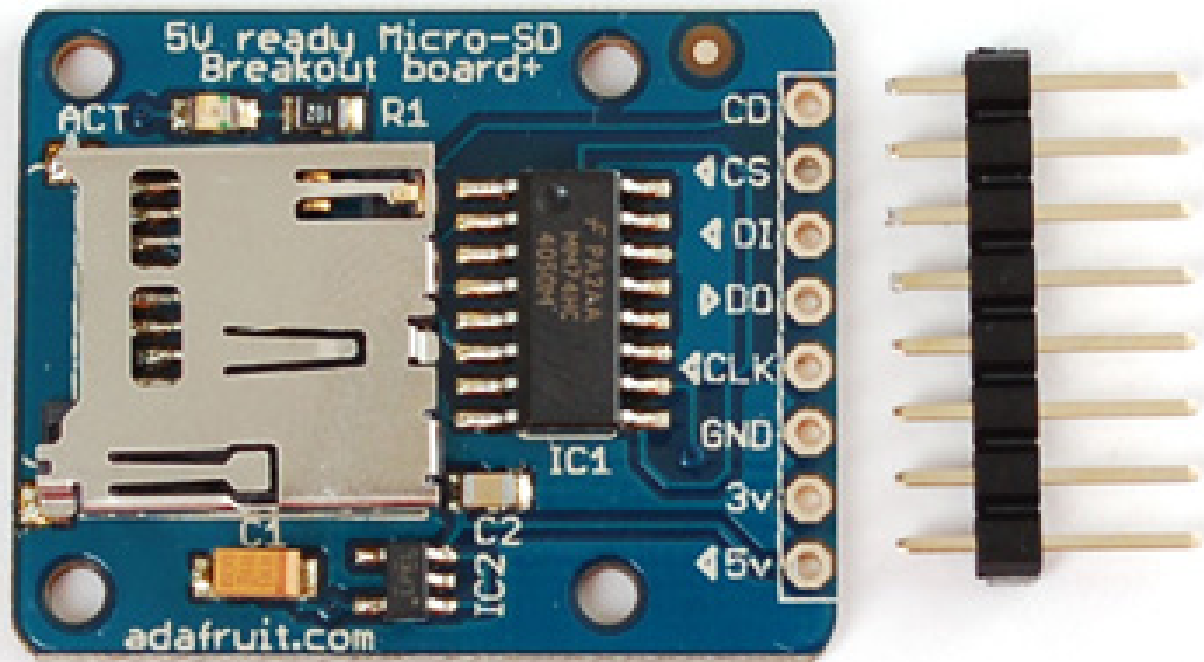
MIDI Connector



Sonar Rangefinder



PWM Driver



Micro-SD Card Reader



Electret Microphone



SHARP IR Rangefinder

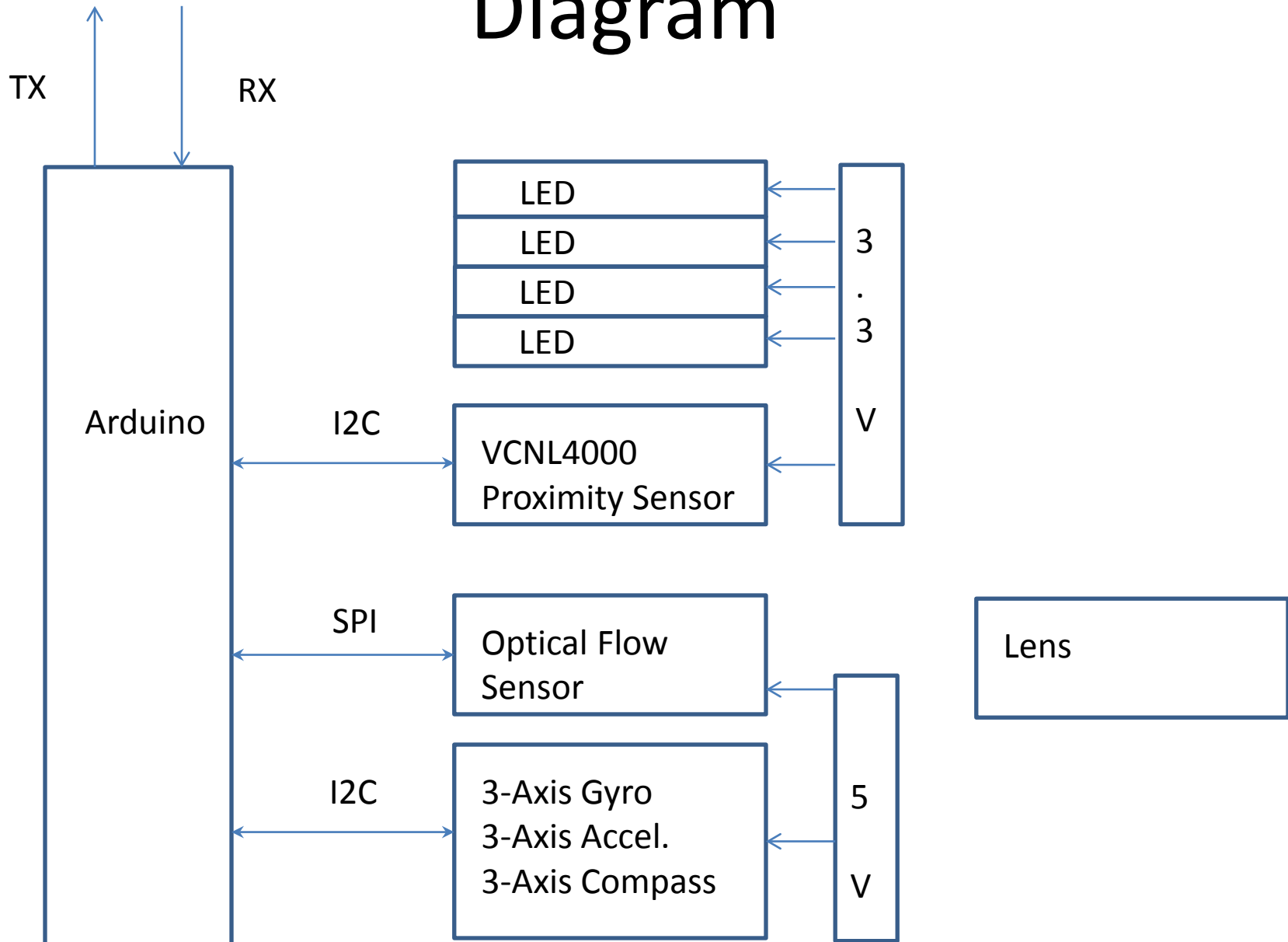


Photo-Resistor



Laser

Diagram



Bill of Materials

1 Arduino Mega 2560

1 USB Cable

1 Full-Length Breadboard

1 VCNL4000 Breakout Board

1 Pololu MiniIMU9 AHRS Board

1 Optical Flow Sensor v1 Board

4 Red LEDs

A 2" square piece of plastic

Lots of Wires

VERY

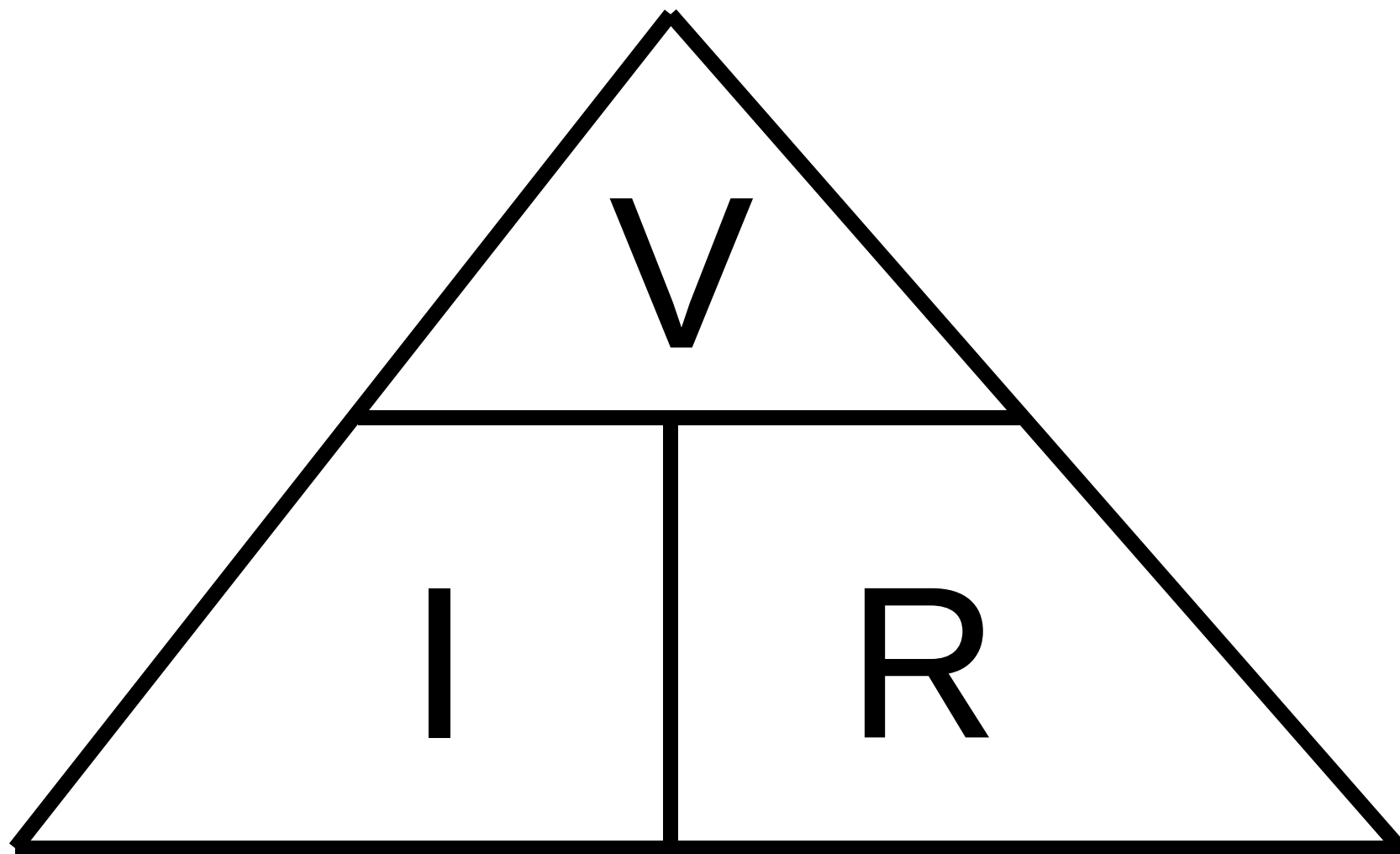
VERY

IMPORTANT

VERY

IMPORTANT

RULE

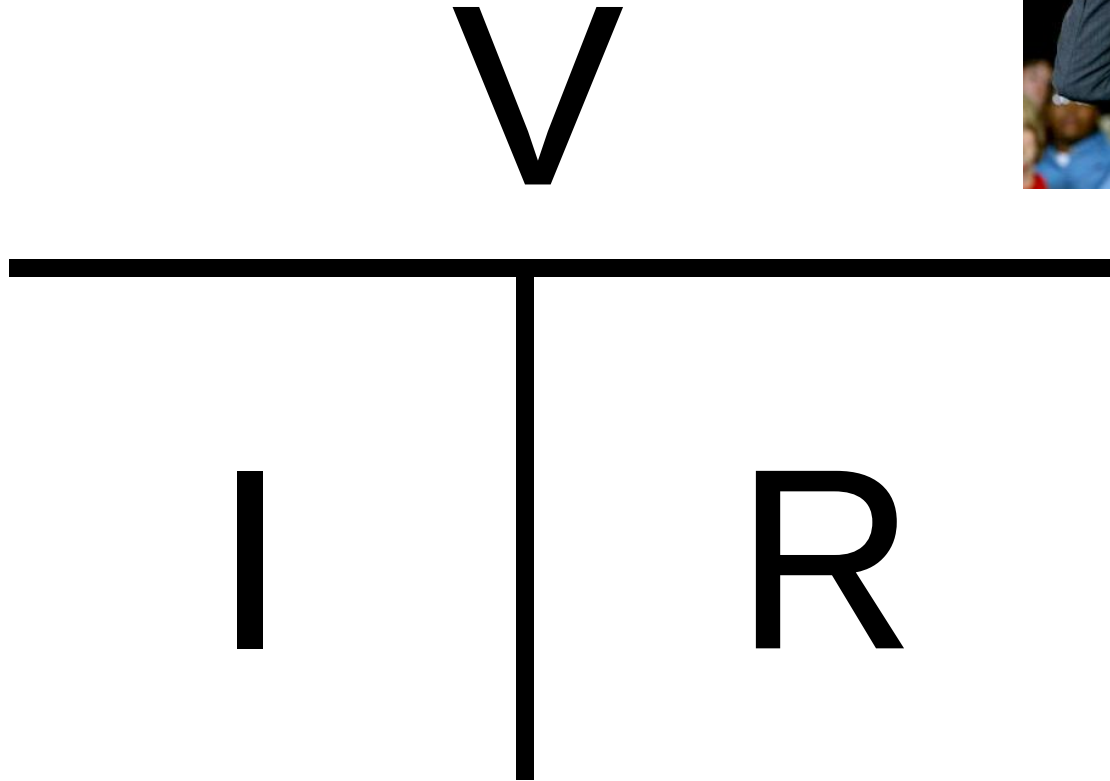


V OLTS

|

I

R



intensité de courant
André-Marie Ampère

V

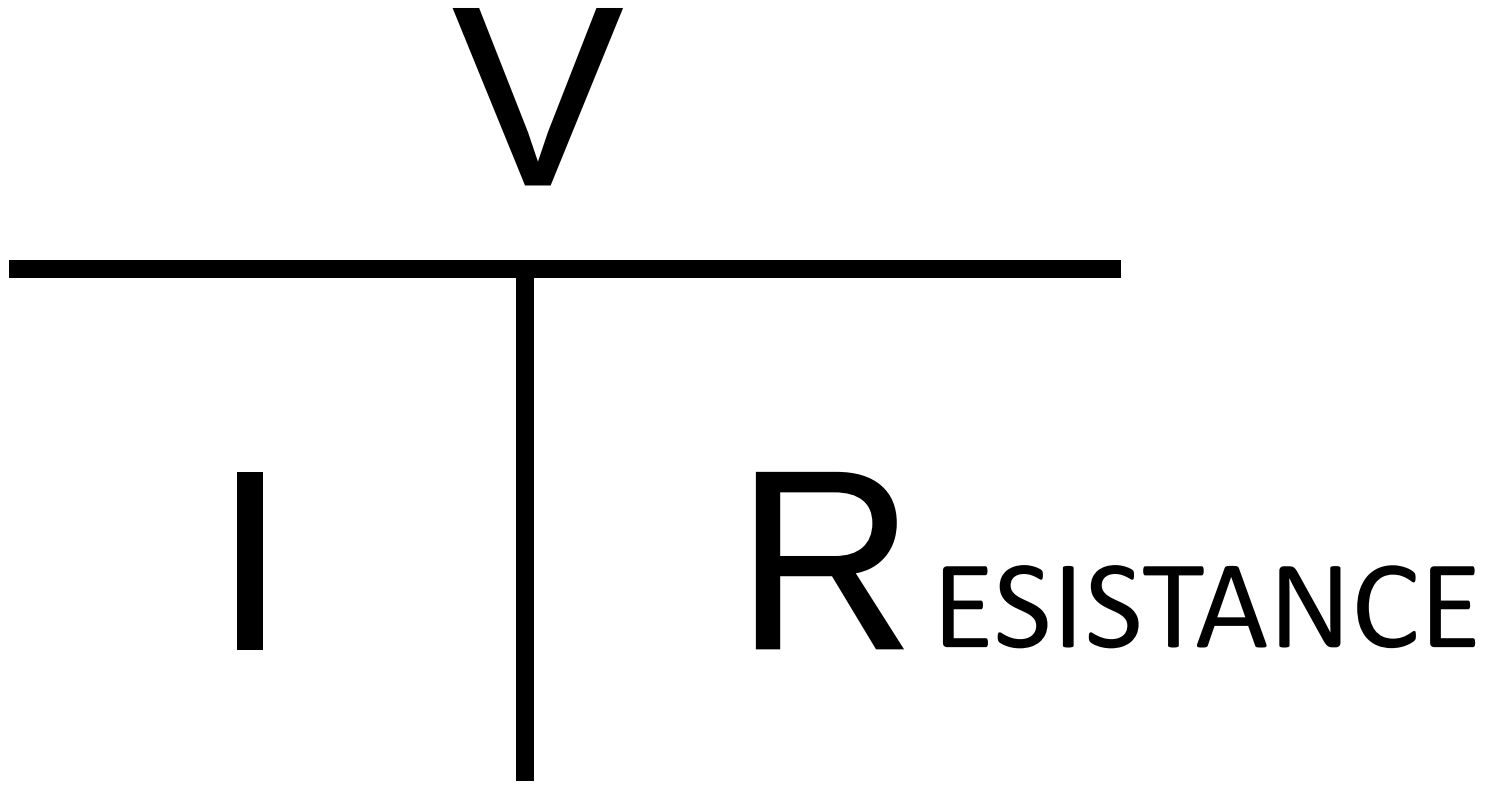


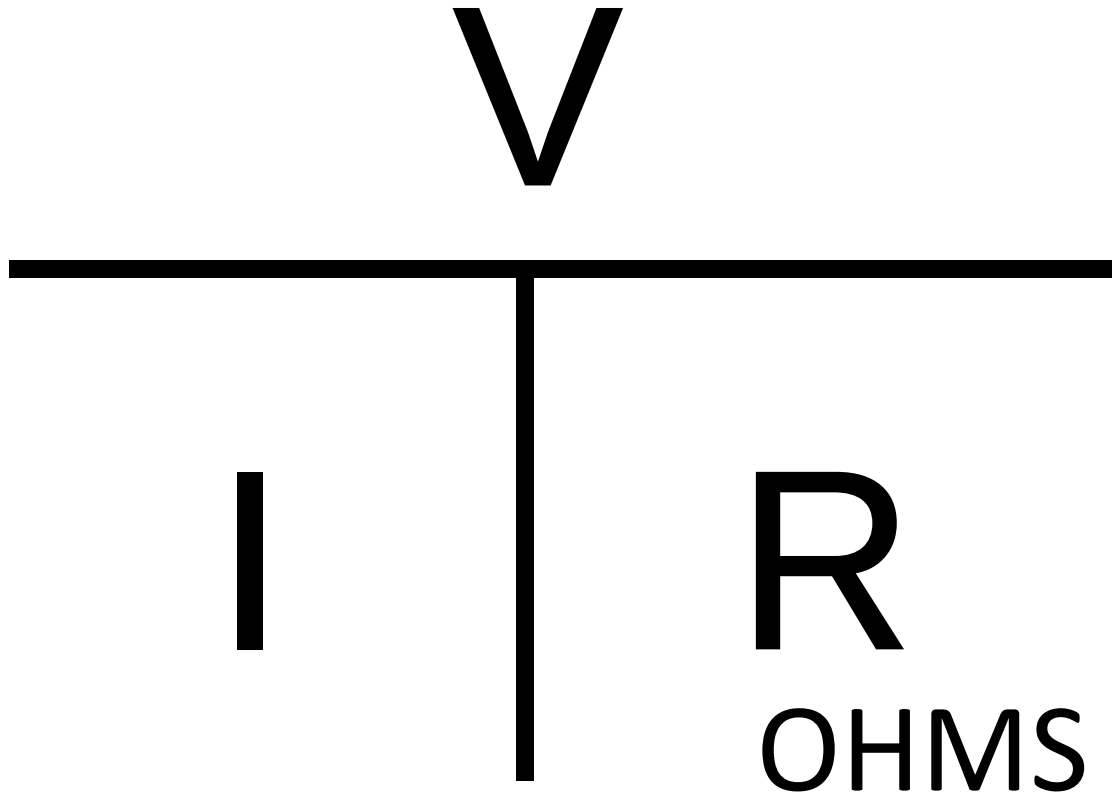
I

R

AMPS

current intensity



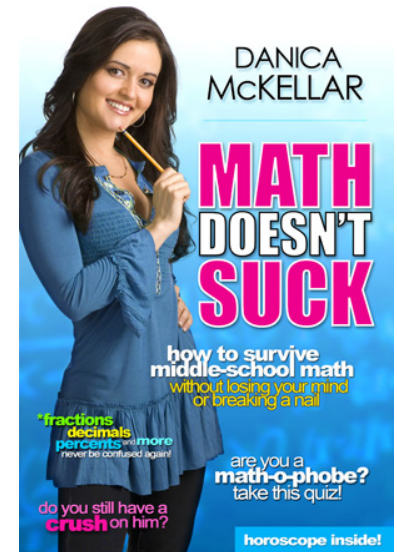


To calculate:

V OLTS

To calculate:

$$\frac{V_{OLTS}}{I_{AMPS} \times R_{OHMS}} =$$



To calculate:

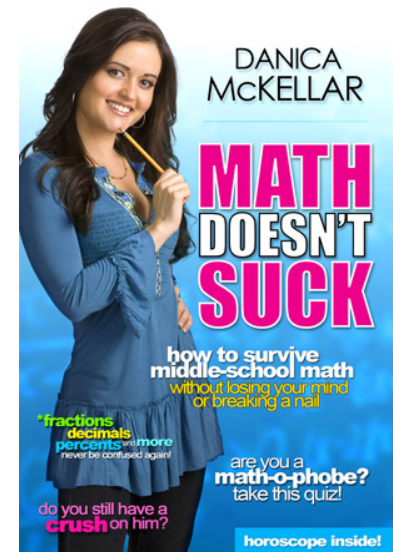
|

AMPS

VOLTS

To calculate:

$$\begin{array}{ccc} \text{I} & = & \text{R} \\ \text{AMPS} & & \text{OHMS} \end{array}$$



To calculate:

R

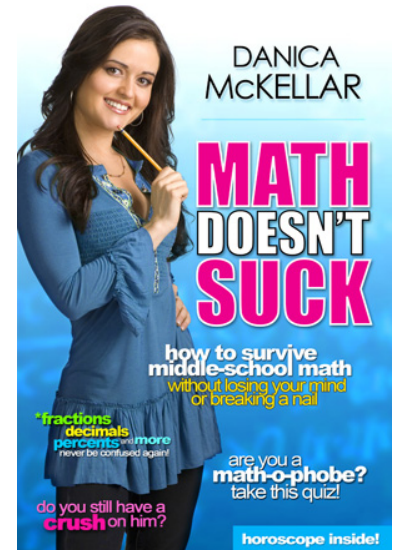
OHMS

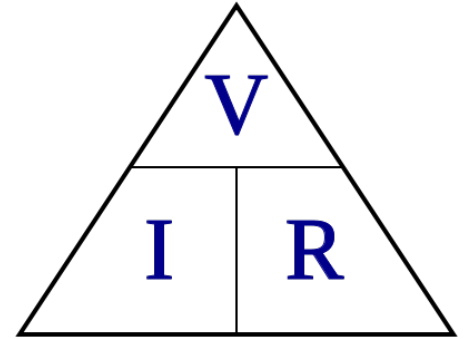
VOLTS

$$I = R$$

AMPS OHMS

To calculate:

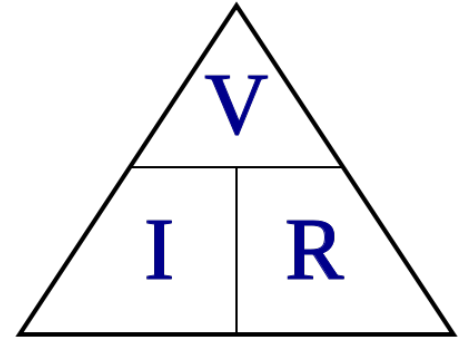


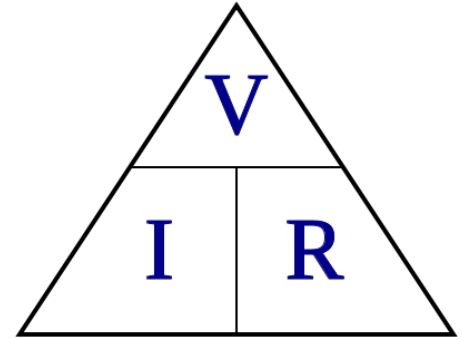


WHAT RESISTOR FOR
A 20mA CIRCUIT ON A
5V ARDUINO?

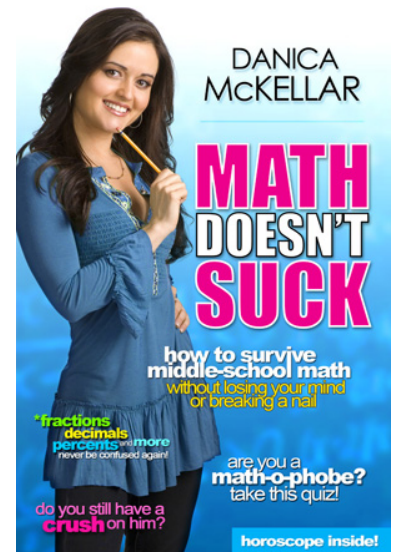
5 VOLTS

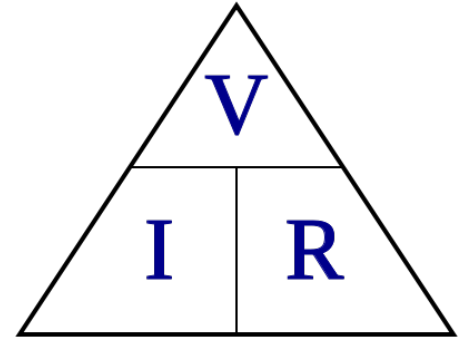
.02 AMPS





$$\frac{5 \text{ VOLTS}}{.02 \text{ AMPS}} = 250 \text{ OHMS}$$

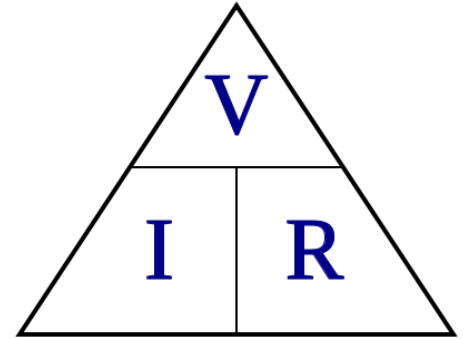




WHAT CURRENT FOR
A 330 OHM RESISTOR ON A
5V ARDUINO?

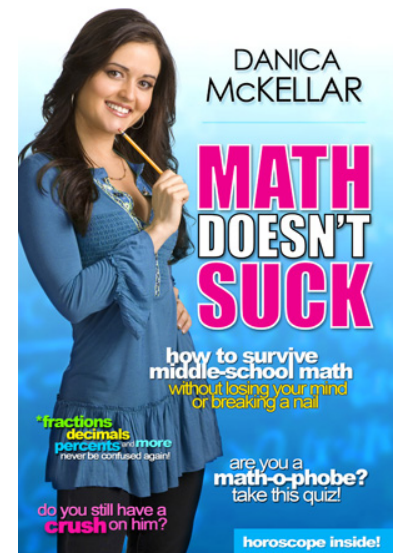
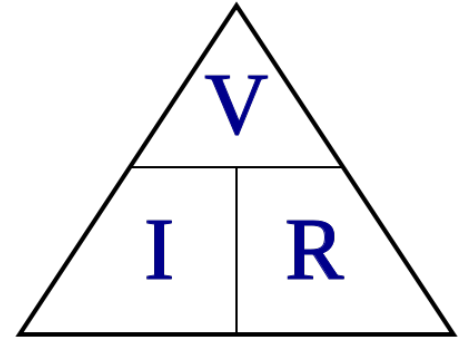
5 VOLTS

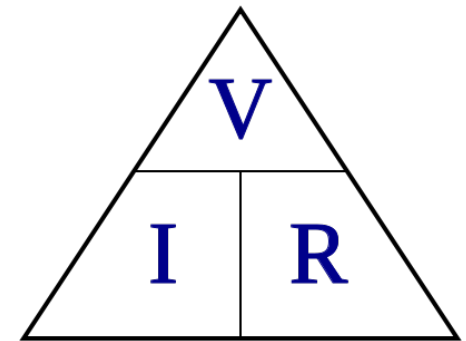
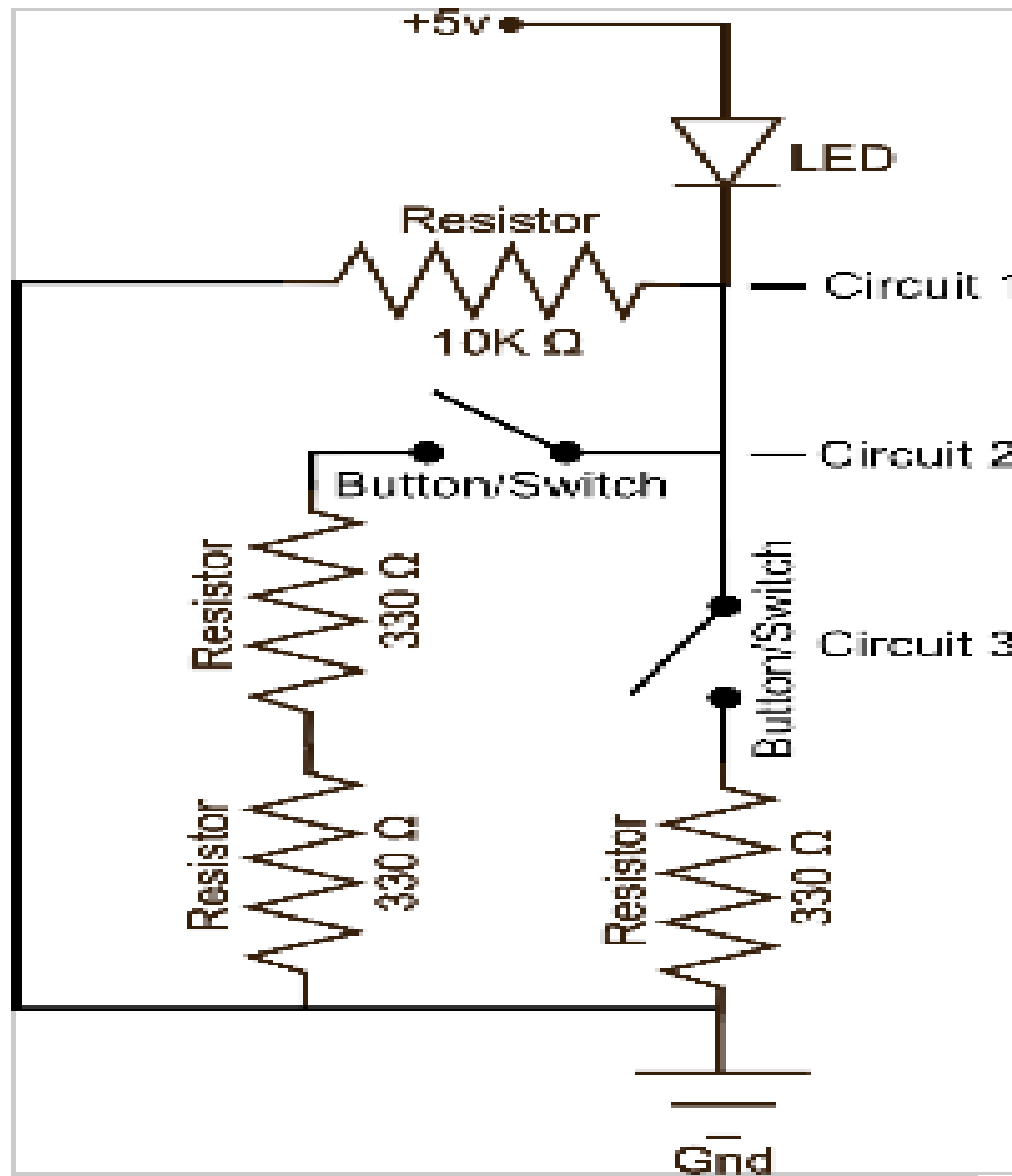
330 OHMS

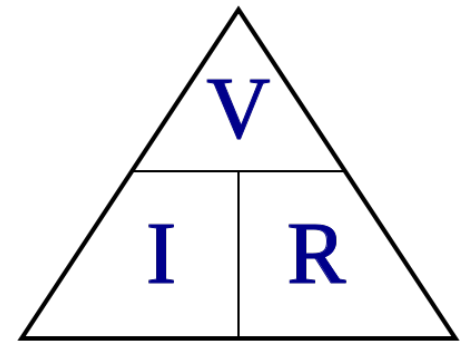
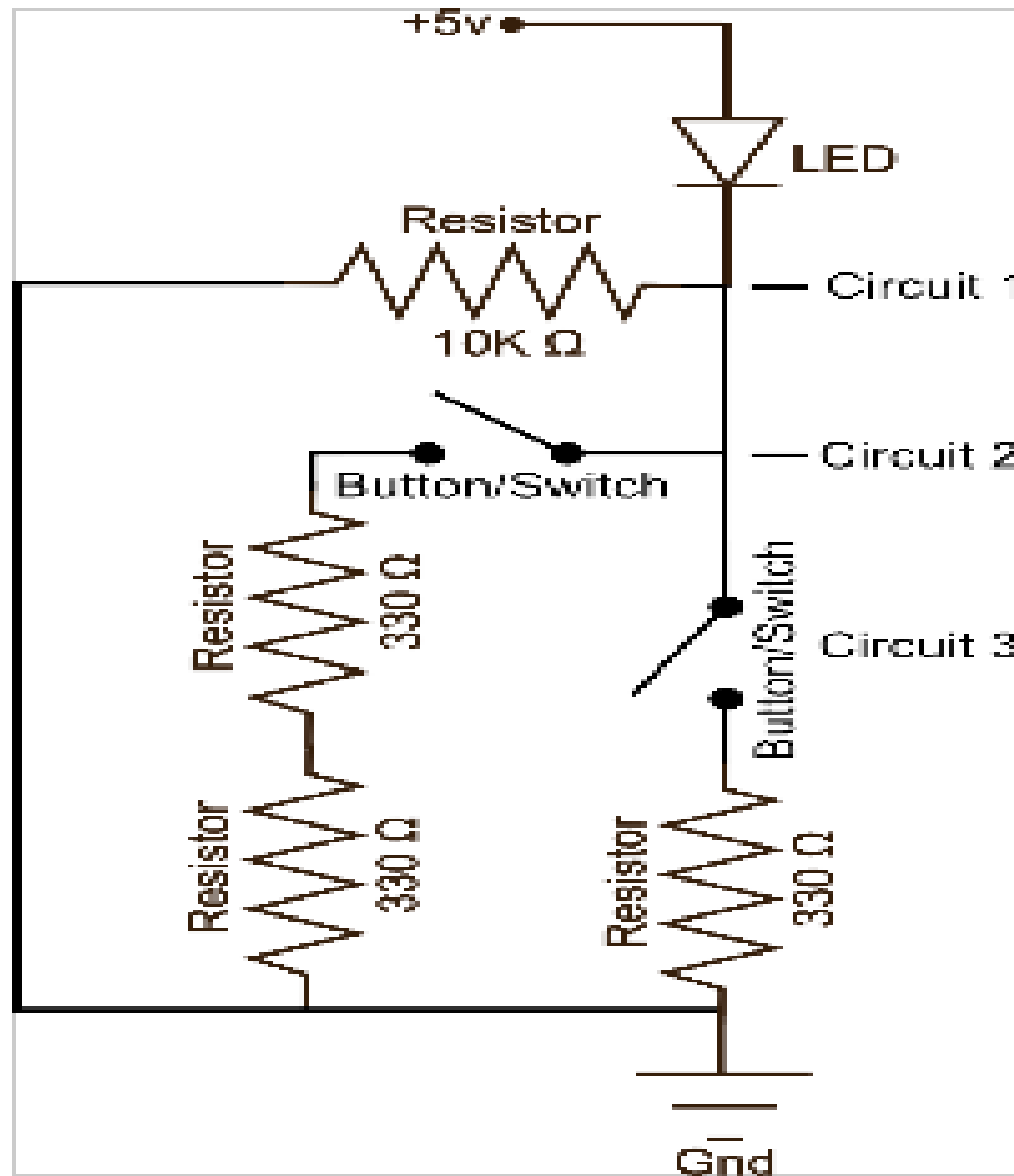


$$\frac{5 \text{ VOLTS}}{330 \text{ OHMS}}$$

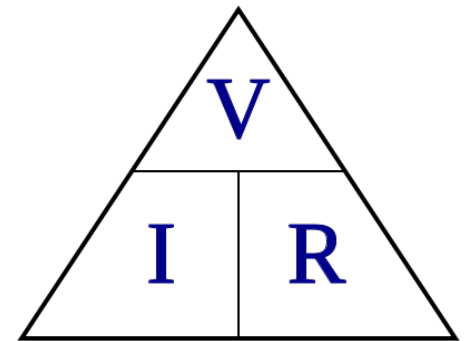
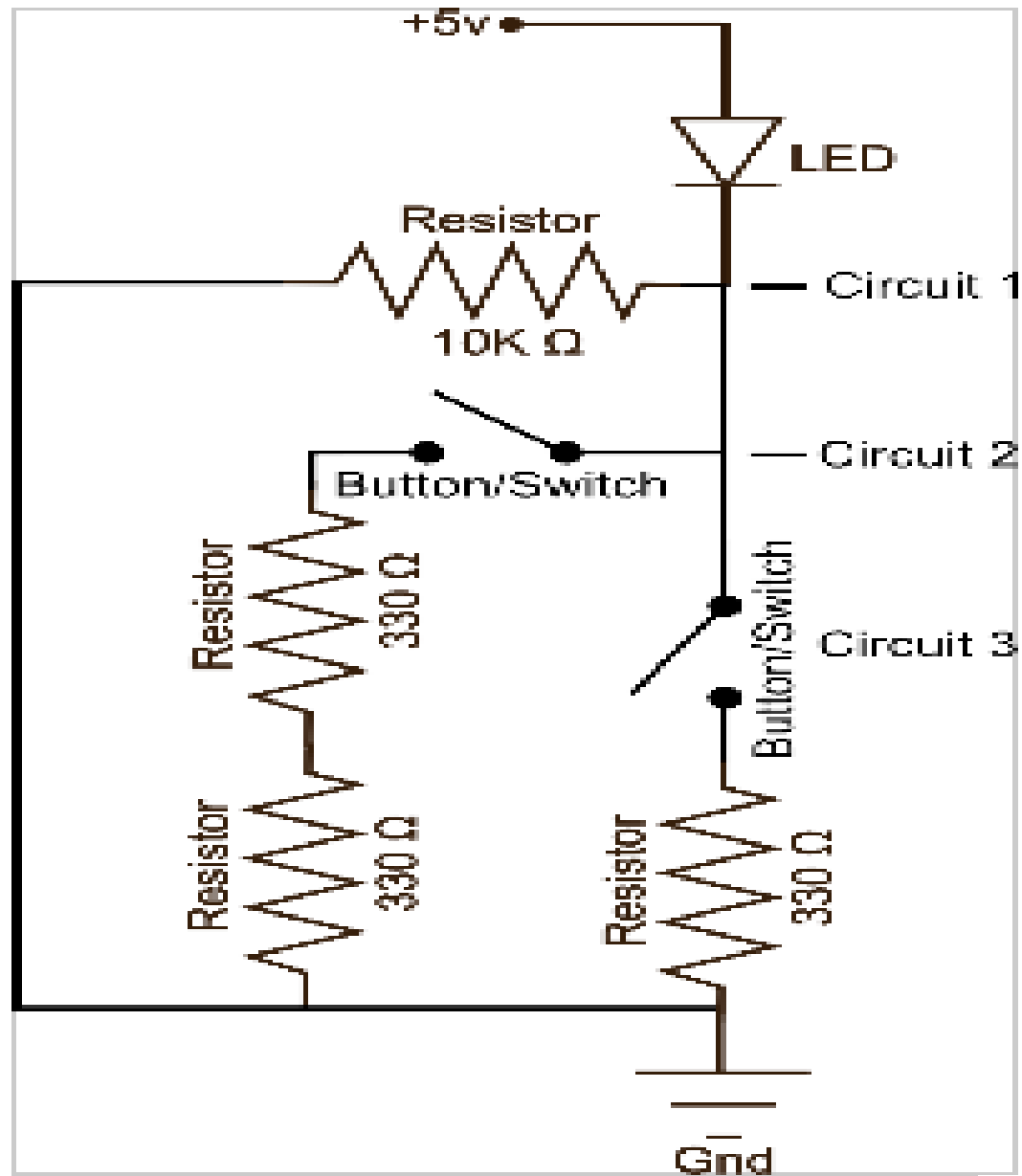
$$= 15.1 \text{ mA}$$





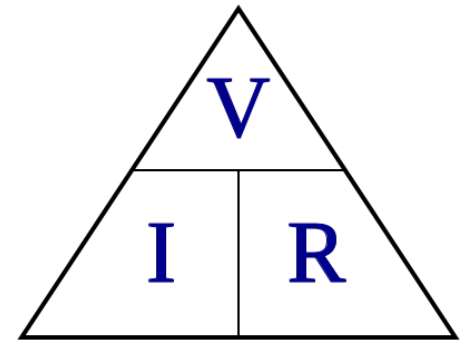
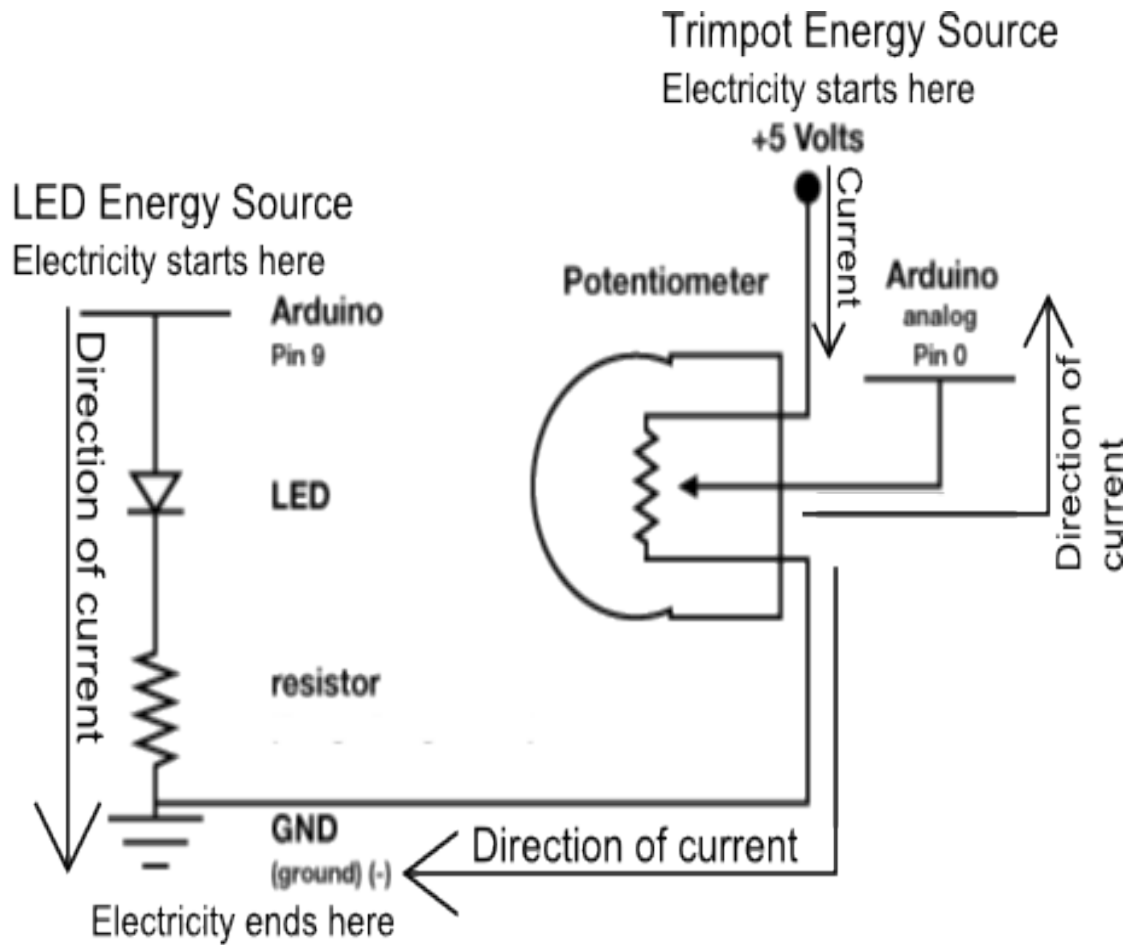


QUIZ!



QUIZ!





QUIZ!



Piezo-Electric Buzzer



What it Does:

A pulse of current will cause it to click. A stream of pulses will cause it to emit a tone.

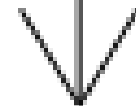
Identifying:

In this kit it comes in a little black barrel, but sometimes they are just a gold disc.

Energy Source

Electricity starts here

Direction of current



GND

Electricity ends here



Arduino

Pin 9

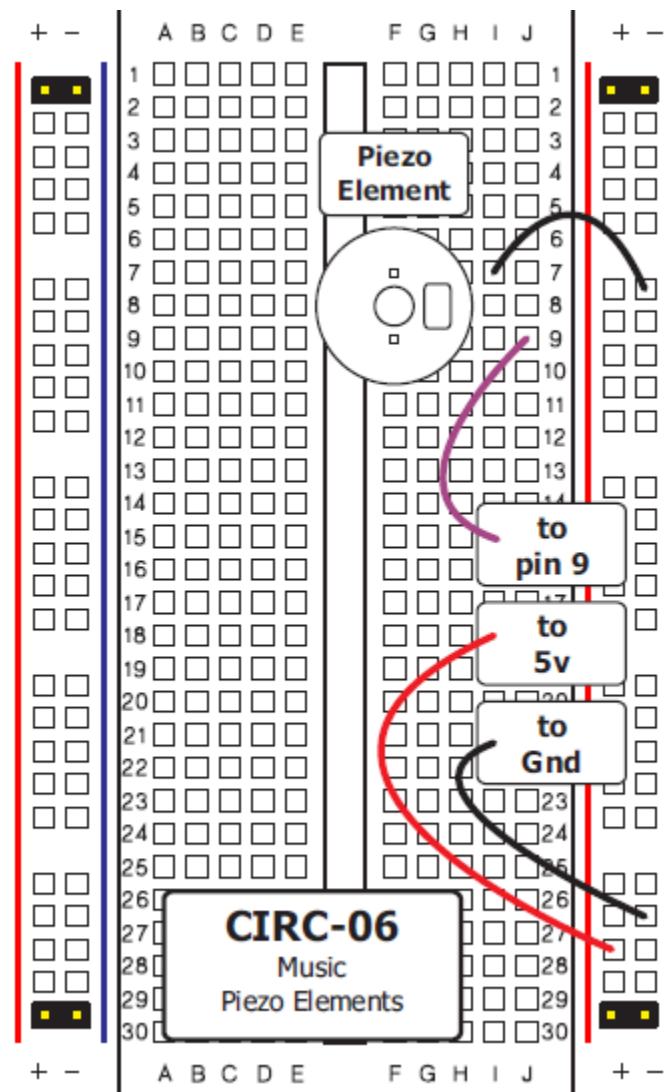


Piezo
Element

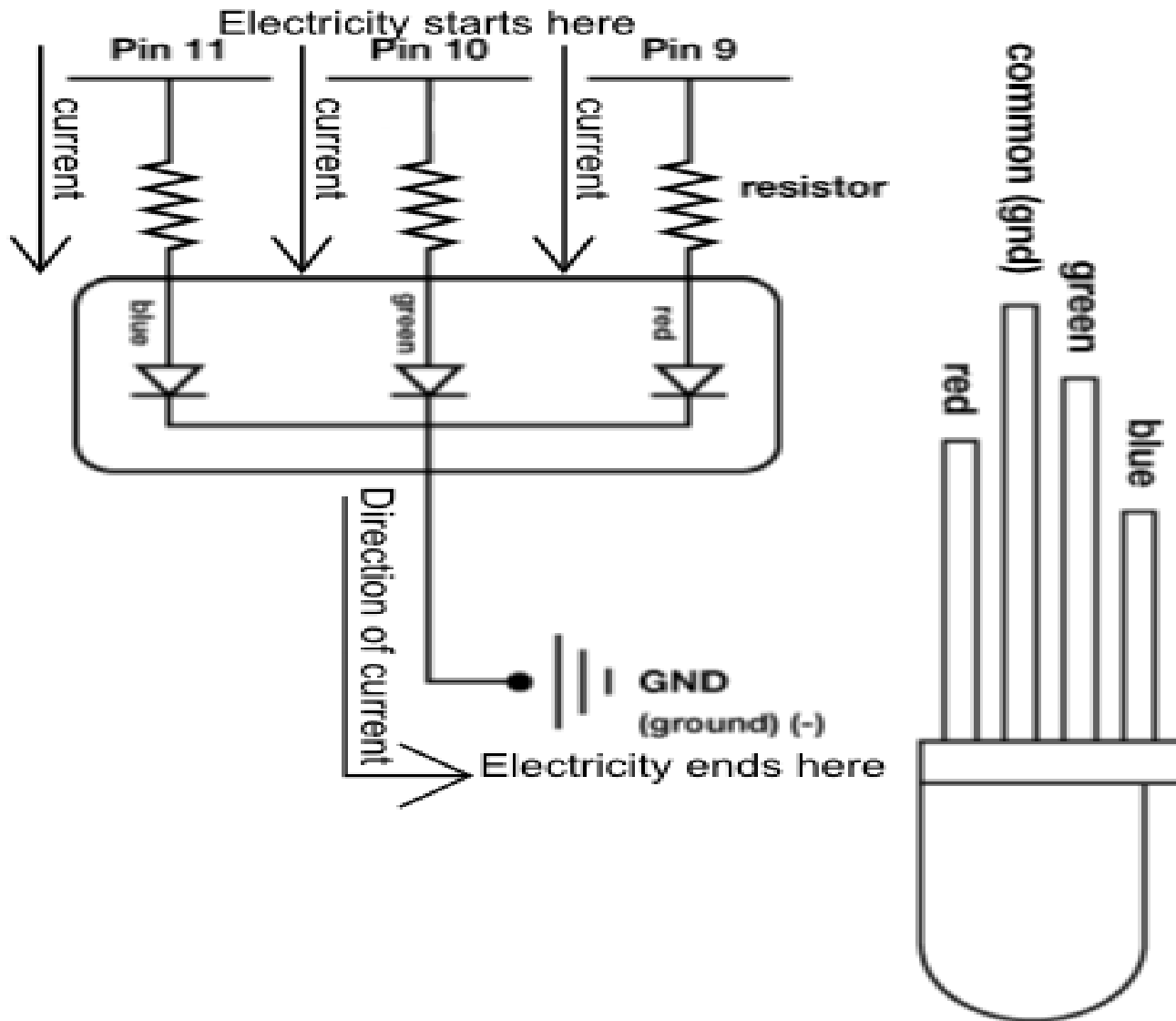


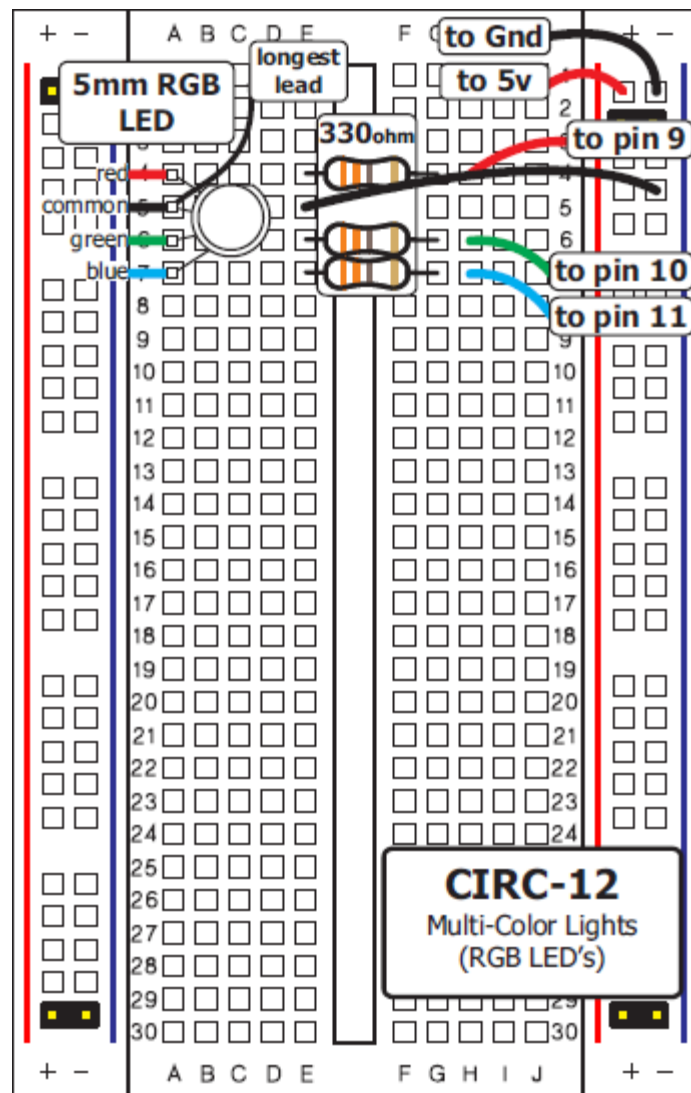
GND

(ground) (-)



3 Different Diode Energy Sources





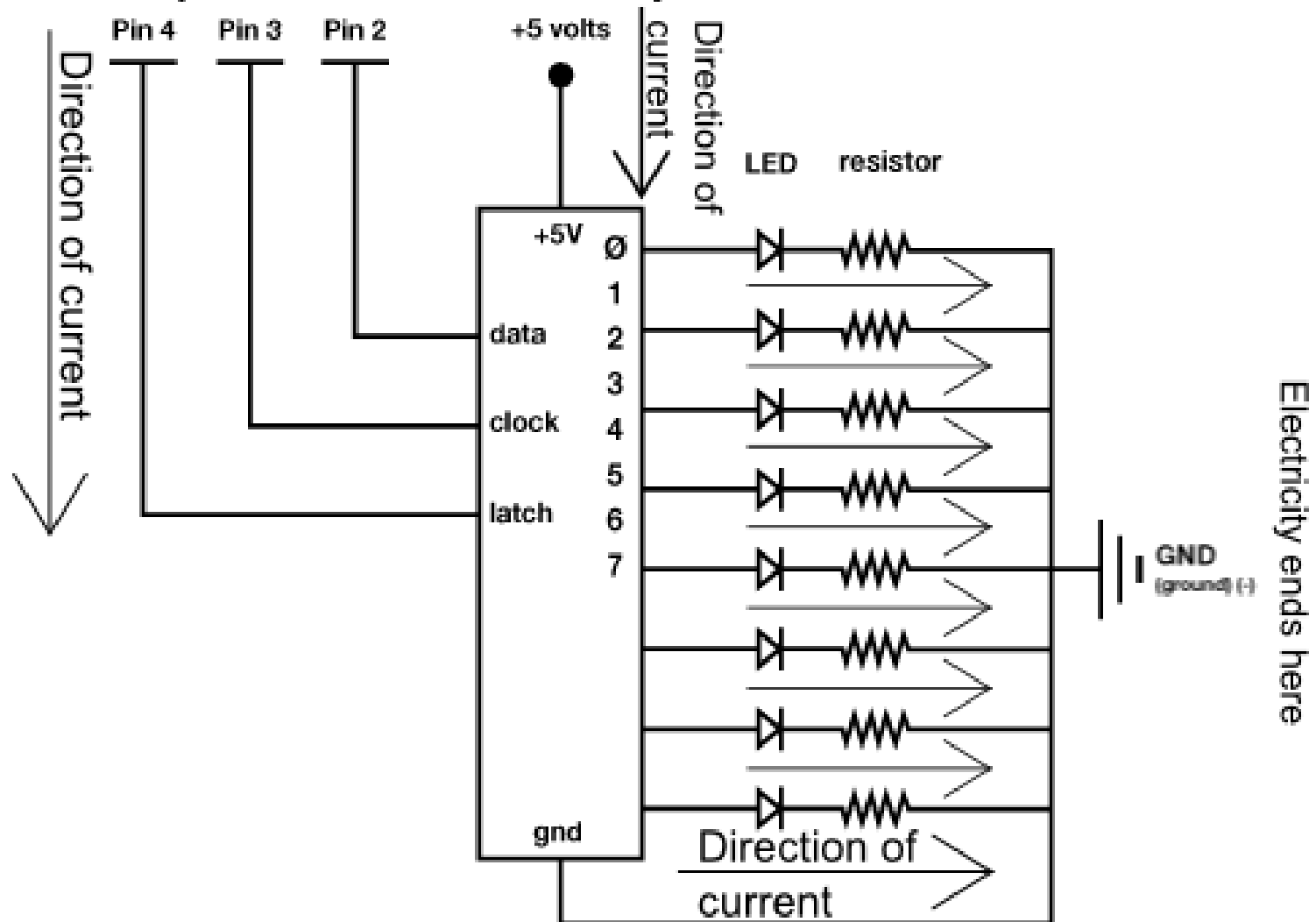
Data, Clock & Latch

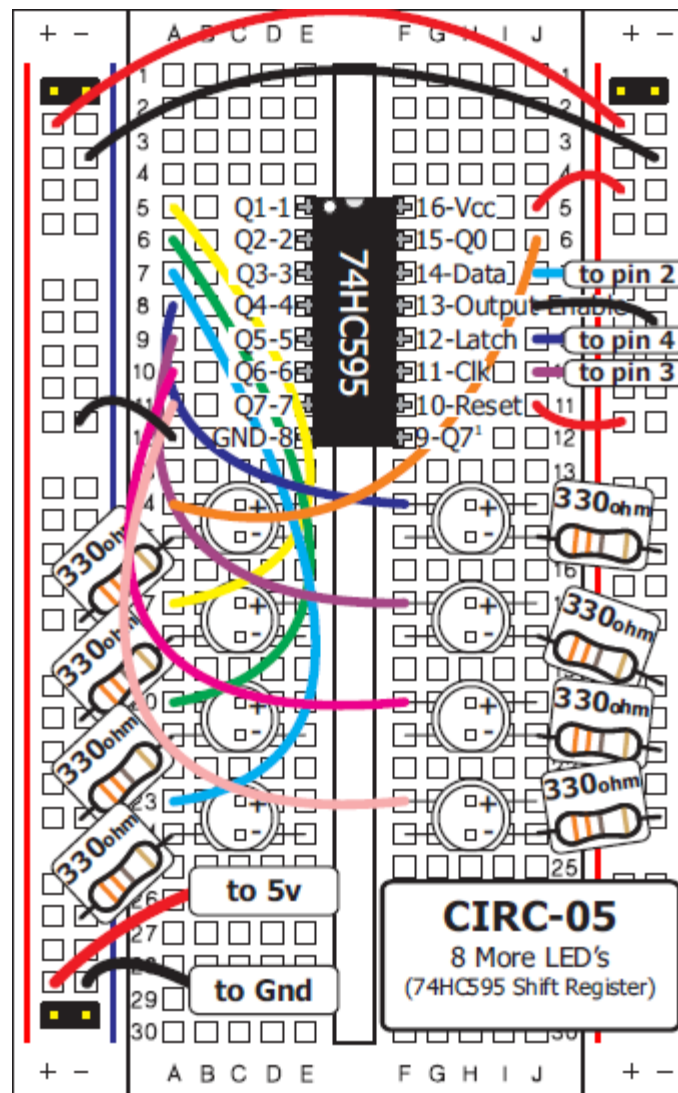
Signal Energy Sources

Electricity starts here

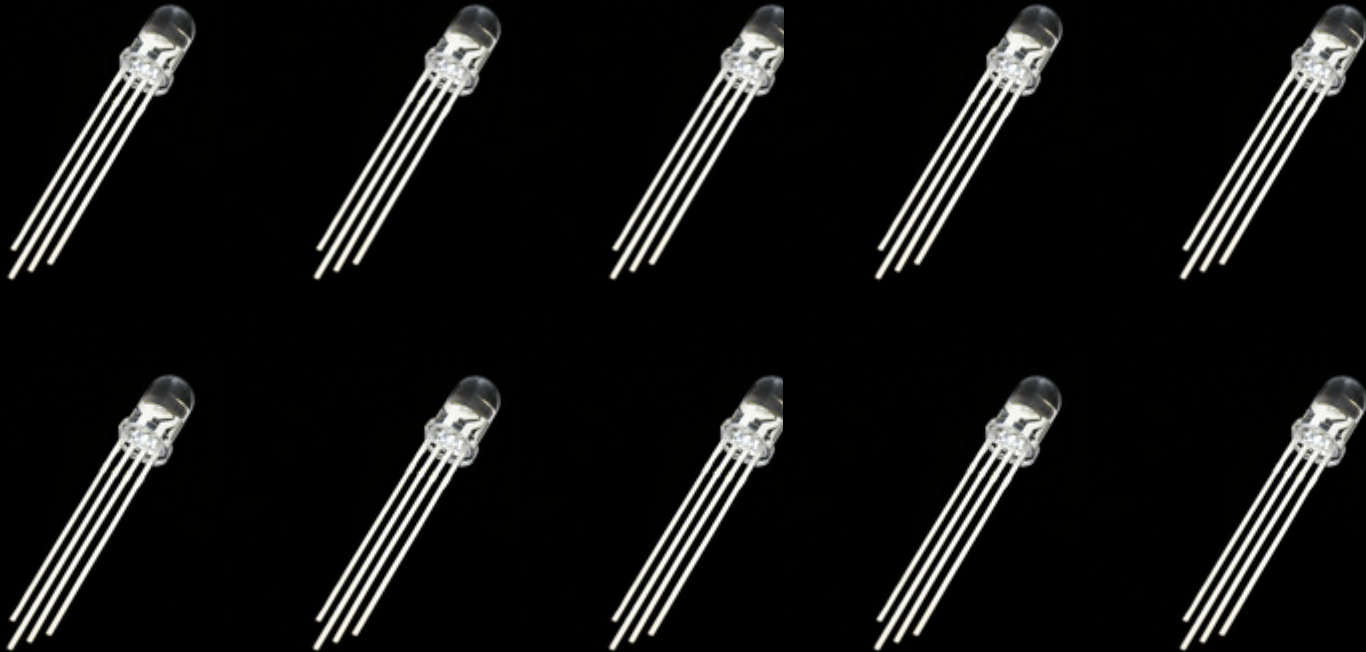
Shift Register Energy Source

Electricity starts here

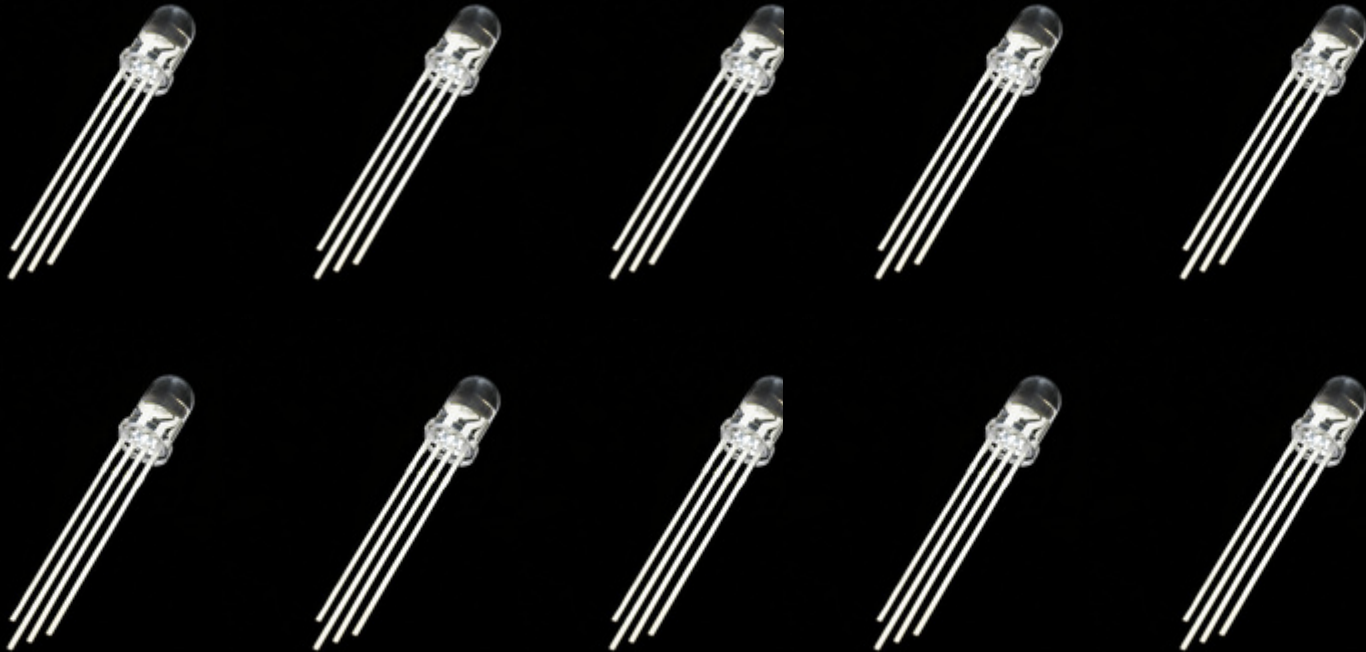




Jasmine's Cool Project

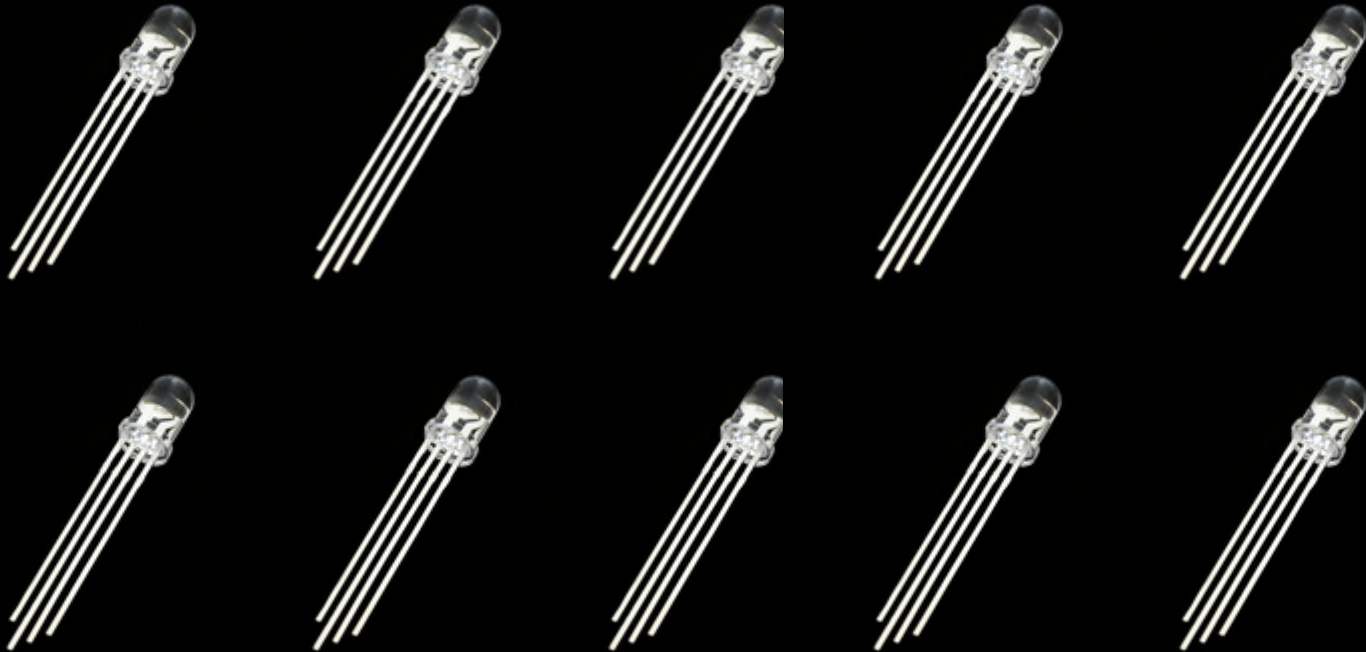


Jasmine's Cool Project



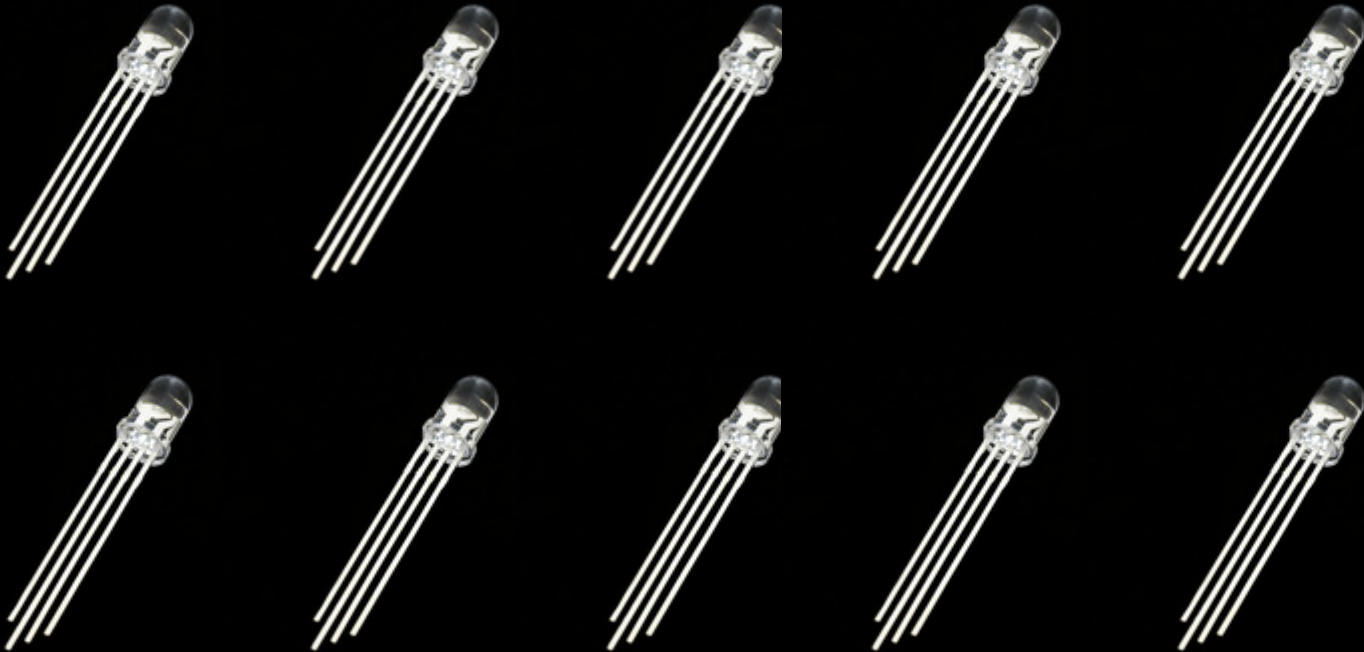
10 Full-Color RGB LEDs

Jasmine's Cool Project



30 PWM Channels!

Jasmine's Cool Project



450 mA!

Jasmine's Cool Project

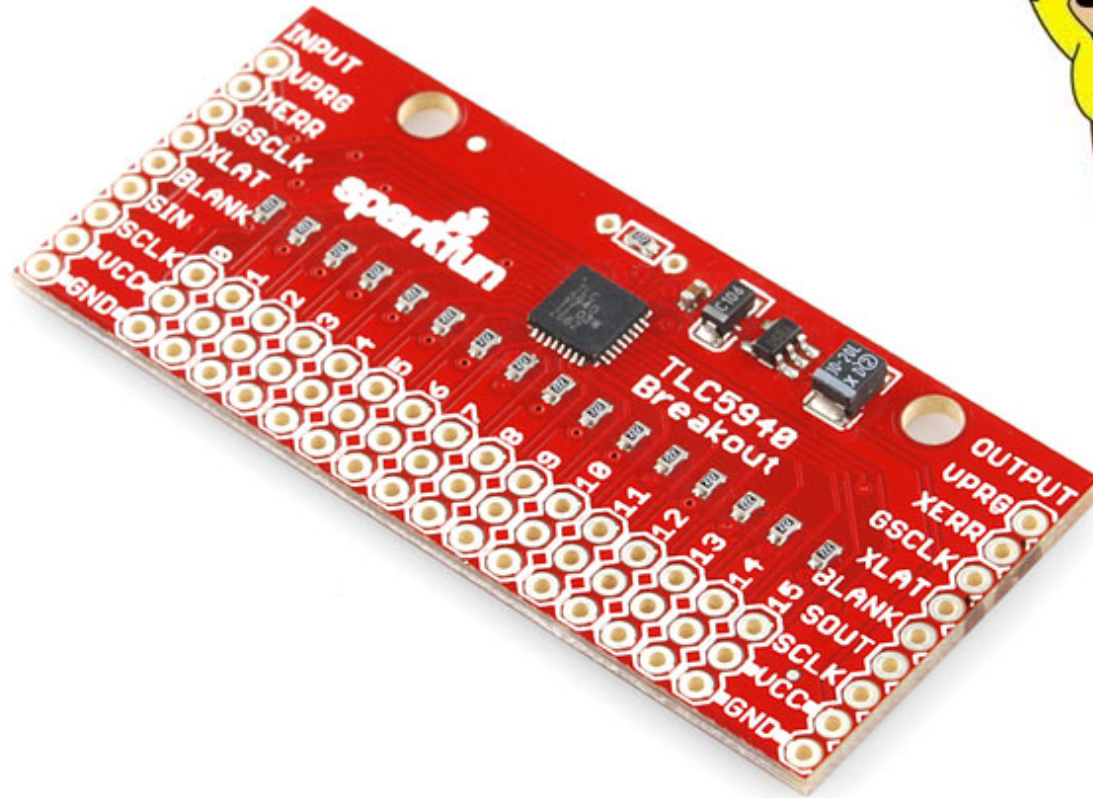
How can this be done?

30 Transistors

30 Resistors

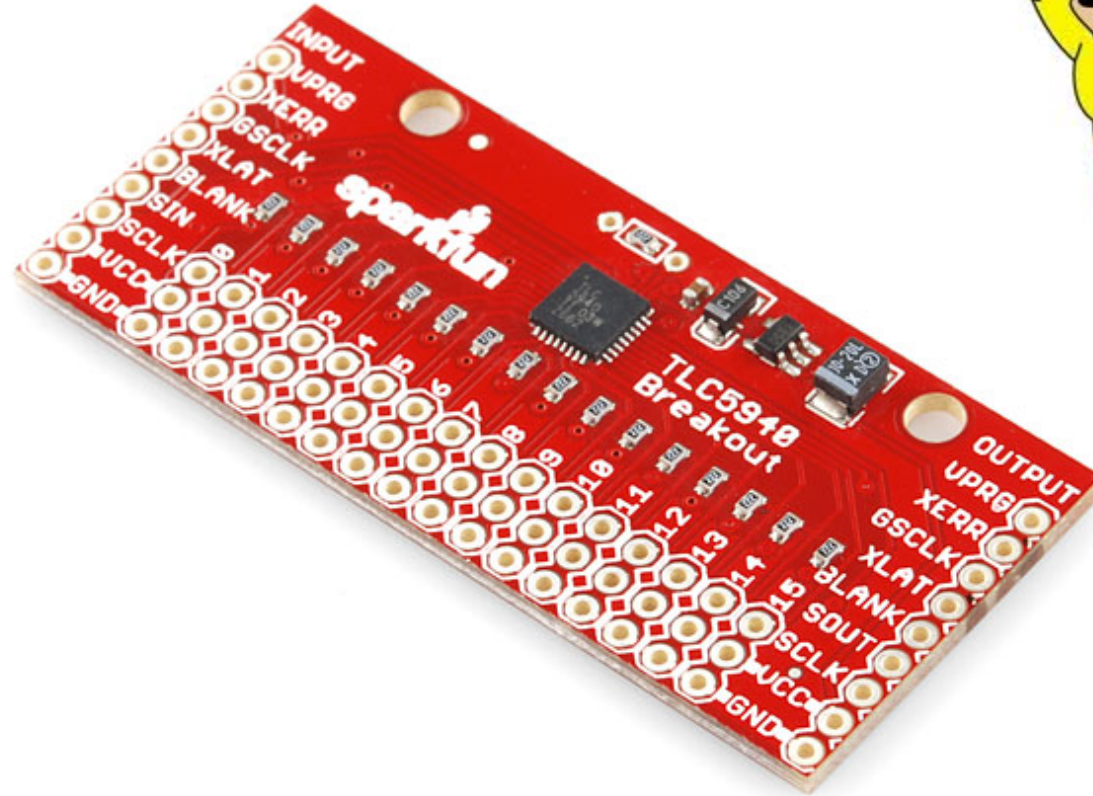
More PWM

Channels (????)



TLC5940 16-channel PWM Driver

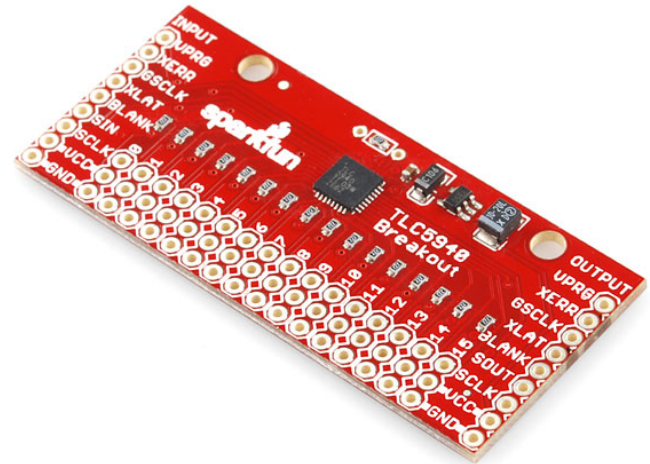
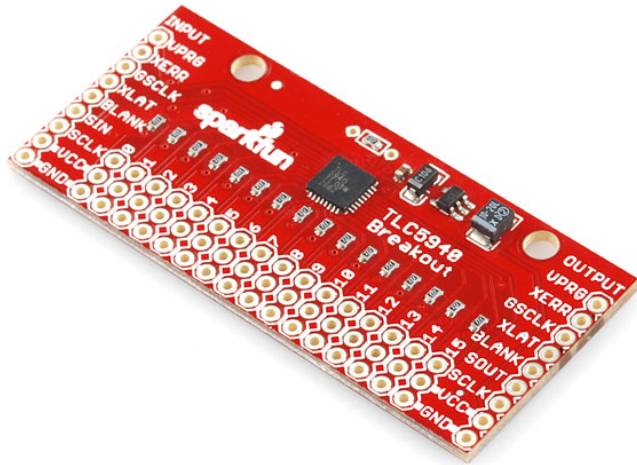
- 16-Channel PWM Driver
- Daisy-chainable
- Adjustable Current Control



12.95\$
at
Sparkfun

TLC5940 16-channel PWM Driver

- 16-Channel PWM Driver
- Daisy-chainable
- Adjustable Current Control



- 32 PWM Channels!
- Adjustable Current Control