6

Circuit #1 Blinking LED

Ohm's Law: $V = I * R$ $I = V / R$ $R = V / I$

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

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Did you get your LED turned on?
Make sure it's red. Switch the RedBoard pin # 9 with 5v on the RedBoard.

Give values for Voltage, Current and Resistance for each LED circuit setup. Find Resistance with Ohm's Law. Hint: Break the circuit between the Arduino pin and LED to measure the current.

2.

330Ω (circuit as is):

V = __5__ v I = ______ mA R = __543__ Ω

3.

With two LEDs and 330Ω :

V = __5__ v I = __3.7__ mA R = __1.35K__ Ω

4.

One LED and 10KΩ resistor:

V = __5__ v I = __.32__ mA R = __15.6K__ Ω

5.

Two LEDs and 10KΩ resistor:

V = __5__ v I = __.15__ mA R = __33.3K__ Ω

6.

Circle the Ground in the circuit.

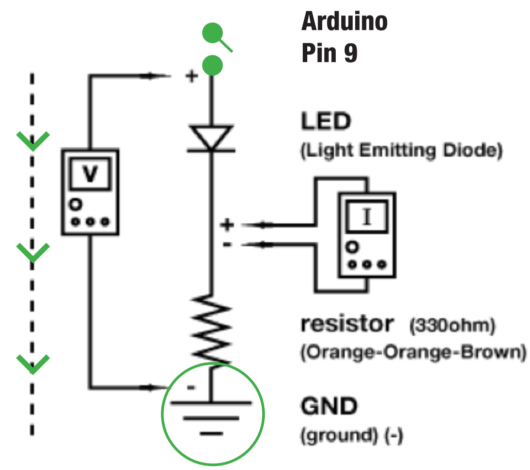
7.

Draw arrows to indicate direction of current on dotted line.

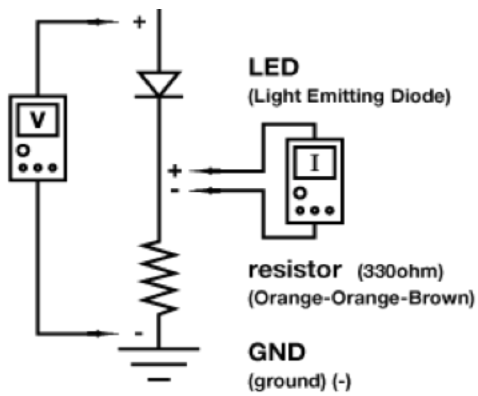
8.

Add an on/off switch to this schematic.

Circuit:



Circuit:



9.

Draw a logic flow chart of the circuit here:

10.

What circuits or projects would you like to add LEDs to? List at least three reasons you might add LEDs to an existing circuit or product that you might use. For example: to indicate when a squirt gun is running low on water or to add a flashlight to your hat.

11.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Circuit #2 Potentiometers

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Can you turn your LED up and down using the potentiometer?

Great. Pay attention to this circuit, potentiometers (also called trimpots) are great for creating analog user interfaces. With a potentiometer there are up to 1024 settings on a single dial!

2.

Add the following to the circuit code and upload:
In Setup: `Serial.begin(9600);`
In Loop after all other code: `Serial.println(sensorValue);`
Now open the Serial Communication window.

3.

Replace the LED component (in the schematic) with an element or component from one of the previous circuits, extra credit if you decide to replace it with a motor. Explain which aspect of the element or component is controlled by the potentiometer. Example: replace LED with Piezo speaker and control pitch with potentiometer.

4.

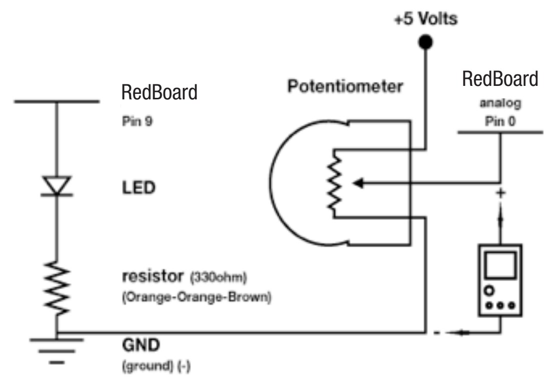
Aspect:

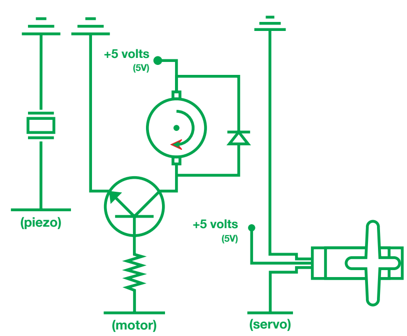
Pitch, speed, or position.

5.

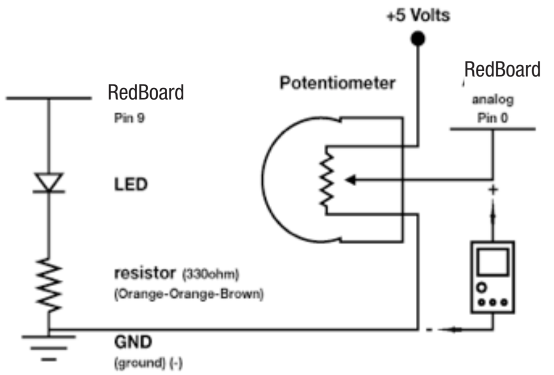
Use your multimeter as indicated and measure the voltage of the potentiometer circuit while you turn the dial up and down. Explain below what happens.

Circuit:





Circuit:



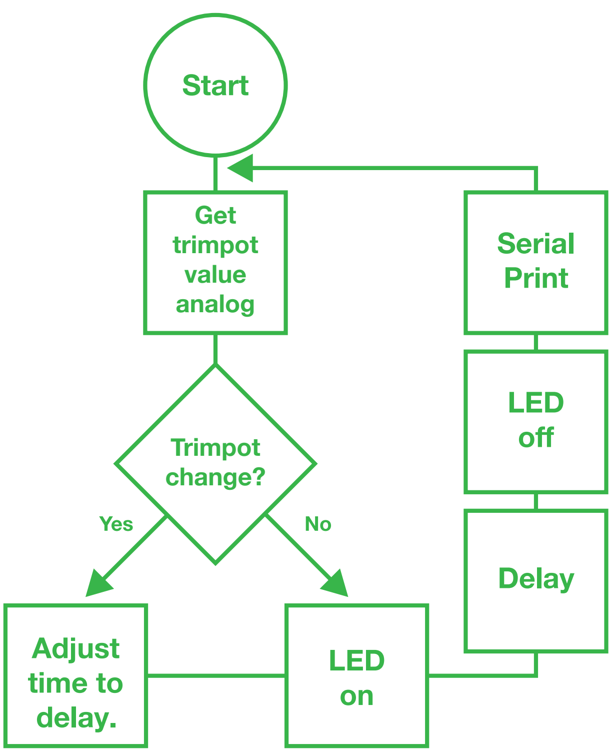
7.

Potentiometers are everywhere. List at least three appliances that use potentiometers as an input. Also list what the potentiometer input controls (also known as an output).

It goes up and down depending on if you turn the potentiometer up or down.

6.

Draw a logic flow chart of the circuit here:



8.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

CHAPTER 6
Tier 1 Difficulty
Circuit #3 RGB LEDs

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

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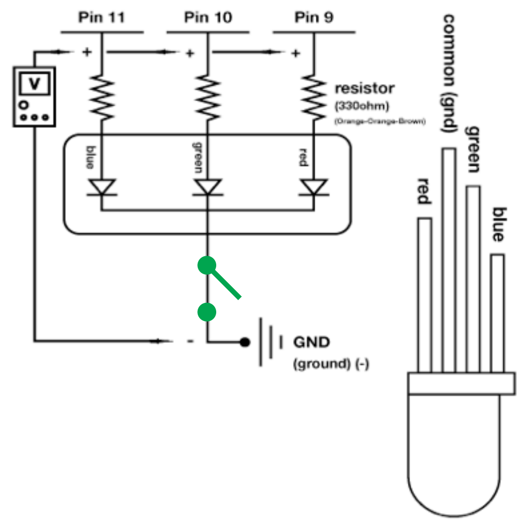
Circuit:



Does the RGB LED work?

Great. Upload the Circ12Expansion Code to your Arduino, add a trimpot, a temperature sensor and a photoresistor to the circuit. Connect the trimpot to analog pin 1, the temperature sensor to analog pin 2, and the photoresistor to analog pin 0. Use some of the previous circuit schematics if you get stumped. You may also switch out the temperature sensor for the flex sensor or soft potentiometer so you have more control of the RGB LED if you like, but you will also need to change the code a little.

2.

Connect a multimeter to each line that is connected to an Arduino pin. Notice how the voltage changes while you use the sensor or interface coupled with each pin.

3.

What should the voltage values for each pin be to make the RGB LED as red as it will get?

V = __0__ v I = __0__ mA R = __5__ Ω

4.

What does "RGB LED" stand for?

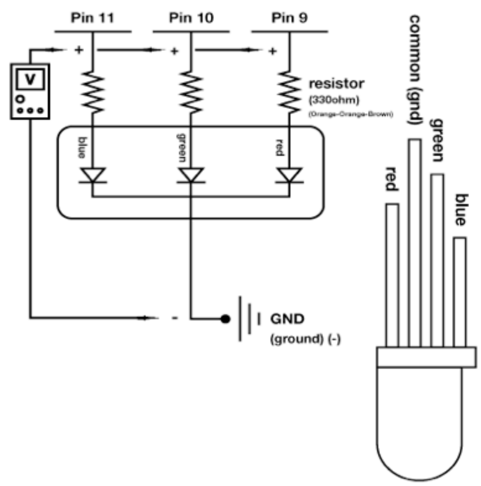
Red, Green, Blue, Light Emitting Diode.

____

5.

Add an On/Off switch to your schematic.

Circuit:

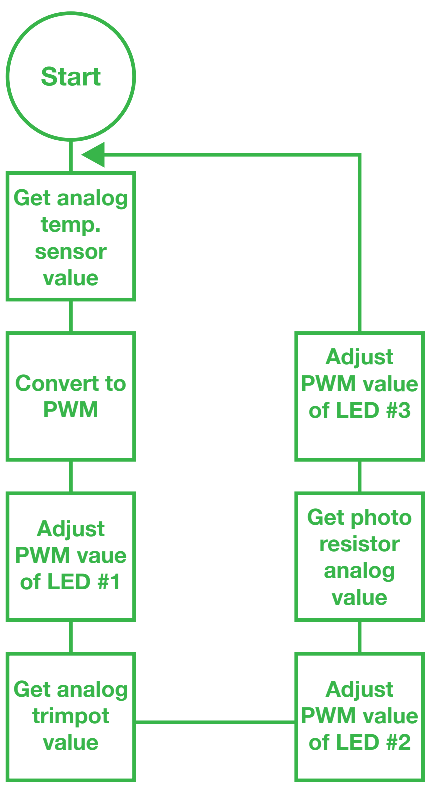


7.

Other than making projects pretty, what are some possible uses for a RGB LED? List at least three.

6.

Draw a logic flow chart of the circuit here:



8.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Circuit #4 Multiple LEDs

Ohm's Law: V = I * R   I = V / R   R = V / I

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

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Did you get your LEDs turned on?
Great. Load the Circ02Expansion Code. In this code the last LED pin is an analog output using PWM (Pulse Width Modulation). Make sure to use a red LED.

Give values for Voltage, Current and Resistance for each LED circuit setup. Find Resistance with Ohm's Law. Hint: Break the circuit between the Arduino pin and LED to measure the current.

2.

PWM @ 63.75 (or 25%)

V = 1.18 v I = 2.06 mA R = 572 Ω

3.

PWM @ 127.5 (or 50%)

V = 2.37 v I = 4.17 mA R = 568 Ω

4.

PWM @ 191.25 (or 75%)

V = 3.57 v I = 6.3 mA R = 566 Ω

5.

PWM @ 255 (or 100%)

V = 4.77 v I = 8.4 mA R = 568 Ω

6.

Circle all the Power Sources in the circuit. (This one is a little trickier)

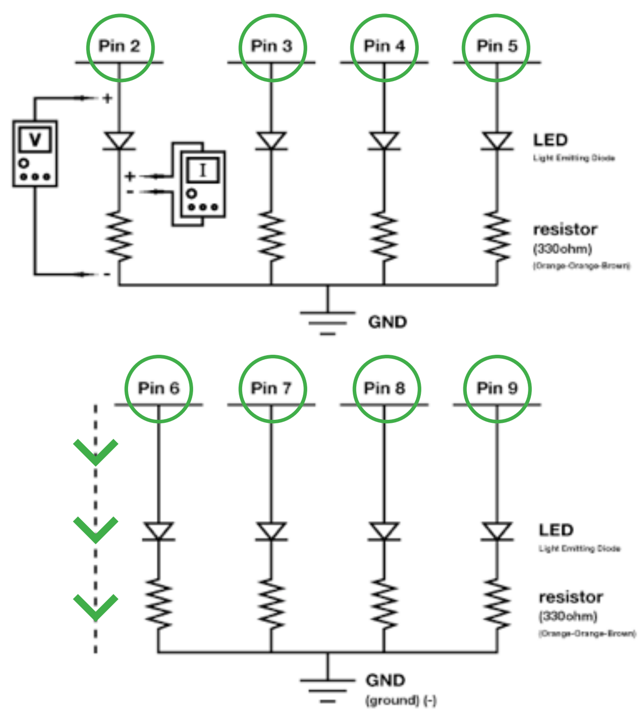
7.

Draw arrows to indicate direction of current on dotted line.

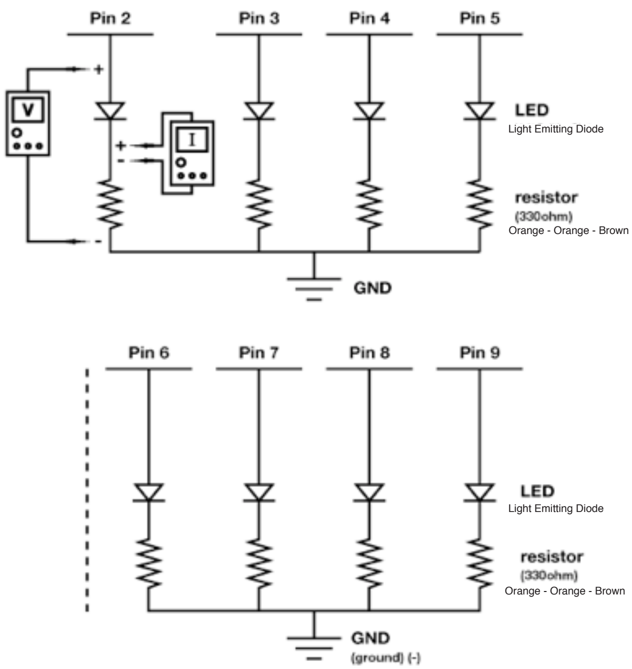
8.

Add an on/off switch for one LED to this schematic.

Circuit:



Circuit:



10.

What circuits or projects would you like to add LEDs to? Can you think of at least three reasons you might add multiple LEDs to an existing circuit or product that you would use? For example: clock that shuts off an LED every time you are done with a class, turning off all the LEDs by the end of the day so you know you are free.

9.

Draw a logic flow chart of the circuit here:

11.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

____

____

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____

Can you turn your LED on and off using both buttons?
Great. Pay attention to this circuit, buttons are one of the most basic forms of user interface.

Give values for Voltage, Current and Resistance for each question. Find Current either by breaking the circuit and/or using your multimeter.

2.

Button on pin 2 pushed:

V = 5 v I = .48 mA R = 10416 Ω

3.

Button on pin 3 pushed:

V = 5 v I = .48 mA R = 10416 Ω

4.

Think about the question above. What makes the LED turn on and off?
The code in the Arduino and the pin # 13

5.

If the resistor's value is 10000Ω, what is the resistance of the button? 416 Ω

6.

Replace the LED component (in the space below the schematic to the right) with an element or component from one of the previous circuits. Extra credit if you decide to replace it with a motor.

7.

Draw arrows indicating current direction on dotted line.

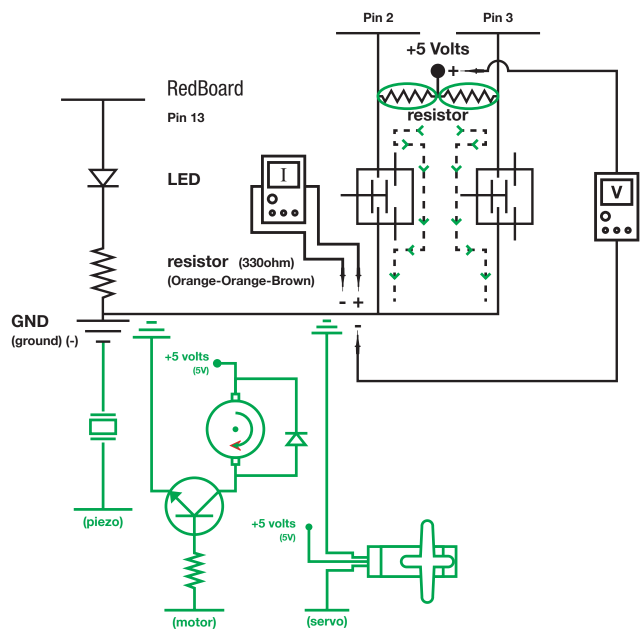
8.

Add another Piezo Element to the schematic so you can write harmonies. Be sure to show which Arduino pin you will attach it to.

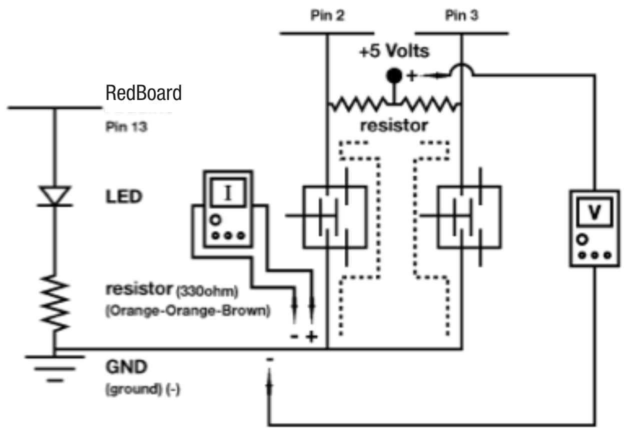
9.

Add an on/off switch to this schematic.

Circuit:



Circuit:

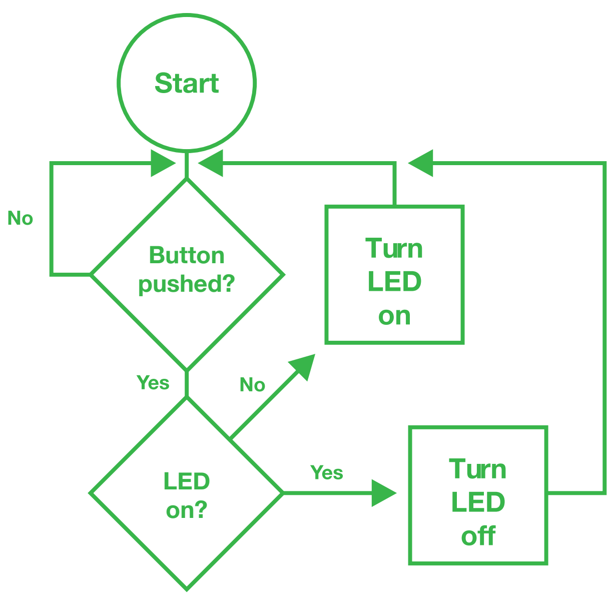


11.

Buttons are everywhere. List at least two different kinds of buttons that you might not think of as being buttons. Examples: piano keys and go Google "reed switches". Now list at least two items that are not technically buttons, but could be used as buttons. Example: snaps on a shirt.

10.

Draw a logic flow chart of the circuit here:



12.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Can you turn your LED up and down using the photoresistor? Great.

2.

Add the following to the circuit code and upload:
In Setup: *Serial.begin(9600);*
In Loop after all other code: *Serial.println(lightValue);*
Now open the Serial Communication window.
Replace the LED component (in the space below the schematic on the right) with an element or component from one of the previous circuits, extra credit if you decide to replace it with a motor and do so correctly.

3.

Make sure an aspect of the element or component is controlled by the photoresistor. Example: replace LED with Piezo and control pitch with potentiometer. Aspect controlled:

Pitch, speed, or position.

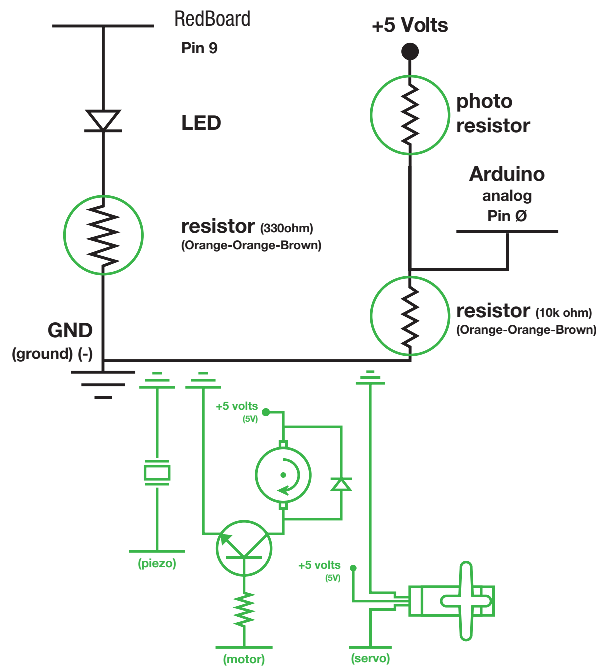
4.

Why does this circuit use an analog pin as an input?
Because the photoresistor is an analog sensor.

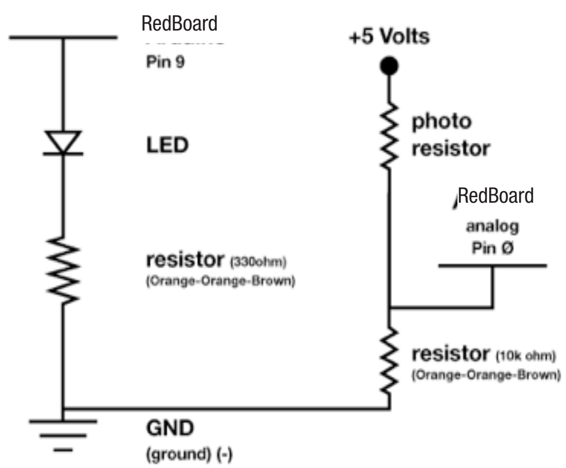
5.

Circle all the resistors.

Circuit:



Circuit:



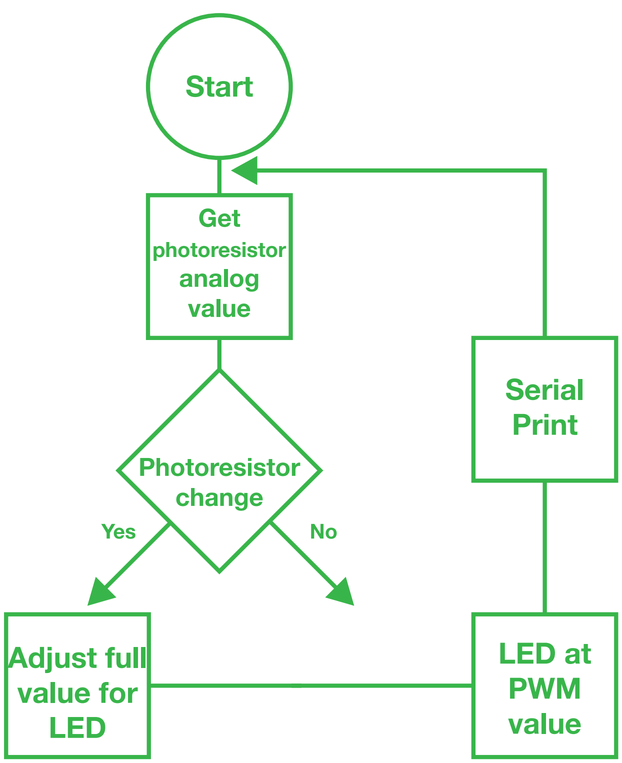
7.

The output variable lightValue can go all the way up to 900 but your LED input can only go up to 255. What word in the code fixes this and how would you describe this action in a mathematical sense?

"Map" is the word that does this in the code. It is similar to multiplication with the addition or subtraction afterward in the order of operation. Addition and subtraction do not always occur.

6.

Draw a logic flow chart of the circuit here:



8.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Circuit #7 Temperature Sensor

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Does your temperature sensor work? Great.

2.

What line in the code displays the temperature?

Serial.println(temperature);

3.

What other line in the code is necessary to establish communication with your computer so it can display the temperature?

Serial.begin(9600);

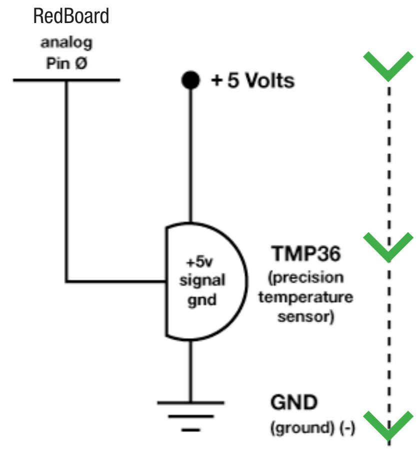
4.

Upload the Circ10Expansion Code to your Arduino, then add an LED and a resistor to the circuit. Control the LED's brightness with the temperature sensor. By now you should be able to do this with no help, but here's a hint anyways: PWM pins = 3, 5, 6, 9, 10, 11

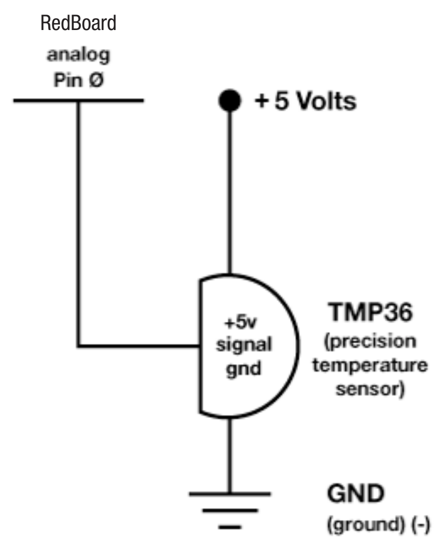
5.

Draw arrows on the dotted line to indicate direction of current flow.

Circuit:



Circuit:



7.

What ways, other than controlling an air conditioner, could a temperature sensor be useful? List at least three and explain what is controlled by the temperature sensor in each.

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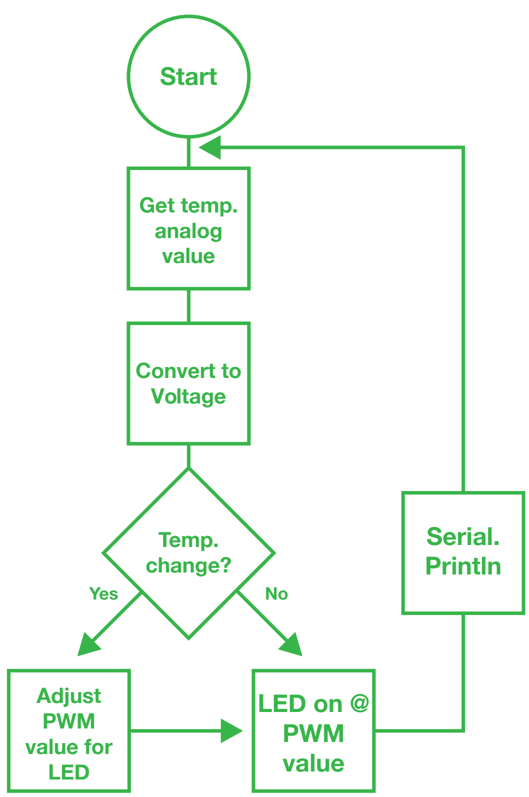
6.

Draw a logic flow chart of the circuit here:



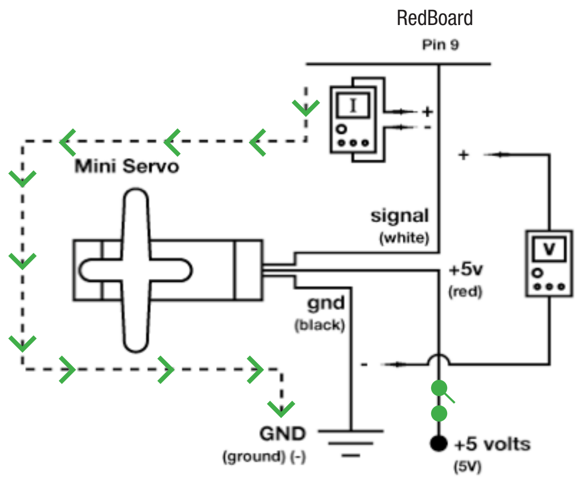
8.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Circuit #8 Single Servo

Ohm's Law: V = I * R I = V / R R = V / I

Circuit:



1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Do you have your servo running? Great.

Give values for Voltage, Current and Resistance for the pin # 9 value while the servo is in motion. Find the current by breaking the circuit and measuring at multimeter with I. Find resistance using Ohm's Law.

2.

Highest reading while Servo is in motion:

V = .4 v I = .03 mA R = 13333 Ω

3.

What does the Arduino pin # 9 do in this circuit?

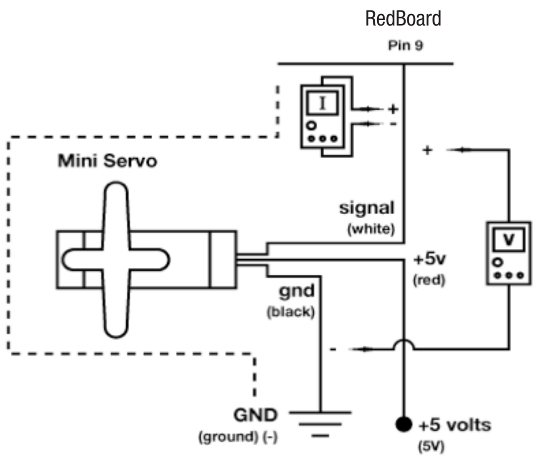
4.

Draw arrows to indicate direction of current on the dotted line.

5.

Add an on/off switch to this schematic.

Circuit:



7.

A Servo can't rotate continuously more than 360 degrees, as opposed to a motor which can turn all the way past 360 degrees as many times as you like. However, a servo remembers what its position is while a motor only knows if it is running forward or backwards. Can you think of any situations in which you would need a Servo instead of a motor? How about the other way around? Write three examples, at least one of each, below.

____

____

____

6.

Draw a logic flow chart of the circuit here:

8.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Circuit #9 Flex Sensor

1.

Now we're starting to work with some more complicated sensors. The flex sensor has tons of real world applications. List three and explain why you can't use a regular potentiometer instead of a flex sensor. Example: use the sensor to measure the flex on a fishing pole and cut the line if the pole ever comes close to breaking. You could not use a potentiometer because it would be difficult to attach it.

Got your flex sensor and servo working? Great, but what if you want to measure flex in both directions? Add the necessary components to the schematic below (add components on right) and describe (in plain English) what you would need to add to the code to keep the single servo as your output with your new schematic.

2.

Unplug the flex sensor completely and look at your Serial Communication window. You should still be getting some values even though there is no sensor plugged in. This is due to something called "float" which occurs when an Arduino pin is expecting input but there is no sensor attached to it. What is the highest value you receive and why is it important to know about float?

Float will be anywhere between zero and the voltage of your positive line. Most often around 2.5 v. Switches that are open often float so you don't know what their value is, sometimes there will be float due to broken sensors or unconnected wires.

3.

What if you wanted your flex sensor to measure a smaller range of flexing (because what you are measuring is less flexible), but you want the same range of motion for your servo, how could you make it do that?

Map a smaller sensor variable range to the same servo range

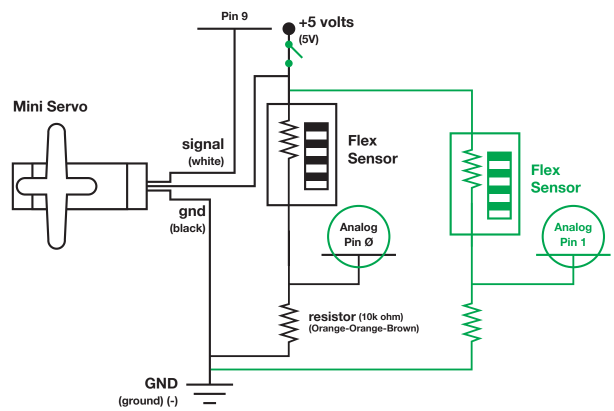
4.

Add an On/Off switch to your schematic.

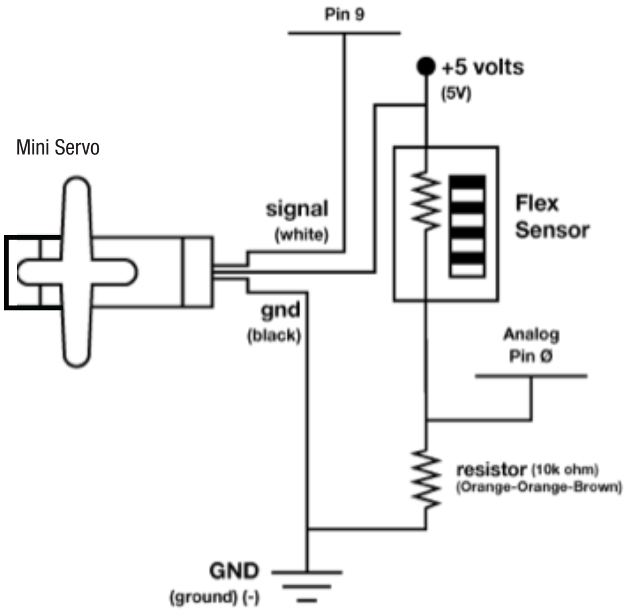
5.

Circle any RedBoard pins that take input on your modified schematic.

Circuit:



Circuit:



7.

Imagine your flex sensor is thirty feet long. List at least three things you could do with it.

6.

Draw a logic flow chart of the circuit here:

8.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Circuit #10 Soft Potentiometer

1.

The soft potentiometer is touchy, sometimes you will notice incorrect readings due to how you touch the sensor. The RGB will even change a little just before you touch the sensor! Explain how this alters the ways in which you can use this sensor. Explain at least one possible fix or work around.

____

____

____

Got your soft potentiometer and RGB LED working? Great. Without looking at the code too much, mark on the soft potentiometer diagram below which areas cause which colors to be displayed.

Soft Potentiometer

2.

This will let you see the values (slowed down a little with the delay line, to see real time output remove delay(100); as the soft potentiometer outputs them. What happens to the values after you stop touching the sensor? Explain why you think this happens. You may have to look up how this sensor works to figure this out.

The values don't go down immediately to zero. They take a little

time to do so. This is because the two layers of the potentiometer

tends to stick together a little

3.

Explain in your own words how you think you could use the soft potentiometer to turn the RGB LED on/off as well as controlling the color.

Change the values of the mapping procedure so the upper most and

lower most values are not used to create a color, then assign those

values (say 0 – 5 and 1018 – 1023) to LOW and HIGH, or OFF and ON.

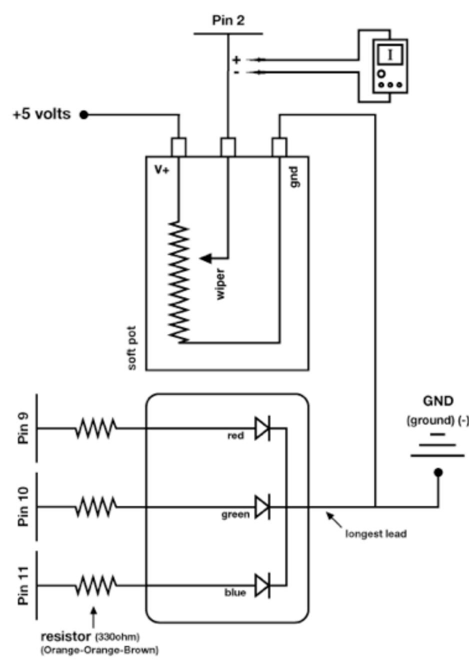
4.

Add the following code to your Arduino code.
In Setup: *Serial.begin(9600);*
In Loop after all other code: Serial.
println(sensorValue);
delay(100);

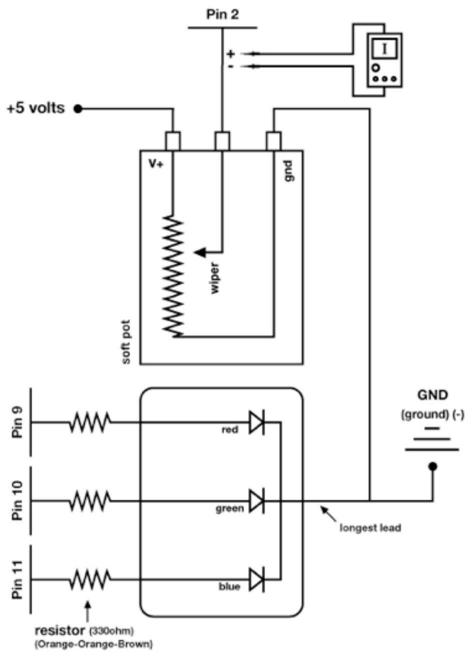
5.

Now open the Serial Communication window.

Circuit:



Circuit:



6.

Draw a logic flow chart of the circuit here:

7.

Calculate resistance of the potentiometer when it is blue, then green, then red. You will need to measure Voltage and Current, then calculate resistence because you can't see the RGB value while measuring resistance.

V = 8K-10kΩ **v I =** 3K-5kΩ **mA R =** 0K-20Ω **Ω**

8.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Circuit #11 Piezo Element

Ohm's Law: V = I * R I = V / R R = V / I

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Do you have the annoying song blaring out of your speaker? Upload Circ06Expansion Code to your RedBoard.

Give values for Voltage, Current and Resistance for each note value. Find Current by breaking the circuit and using your multimeter. Record voltage to the thousandths place. Calculate Resistance using Ohm's Law.

2.

Note A:

V = .689 v I = 39.2 mA R = 18 Ω

3.

Note C:

V = .681 v I = 38.7 mA R = 18 Ω

4.

Note E:

V = .684 v I = 38.8 mA R = 18 Ω

5.

Note G:

V = .686 v I = 39.1 mA R = 18 Ω

6.

What does the Arduino pin # 9 do in this circuit?

7.

Draw arrows indicating current direction on dotted line.

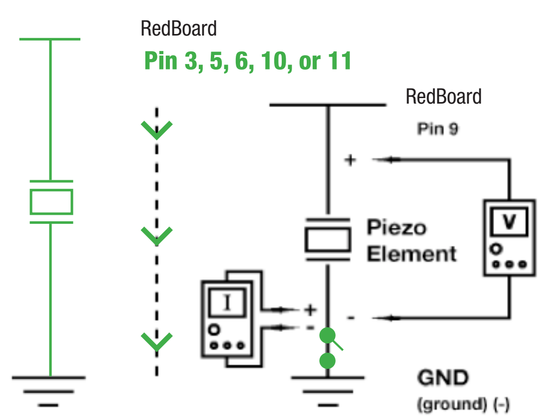
8.

Add another Piezo Element to the schematic so you can write harmonies. Be sure to show which Arduino pin you will attach it to.

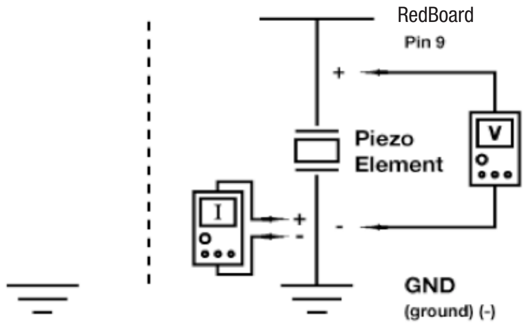
9.

Add an on/off switch to this schematic.

Circuit:



Circuit:



11.

Other than annoying your friends, how could you use the Piezo Element in a project? Example: create a timer that plays an annoying song faster and faster as time runs out. Write at least two examples.

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____

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10.

Draw a logic flow chart of the circuit here:

12.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Circuit #12 Spinning Motor

Ohm's Law: V = I * R I = V / R R = V / I

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

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Do you have your motor running?
Great. Load the Circ03Expansion Code. Fill in the answers below.

Give values for Voltage, Current and Resistance for each motor value. Find Current by breaking the circuit and using your multimeter. Calculate the Resistance using Ohm's Law. Record all values to the hundredths place.

2.

Motor 50%

V = 1.1 v I = 34.4 mA R = 31 Ω

3.

Motor 60%

V = 1.55 v I = 40.4 mA R = 38 Ω

4.

Motor 75%

5.

V = 2.48 v I = 51.2 mA R = 48 Ω

6.

Motor 100%

V = 4.2 v I = 66.5 mA R = 63 Ω

7.

Circle the diode in the circuit.

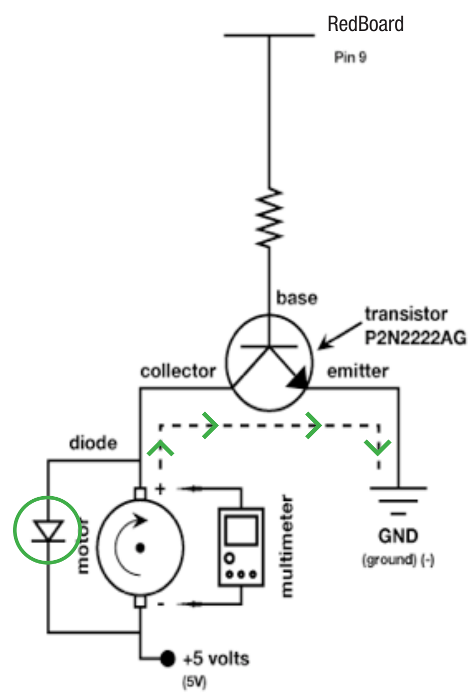
8.

Draw arrows to indicate direction of current on dotted line.

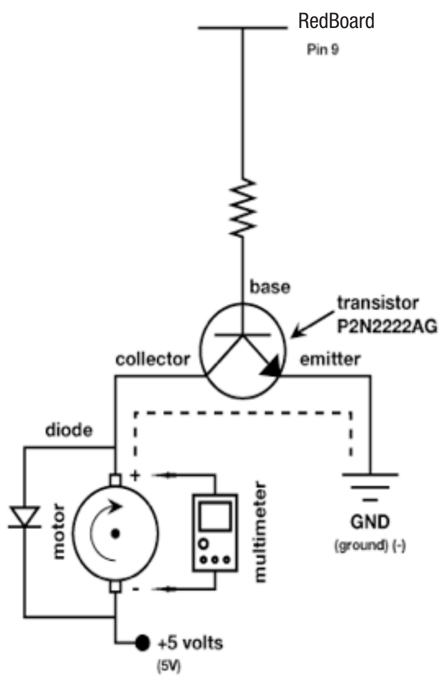
9.

Add an on/off switch to this schematic.

Circuit:



Circuit:



10.

Draw a logic flow chart of the circuit here:

11.

How would you use this circuit if you were an engineer? Would you make a break-dancing robot penguin? To move a trapdoor? To make a yo-yo that plays itself? Get creative.

12.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Circuit #13 Relays

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Does your relay work?

If so, upload Circ11Expansion Code to your RedBoard, then add a button to your circuit and to the right of the schematic, make sure you include a pull up resistor (10KΩ resistor).

2.

Name one thing you would have to change to use a potentiometer to control the relay instead of a button, extra credit for writing what you would need to add in the code as well. Use English, not code.

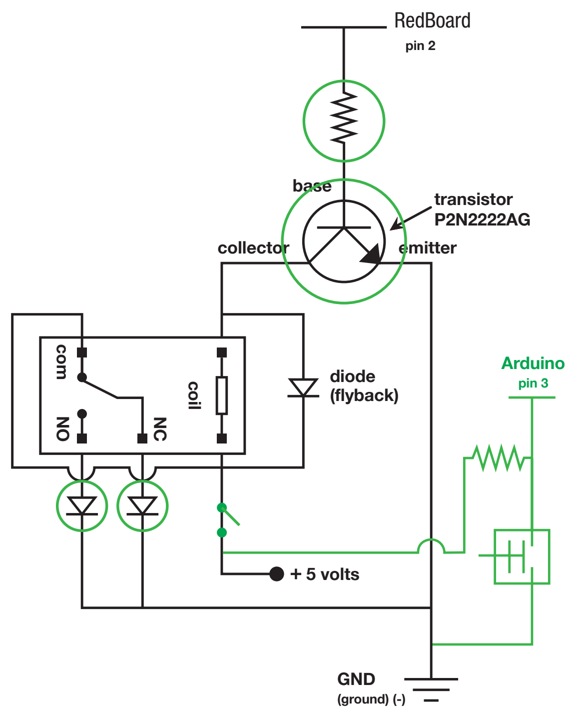
No pull down resistor, analogRead not digitalRead

3.

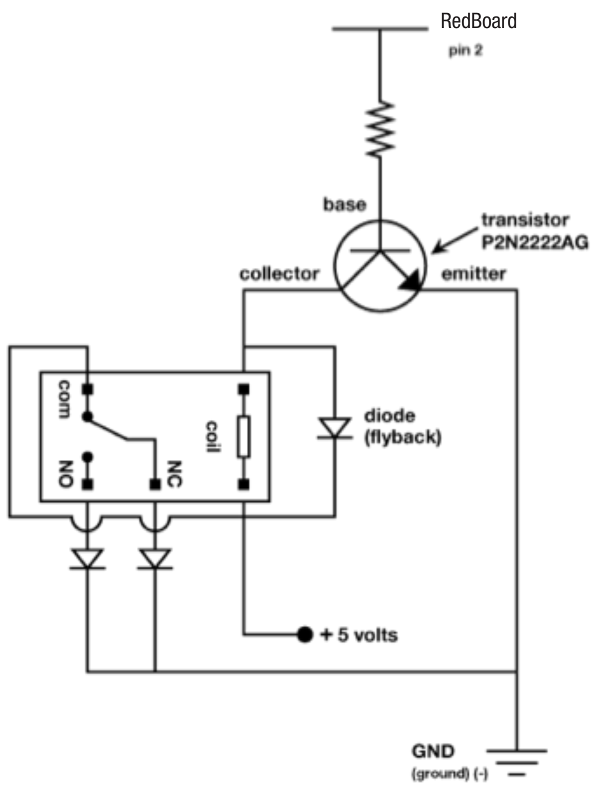
If the NO in the relay stands for Normally Open, what do you think NC stands for?

Normally closed.

Circuit:

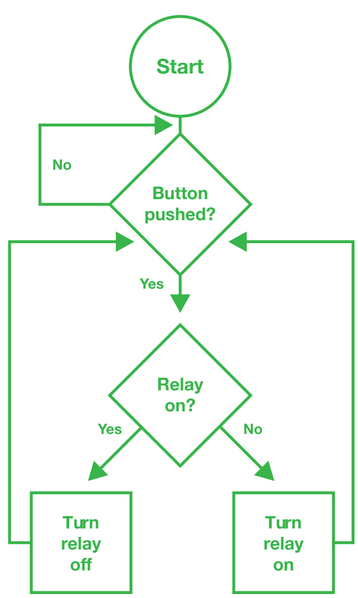


Circuit:



4.

Draw a logic flow chart of the circuit here:



5.

Imagine your perfect relay machine. What two things would your relay switch back and forth between and why? Get creative. Example: a soft serve ice cream machine and an electric caramel pump so that making sundaes would be a little less work and give you more time to eat them.

6.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Circuit #14 Shift Register

1.

Shift Registers are used to control multiple pins using only three input pins to set the output pins. This can be useful if you want to control more than three objects using only three pins (as long as they always operate in the same order). What objects would you control using a shift register? List at least four and make sure the objects make sense together. Ex: A waffle iron, an eggbeater, a servo to pour the batter, and a timer.

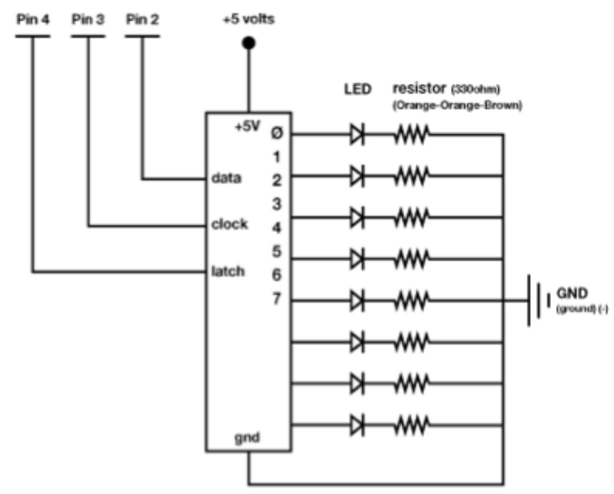
____

____

____

____

Circuit:



2.

What does the RedBoard pin # 2 do in this circuit?

Send binary data to shift register bins.

3.

What does the RedBoard pin # 3 do in this circuit?

Pulses clock so register knows to shift a bit.

4.

What does the RedBoard pin # 4 do in this circuit?

Latches ability to write to shift register
either true or false.

5.

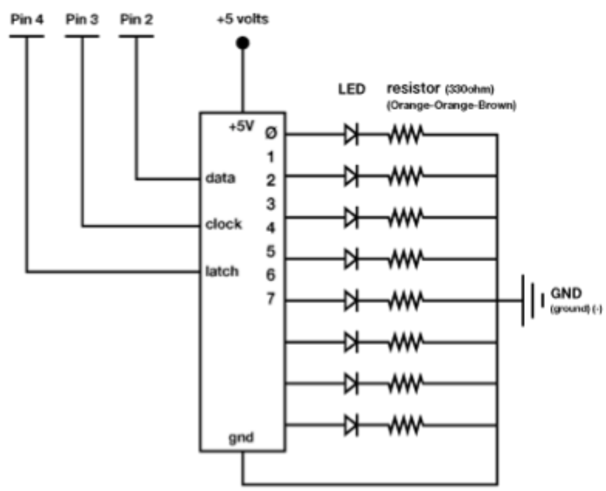
If all the LEDs are turned on, what would have to happen in order for LED # 5 to turn off?

LEDs # 0 - 4 would have to turn off first (by

pulling latch HIGH, bitshifting in a zero and

pulsing clock.

Circuit:



7.

Using the circuit exactly as it is, with eight LEDs, what applications can you think of for the shift register? List at least three and explain what each LED would indicate.

6.

Draw a logic flow chart of the circuit here:

8.

Draw one example of how this circuit could be used in everyday life. Label all components and give it a title.

Soft potentiometers come in a bunch of shapes and sizes. Explain how you can combine multiple soft potentiometers to create a basic touchscreen interface with X and Y position output, or just go build one instead of explaining how it might work. You've finished the SIK, what are you waiting for? In fact, forget these guiding questions, if you want just use this page to brainstorm what your next project will be.

Circuit #1 Blinking LED

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Did you get your LED (Light Emitting Diode) turned on?
Great. Fill in the answers below using red LEDs.

2.

Two LEDs in series, 5V:

V = 4.95v I = 3.6mA R = 1375Ω

3.

Two LEDs, parallel, 5V:

V = 4.93v I = 8.9mA R = 554Ω

4.

One LED, 3.3V power:

V = 3.3v I = 4.4mA R = 750Ω

5.

Two LEDs, series 3.3V:

V = 3.4v I = .07mA R = 4857Ω

6.

Two LED, parallel 3.3V:

V = 3.3v I = 4.5mA R = 733Ω

Replace your 330Ω resistor with a 10KΩ resistor.

7.

Two LEDs in series, 5V:

V = 4.99v I = .15mA R = 3327Ω

8.

Two LEDs, series, 3.3V:

V = 3.36v I = .01mA R = 33600Ω

9.

What do you think would happen if you connected a 9V battery as your power source for the first circuit?

The current and resistance would be higher. Also

the LED would burn brighter due to a higher voltage.

10.

Assuming the same resistance as the original circuit, what would the current equal with a 9V power source? Show your work.

V=I*R so 9v = I *1375Ω or 9v/1375Ω = 6.5mA

so, I = 6.5mA_

11.

In the code below circle the "*setup( )*" method and explain below what it does in this instance.

Setup method declares ledPin (Arduino pin #9) as an output pin

12.

Underline the code that turns the LED on.

```
int ledPin =  9;

  void setup()
  {
  pinMode(ledPin, OUTPUT);
  }

  void loop()
  {
    analogWrite(ledPin, 200);
    delay(1000);
    analogWrite(ledPin, 0);
    delay(1000);
  }
```

13.

Why does the code above use pin # 9 instead of pin # 0 or pin # 1? Explain why pin # 0 and pin # 1 are not options. Make sure you explain for both digital pins and analog input pins.

The code above uses pin # 9 because it can output PWM values instead of just on and off like digital pins # 1 and 2. You could not use the analog input pins because, although they can be used as digital output pins, they also do not have PWM capability

14.

Explain why you might use LEDs on an illuminated shirt (or hat, etc) instead of other types of light bulbs.

LEDs do not take as much electricity. This way you can have an illuminated shirt or skirt and not have to worry about lugging around a huge battery. The lower voltage amount also makes them safer than higher voltage lightbulbs

Circuit #2 Potentiometers

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Can you turn your LED up and down using the potentiometer? Potentiometers are also called trimpots.

2.

Describe how the potentiometer is being adjusted according to the PWM diagram above.

It is being adjusted from a 75% duty cycle down to a 25% duty cycle. Short answer: down.

3.

Who invented the potentiometer and when?

The potentiometer was invented by Johann Christian Poggendorff in 1841.

4.

What basic component does a potentiometer act like when it is not being adjusted?

A resistor.

5.

In your own words describe what voltage dividers do.

A voltage divider divides the amount of voltage present into two or more fractions of the original voltage depending on the resistor values.

6.

Describe how you would use potentiometers to control a marshmallow (because they are soft) launcher's trajectory. What other pieces of hardware would you need to create this marshmallow launcher?

Calculate percentage for each of the analogWrite values, then draw a line from the PWM code on the left to the corresponding PWM diagram on the right.

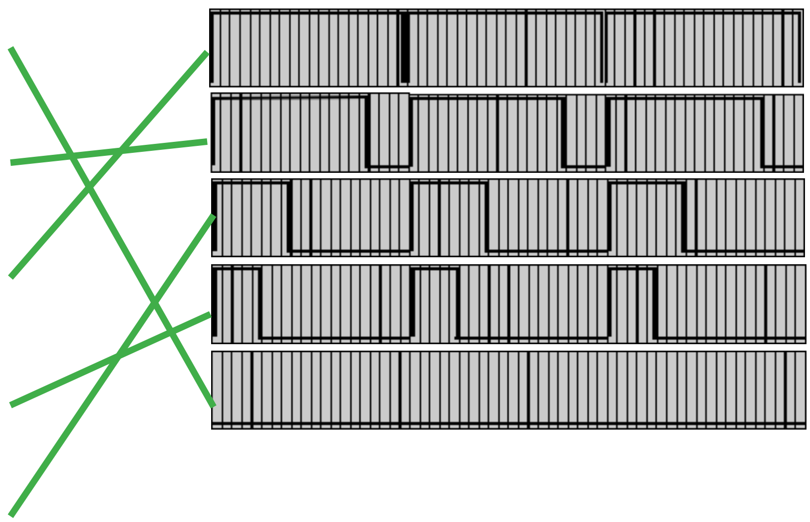
7.
analogWrite (ledPin, 0); 0 %

8.
analogWrite (ledPin, 200); 78 %

9.
analogWrite (ledPin, 255); 100 %

10.
analogWrite (ledPin, 70); 27 %

11.
analogWrite (ledPin, 100); 39 %



(analog# / 255)*100 = percentage

Circuit #3 RGB LEDs

1.

This LED has three inputs and three outputs. What other circuits have three inputs? Three outputs? Provide an example of each.

Does the RGB LED work?

Great. Hint for questions below: if you're really stuck add a button to your circuit that uses *Serial.println();* to print RGB values when you press it.

Connect a multimeter to each line that is connected to an Arduino pin. Notice how the voltage changes while you use the sensor or interface coupled with each pin.

2.

What should the voltage values for each pin be to make the RGB LED as red as it can get?
Pin 11 V = 0 v Pin 10 V = 0 v Pin 9 V = 5 v

3.

What should the voltage values for each pin be to make the RGB LED as yellow as it can get?
Pin 11 V = 0 v Pin 10 V = 2 to 3 v Pin 9 V = 5 v

4.

What should the voltage values for each pin be to make the RGB LED as white as it can get, but at 1/2 intensity?
Pin 11 V = 2.5 v Pin 10 V = 2.5 v Pin 9 V = 2.5 v

5.

Given that there are 256 (0 – 255) different intensity values for each color in an RGB LED, how many different colors can an RGB LED emit? Show your work.

256 * 256 * 256 = 16777216 different colors!

6.

How many different colors can a RGBY LED emit?

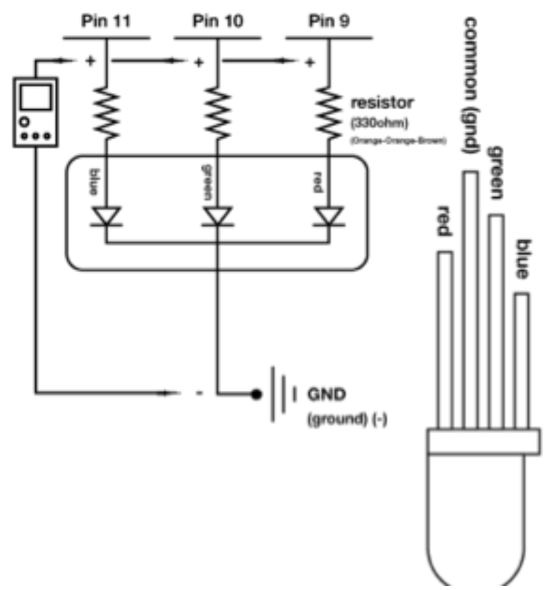
256 * 256 * 256 * 256 = 4294967296

7.

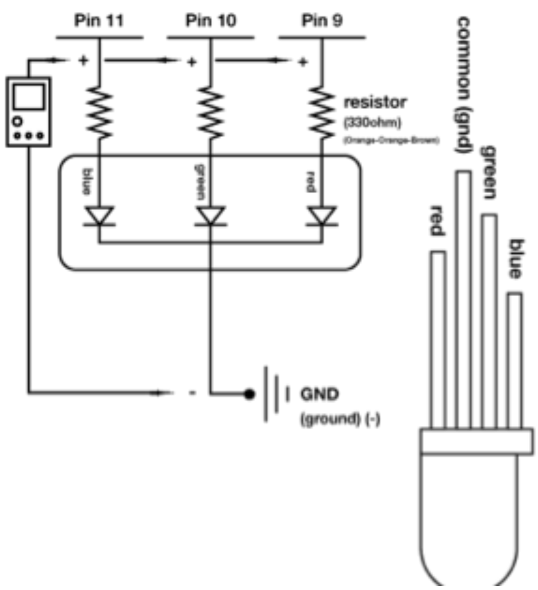
Why are there 256 LED intensities, and not 300?

That's # of values in PWM b/c it has 8 bits of memory allotted for one PWM value.

Circuit:



Circuit:



8.

Light is a small part of a big group of electromagnetic fields called the Electromagnetic Spectrum. Name at least three other electromagnetic fields and state if their frequencies are higher or lower than light.

Higher: Radio, microwave, infrared. Lower: X-rays, gamma rays

9.

Who discovered the theory of Electromagnetic Spectrum? Who expanded it beyond light?

M. Faraday & J. Maxwell, H. Hertz expanded it.

10.

Upload Circ12BExpansion to your Arduino and add a piezo element to digital pin # 1. Change the code so you don't go crazy listening to "Twinkle, Twinkle Little Star". Explain how you could add another RGB LED so it also changes color depending on the note your piezo plays, but with different code so it displays a different color.

Inverse the sensorValue using Map method and then save to a different variable. Use different PWM pins to display these values in a different RGB LED. Or something like that.

11.

Other than Red, Green and Blue, what else could RGB stand for? Example: Roasted Gooey Baloney, Random Gargantuan Baboons, Rappers Got Beef, or Robot Guild Butlers. List at least three.

Circuit #4 Multiple LEDs

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Did you get your LED turned on?
Great. Now you are going to add a dimmer switch to your LED on pin # 9.

2.

What user interface component will you need to use as a dimmer?

Potentiometer, or soft pot

3.

Add the necessary text to the *oneOnAtATime( )* method for the code heavy way to add the dimmer.

4.

There are three different ways to add a dimmer without changing or adding code. Try to find one of these ways without destroying your LED.

5.

Draw a schematic of your circuit in the space to the right, adding your dimmer component so that it works. There are four different ways to do this.

6.

What other component does the dimmer component in this circuit act as?

Resistor

7.

The LED needs a PWM value that ranges from 0 – 255. The dimmer component gives you values from 0 – 1023. Write an equation below that will convert the value the dimmer component outputs to a LED friendly value.

PWM = (dimmer/1024)* 256

8.

The LED values 0 – 255 actually represent 256 different values. Why is that?

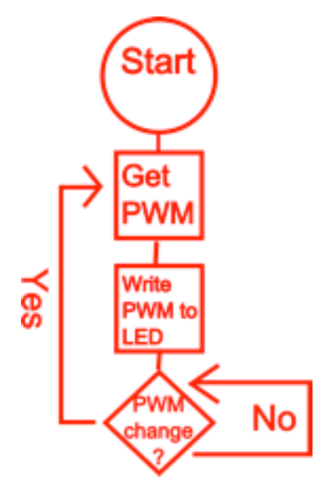
Zero is the first value but is not counted in the number system

9.

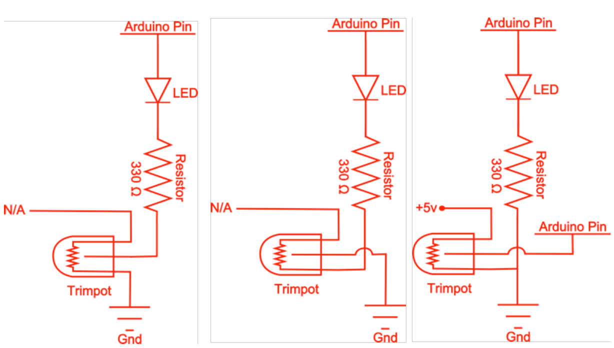
Imagine your LED circuit (without dimmer) as a meter indicating a sensor reading. Decide what kind of sensor you would like to use as an input and describe in your own words what would cause the meter to rise and fall.

5.

Draw a logic flow chart of the LED with dimmer:



(Other options for schematics below)



Circuit #5 Push Buttons

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Can you turn your LED on and off using both buttons? Great. Upload Circ07Expansion Code to your RedBoard and add an RGB LED to pins 9, 10 and 11. Check the code if you are unsure which leads go to which pins.

2.

The buttons in your circuit now adjust the variable "RGBValue" either up or down. What are the upper and lower parameters of "RGBValue"?

255 and 0

3.

With the code as is, what happens if you press the "down" button while pressing the "up" button? Why do you think this is?

The second buttons that is pressed does not work.

This is because the code checks to see if one button is pressed at a time and while that button is pressed runs one line of code until button is released

4.

What could you add to the code to fix this bug?

another IF statement inside the buttonPress == HIGH IF statement that checks to see if the other button has been pressed. If the other button is pressed while the first is pressed then have color variable go down instead of up and vice versa.

5.

In the code below underline the command that happens when the button is not being pressed.

```
void loop()
{
  buttonState = digitalRead(buttonPin);

  if (buttonState == HIGH) {
    digitalWrite(ledPin, HIGH);
  }
  else {
    digitalWrite(ledPin, LOW);
  }
}
```

6.

Explain the difference between = and ==.

= sets a variable equal to something.

== compares a variable to something.

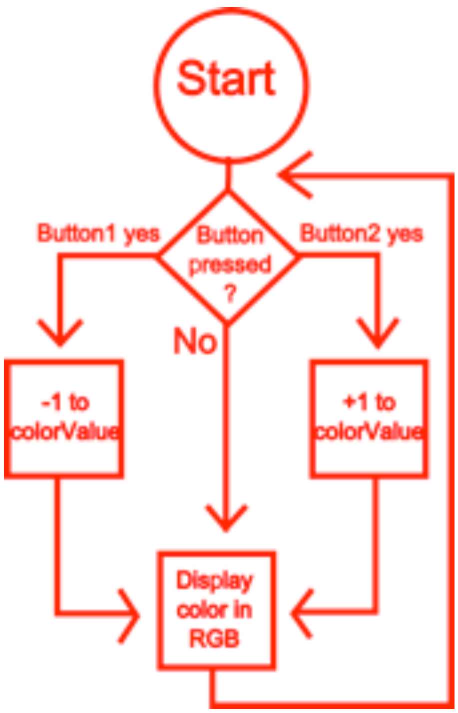
7.

Buttons are everywhere, however it is possible to substitute other user interface components for buttons, list at least three components that you could switch with a button in some way.

Potentiometer, a relay, a shift register, a temperature sensor, a flex sensor, or a soft potentiometer.

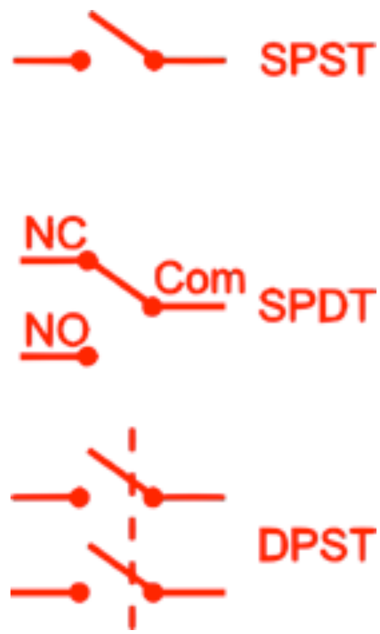
8.

Draw a logic flow chart of the expanded circuit here:



9.

In the space below draw the symbols for a two way switch (SPST), a three way switch (SPDT), and a double pole switch (DPST).



Circuit #6 Photo Resistor

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Can you turn your LED up and down using the photoresistor? Great.

2.

In the code you uploaded to your RedBoard change the line:

lightLevel = map(lightLevel, 0, 900, 0, 255);
to: lightLevel = map(lightLevel, 0, 900, 255, 0);

3.

How does this change the way your circuit acts?

The LED light level goes up as the light level on the photoresistor goes down, instead of the other way around

4.

Leave the code above in and turn your photoresistor so that it faces the LED. Turn the lights off. Does your LED turn all the way off? Why is this?

No, because the LED supplies a little light to the photo resistor so there is always a little light.

5.

What two lines do you need to add to your code to see what the output values from the photoresistor are and where do you need to add them?

Serial.begin(9600); in Setup() method=Serial.
println(lightLevel); in Loop() method

6.

Who invented the photoresistor, or photocell, and where was it invented?

Johann Elster and Hans Geistel in Heidelberg invented the first practical photoelectric cells that could be used to measure the intensity of light.

7.

There are three reasons the code below will not work, find all three errors and change or add the necessary code so it does work.

```
int lightPin = 0;
int ledPin = 9; //pin 8 is not PWM

void setup()
{
  pinMode(ledPin, OUTPUT)
}

void loop() {

 int lightLevel = analogRead(lightPin);
 lightLevel = map(lightLevel, 0, 900, 0, 255);
 lightLevel = constrain(lightLevel, 0, 255);
 analogWrite(ledPin, lightLevel);
}
```

8.

From the code above copy the command you would need to change if you wanted the LED to light up only when the photoresistor value is above 50%.

lightLevel = map (lightLevel, 0, 900, 0, 255);

9.

Write below what you would need to change the command to so that it functions as described above.

lightLevel = map (lightLevel, 450, 900, 0, 255);

10.

Photoresistors are great for light control, what else would you like to control with them? You can turn other circuits on or off by turning on your lights or opening your blinds. List at least three circuits.

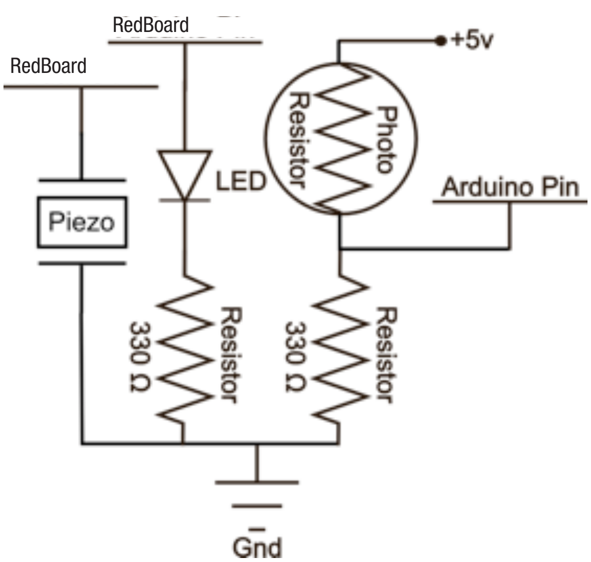
Eyes (iris), morning glories (plants in general) and Panamanian Golden Frog eggs (random!) I am sure there are more too....

Circuit #6b Photo Resistor

1.

Now you are going to use your SIK to create an alarm system using analog and PWM signals. Upload the Circ9Expansion Code onto your Arduino and setup your breadboard according to the schematics below.

Circuit:



2.

This simple alarm is designed so that when something comes between the light source (LED) and the photoresistor the piezo element starts it's annoying beeping. If you open your Serial communicator you will see it printing out a PWM value for the strength of the LED and an analog value for what the photoresistor sensor is receiving in the way of light. Without changing any of the code your alarm should work if you turn off the lights and pass your finger between the LED and the sensor.
What changes in this circuit and causes the alarm to go off? It's not just a lack of sunlight. Explain what is happening with the electricity. Write below and explain the exact variable that changes as well as the value that causes the alarm to be triggered.

When the light is reduced the photoresistor supplies a lower voltage to the analog in pin on the arduino. This reduces the lightLevel variable and when it reaches less than 50% (or less than 511) the piezo element is triggered my the alarmSound method. The alarmSound method runs until it has played the entirety of "Twinkle Twinkle Little Star".

3.

In order to make the alarm work during daylight you will need to be out of any direct lighting and you will need to change one of the values in the code. In the space below, write the line you changed in the code and explain why.

if(lightLevel < 511 { should be changed to if (lightLevel < 750{ so that the light doesn't need to go down as much in order for the alarmSound method to be triggered (value may be different than 750). This is because there is ambient light that is not emitted by the LED so we need to compensate for that.

4.

What component in the SIK do you think you could use to physically change the sensitivity of the photoresistor so you don't have to change the code whenever the sunlight levels change? Explain how.

You can use a potentiometer to change the resistance of the photoresistor circuit. This way if there is more sunlight you could turn up the potentiometer, thereby decreasing the voltage the circuit emits and vice versa.

Circuit #7 Temperature Sensor

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

____

____

____

____

____

Does your temperature sensor work?

Great. Upload Circ10BExpansion Code to your RedBoard. Attach the shift register and LEDs as shown in the schematic below. You may have to alter some code depending on how hot or cold it is where you are.

Write voltage values for the two temperature values below. Also record the amount of LEDs that light up with each temperature. For the first temp use whatever temp your room currently is.

2.

75.2 °F ≈ 24 °C (room temperature, fill in degrees)

V = .703 v LEDs = 4

3.

98.6°F = 37°C (use a cup of cocoa to warm up sensor)

V = .837 v LEDs = 8

4.

50°F = 10°C (use an ice pack to cool down sensor)

V = .577 v LEDs = 0

Using the values above, formulate an equation so you can calculate values for the temperatures below.

5.

105°F ≈ 40.5°C V = .577 v LEDs = 8

6.

86°F ≈ 30°C V = .763 v LEDs = 6

7.

32°F ≈ 0°C V = .477 v LEDs = 0

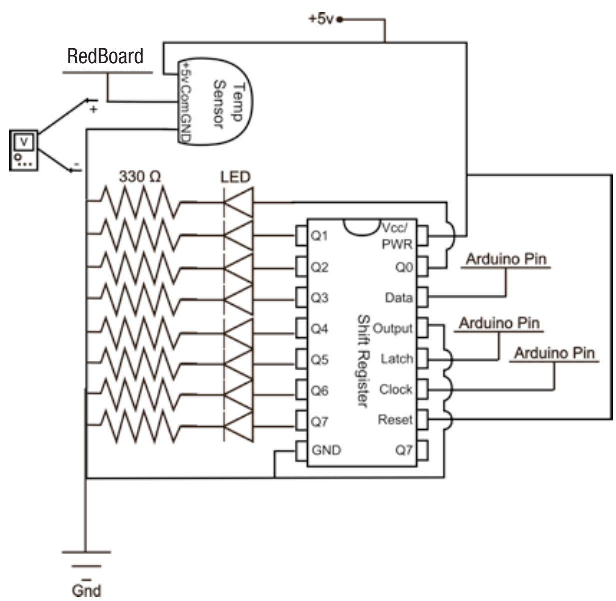
8.

-49°F ≈ -45°C V = .027 v LEDs = 0

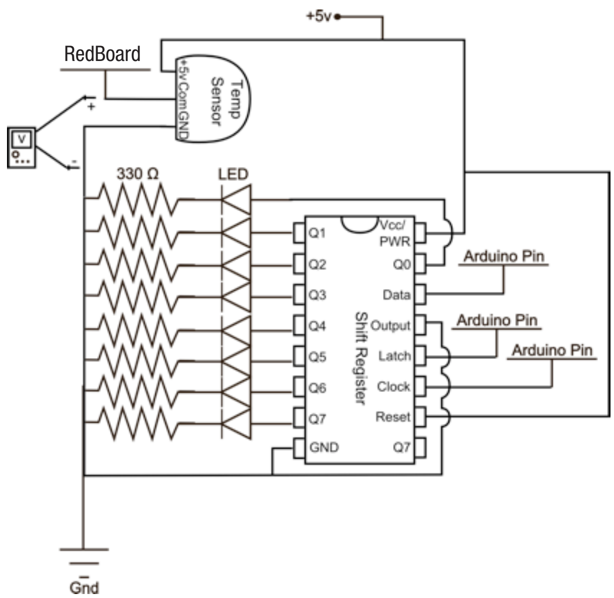
9.

It is impossible to get a reading for one of the temperatures above. Place an X beside this value.

Circuit:

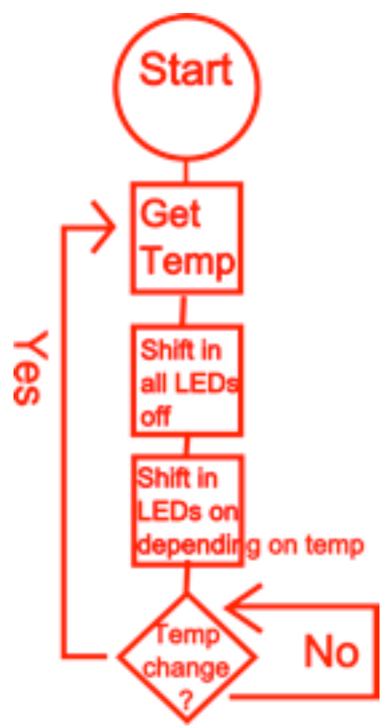


Circuit:



10.

Draw a logic flow chart of the circuit here:



11.

Write the equation below that solves for the change in voltage (V) given a change in temp (X).

V≈.477+X*.01(equation will vary) actual: V=.5+X*.01

equation & answers vary slightly due to sensor variance

12.

There are four main types of temperature sensors, thermocouples, resistance temperature detectors, thermistors, and temperature-transducing ICs. Which one are you playing with and is it analog or digital?

The tmp36 is a resistance temperature detector and an analog sensor,

that's why it plugs into an analog in Arduino pin.

13.

How is this similar to a LED? To a motor?

This is similar to an LED and a motor because it uses analog values. The LED

and motors do not use analog values, but PWM is the digital equivalent.

14.

Find a way to quickly change the temp read by the sensor. How fast can you get it to change by 20°F?

Circuit #8 Single Servo

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Got your servo running? Great.
Upload Circ04Expansion to your RedBoard and add a temperature sensor (pin 0) to your circuit so it controls the position of the servo depending on the temperature.

2.

Decide what the parameters of your temperature gauge will be in Celsius. Find the line of code that controls this and change as necessary.

3.

Using the *delay( );* command change the code so that the speed of the servo is also controlled by the temperature. You can make it move faster or slower depending on the temperature sensor input. Ideally you will only need to change a single line of code to do this. Write the line of code you used below.

delay(temperatureTime); where temperatureTime is a variable produced by altering the temperature reading.

4.

Add a button to the schematic on the right which allows the user to change what aspect of the servo the temperature sensor controls. Extra credit if you can modify the code so your circuit does this in real life.

5.

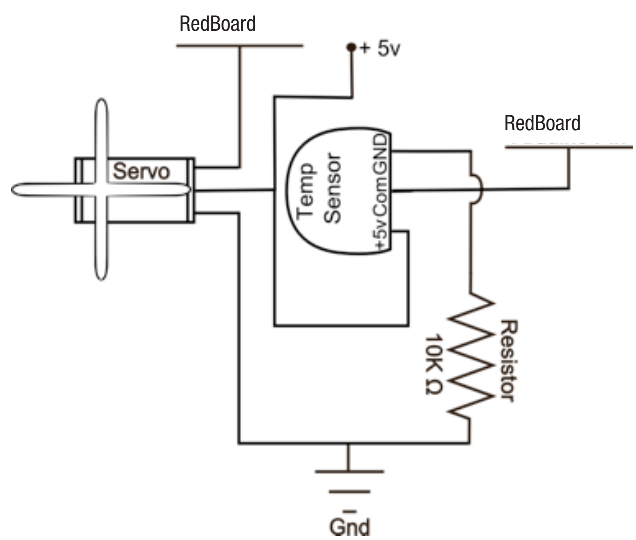
Define a servo mechanism in your own words.

A servo mechanism is a motor that remembers where it is positioned and has designated values for all possible positions. Basically a motor that knows where it is.

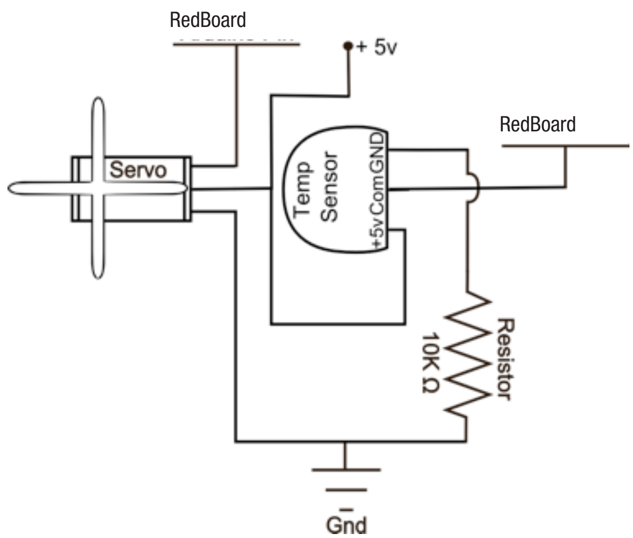
6.

There are many types of servo mechanisms that are not simple motors with position feedback, what is the most complicated servo you can think of?

Circuit:



Circuit:



7.

In your own words explain what this transistor does and the ways in which the motor's action would change if it were hooked up directly to a 5V power source and a ground?

8.

Instead of a temperature sensor you could have added almost any sensor or interface component to your servo. Document at least three other options and explain briefly how you would control the servo.

Mic, no noise: servo to 0 degrees, max noise servo to 180 degrees. Light sensor, no light: servo to 0 degrees. Most light: 180 degrees. Soft potentiometer, all the way on bottom: servo at 0 degrees. All the way at top: servo at 180 degrees. (just 3 examples)

9.

It is possible to do amazing things with servomechanisms. In your own words, explain below how you could use the servo to create an autonomous marshmallow (because they are soft) launcher that corrects its angle depending on where the previous shot landed. Don't worry about how to get data about where the previous marshmallow landed, just explain how the servo would react to a marshmallow that went too far or too short.

Name:
Date:

Circuit #9 Flex Sensor

1.

Now we're starting to work with some more complicated sensors. The flex sensor has tons of real world applications. List three and explain why you can't use a regular potentiometer instead of a flex sensor. Example: use the sensor to measure the flex on a fishing pole and cut the line if the pole ever comes close to breaking. You could not use a potentiometer because it would be difficult to attach it.

____

____

____

____

____

Got your flex sensor and servo working? Great.

Give two values for Voltage, Current and Resistance for each multimeter placement. The first value is without bending the flex sensor and the second is with the flex sensor bent so the sensor creates a half circle. Don't crimp the flex sensor, just bend it. Find Current by breaking the circuit and using the multimeter. Calculate resistance.

2.

Multimeter 1, no bend:

V = 3.68 v I = .12 mA R = 30.66k Ω

3.

Multimeter 1, with bend:

V = 4.5 v I = .03 mA R = 150k Ω

4.

Multimeter 2, no bend:

V = 1.2 v I = .12 mA R = 10k Ω

5.

Multimeter 2, with bend:

V = .3 v I = .03 mA R = 10k Ω

6.

For each multimeter position mark two Xs in additional places where you could attach the multimeter (+ and -) to get these same readings.

7.

Using a protractor to measure the servo angle, and the Serial Monitor to output the analogRead value of the flex sensor. Create a graph that shows correlation. Remember to label your graph.

8.

There are many kinds of flex sensors, list 3.

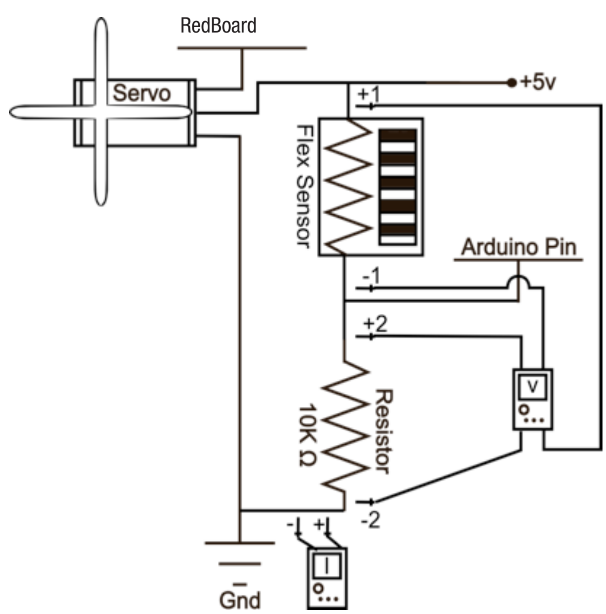
Conductive ink based flex sensor, fibre optic flex sensor, conductive fabric/polymer flex sensor

9.

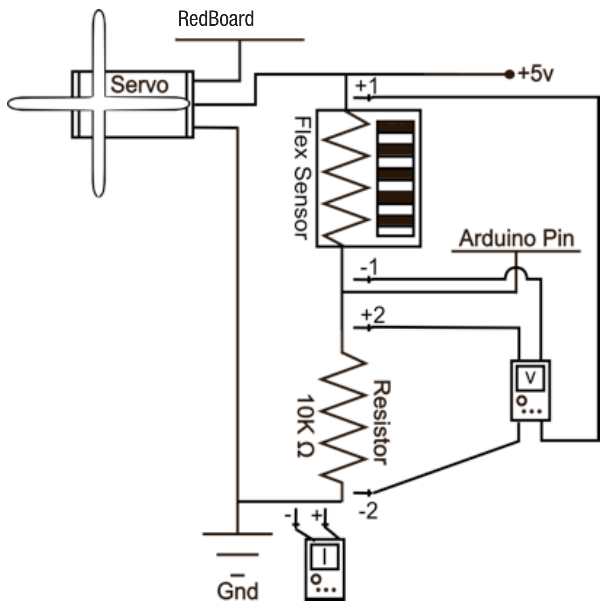
What kind of flex sensor are you working with now?

Conductive polymer

Circuit:



Circuit:



10.

What other kinds of sensors is this similar to?

Similar to a soft trimpot, sort of similar to a potentiometer.

11.

How could you figure out the values for the second multimeter placement given the first set of values?

The current for each of the bend values will be the same for the second set of values, and the voltage for each bend value will be 5v – the voltage through the sensor.

12.

If the flex sensor itself is a resistor, why is the 10K resistor necessary? Explain.

It is necessary because otherwise the Arduino Pin is reading either 5v or 0v because it would be on the power source or ground line. Also without the 10k when the flex sensor's resistance is equal to zero the circuit will short directly to ground.

13.

Take your favorite hypothetical project that you have written about so far in these worksheets, explain how and why you might add at least one flex sensor to this project.

Name:
Date:

Circuit #10 Soft Potentiometer

1.

The soft potentiometer is very touchy; sometimes you will notice incorrect readings due to how you touch the sensor. Be careful not to touch below the sensor pad, you will short out the sensor. Also the sensor reads a value even when you are not touching it. Explain how this alters the ways in which you can use this sensor. Explain at least one possible fix or work around.

The sensor gives a false positive reading when it is not being touched. One possible work around is to make contact at the point where it reads zero (bottom of sensor) whenever the sensor is not in use.

2.

Add the following code to your Arduino code.
In setup: *Serial.begin(9600);*
In loop (at end):

```
Serial.println(sensorValue);
delay(100);
```

3.

Now open the Serial Communication window.
This will let you see the values (slowed down a little with the delay line, to see real time output remove delay(100);) as the soft trimpot outputs them. What happens to the values after you stop touching the sensor? Explain why you think this happens.

The values slowly return to their original value. This is because the two layers tend to stick together.

Give values for sensorValue, Voltage, Current and Resistance for each question. To measure resistance; disconnect trimpot, press area that corresponds to color and attach the multimeter to the com line and ground. Find Current by calculating with Ohm's Law.

4.

RGB in red range: V = 5 - 1 v I = .05 - 2 mA R = 100 - 50 Ω

sensorValue = 1-0'ish

5.

in blue range: V = 4.99-4.9 v I = .47-.467 mA R = 10.6K - Ω

sensorValue = 1023'ish

6.

in green range: V = 1.7-1.3 v I = .34-.325 mA R = 5K-4K Ω

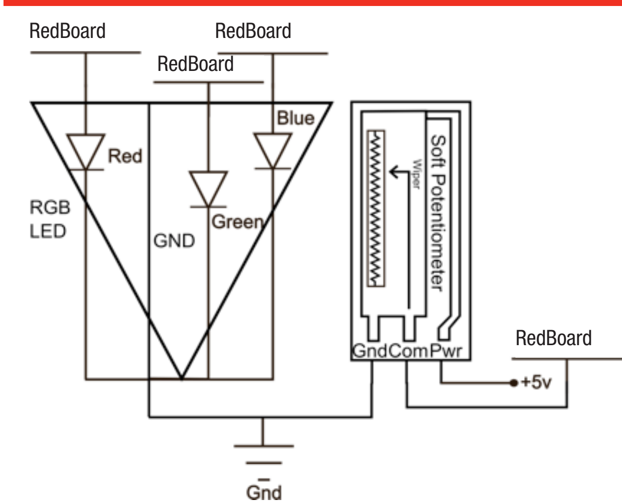
sensorValue = 460'ish

7.

in yellow range: V = 1-.36 v I = .2-.24 mA R = 2K-245'ish Ω

sensorValue = 245'ish

Circuit:



8.

What RGB values do you need to display purple?

9.

Touch the sensor lightly (don't push or hold it) and run your finger from one end to the other. What happens? Why do you think this is? Explain.

The sensor reads about 500 – 600 no matter where you touch it. This is because there is more pressure necessary to close the connection between the layers of the sensor

10.

You can make the RGB LED display red when you touch the bottom and blue when you touch the top by changing two lines of code. Write one these lines of code below as well as what you need to change it to.

int redValue = constrain(map(sensorValue, 0, 512, 255, 0),0,255);_to_int redValue = constrain(map (sensorValue, 512, 1023, 0, 255),0,255);

11.

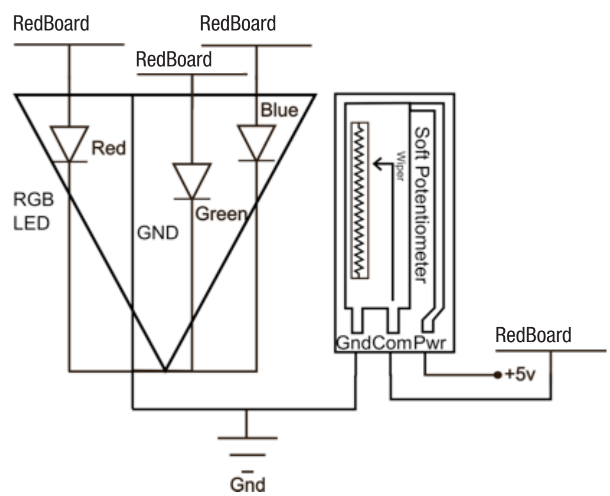
Write an if statement you could add to your *loop()* method that causes the RGB LED to display purple when you touch the absolute top of the trimpot.

if(sensorValue == 1023){analogWrite (RED_LED_PIN, 255) analogWrite (GREEN_LED_PIN, 0) analogWrite (BLUE_LED_PIN, 255)}

12.

Imagine your soft potentiometer is thirty feet long. Explain at least three things you could use it for.

Circuit:



Circuit #11a Piezo Element

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

PWM

Got your incredibly annoying song blaring out of your tiny speaker? Great.

2.

The piezo speaker uses digital pulsing (on or off) to create an analog sound value which can rise or fall in an analog fashion even though it is technically digital. What other digitally simulated analog signal is this similar to?

PWM

3.

Although the action of the piezo speaker is similar to the simulated analog signal, what word or command in the code shows us that it is different? What command would you use if you wanted to use the simulated analog signal instead of the purely digital one?

digitalWrite(speakerPin, value); shows that it is digital.

analogWrite(speakerPin, value); for PWM.

(value can equal either HIGH or LOW)

4.

Is it possible to make the piezo speaker play a note so low that the human ear cannot hear it?

No, you will always hear a tick of some type.

5.

Piezo elements are used for many things other than playing music. In fact you might have a piezo element in your pocket right now. List at least three usages of a piezo element other than a piezoelectric speaker.

Microphone, a knock sensor and an inkjet printer.

There are many, these are the first 3 that I found.

Piezo elements are also in cell phones in pocket

6.

Find and correct the three errors in the code below.

```
void loop() {
for (int i = 0; i < length; i++) {
      if  notes[i] == ' ' {
        delay(beats[i] * tempo); // rest
      } else {
playNote(notes[i], beats[i] *  tempo);
      }
         pause between notes
      Delay(tempo / 2);
   }
 }
```

Uppercase D should be lowercase. Also the two missing ( ) could be two errors. Too tricky? Change it.

7.

Underline all instances of matrices in the code above.

Fun Fact:

There are now digital turntables which manipulate digital sound samples similar to this piezo element. When the sample is slowed down the sample's frequency drops as well due to the increase in gap size between the digital values. When the sample is sped up the pitch rises because the gaps decrease.

8.

There are many different outputs you can couple with this circuit. For example: add a servo with a backdrop to indicate which note is being played, or couple it with an RGB LED that shines a different color depending on where in the scale the note is positioned. Write, in plain English, how you would control a chosen output as well as the piezo component.

9.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

Got your incredibly annoying song blaring out of your tiny speaker? Great.

10.

Now you are going to add volume control to your piezo speaker. First place a 330Ω resistor on the circuit. Draw the two possible schematics of this new circuit to the right. What changes when you add the 330Ω resistor?

The sound gets quieter

11.

Next replace the 330Ω resistor with a 10KΩ resistor. What changes this time? What does this lead you to believe about resistors and the piezo speaker? Explain.

The sound gets even quieter than with the 330 resistor. This means the less voltage that passes through the piezo the quieter the sound that emits from it.

12.

Now replace the resistor with the potentiometer. Measure the resistance of the potentiometer and write below the lowest resistance value it can be set to and the highest resistance value it can be set to.

Lowest resistance: 0 ______ Ω

Highest resistance: 10.19 K ______ Ω

13.

But wait! Can't we just turn down the volume using a lower PWM value in the code? Why are we changing resistors when it's so much easier to just rewrite the code a little? Find the line of code you will need to change to try using PWM to control the volume instead of a resistor and write it below.

digitalWrite(speakerPin, HIGH);

14.

Now actually change the code and listen to the results. Can't hear any difference? Try using a lower PWM value. You should definitely notice a difference now. That's different from changing the volume right? Now use your potentiometer to change the PWM value of the piezo speaker circuit. You will need to change the code to do this. Write the three essential lines of code you used to make this happen below, don't forget semicolons. (Hint, one of them is a variable declaration before the setup() method.)

int trimPotPin = 0; trimPotPinVal = analogRead (trimPotPin);

analogWrite(speakerPin, trimPotPinVal);

15.

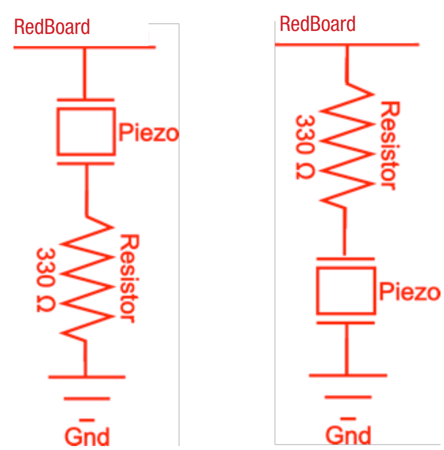
Does your piezo speaker turn off when you turn your potentiometer all the way one way? This is because the analog values go up to 1023 but the PWM only go to 255. You can use the map() method to fix this. Write the line of code which will fix the problem below. (If it still turns off with map, make sure your PWM value never goes all the way down to zero.)

trimPotPinVal = map(trimPotPinVal, 0, 1023, 1, 255);

The effect that changing the PWM has on "Twinkle, Twinkle Little Star" is kind of like an effect that many musicians use in on their instruments in modern music. What is that effect?

16.

Distortion



Circuit #12 Spinning Motor

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

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Got your motor running?
Upload Circ03Expansion Code to your RedBoard. Fill in the answers below.

Give Voltage values for each PWM value listed at each multimeter location. You will need to change the code to measure the PWM values listed.

2.

Position 1:

PWM @ 100%, V = 3.65 v

3.

Position 1:

PWM @ 75%, V = 2.44 v

4.

Position 2:

PWM @ 100%, V = 1.06 v

5.

Position 2:

PWM @ 75%, V = 2.28 v

6.

Position 3:

PWM @ 100%, V = 4.76 v

7.

Position 3:

PWM @ 75%, V = 4.81 v

8.

Position 4:

PWM @ 100%, V = 4.74 v

9.

Position 4:

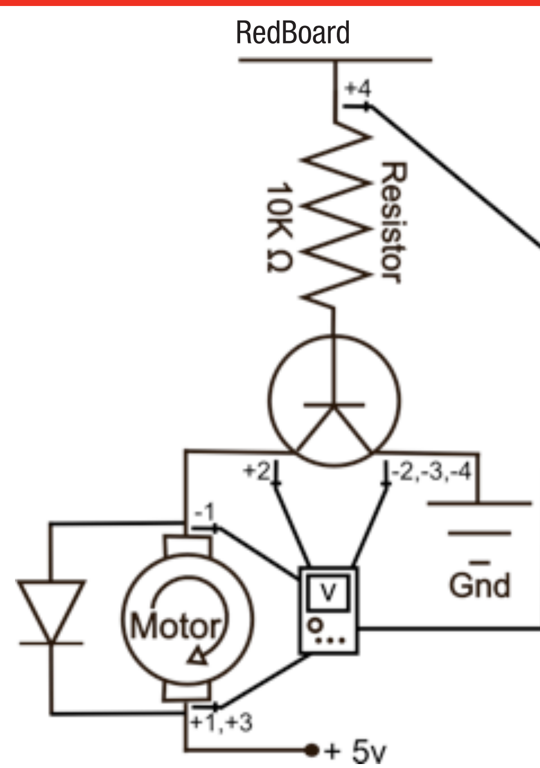
PWM @ 75%, V = 3.56 v

10.

The amount the voltage decreases as it passes through components is called voltage drop. What is the correlation between the various voltage drops you just measured?

PWM @ 100 requires more voltage than 75, except at position # 2, where excess voltage is shunted off. Positions 1 + 2 should equal a little under 5v. Position 3 should also equal a little under 5v.

Circuit:



11.

In your own words explain what this transistor does and the ways in which the motor's action would change if it were hooked up directly to a 5V power source and a ground?

The transistor acts as a switch. The higher the voltage from the Arduino pin the more current the transistor allows through to ground.

12.

Without using any code how could you make the motor run the other direction?

Switch the positive and negative leads on the motor.

A Little History:

13.

The word transistor is a combination of what two words?

Transfer and resistor.

14.

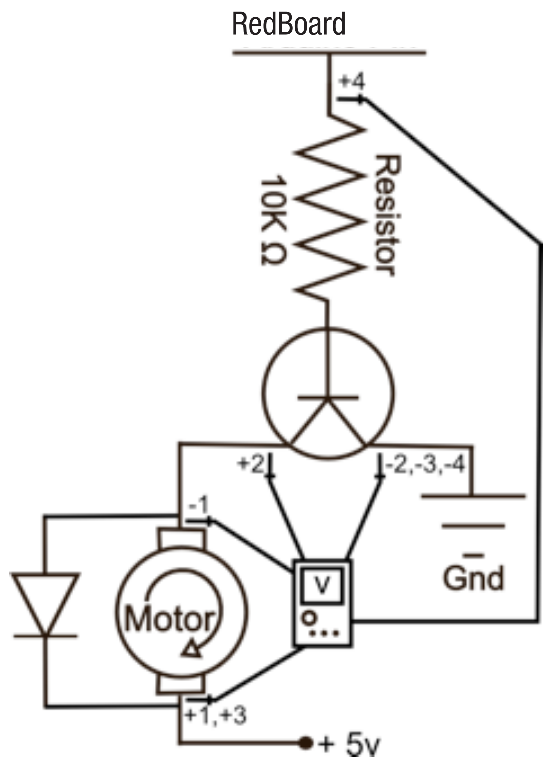
What was the first type of transistor to be mass produced, and by who?

Silicon transistors mass produced by Texas Instruments.

15.

Transistors are used in almost ever piece of modern electronics and considered one of the most important inventions of the 20th century. What are some of your favorite items that contain a transistor? Name at least five.

Circuit:



Circuit #13 Relays

1.

How is this circuit, or a circuit like it, used in everyday life? Provide at least three examples.

____

____

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____

____

Does your relay work? Great.

2.

There are many different types of relays. List at least three and explain the differences between them.

Latching: coils that set 2 states. Reed: contact closes due to magnetic field. Mercury-wetted: used for signal of 1 volt or less. Polarized: switch between 2 magnets for high sensitivity. Machine tool: used for sequential control, large # of contacts. Contactor: for switching large loads. Solid-state: No moving parts. Buchholz: safety device for sensing gas.

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3.

Give values for Voltage, Current and Resistance for the multimeter position shown. Break the circuit or use Ohm's law to solve for current and resistance. You should get two different sets of values depending on the action of the relay.

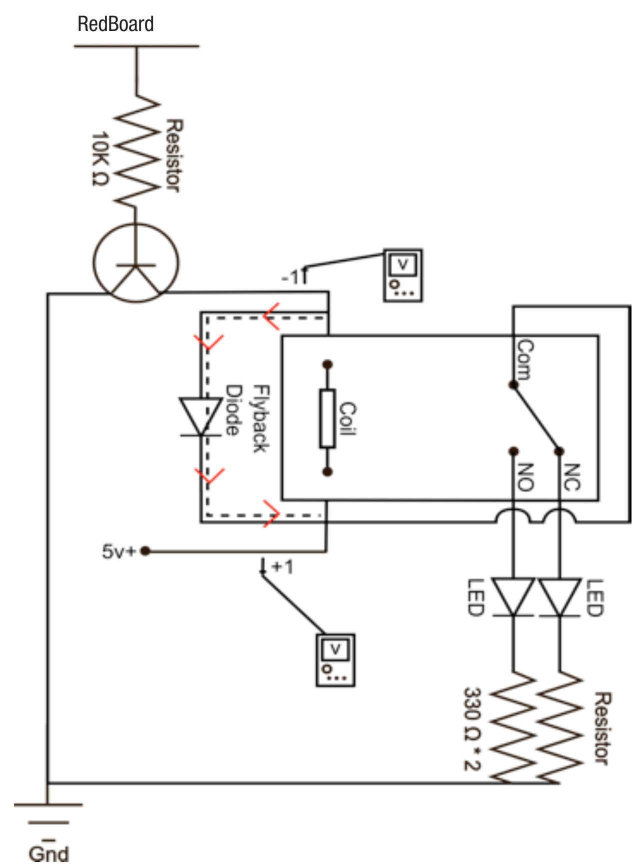
4.

Value # 1:
V = 2.6 v I = 46.5 mA R = 56.8 Ω

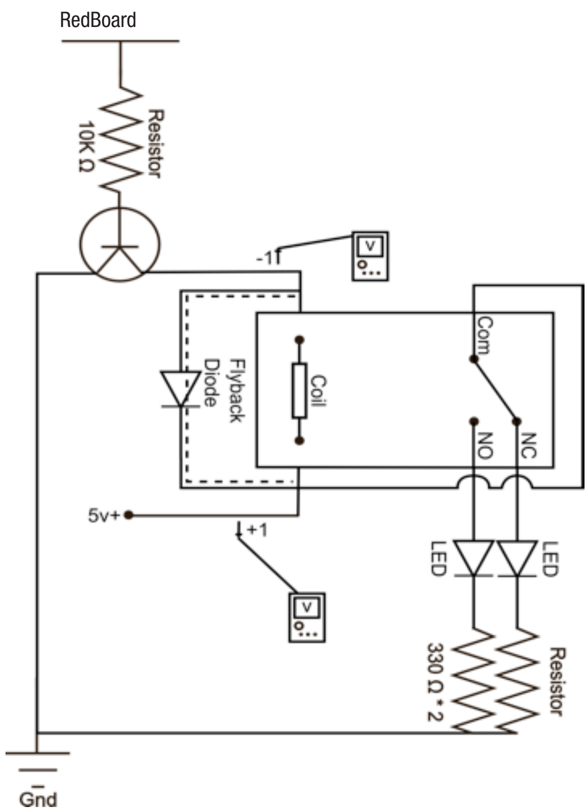
5.

Value # 2:
V = .1 v I = .002 mA R = 56.8 Ω

Meter 1:



Meter 1:



6.

Draw arrows on the dotted line to show possible direction of current flow when RedBoard is turned off.

7.

Explain the two sets of values for the Voltage, Resistance and Current and what each set does.

One of the sets turns the relay to NC and the other turns it to NO. The higher voltage value turns the relay to NO (normally open) and the lower value turns it to NC (normally closed).

8.

Explain how a diode effects the current flow of a circuit.

A diode only allows current flow in one direction, the direction the triangle points, in this case down.

9.

Given what you answered above, explain what you think is the reason for the Flyback Diode, also explain what might happen without this Flyback Diode.

The flyback diode protects against current spikes that may occur when the Arduino Pin is turned off or unplugged. Without the flyback diode these spikes could damage the coil in the relay.

10.

What machine houses your favorite relay? Why is it your favorite relay? Because of the machine that houses it? Because it keeps someone safe? Because it's really big and powerful? Explain.

Circuit #14a Shift Register

1.

The byte in this circuit's shift register is used to turn LEDs on and off. It can also be used to represent many other types of data in binary. Explain how a number is written in binary, then write the number nine using ones and zeros.

A number is written in binary by representing it in base 2 mathematics. For example one is 1 but two is 10 and 4 is 100 and 5 is 101 and 9 is 1001. It's easier to show than to explain.

Does your shift register light up all the LEDs in a pattern? Great.

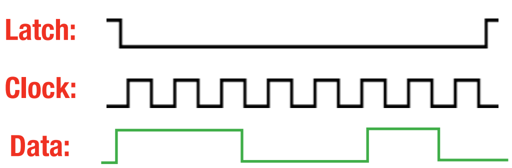
2.

Explain why the shift register needs the clock pin as part of how it operates.

The clock tells the shift register when to shift a new set of data in because it is ready to accept data for a new pin. When the clock rises a pin is set.

3.

Fill in the diagram below if you were trying to shift in the following bits for data: 11100110



4.

On the schematic to the right label the most significant bit's pin with MSB and the least significant bit's pin with LSB.

Most Significant Bit:	Least Significant Bit:

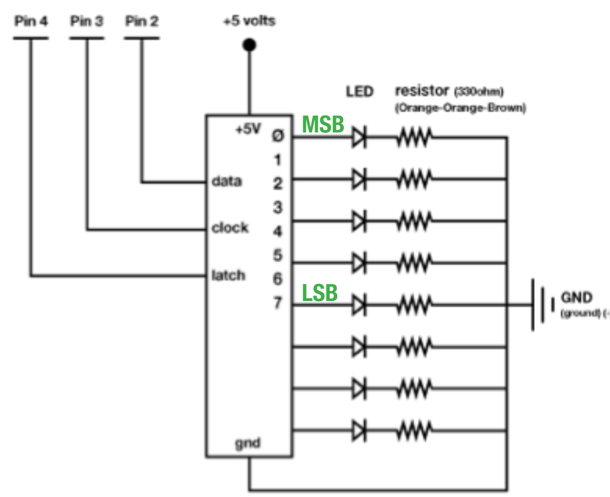
(MSB) → 10110100 ← (LSB)

5.

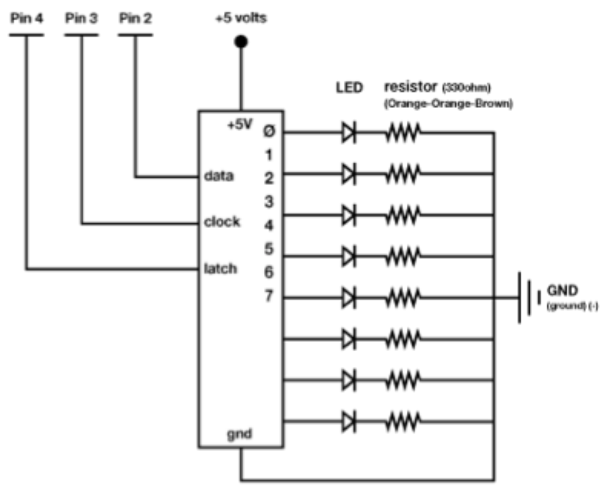
While shifting bits in and out of your chip you can move them so you drop either the MSB, or the LSB. Assuming you drop the LSB and are adding a 1 to the byte above, what is the resulting byte?

11011010

Circuit:



Circuit:



A Little History:

6.

What was one of the first known uses of the shift register?

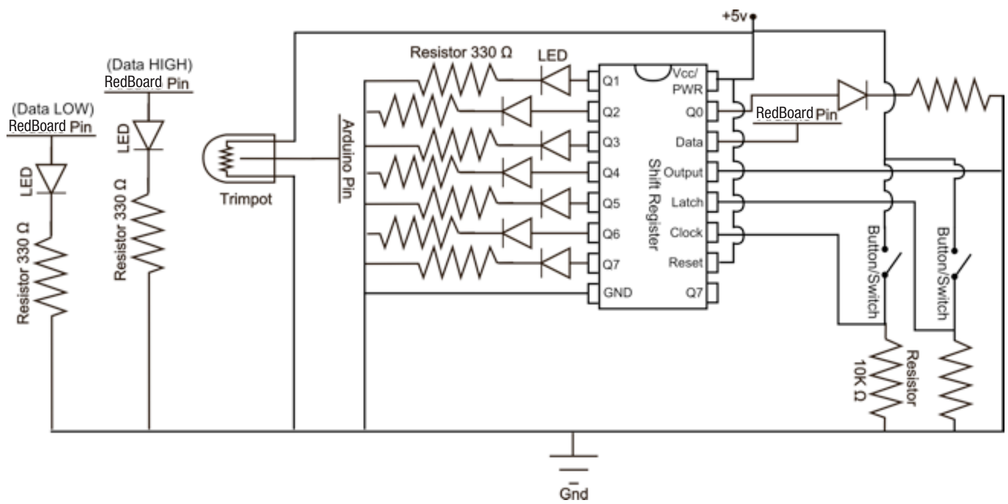
One of the first know uses was in Colossus, a code breaking machine in the 1940s. It was used during WWII by the British to decode intercepted German communication

7.

This shift register and LED combination is a powerful display or interface circuit. Explain a sensor or two you might attach to this circuit and what the LEDs attached to the shift register would signify. Example: connect a mic and each LED would represent a different musical note heard by the mic.

Circuit #14b Shift Register

Circuit:



1.

The byte in this circuit's shift register is used to turn LEDs on and off. It can also be used to represent many other types of data in binary. Explain how a number is written in binary, then write the number fifteen using ones and zeros.

A number is written in binary by representing it in base 2 mathematics. For example one is 1 but two is 10 and 4 is 100 and 5 is 101, 9 is 1001 and 15 is 1111. It's easier to show than to explain.

Does your shift register light up all the LEDs in a pattern?

Upload Circ05Expansion to your Arduino and add two buttons, two LEDs and a trimpot to your circuit, use the schematic for reference.

Your two buttons now pulse the clock and latch the shift register. Make sure you don't confuse the two! You will use the trimpot to set your data either HIGH or LOW. Play with the trimpot to figure out which setting is HIGH and which is LOW. One of the indicator LEDs will light up depending on which value it represents. Then use the clock pulse button to send the data value to the shift register. To see the data that you have shifted into the register so far hit the latch button. To really get a feel for how shift registers work first set all the LEDs LOW, then start playing with different patterns of data values.

Before answering the questions below set all your pins all back to LOW, or off (Remember, LOW == 0)

2.

Try setting just one data pin before hitting the latch button. What happens?

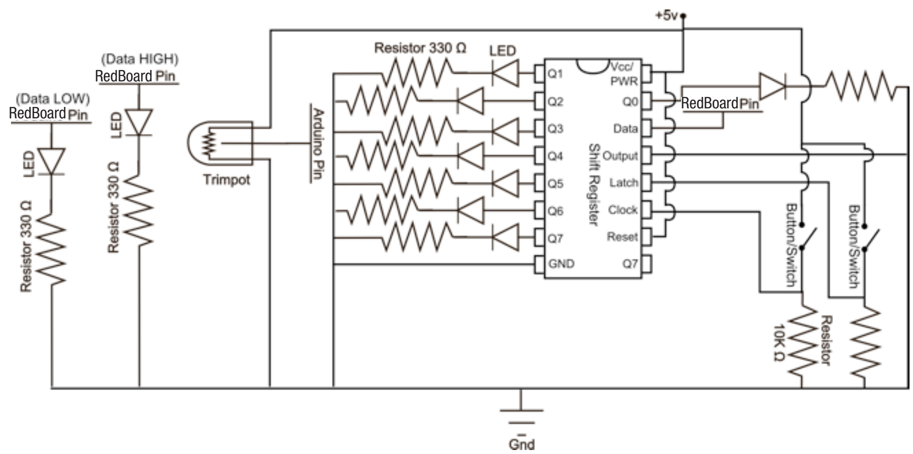
One LED changes.

3.

Try setting eight data pins before hitting the latch button. What happens?

All eight LEDs change.

Circuit:



4.

Now set seven data pins before hitting the latch button. What happens this time?

Seven LEDs change.

5.

Now enter nine bits in the following order: 0,1,0,0,1,1,0,0,0. What does your LED pattern look like? Answer in binary.

01001100

6.

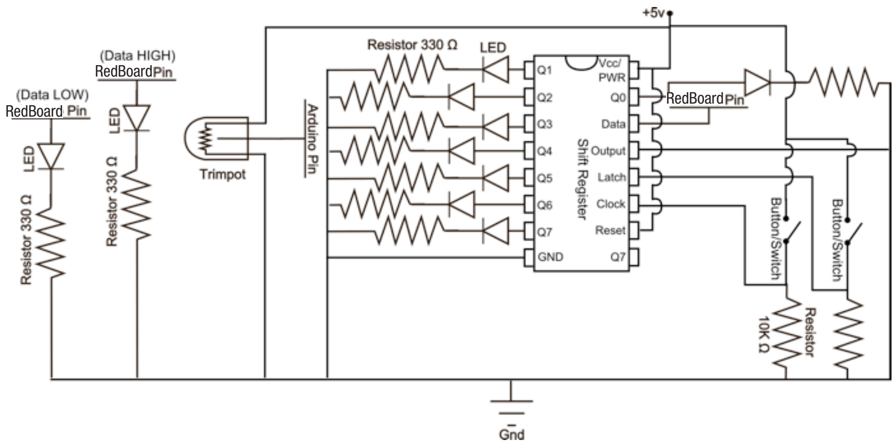
Explain how the LED pattern and shift register would act if you were shifting out the Most Significant Bit instead of the Least Significant Bit. Find the one command or word you would need to change in the code to make this happen and write it below.

If one shifted out the Most Significant Bit instead of the least significant bit the LED pattern would shift in the opposite direction. If it was going from left to right before, it would shift from right to left instead. shiftOut(data, clock, MSBFIRST, value); would change to: shiftOut(data, clock, LSBFIRST, value);

MSBFIRST to LSBFIRST also works

Circuit #14c Shift Register

Circuit:



Got your shift register lighting up all the LEDs in a pattern?
Upload Circ05Expansion to your Arduino and add two buttons, two LEDs and a trimpot to your circuit, use the schematic for reference.

Your two buttons now pulse the clock and latch the shift register. You will use the trimpot to set your data either HIGH or LOW. Play with the trimpot to figure out which setting is HIGH and which setting is LOW. One of the indicator LEDs will light up depending on the value. Then use the clock pulse button to send the data value to the shift register. To see the data that you have shifted into the register so far hit the latch button.

Before answering the questions below set your data pins all back to LOW, or off (Remember, LOW == 0)

1.

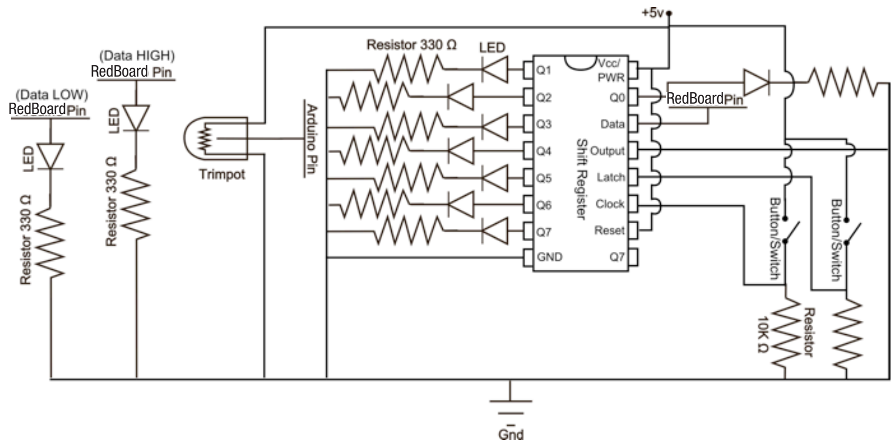
Which circuit, original or expanded makes more sense to you?

2.

Using this interface you have more control over the shift register than the original code. Explain the difference between this circuit and the original. Use examples from the original code and explain what physical element has replaced it. Also explain what the various states of the components are.

In the expanded circuit the latch pin has been replaced by one of the buttons. When the button is not pressed it is HIGH and when it is pressed it LOW. This way the circuit is always ready for data. The data pin has been replaced by the potentiometer with the two LEDs to show if the "data" is HIGH or LOW. Lastly the clock has been replaced by the other button which is HIGH unless pushed

Circuit:



3.

Because you decide when to "latch" your data in you can control all the pins in any order you like as long as you "clock" in the proper sequence. This lets you decide which pins are ON or OFF without having to cycle through them all. Decide on eight different circuits (or objects) you would like to turn on and off using a register and then explain at least two different patterns you would send the shift register to control these objects. Use binary to write the patterns. Example: servo, servo, egg beater motor, spray on butter object, servo, waffle iron, servo, hot plate. 1111100: first two servos pour ingredients, egg beater mixes, butter sprays on waffle iron which is heating up, servo and hot plate off. 00000111: first two servos reset, egg beater off, no butter, waffle iron stays on, servo tilts waffle off of iron onto hot plate which keeps waffle warm. Note: Zero does not always mean off, it can make the circuit (or object) do something else, like reset a servo position or squirt syrup instead of butter.

Name:
Date:

Circuit #10 Soft Potentiometers

Soft potentiometers come in a bunch of shapes and sizes. Explain how you could combine two soft potentiometers, two servos and a slingshot to create a machine that launches marshmallows (because they are soft) towards wherever the two soft potentiometers tell it to, include a schematic or logic flow chart in the blank section .... or just go build one instead of explaining how it might work. You've finished the SIK, what are you waiting for? In fact, forget these guiding questions, if you want just use this page to brainstorm what your next project will be.

Circuit #10 Soft Potentiometers

Name:
Date:

PWM

We know by now that PWM is represented in Arduino language as a value somewhere between 0 and 255. We also know that the PWM signal is just the RedBoard turning the PWM pin ON, or HIGH, then LOW, or OFF, a bunch of times really, really fast. The thing is the computer can turn the signal HIGH and LOW a lot faster than a human can follow. So what does the PWM signal look like to us and how can we measure it? Good question. Upload the PWM Expansion Code to your Arduino, attach PWM pin # 9 to ground on your breadboard and measure the voltage between the two wires. Switch values and reload the code as necessary to fill in the table below.

Fill in the table below:

Percentage:	0	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
PWM value:	0	25.5	51.0	76.5	102.0	127	152.5	178.5	204.0	229.5	255

What is the equation you use to convert the percentage to PWM values and back again?

(%val * 255) = PWM value

Why does the PWM value only go up to 255 if it represents 256 different values?

Map(%val, 0, 100, 0 , 255)= convertedValue (variable name) convertedValue may differ

Often you will use analog sensors with your digital microprocessor. These analog sensors are even more difficult than the PWM signal. They talk to the microprocessor in 1024 little pieces!

Fill in the table below:

Percentage:	0	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Analog value:	0					511					1023

What is the equation you use to convert the percentage to analog values and back again?

(%val * 1023) = analog value

Fill in the table below:

Percentage:	0%	25%	50%	75%	100%
PWM value:	0				255
Analog value:	0				1023

What is the relationship between the analog and PWM value? Explain with words or math.

Analog is more or less 4 times PWM. PWM ≈ Analog * .25

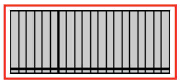
What is one advantage to representing an analog sensor's value with 1024 numbers instead of just 100?

There is more resolution with 1024 numbers instead of 100.

Name:
Date:

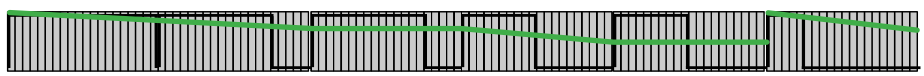
PWM

Below are a bunch of different PWM wave diagrams.
The “window” is this size:

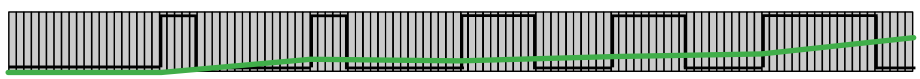


Record below each wave diagram the starting value in the unit given, the highest value the PWM wave reaches (PWM value, 0 - 255), the lowest value the PWM wave reaches (PWM value, 0 - 255), and the ending value of the wave diagram. Finally, draw a line through the diagram showing the PWM value as it rises and falls.

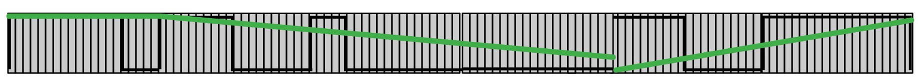
Remember for the SIK PWM values: 100% = 255 PWM = 1.8mV

1.


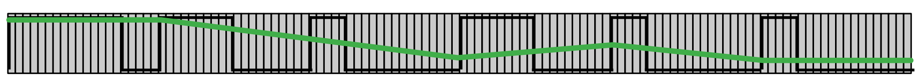
255 starting PWM 255 Highest PWM 64 Lowest PWM 64 ending PWM

2.


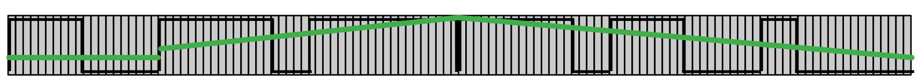
0 starting % 192 Highest PWM 0 Lowest PWM 75 ending %

3.


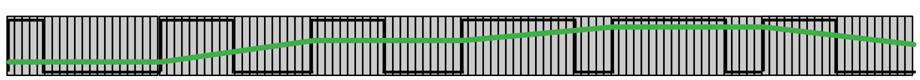
3.78V starting voltage 255 Highest PWM 0 Lowest PWM 5.05V ending voltage

4.


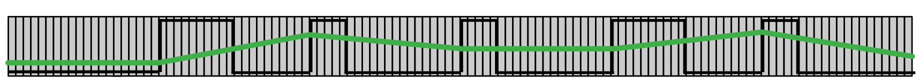
192 starting PWM 192 Highest PWM 64 Lowest PWM 64 ending PWM

5.


50 starting % 255 Highest PWM 64 Lowest PWM 25 ending %

6.


1.26V starting voltage 192 Highest PWM 64 Lowest PWM 2.53V ending voltage

7.


0 starting PWM 128 Highest PWM 64 Lowest PWM 64 ending PWM

These PWM windows are nicely divided into ten sections so you can count out the windows and figure out the PWM values and percentages easier. Real PWM signals are not so convenient and are usually represented by one of the following with no diagram: the PWM value, a percentage, or a voltage value.

CHAPTER 6 **Name:**

Using a Multimeter **Date:**

PWM

We know by now that PWM is represented in Arduino language as a value somewhere between 0 and 255. We also know that the PWM signal is just the Arduino turning the PWM pin ON, or HIGH, then LOW, or OFF, a bunch of times really, really fast. The thing is the computer can turn the signal HIGH and LOW a lot faster than a human can follow. So what does the PWM signal look like to us and how can we measure it? Good question. Upload the PWMExpansion Code to your Arduino, attach PWM pin # 9 to ground on your breadboard and measure the voltage between the two wires. Switch values and reload the code as necessary to fill in the table below.

Percentage:	0%	10%	25%	33%	50%	66%	75%	80%	90%	100%
PWM value:	0	25.5	63.75	85	127.5	170	191.25	204	229.5	255
Analog Value	0	102.3	255.75	341	511.5	682	767.25	818.4	920.7	1023
Voltage (mV)	0	0	1.26	1.68	2.53	3.36	3.78	4.04	4.53	5.05

One of the easiest ways to find a correlation between numbers is to look at a lower set of values and compare them to a larger set of values with a common denominator. Look at all the values for 10% and then look at all the values for 100%. If there is a pattern it should be easier to see it with these two set of values simply because they are different by a factor of 10, or one decimal place.

Using the table above create an equation that you can use to change PWM or Percentage into an analog value. Don't forget that zero is a value in PWM and analog.

% to analog: (%val * 10.23) = analog__PWM to analog: (PWMval/255*1023)________________=analog value

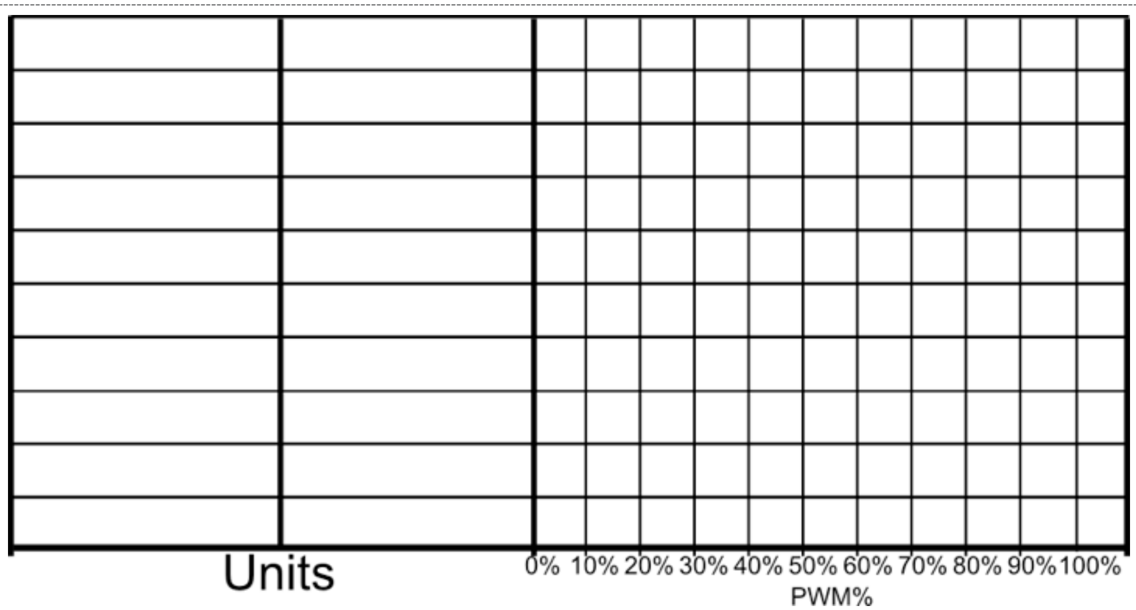
Using the table above create an equation that you can use to change a PWM or Percentage value into a voltage value. Take into account any difference in units that may make the math weird.

PWM to voltage:PWMval/255*5.05=voltage
__________% into voltage: %val * 5.05________________=voltage (mV)

Now, you should be able to mash these two equation together into one equation that you can use to convert from analog to voltage. Think this is tough? Lucky we're not using a temperature sensor and making you also convert Fahrenheit and Celsius and resistance values! Write your equation below.

analogValue/1023*5.05=VoltageValue

Using your equations fill in the line graph below for the analog and voltage variables above. Label your graph wherever you think necessary. Use a different color for the analog and voltage lines.



Name:
Date:

PWM

Write below these different values whether they are a PWM value, an analog sensor value, a percentage or a voltage. Then match each value below with the PWM wave diagram that best represents them by drawing a line from the value to the diagram.

50%
percent

5.05V
voltage

analogWrite(pin, 64)
PWM

analogRead(pin)= 768
analog

511
analog

194 out of 256
PWM

.45mV
voltage

100 out of 100
percent