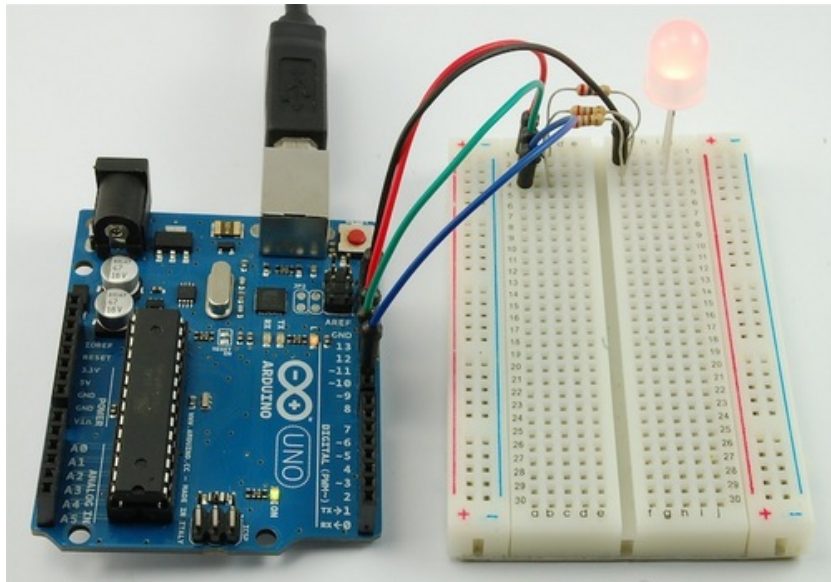


## Arduino Lesson 3. RGB LEDs

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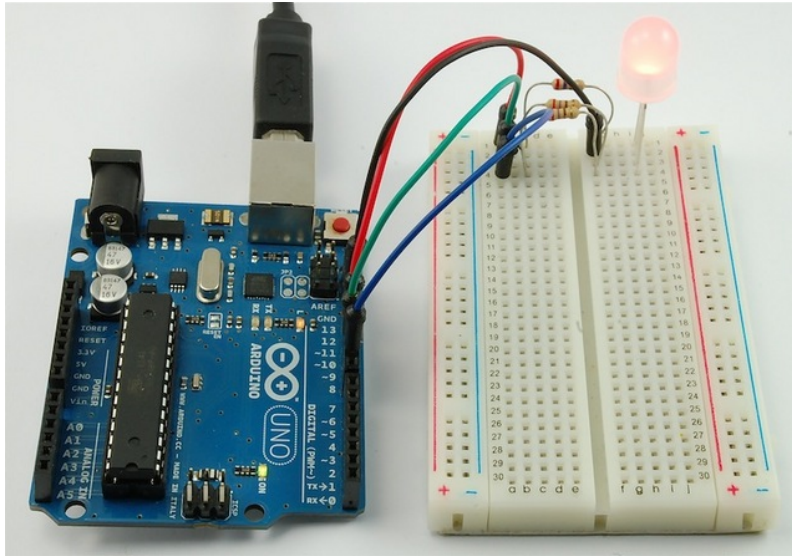
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## Overview

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In this lesson, you will learn how to use a RGB (Red Green Blue) LED with an Arduino.

You will use the *analogWrite* function of Arduino to control the color of the LED.



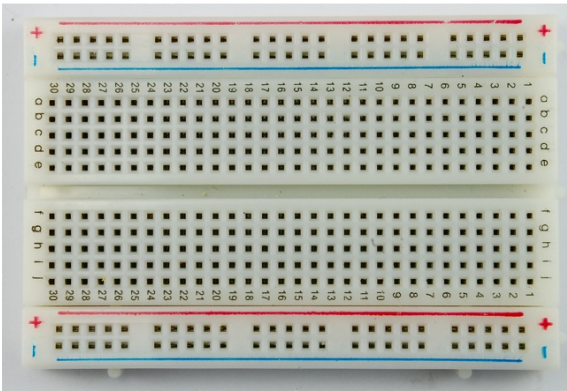


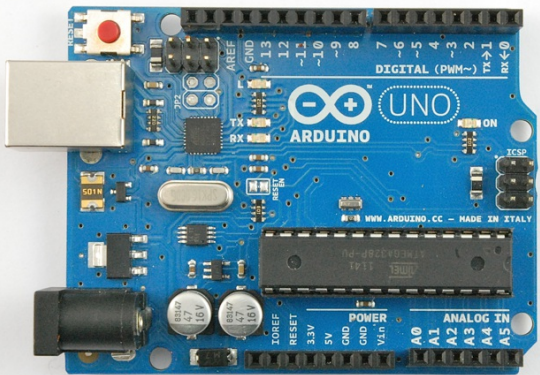
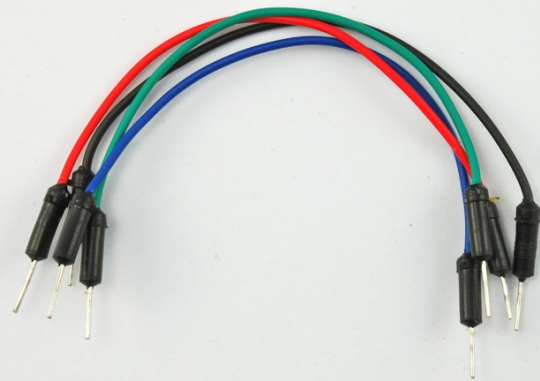
At first glance, RGB (Red, Green, Blue) LEDs look just like regular LEDs, however, inside the usual LED package, there are actually three LEDs, one red, one green and yes, one blue. By controlling the brightness of each of the individual LEDs you can mix pretty much any color you want.

We mix colors just like you would mix audio with a 'mixing board' or paint on a palette - by adjusting the brightness of each of the three LEDs. The hard way to do this would be to use different value resistors (or variable resistors) as we played with in lesson 2. That's a lot of work! Fortunately for us, the Arduino has an *analogWrite* function that you can use with pins marked with a ~ to output a variable amount of power to the appropriate LEDs.

## Parts

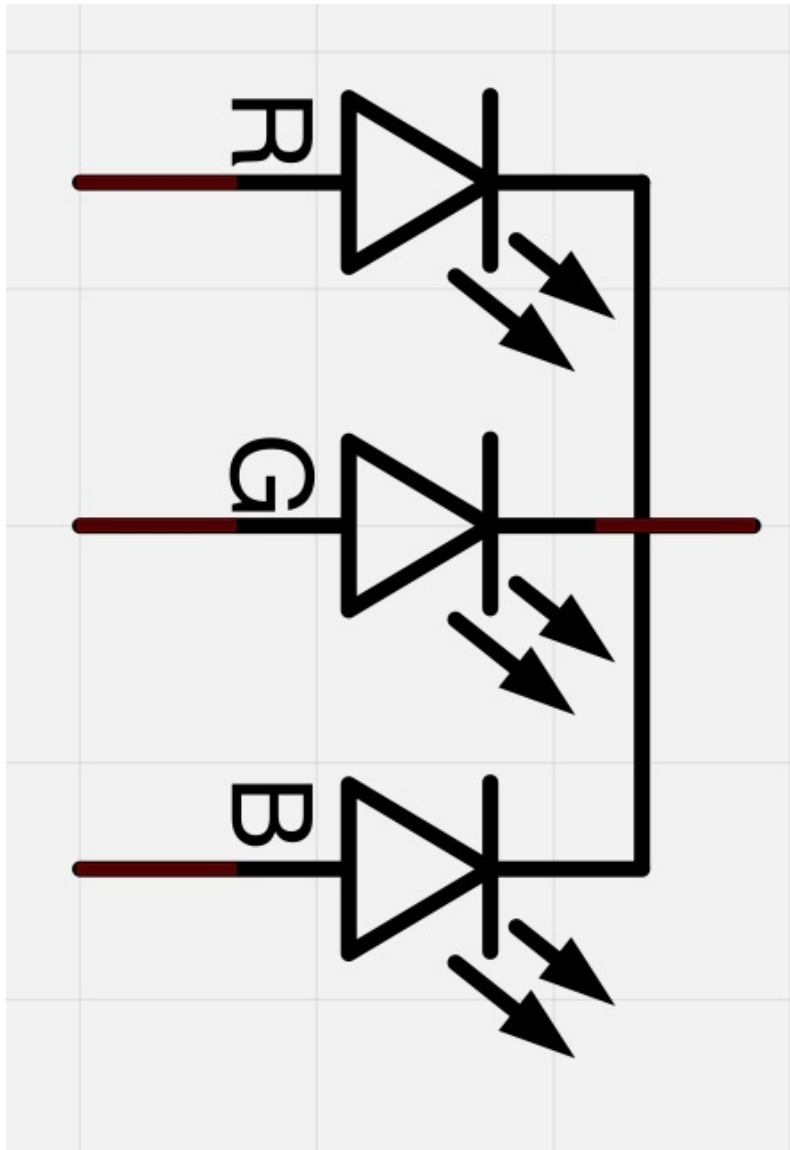
To build the project described in this lesson, you will need the following parts.

	Part	Qty
	Diffuse RGB LED 10mm	1
	270 $\Omega$ Resistors (red, purple, brown stripes) - you can use up to 1K ohm although it will be a little dimmer	3
	Half-size Breadboard	1

	<p>Arduino Uno R3</p>	<p>1</p>
	<p>Jumper wire pack</p>	<p>1</p>

## Breadboard Layout

The RGB LED has four leads. There is one lead going to the positive connection of each of the single LEDs within the package and a single lead that is connected to all three negative sides of the LEDs.

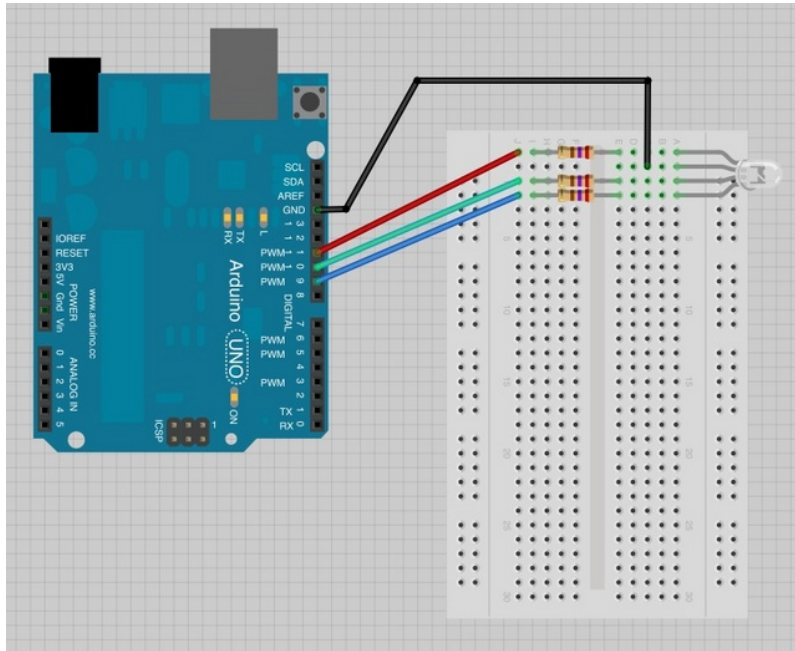


The common negative connection of the LED package is the second pin from the flat side of the LED package. It is also the longest of the four leads. This lead will be connected to ground.

Each LED inside the package requires its own  $270\Omega$  resistor to prevent too much current flowing through it. The three positive leads of the LEDs (one red, one green and one blue) are connected to Arduino output pins using these resistors.

If you are using a common ANODE LED instead of common CATHODE, connect the

long pin to +5 instead of ground

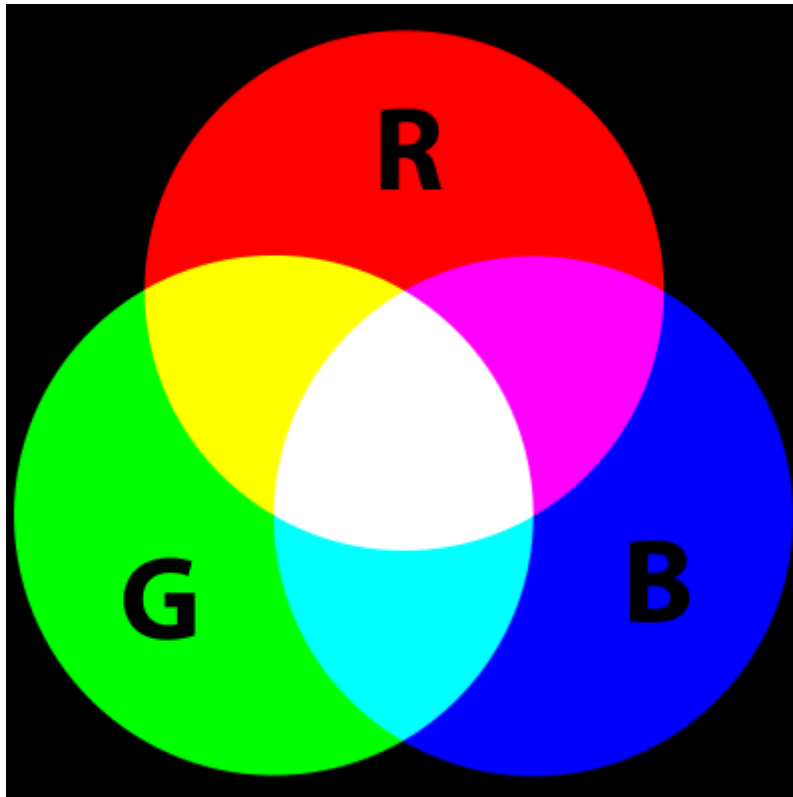


## Colors

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The reason that you can mix any color you like by varying the quantities of red, green and blue light is that your eye has three types of light receptor in it (red, green and blue). Your eye and brain process the amounts of red, green and blue and convert it into a color of the spectrum.

In a way, by using the three LEDs we are playing a trick on the eye. This same idea is used in TVs, where the LCD has red, green and blue color dots next to each other making up each pixel.



If we set the brightness of all three LEDs to be the same, then the overall color of the light will be white. If we turn off the blue LED, so that just the red and green LEDs are the same brightness, then the light will appear yellow.

We can control the brightness of each of the red, green and blue parts of the LED separately, making it possible to mix any color we like.

Black is not so much a color as an absence of light. So the closest we can come to black with our LED is to turn off all three colors.



## Arduino Sketch

The following test sketch will cycle through the colors red, green, blue, yellow, purple, and aqua. These colors being some of the standard Internet colors.

```
/*  
Adafruit Arduino - Lesson 3. RGB LED  
*/  
  
int redPin = 11;  
int greenPin = 10;  
int bluePin = 9;  
  
void setup()  
{  
  pinMode(redPin, OUTPUT);  
  pinMode(greenPin, OUTPUT);  
  pinMode(bluePin, OUTPUT);  
}  
  
void loop()  
{  
  setColor(255, 0, 0); // red  
  delay(1000);  
  setColor(0, 255, 0); // green  
  delay(1000);  
  setColor(0, 0, 255); // blue  
  delay(1000);  
  setColor(255, 255, 0); // yellow  
  delay(1000);  
  setColor(80, 0, 80); // purple  
  delay(1000);  
  setColor(0, 255, 255); // aqua  
  delay(1000);  
}  
  
void setColor(int red, int green, int blue)  
{  
  analogWrite(redPin, red);  
  analogWrite(greenPin, green);  
  analogWrite(bluePin, blue);  
}
```

Try the sketch out and then we will dissect it in some detail.....

The sketch starts by specifying which pins are going to be used for each of the colors:

```
int redPin = 11;  
int greenPin = 10;  
int bluePin = 9;
```

The next step is to write the 'setup' function. As we have learnt in earlier lessons, the setup function runs just once after the Arduino has reset. In this case, all it has to do is define the three pins we are using as being outputs.

```
void setup()
{
  pinMode(redPin, OUTPUT);
  pinMode(greenPin, OUTPUT);
  pinMode(bluePin, OUTPUT);
}
```

Before we take a look at the 'loop' function, let's look at the last function in the sketch.

```
void setColor(int red, int green, int blue)
{
  analogWrite(redPin, red);
  analogWrite(greenPin, green);
  analogWrite(bluePin, blue);
}
```

This function takes three arguments, one for the brightness of the red, green and blue LEDs. In each case the number will be in the range 0 to 255, where 0 means off and 255 means maximum brightness. The function then calls 'analogWrite' to set the brightness of each LED.

If you look at the 'loop' function you can see that we are setting the amount of red, green and blue light that we want to display and then pausing for a second before moving on to the next color.

```
void loop()
{
  setColor(255, 0, 0); // red
  delay(1000);
  setColor(0, 255, 0); // green
  delay(1000);
  setColor(0, 0, 255); // blue
  delay(1000);
  setColor(255, 255, 0); // yellow
  delay(1000);
  setColor(80, 0, 80); // purple
  delay(1000);
  setColor(0, 255, 255); // aqua
  delay(1000);
}
```

Try adding a few colors of your own to the sketch and watch the effect on your LED.

If you are using a Common Anode RGB LED, then you will need to change the analog write values so that the color is subtracted from 255, like this: `analogWrite(redPin, 255-red);` for each of the three colors.



## Using Internet Colors

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If you have done any Internet programming, you will probably be aware that colors are often represented as a 'hex' number. For example the color red has the number #FF0000. You can find the numbers associated with a particular color using tables like these:

<http://www.devguru.com/features/colors> (<http://adafru.it/aZ6>)

The six digits of the number are actually three pairs of numbers; the first pair being the red component of the color, the next two digits the green part and the final pair the blue part. Red is #FF0000, because its maximum red (FF is 255 in hex) and it has no green or blue part.

It would be pretty useful to be able to dial up one of these color numbers so that it is displayed on the RGB LED.

Let's try and make the color indigo (#4B0082).



The red, green and blue parts of indigo are (in hex) 4B, 00 and 82 respectively. We can plug those into the 'setColor' function like this:

```
setColor(0x4B, 0x0, 0x82); // indigo
```



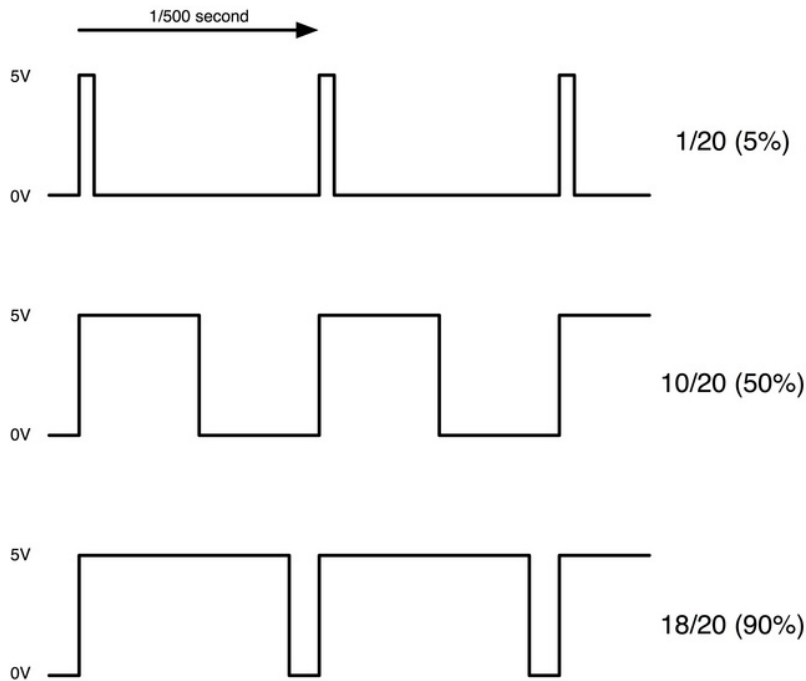
We have used hex numbers for the three parts of the color by putting '0x' in front of them.

Try adding a few colors of your own to the 'loop' function. Don't forget to add a delay after each one.

## Theory (PWM)

Pulse Width Modulation (or PWM) is a technique for controlling power. We also use it here to control the brightness of each of the LEDs.

The diagram below shows the signal from one of the PWM pins on the Arduino.



Roughly every 1/500 of a second, the PWM output will produce a pulse. The length of this pulse is controlled by the 'analogWrite' function. So 'analogWrite(0)' will not produce any pulse at all and 'analogWrite(255)' will produce a pulse that lasts all the way until the next pulse is due, so that the output is actually on all the time.

If we specify a value in the analogWrite that is somewhere in between 0 and 255 then we will produce a pulse. If the output pulse is only high for 5% of the time then whatever we are driving will only receive 5% of full power.

If however the output is at 5V for 90% of the time then the load will get 90% of the power delivered to it. We cannot see the LEDs turning on and off at that speed, so to us, it just looks like the brightness is changing.

## Other Things to Do

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- Try putting a ping-pong ball over the LED
- Try changing the delays to speed up or slow down the color changing

There are lots of things you can do with RGB LEDs. Check out some of the projects on the Internet using RGB LEDs and you will find multi-color persistence of vision devices, as well as all sorts of lighting effects.

### About the Author

Simon Monk is author of a number of books relating to Open Source Hardware. The following books written by Simon are available from Adafruit: [Programming Arduino](http://adafru.it/1019) (<http://adafru.it/1019>), [30 Arduino Projects for the Evil Genius](http://adafru.it/868) (<http://adafru.it/868>) and [Programming the Raspberry Pi](http://adafru.it/aM5) (<http://adafru.it/aM5>).