



Lesson 2 – PWM & Dimming Effect

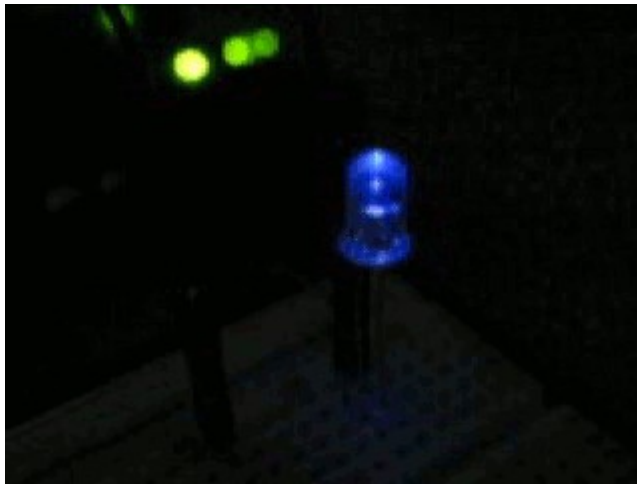
Variables, Loops, and Light Shows*

Light Shows may be omitted due to time constraints.

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Light Control

- In this lesson we will improve the Basic LED project by introducing dimmer effect



Digital vs. Analog

Digital

0 or 1

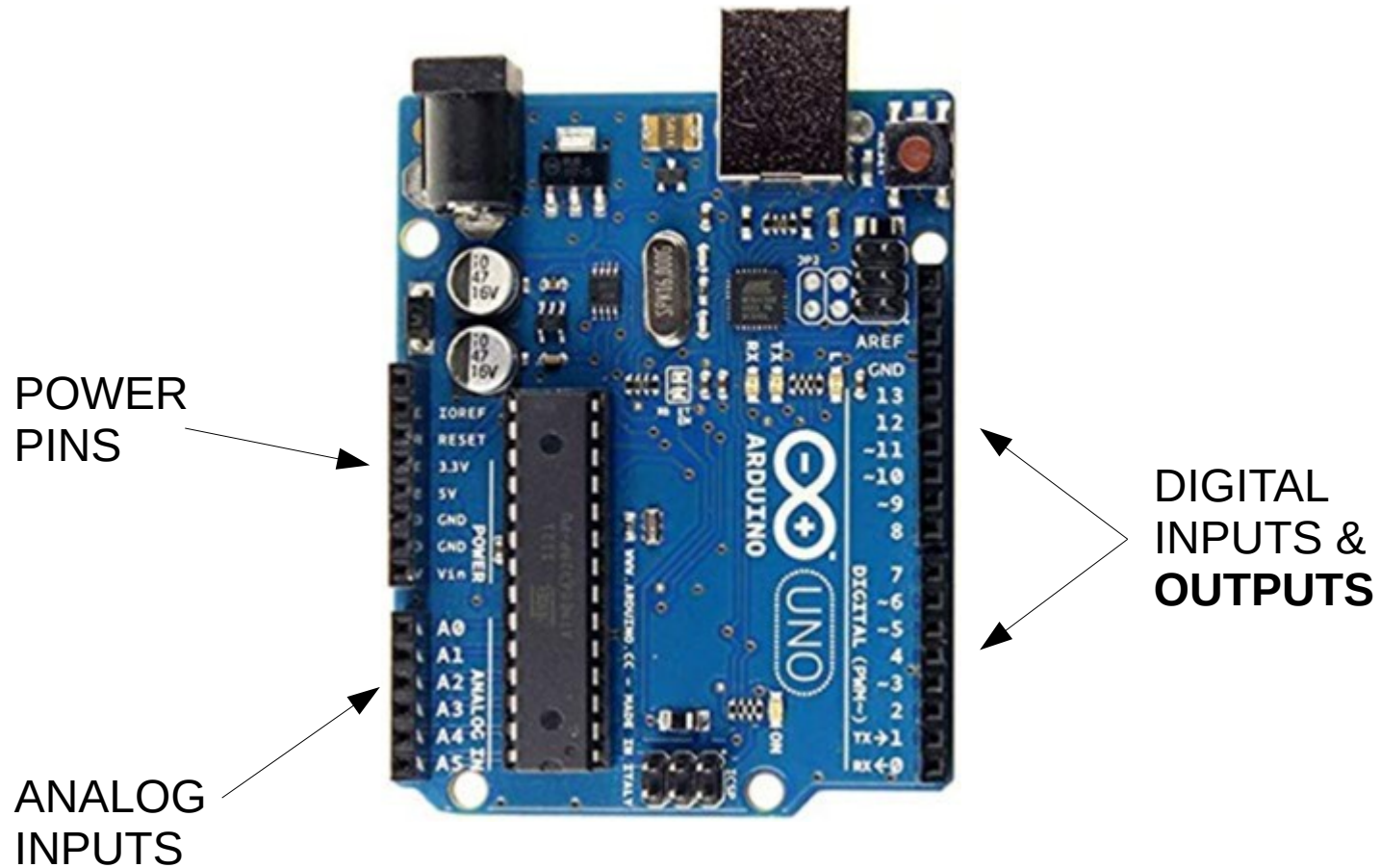
LOW or HIGH

0v or 5v

Analog

Range of integers or real numbers

Digital vs. Analog



Controlling Brightness

So, how can we control Brightness?

⚡ Change Resistor
(not really programmable, but let's **revisit in another lesson!**)

⚡ Change Power
But, all of our Output pins are **Digital (On/Off)**

We need PWM!!!

What is PWM?

Pulse Width Modulation (PWM)

- An efficient method to vary and control power
- Used in various electrical systems
 - Lights
 - Motors
 - Comms & others



Change Power

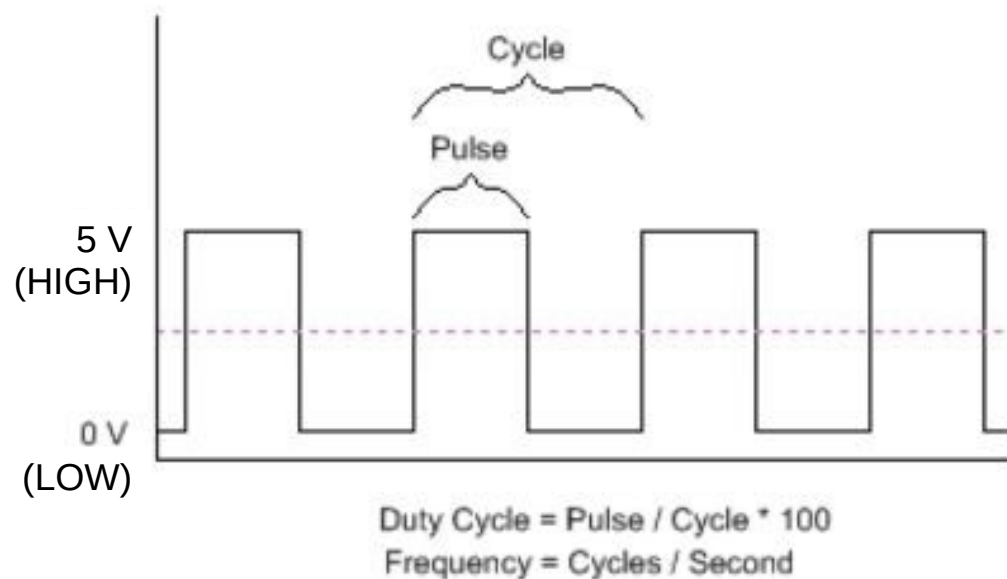
- We can On/Off or HIGH/LOW or 5V/0V

But, what if we wanted **%50 power**?

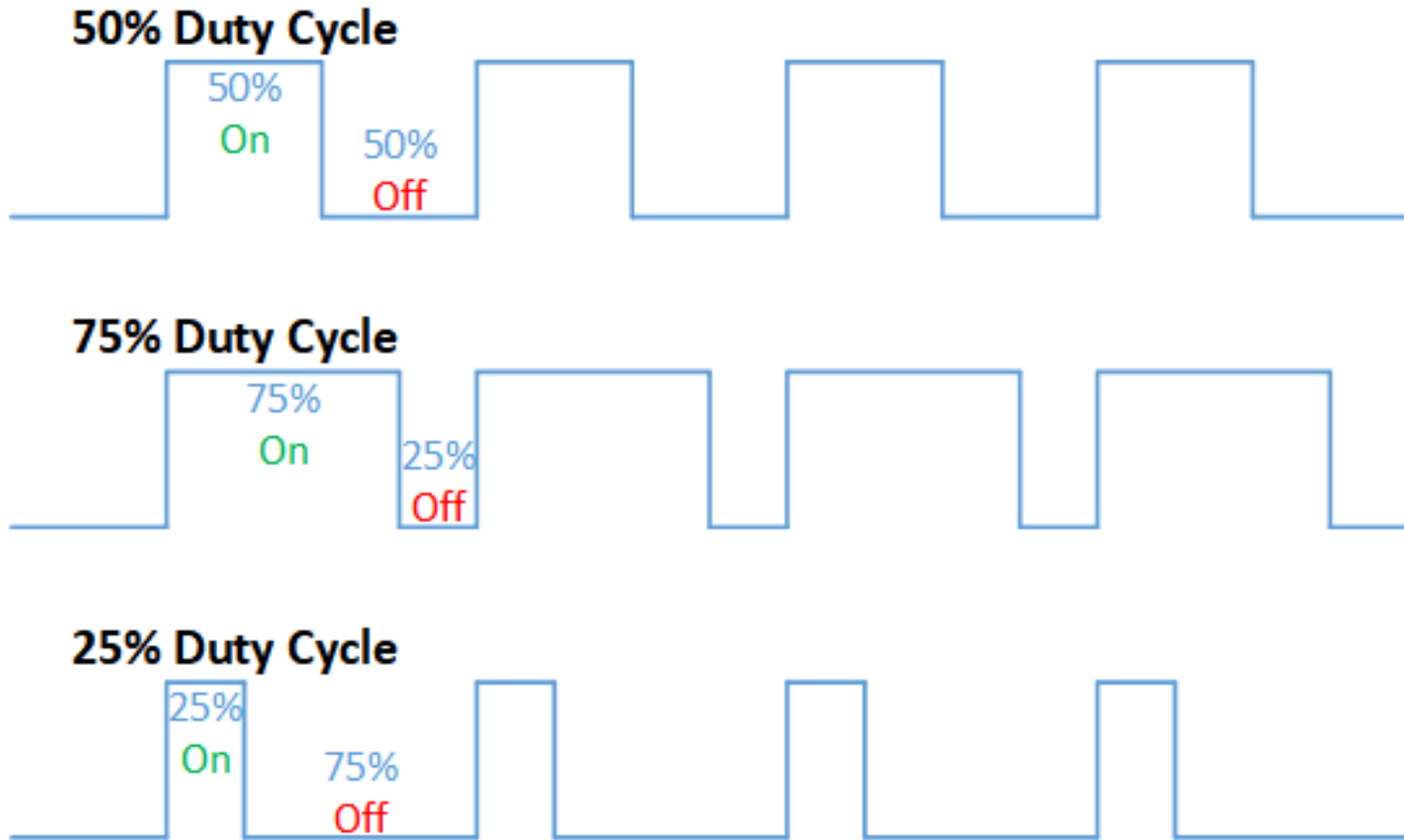
- Can't set digital output to 2.5V....
 - So, add ***Time*** to the equation!

%50 Duty Cycle

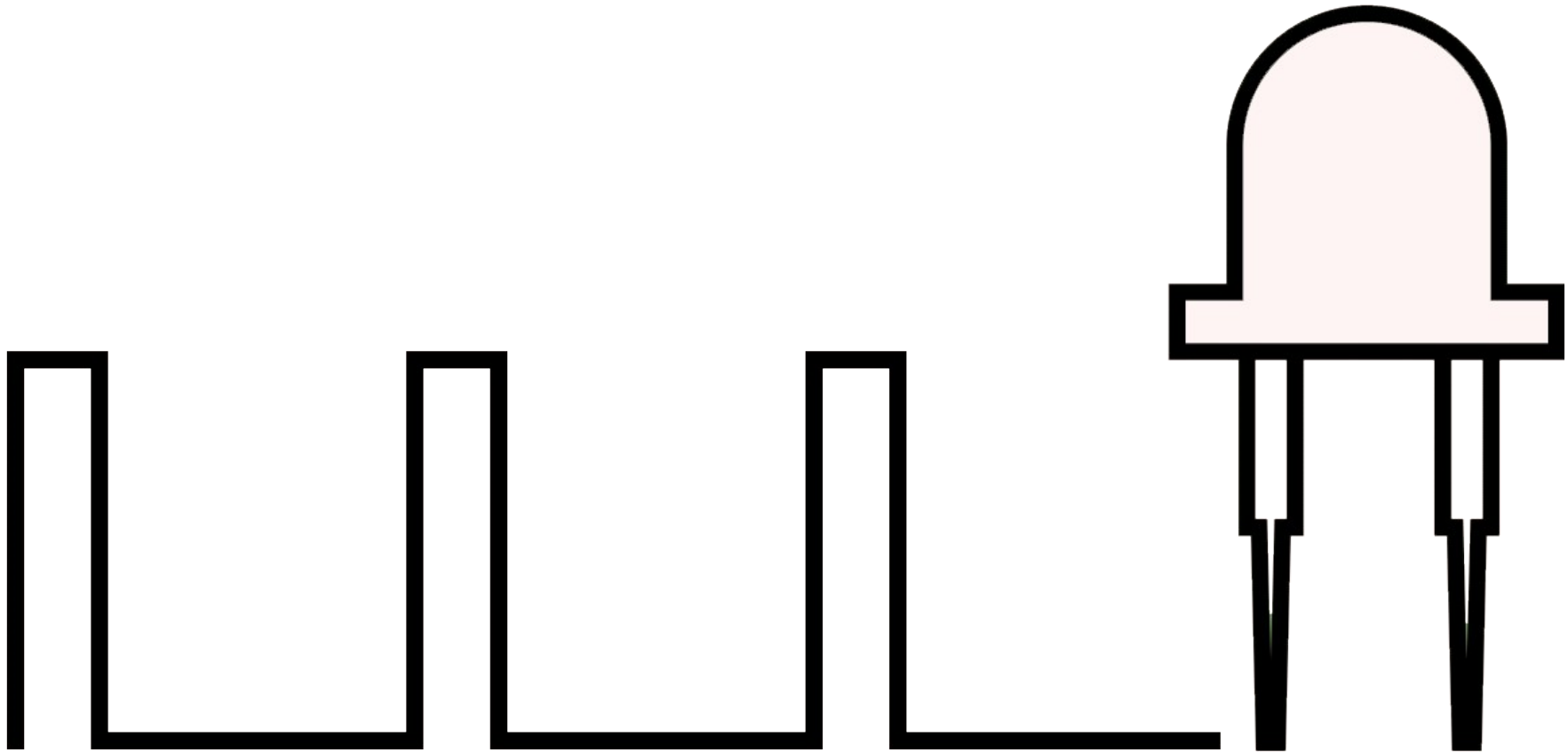
- Pick some Interval or Period (e.g. 1 ms, or 1000 Hz)
- Set signal to HIGH $\frac{1}{2}$ of the period (0.5 ms)
- Set signal to LOW rest of the period (0.5 ms)
- Run signal over and over...



Duty Cycle

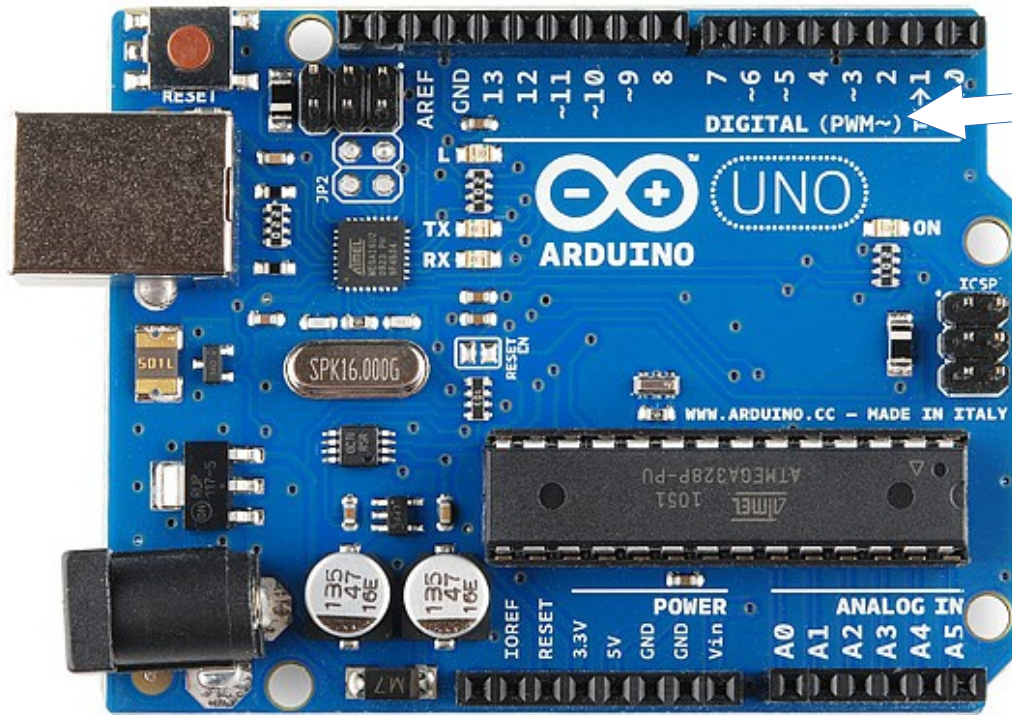


Duty Cycle



PWM Pins

- Today we'll work with Pulse Width Modulation (PWM)
- Take note which pins support PWM



The board usually indicates which pins have PWM built-in support

In this case Pins
3,5,6,9,10,11
(see '~')

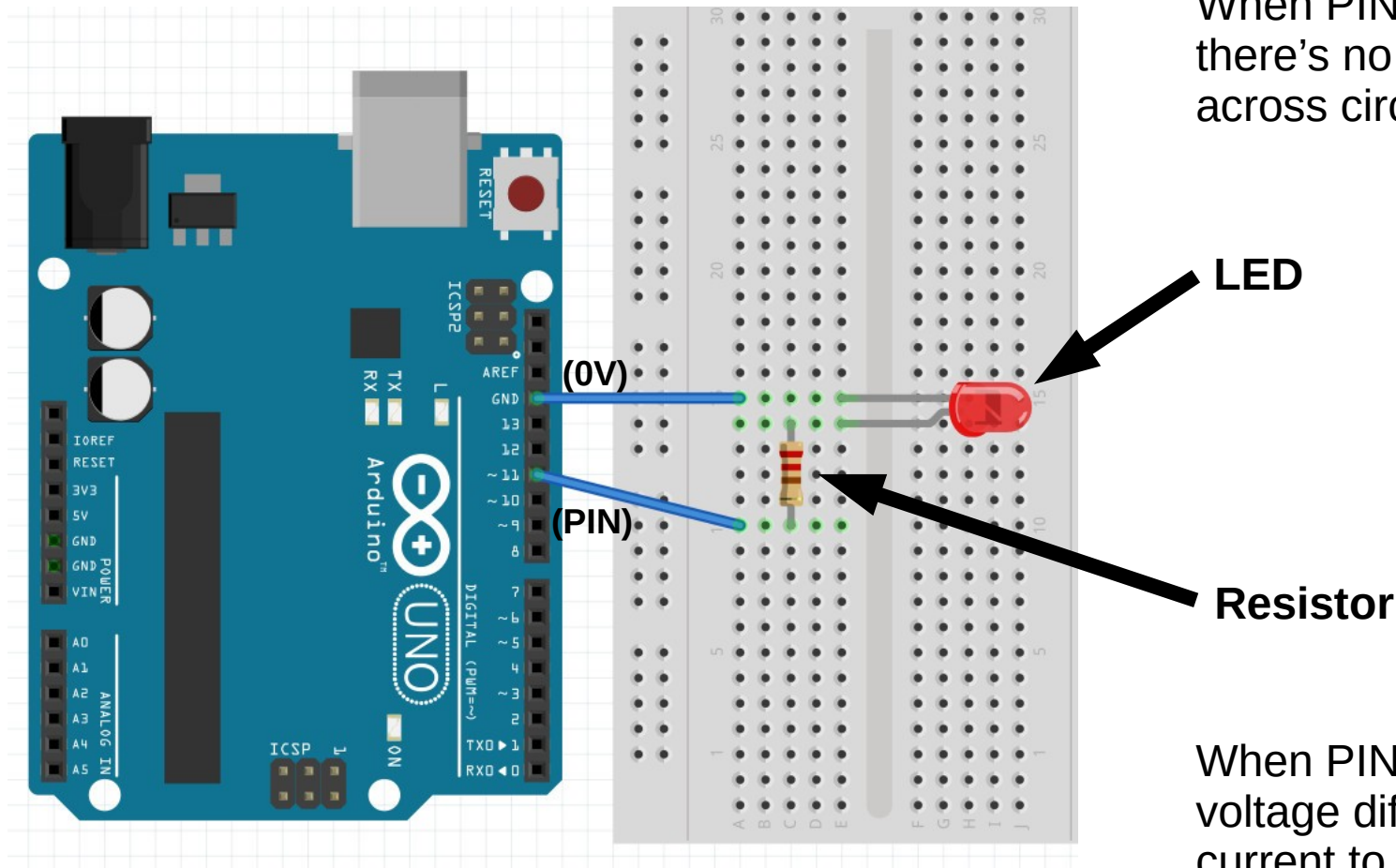
All output pins are **digital** (LOW/HIGH), so we can only vary power using something like the PWM method

Let's Get Hands-On

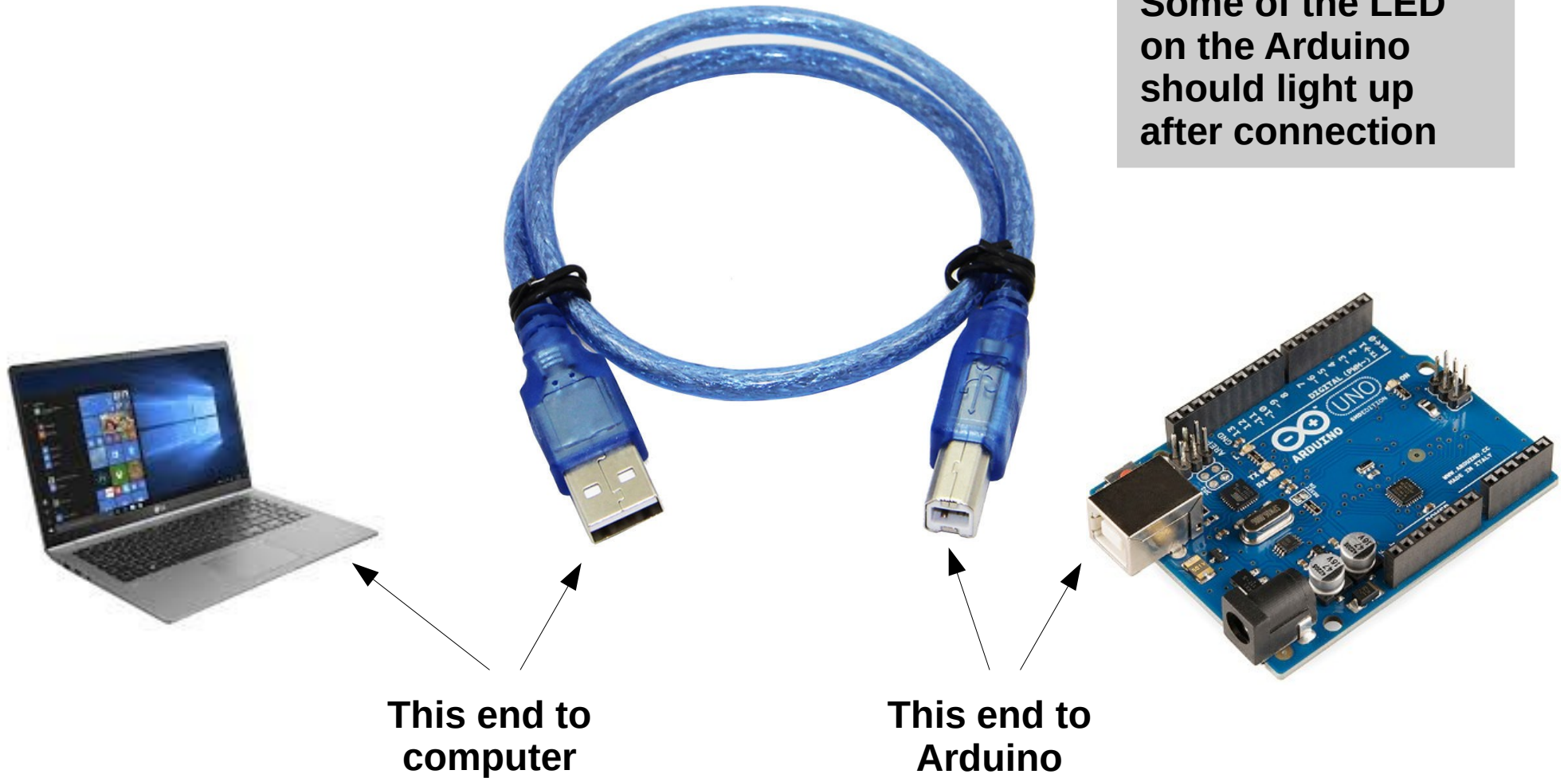
(The fun part...?)

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Review LED Circuit



Physical Connection

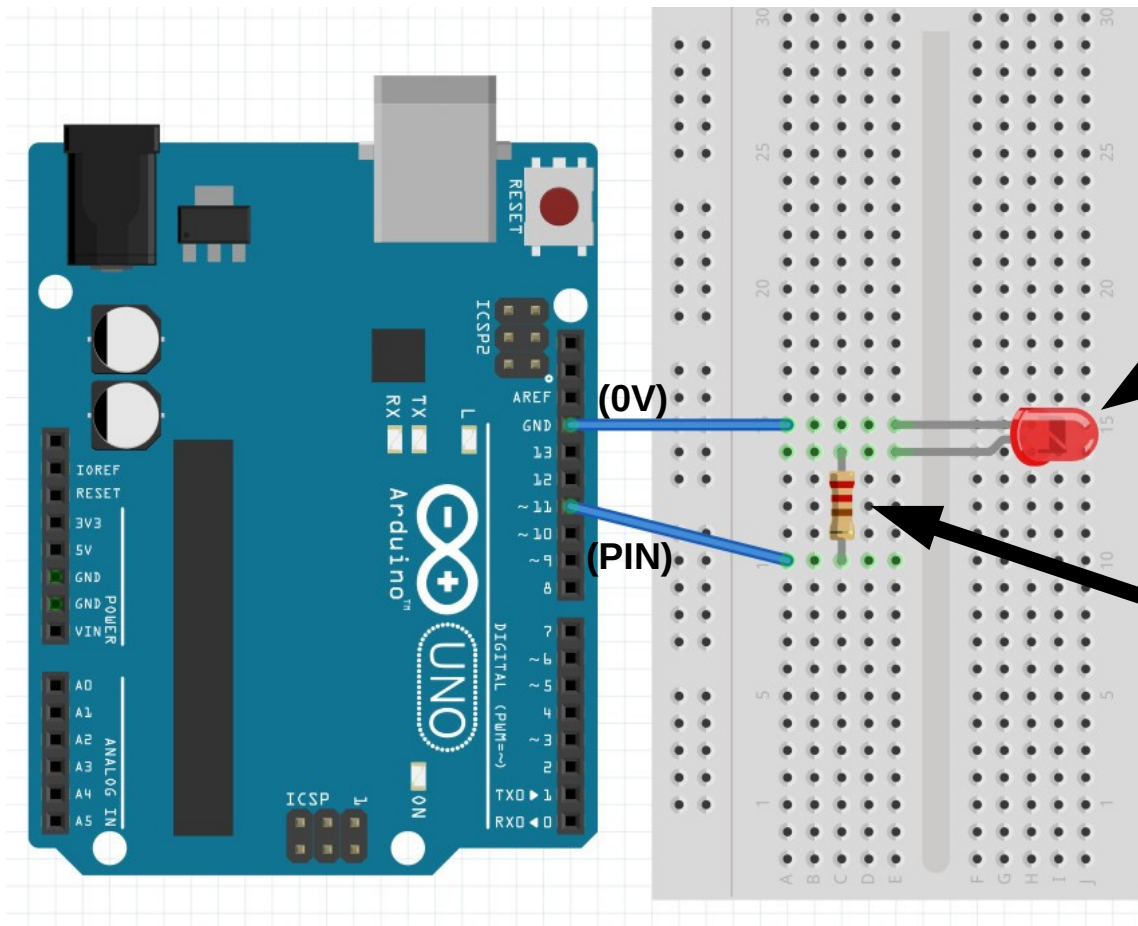


Exercise 1

Control LED Brightness

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Review LED Circuit



When PIN is set to LOW (0V), there's no voltage differential across circuit, so no current.

LED

**Resistor
(330 ohms)**

When PIN is set to HIGH (5V), voltage differential causes current to flow and light LED.

Vary PWM on LED Pin

```
int ledPin = 11;    // LED connected to digital pin 11

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

void loop() {
  // let's test different values
  analogWrite(ledPin, 255); // %100 duty cycle
  delay(1000); // sleep to get a chance to see the effect

  analogWrite(ledPin, 190); // %75
  delay(1000);

  analogWrite(ledPin, 127); // %50
  delay(1000);

  analogWrite(ledPin, 63); // %25
  delay(1000);
}
```

Test it out!

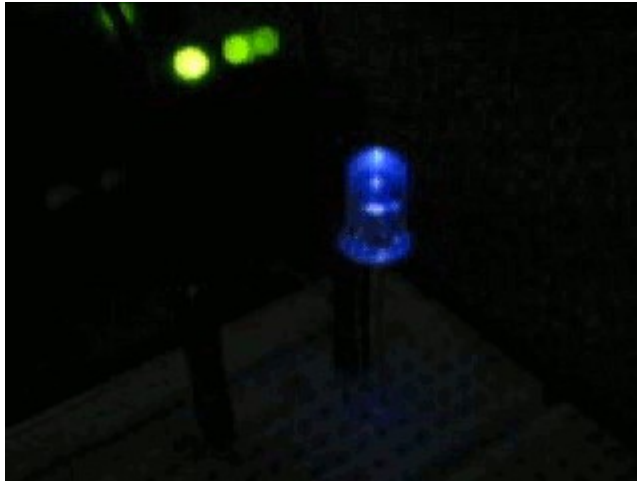
Exercise 2

Create a Dimmer Effect

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Light Control

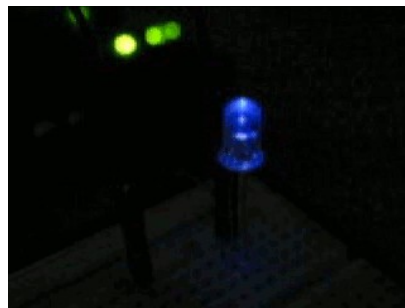
- Back to our dimmer effect...



- Can you use your program to create this effect?

Challenges

- Hint: Use Loops (for, while, etc)
- Try different **PWM Step Sizes**
 - You can also vary Delay/Sleep Times
- Extend the program to make dimmer effect run **from low to high and back to low again**



For-Loop PWM Dimmer

```
int ledPin = 11;    // LED connected to digital pin 11

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

void loop() {
  // fade in from min to max values in increments of 5:
  for (int fadeValue = 0 ; fadeValue <= 255; fadeValue += 5) {
    analogWrite(ledPin, fadeValue);
    delay(30); // wait 30ms to see the dimming effect
  }

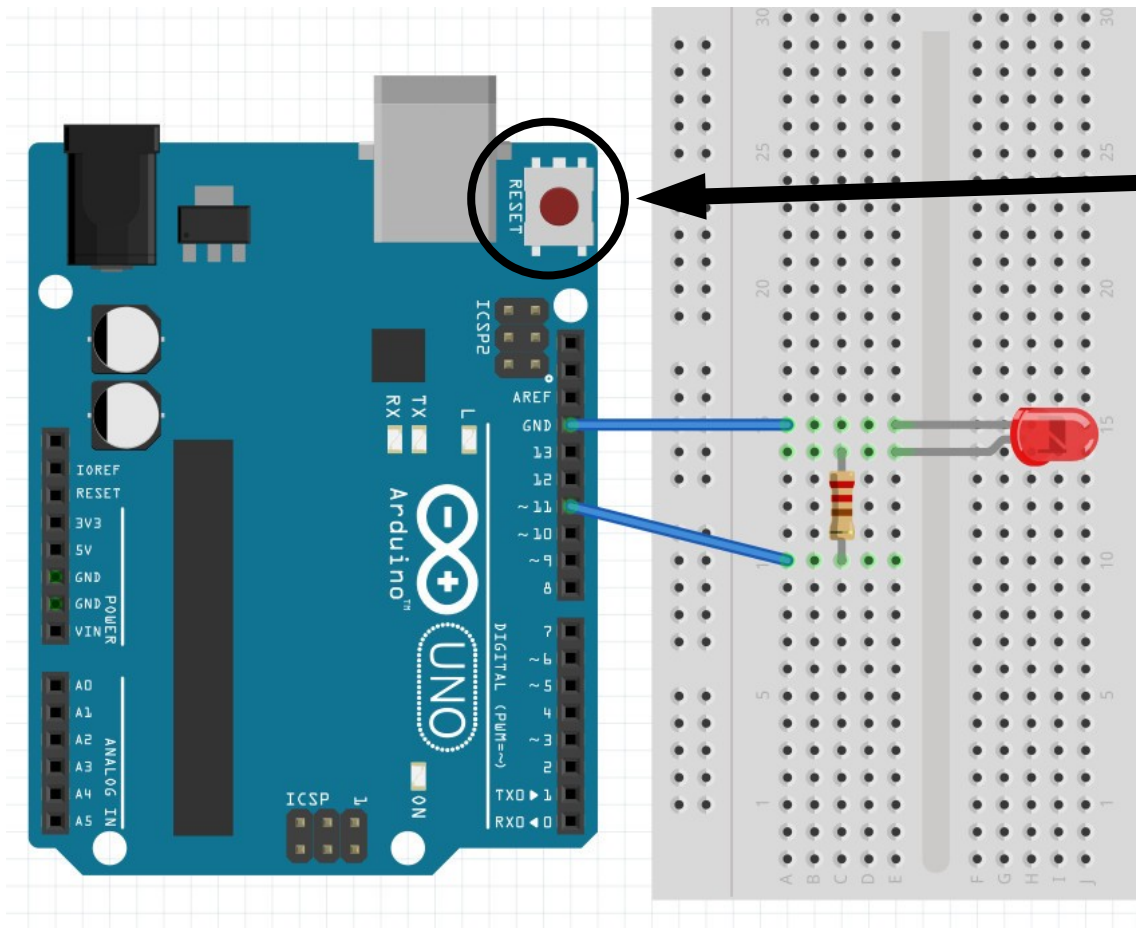
  // Then fade out...
  for (int fadeValue = 255 ; fadeValue >= 0; fadeValue -= 5) {
    analogWrite(ledPin, fadeValue);
    delay(30);
  }
}
```

Test it out!

Extra Challenges

- Change the **For** Loop to a **While** Loop
- Use a physical button to act as a **Toggle** Dimmer Switch (on/off)
- Use multiple LEDs to create a **Light Show** with blinking, dimming, and any other effects you can muster

RESET to Restart



Press **RESET** button to restart Arduino, and rerun the uploaded program

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