

# *LED Strips for Everyone Everywhere*

## Mitch Altman

Chief Scientist, **Cornfield Electronics**, San Francisco, CA

Inventor of **TV-B-Gone** universal remote controls

Co-founder of **3Ware** (successful Silicon Valley startup)

Pioneer of **VR** (in the mid-1980s)

Founding mentor at **HAX** (1<sup>st</sup> and biggest hardware accelerator)

Co-founder of **Noisebridge** (San Francisco hackerspace)

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CORNFIELD ELECTRONICS

# *LED Strips for Everyone Everywhere*



# Syllabus

- Intro to LEDs
- A bit about electronics
- RGB color theory
- A bit about Arduino
- PWM basics
- Programming RGB LED strips
- Ordering RGB LED strips

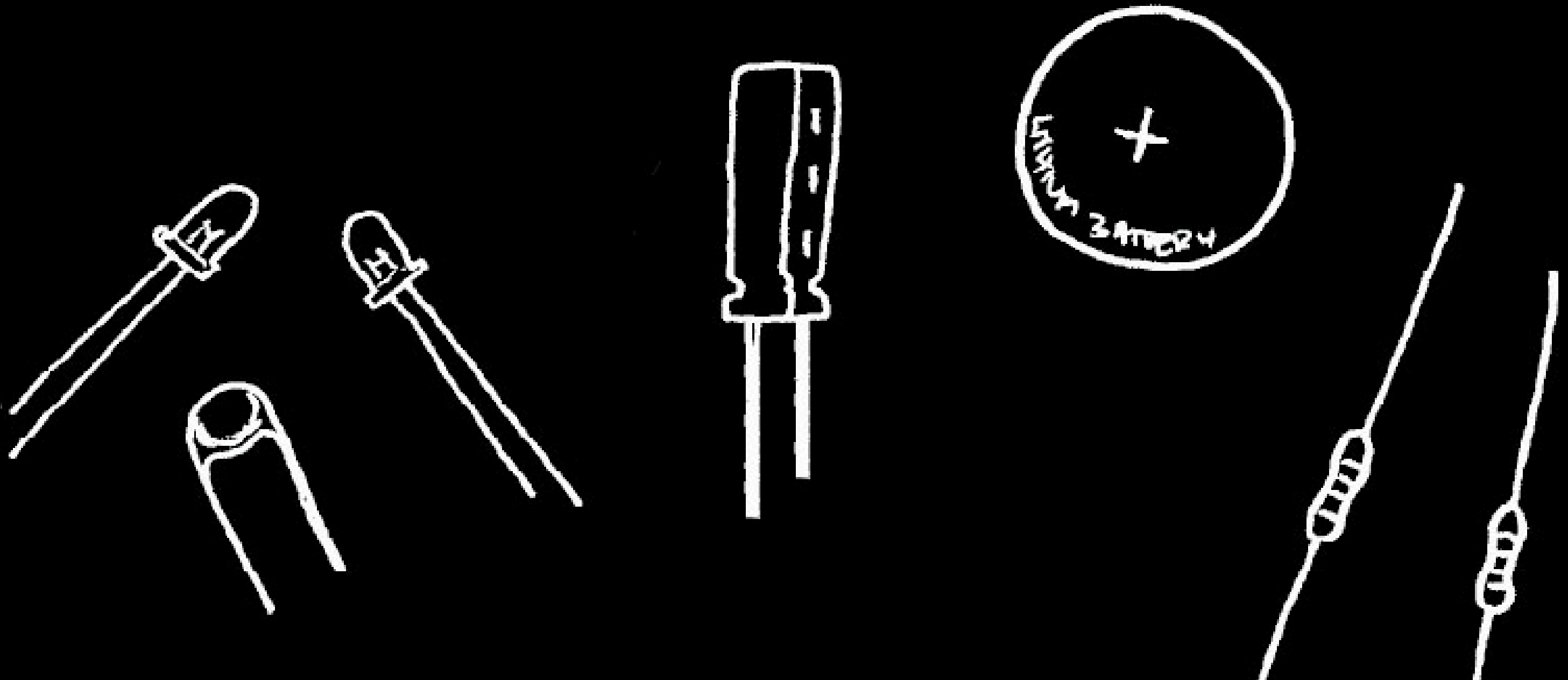
# LEDs



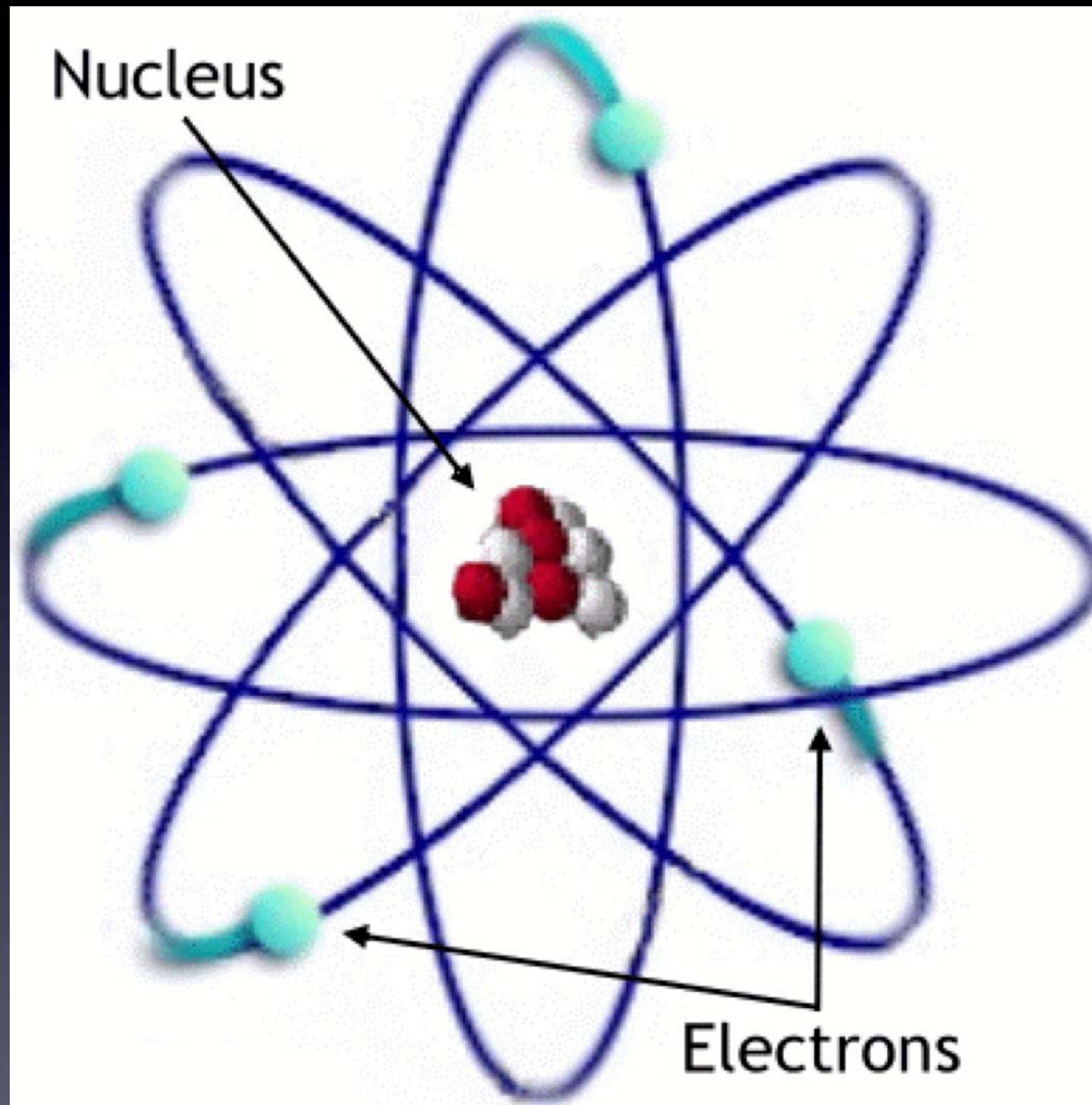
Lots of different colored LEDs!



# *A Little About Electronics*

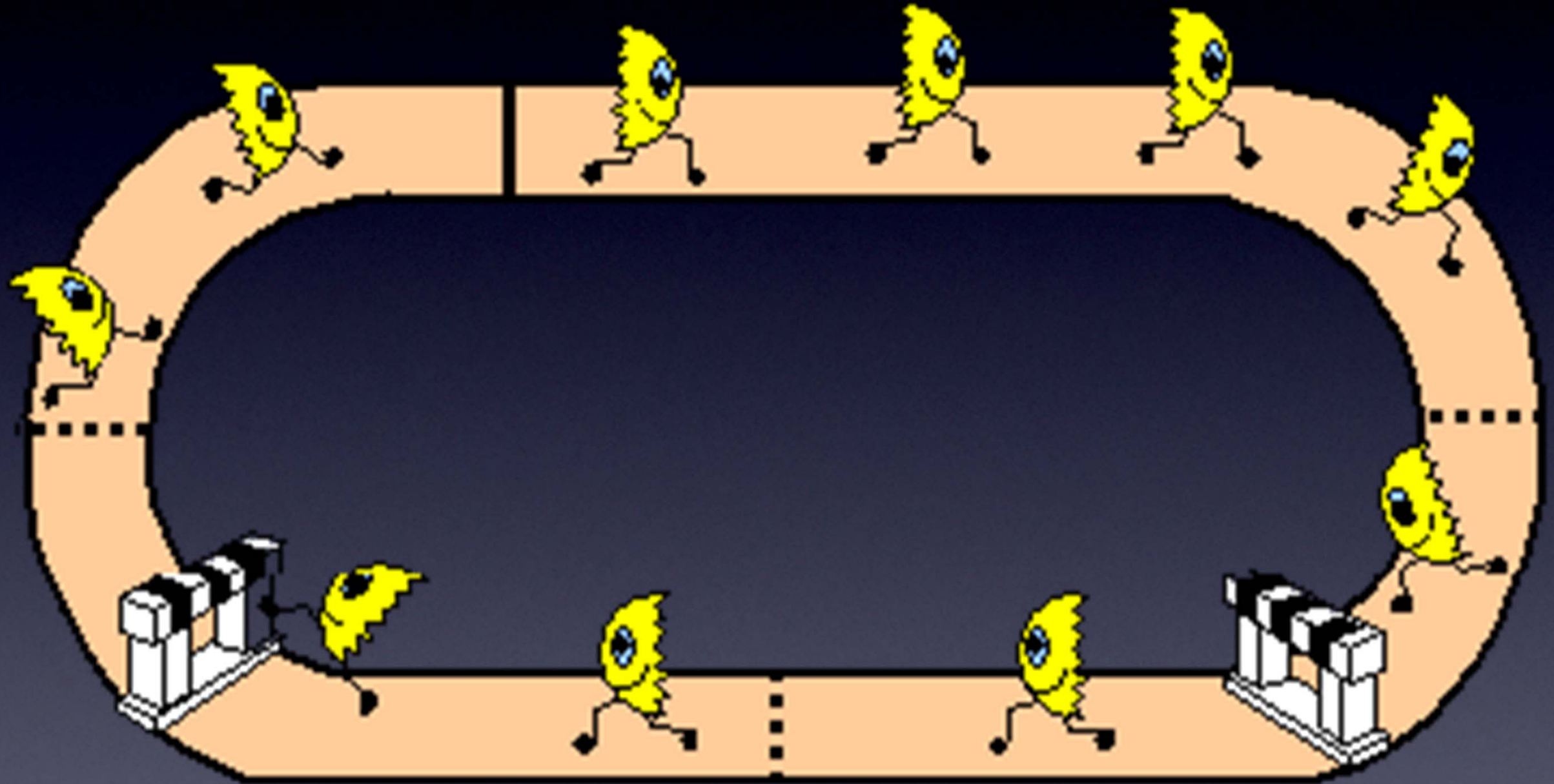


# A Little About Electronics



Electrons

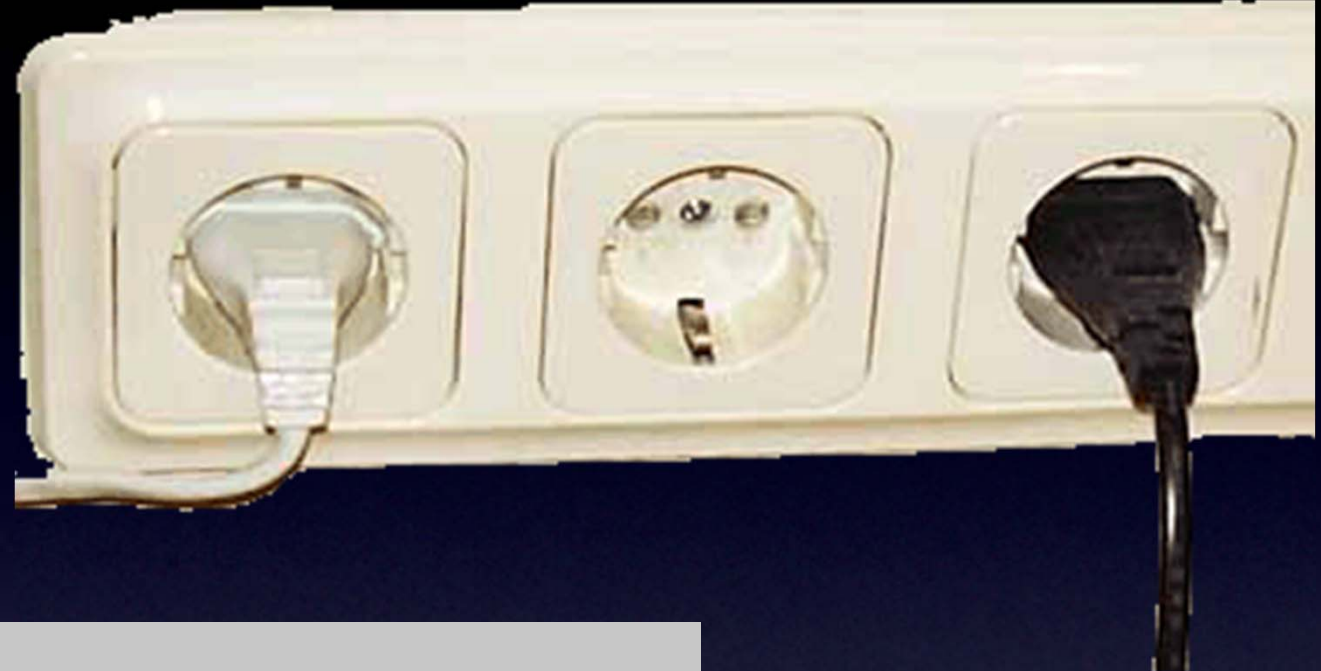
# A Little About Electronics



Circuit = Electrons going in complete circle = Magic!



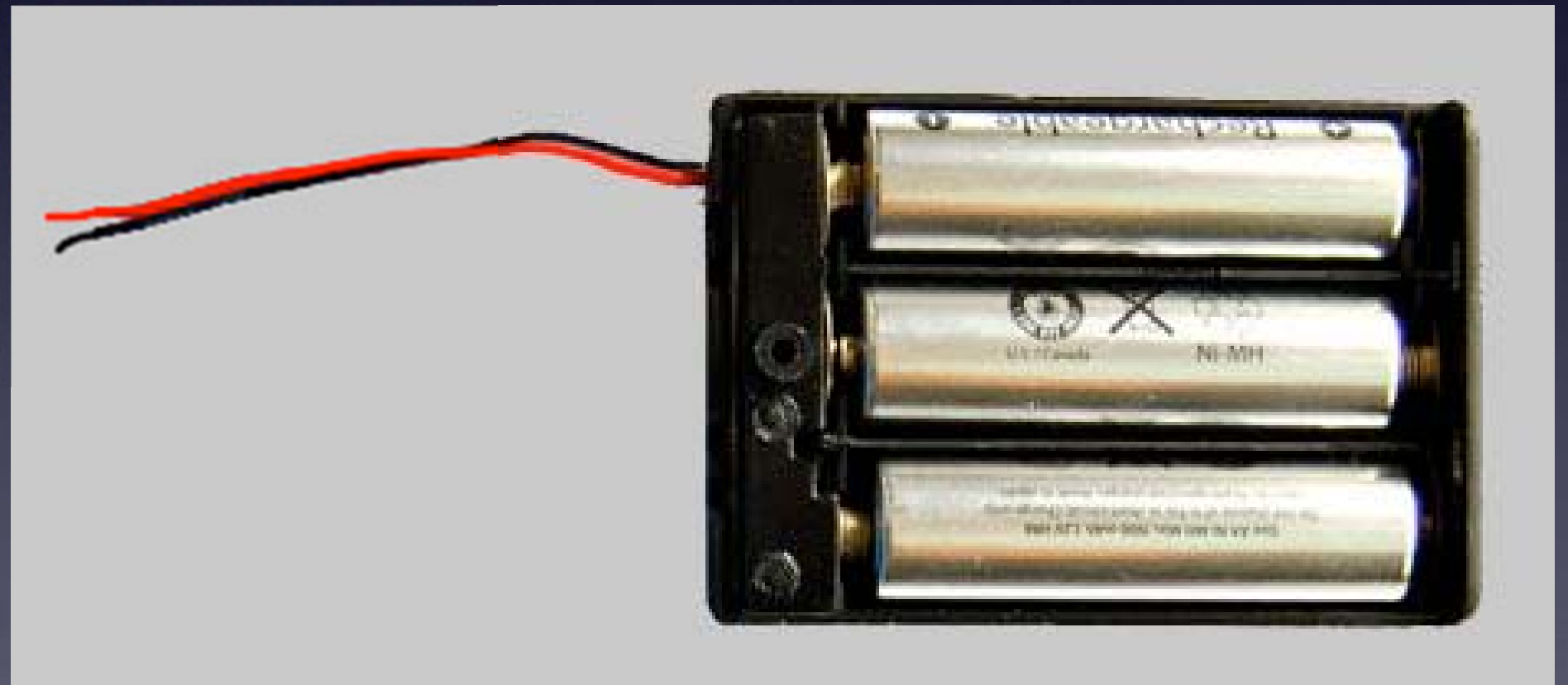
# A Little About Electronics



Power Supplies

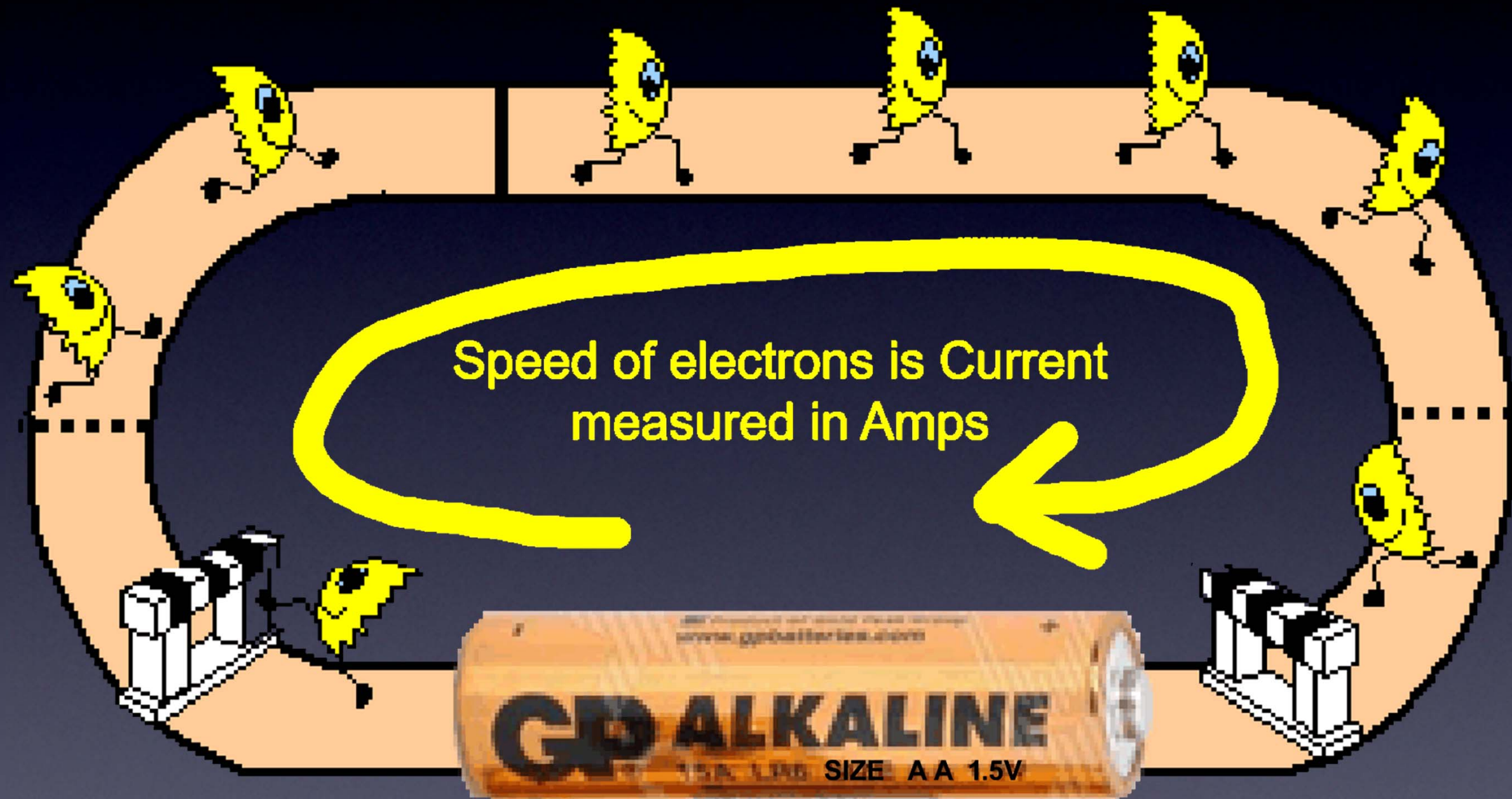


# Everything You Need to Know About Electronics



Voltage / **Volts**

# Everything You Need to Know About Electronics

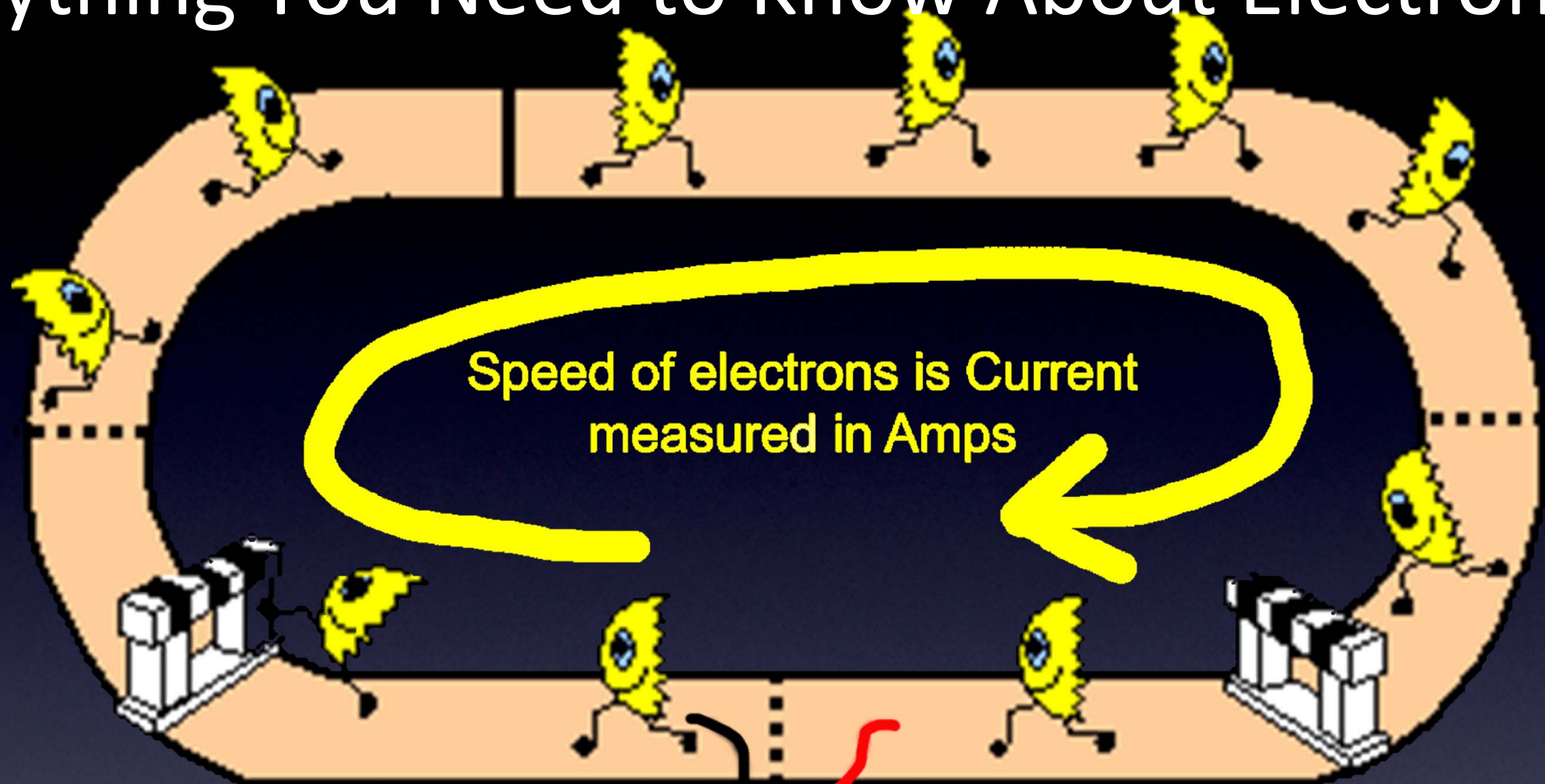


Electrons pushed with 1.5V.  
So, they move!

Current / **Amps**



# Everything You Need to Know About Electronics



3 times more Volts  
3 times more push  
3 times faster electrons  
3 times more current / Amps

Current / Amps



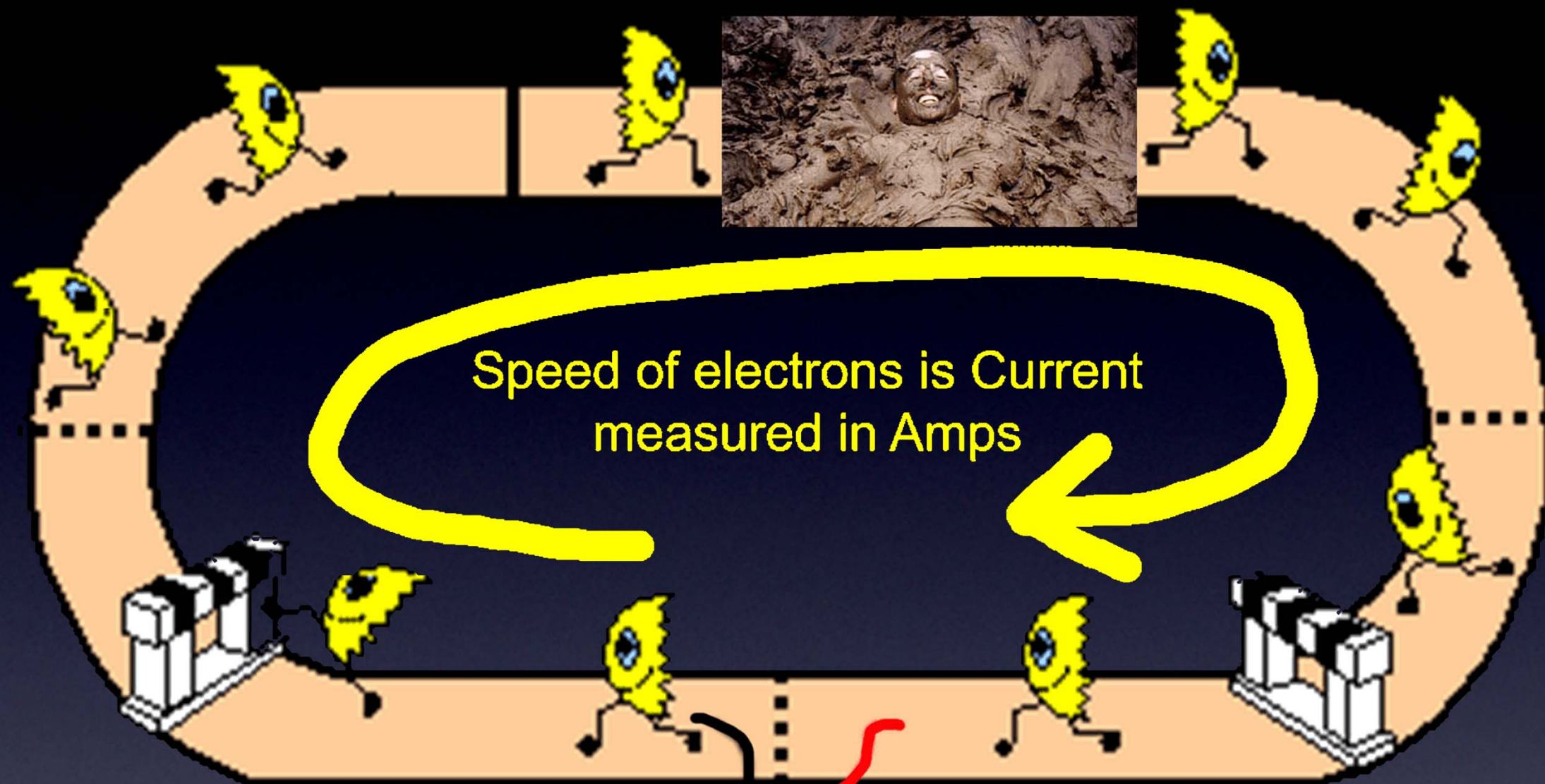
# Everything You Need to Know About Electronics

**Too much energy?**

**Lots of energy!**

Current / Amps

# Everything You Need to Know About Electronics



Resistance in the electrons' path slows them down, which means less current (less Amps).



Resistance / **Ohms**



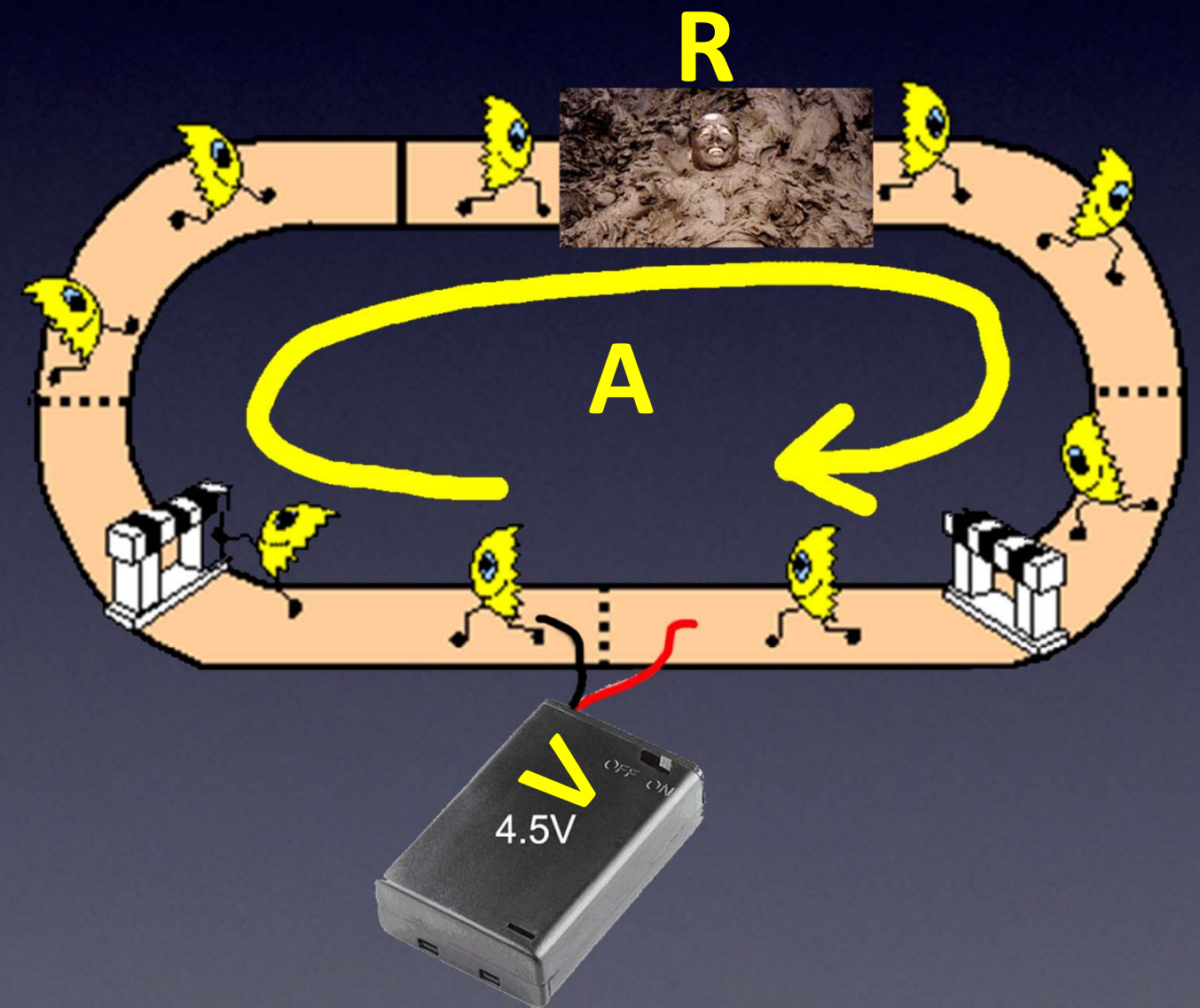
# A Little About Electronics

## Ohm's Law

**V**olts -- *force* pushing electrons

**A**mps -- *speed* of electrons

**O**hms -- *Resistance* to flow of electrons



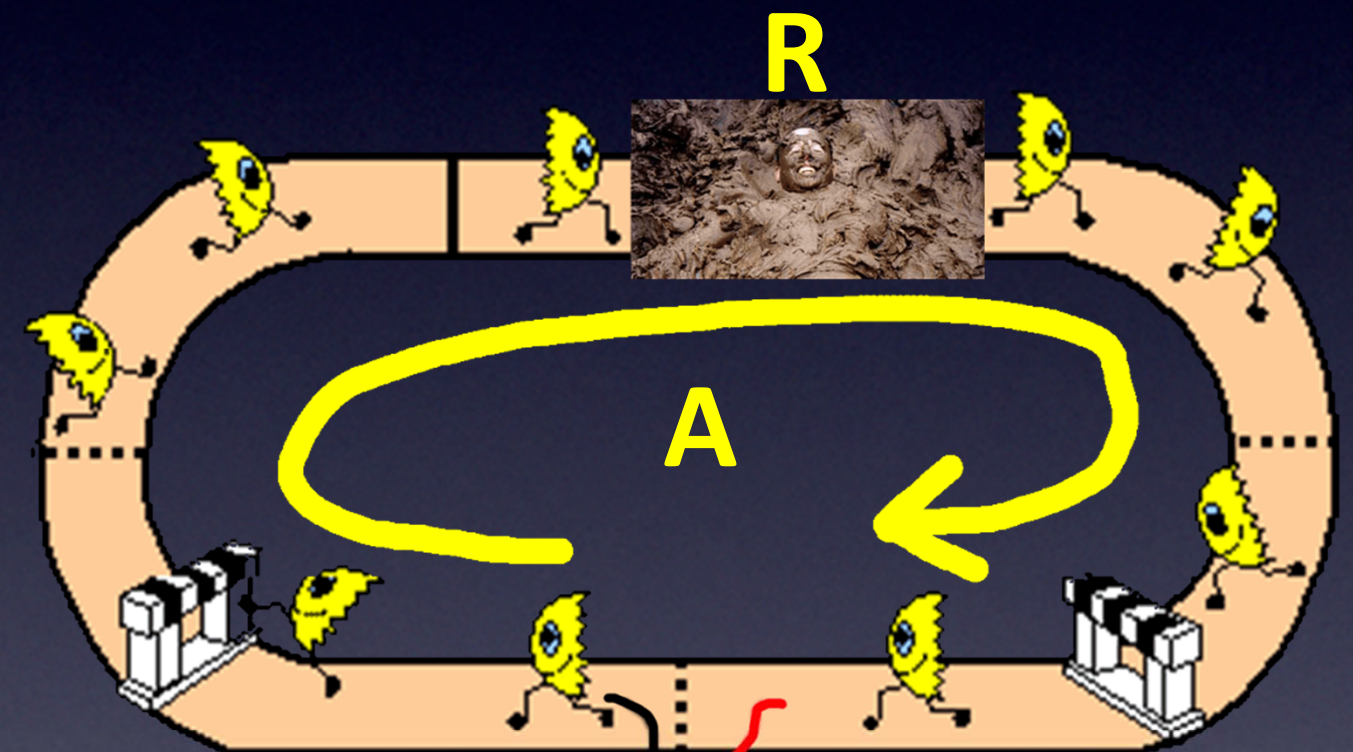
# A Little About Electronics

## Ohm's Law

**V**olts -- *force* pushing electrons

**A**mps -- *speed* of electrons

Ohms -- *Resistance* to flow of electrons



$$\mathbf{V_{olts} = A_{mps} \times R}$$



(Ohms)



# A Little About Electronics



# What happens?

*polarity*

Power Supply – it matters how you connect it!

LED

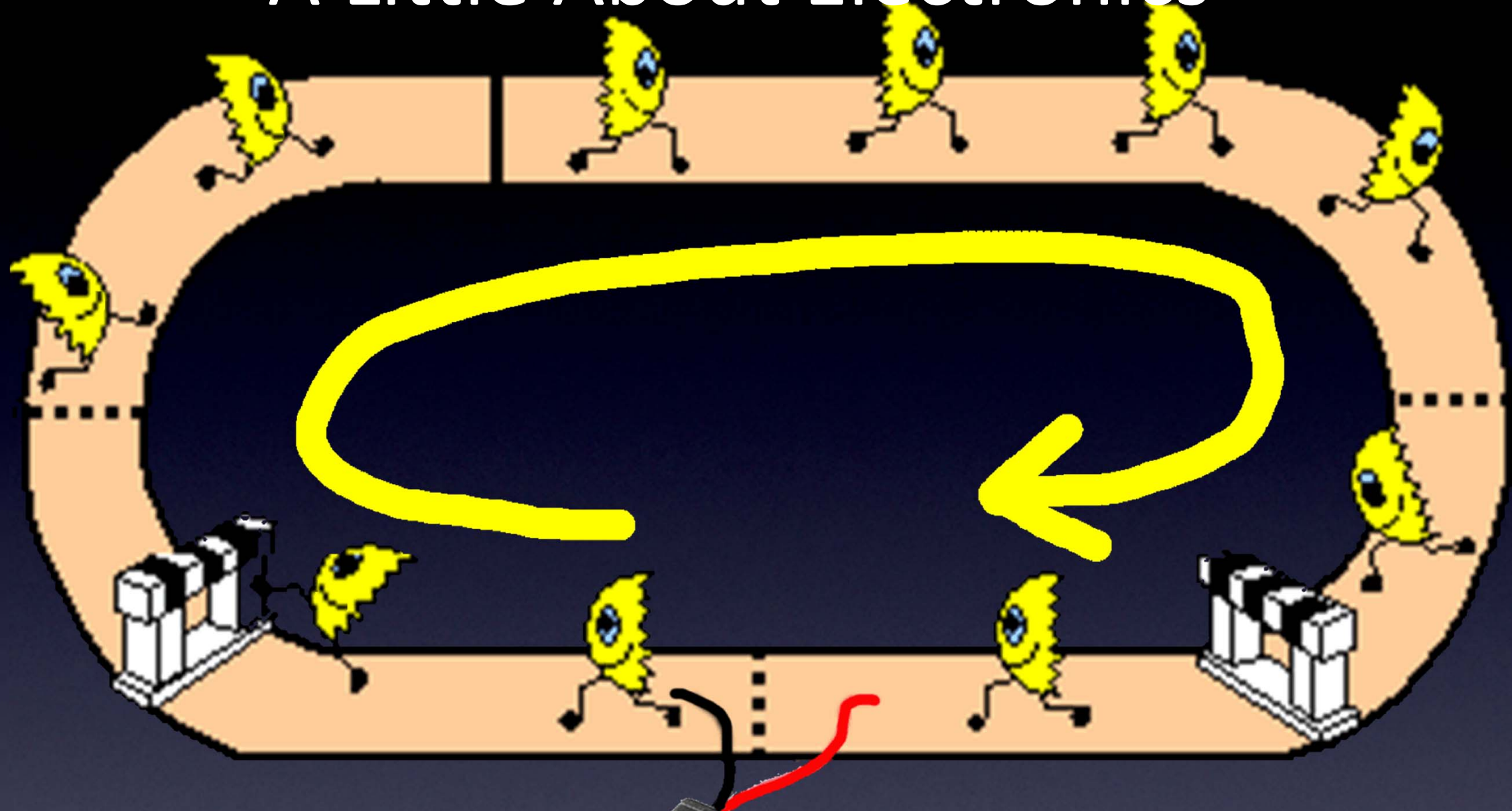


Plus / Positive (+)

Minus / Negative (-)



# A Little About Electronics



Black Wire = “-”

Red Wire = “+”



Power Supply – it matters how you connect it!

# A Little About Electronics



**Red wire:**  
**Power,**  
**Plus, Positive,**  
**4.5V,**  
**Vcc**

**Black wire:**  
**Minus, Negative,**  
**0V,**  
**Ground (GND)**

Power Supply – it matters how you connect it!



# A Little About Electronics

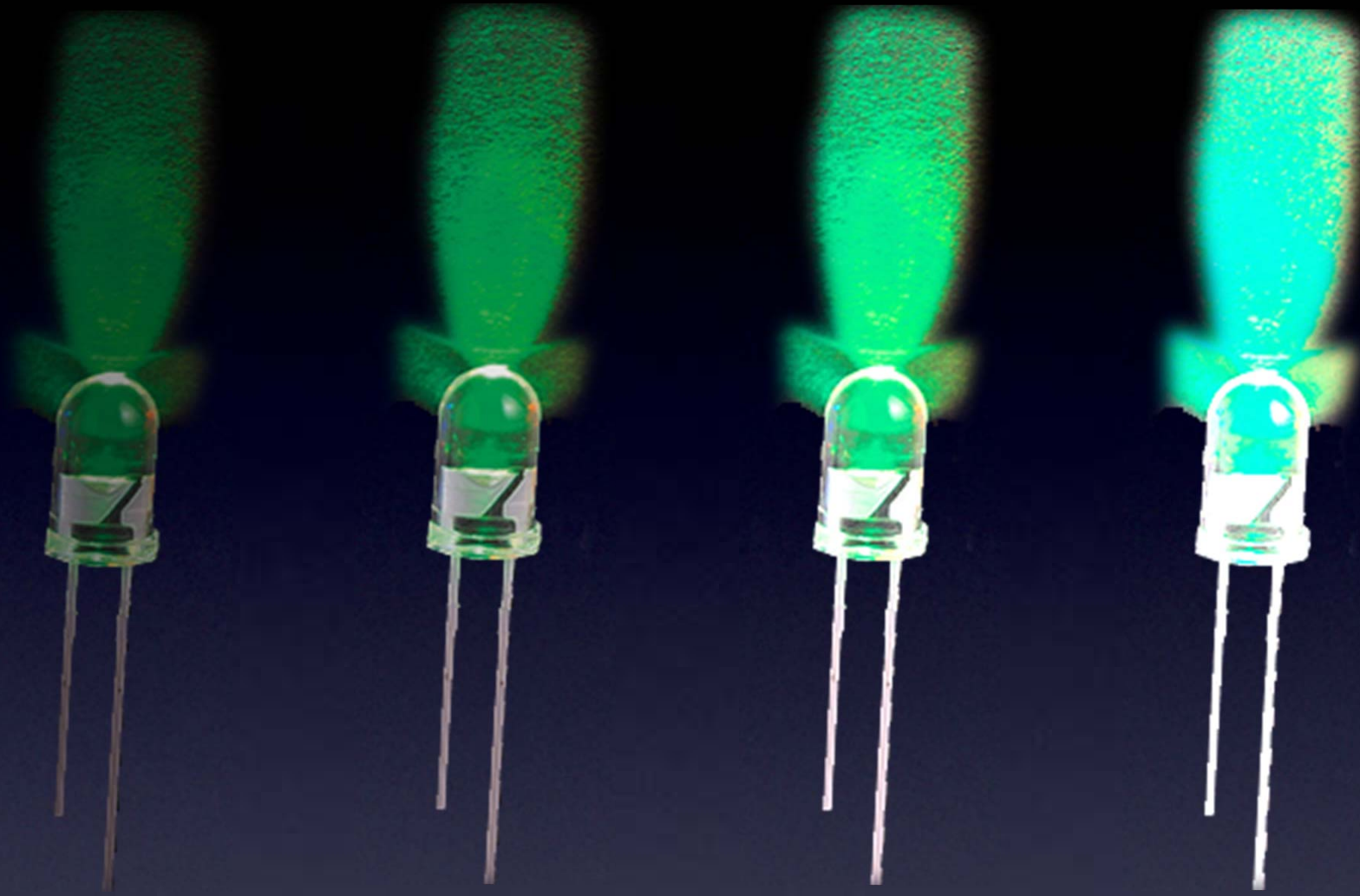


Lots of different colored LEDs!

LED



# Everything You Need to Know About Electronics



More current → More brightness! (until...)

LED

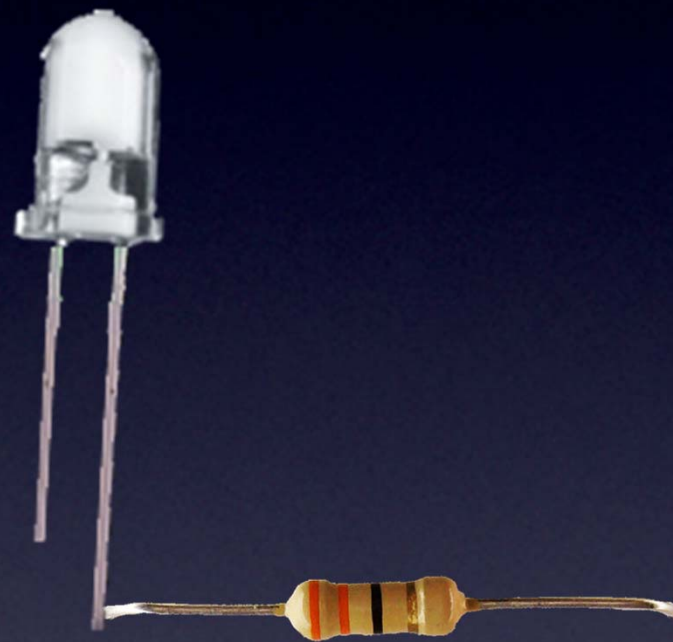
# Everything You Need to Know About Electronics



More current → More brightness! (until...)

LED

# Everything You Need to Know About Electronics



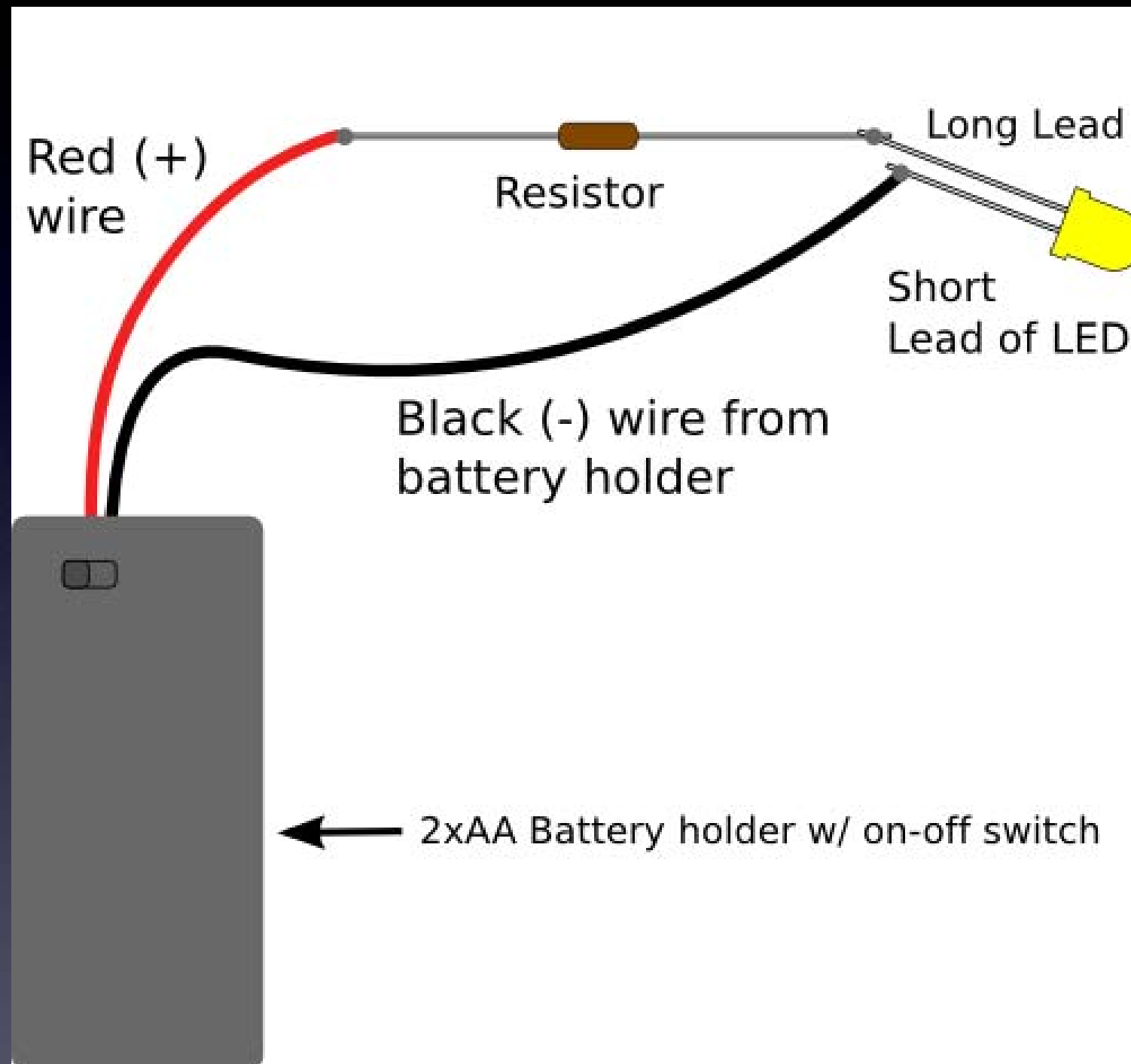
*(with a resistor  
so no magic smoke goes away)*

This is why we put a resistor in line with an LED

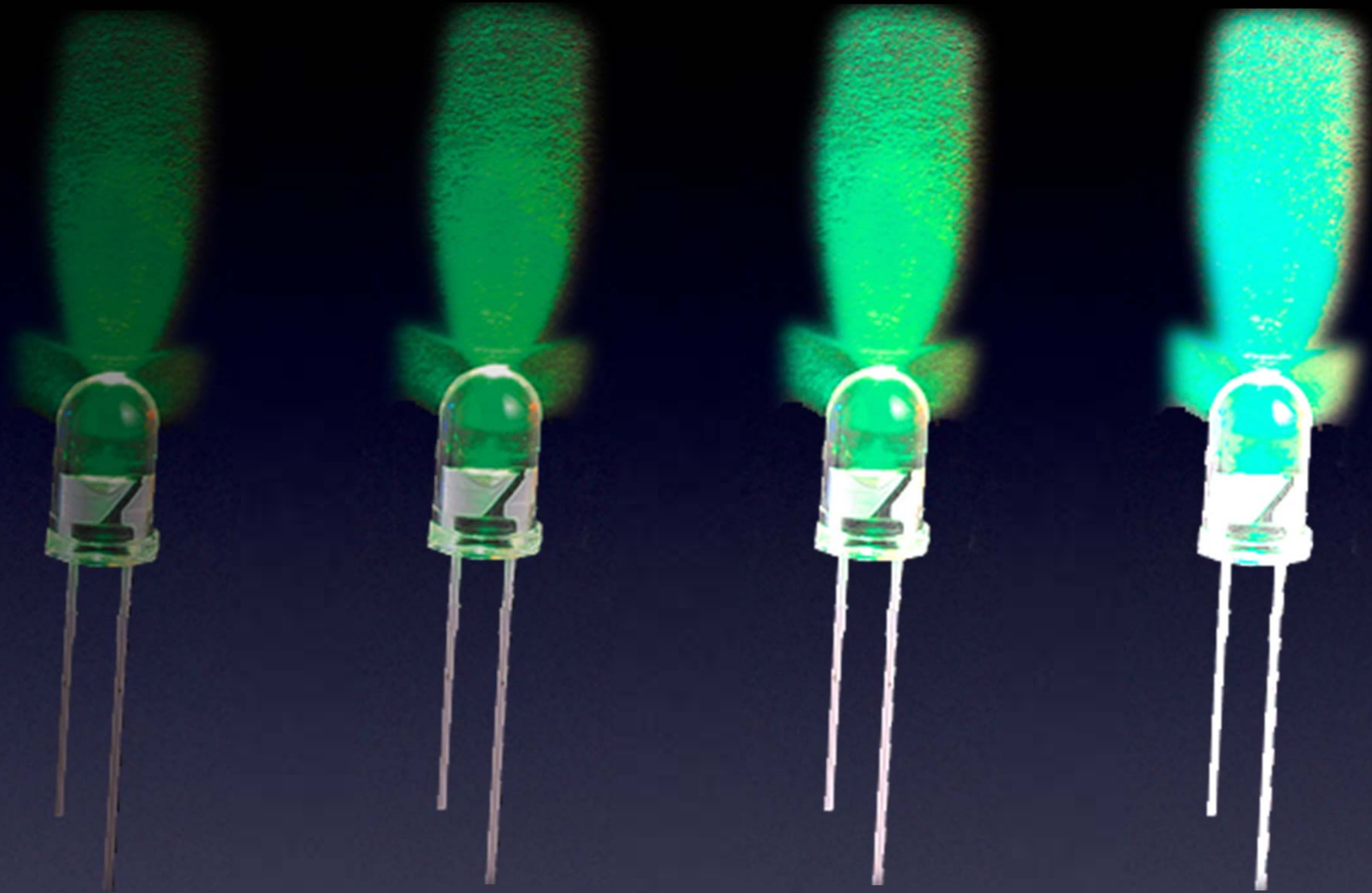
LED



# LED Brightness



# LED Brightness



Less resistance

# LED Brightness

But, we will use:

**PWM**

*(coming soon)*



# Lighting an LED

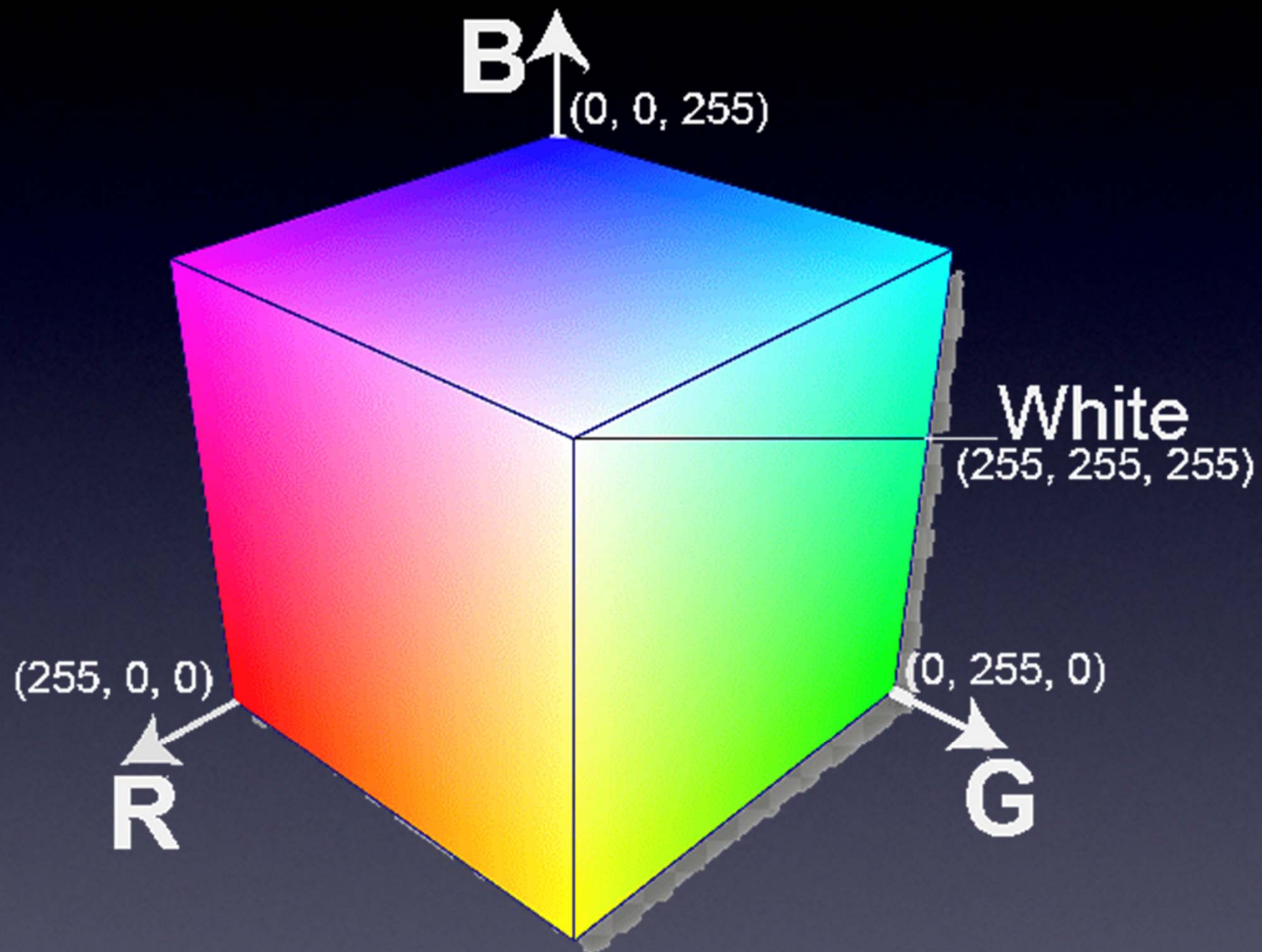


LED & battery

# Light Color Mixing

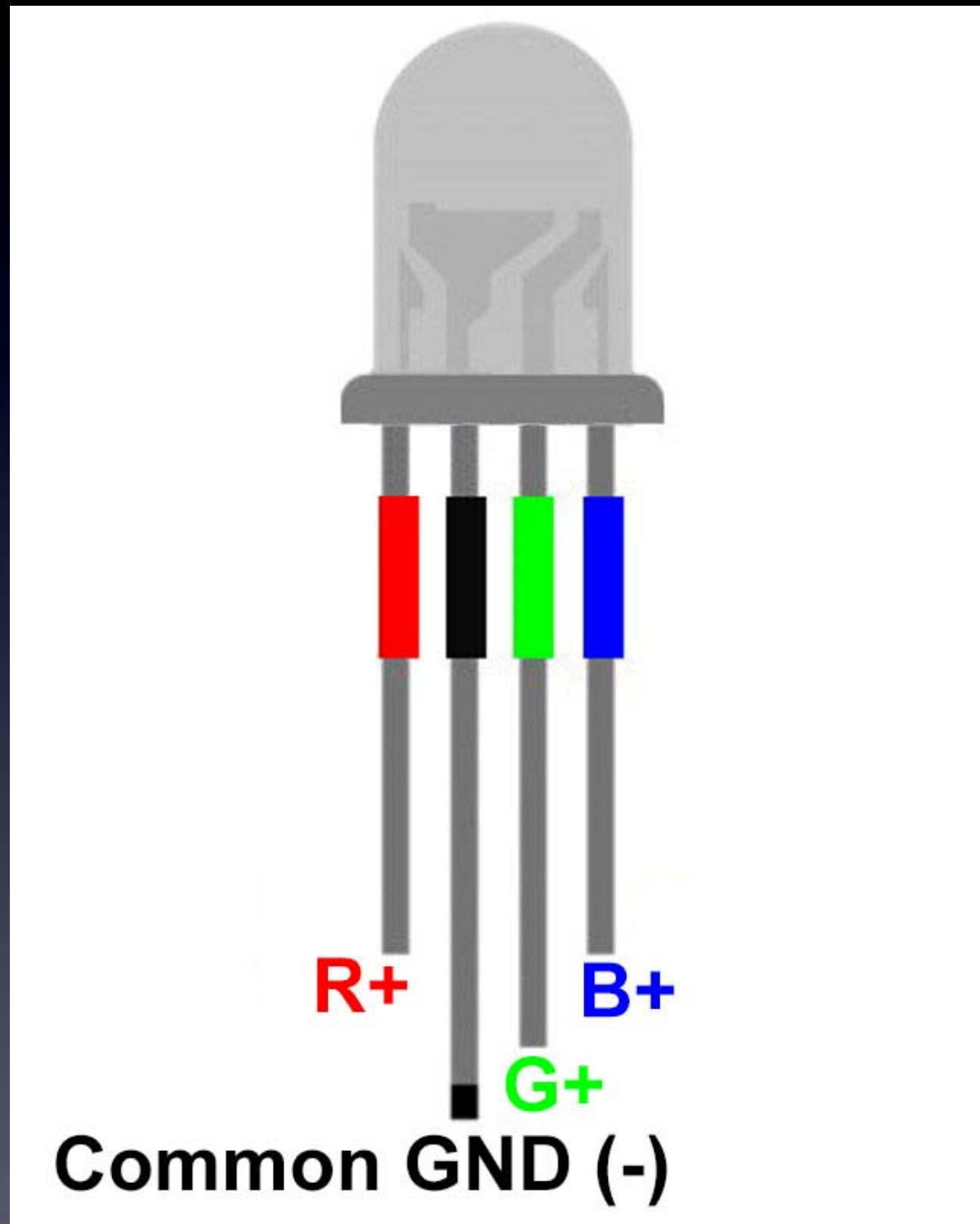


# Light Color Mixing





# RGB LED



# RGB LED with microcontroller (Example)

Trippy RGB Waves kit

# Intro to Arduino





# Intro to Arduino



Super easy to  
connect parts  
to its microcontroller's pins

*Use an Arduino board*

# Intro to Arduino

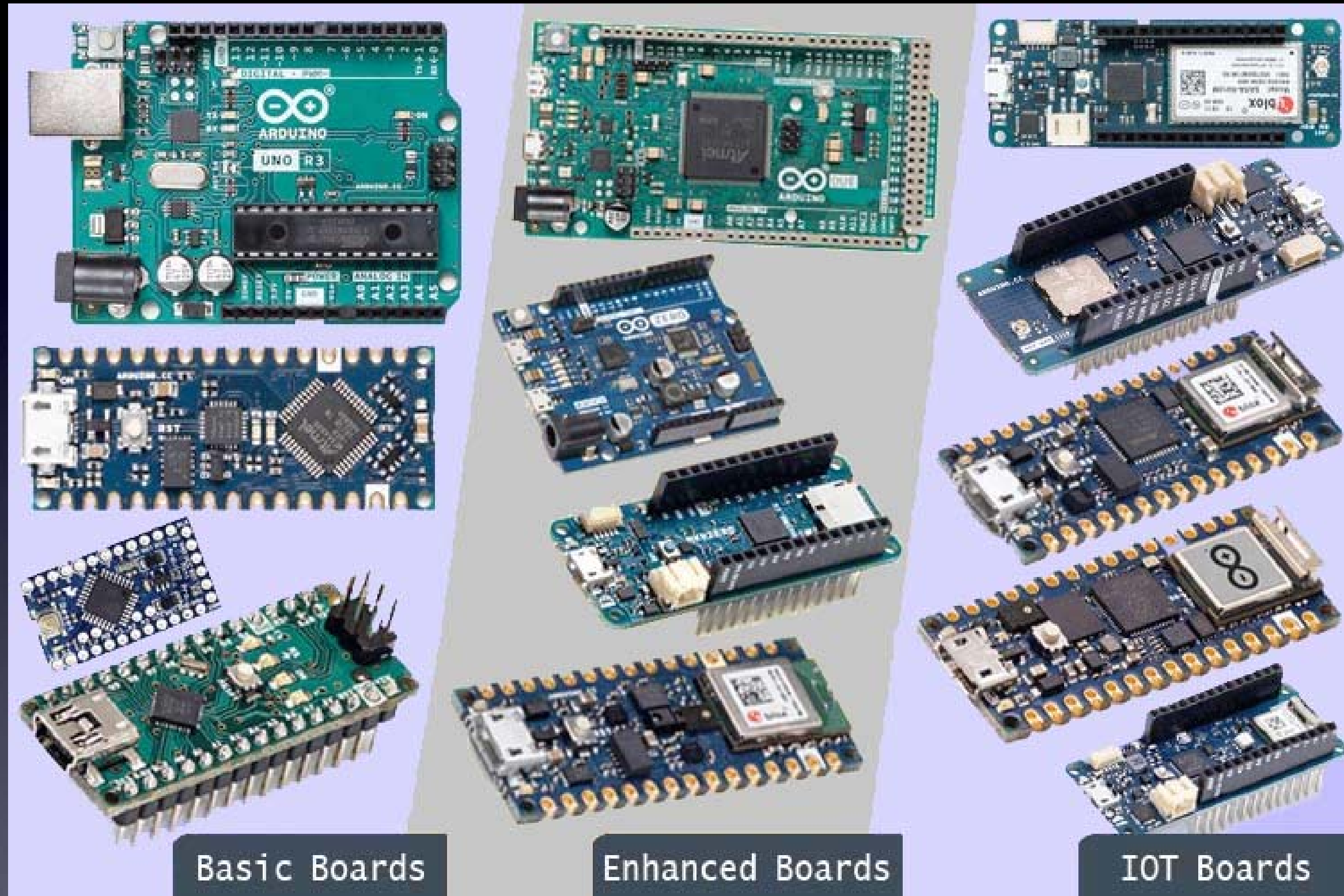


Super easy to  
connect parts  
to its microcontroller's pins

*Use an Arduino board*

Super easy to  
create and upload a program  
to control the parts

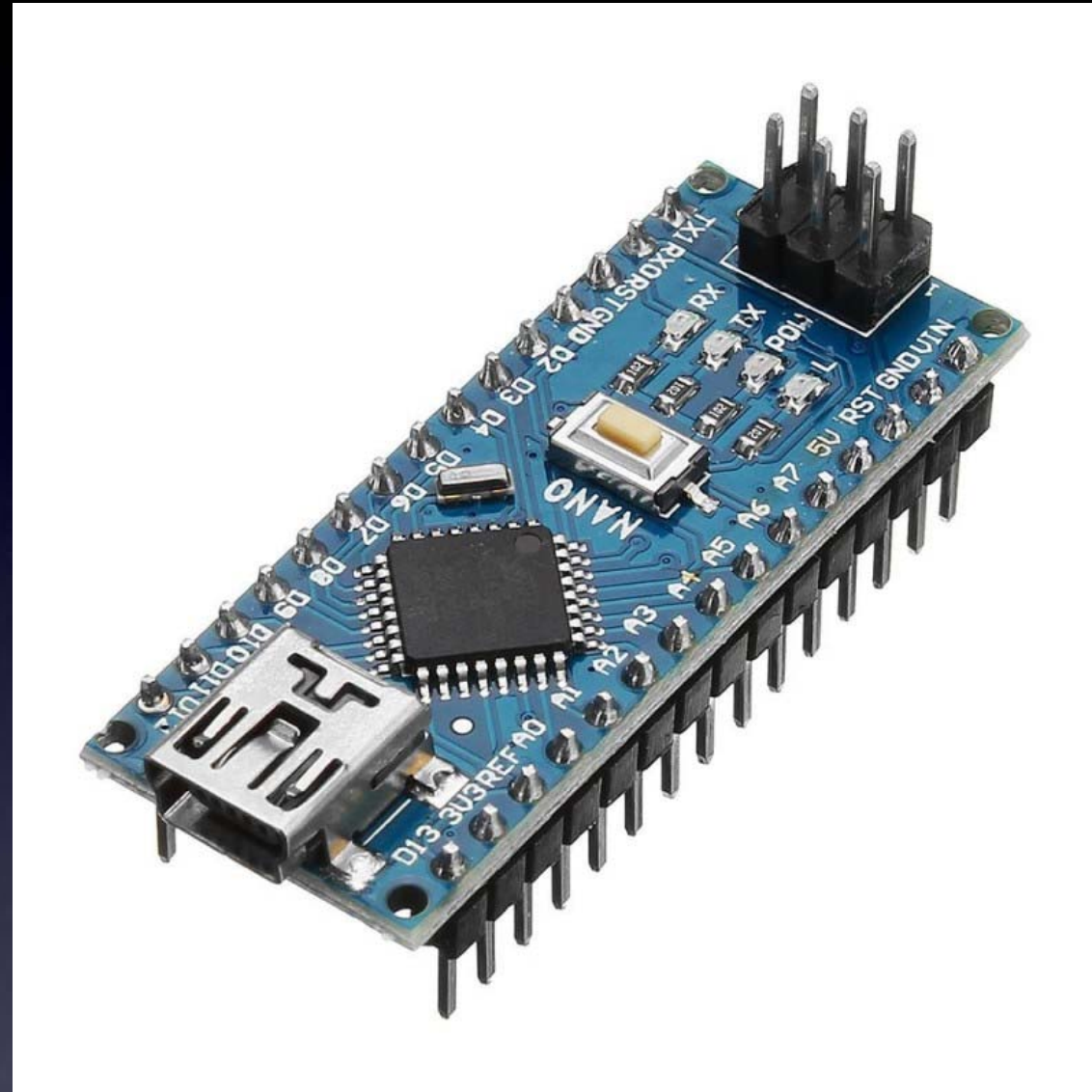
# Intro to Arduino



Open Source



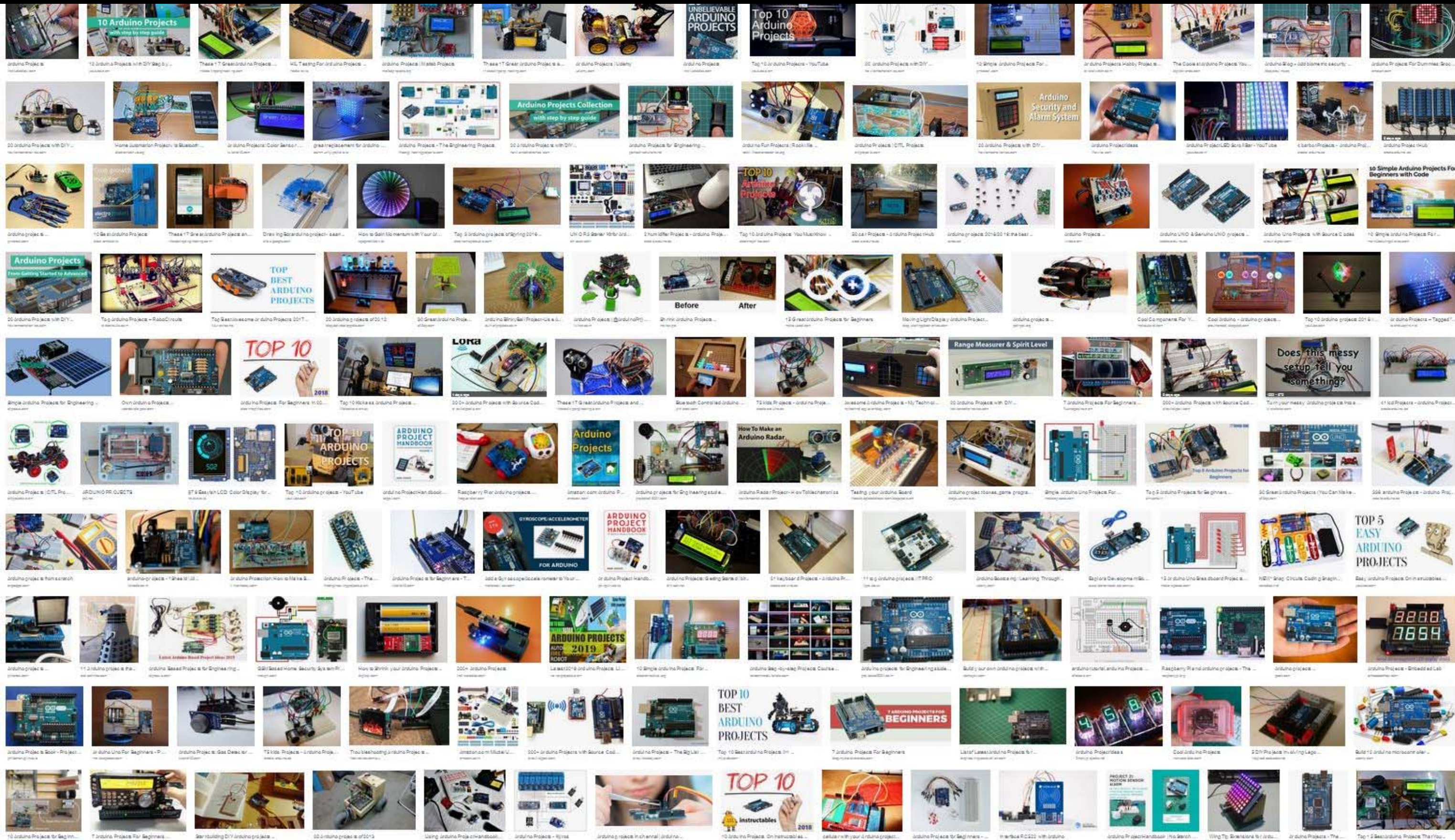
# Intro to Arduino



# Arduino Nano “clone”



# Intro to Arduino



*hundreds of thousands of projects online!*



# Intro to Arduino



## Arduino For Total Newbies workshop

Day 3 Tuesday 29-December, 13:00 to 16:30

→ → *Right-click on this link, and open in a new window*  
[Arduino For Total Newbies workshop room on Big Blue](#)

**NOTE: You do NOT need to register to take this works**  
Just show up before the start time at the Big Blue Button room,  
given above.

*Learn Arduino  
using TV-B-Gone  
as an example project  
(no materials required)*



*Arduino For Total Newbies workshops*



# Arduino

For more info, there are many good Arduino tutorials online.  
A good place to start is:

[<https://www.arduino.cc/en/Tutorial/HomePage>](https://www.arduino.cc/en/Tutorial/HomePage)



# Arduino

## First:

Download and install the Arduino software

< <http://arduino.cc> >



# Arduino

## Second:

Download Arduino sketches

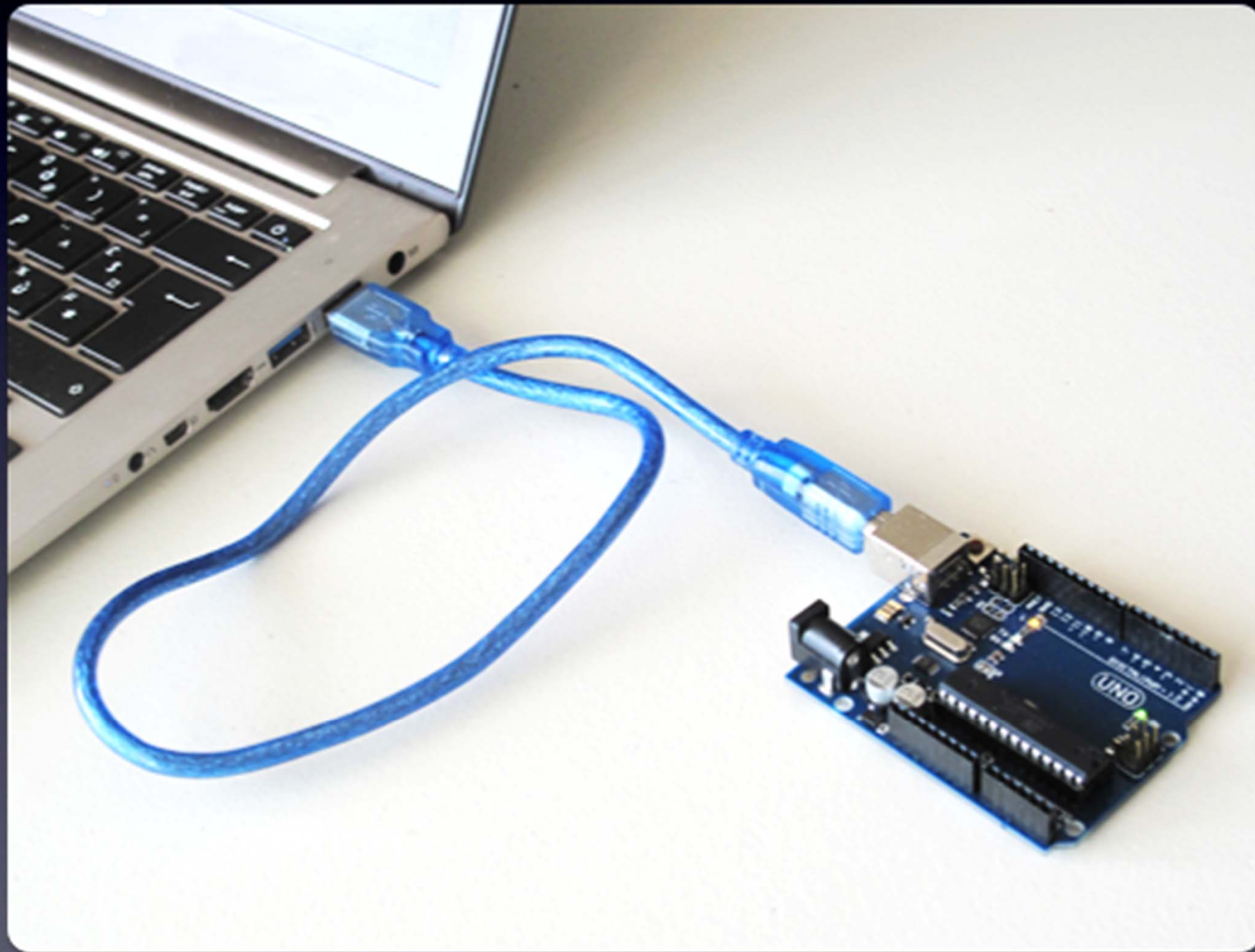
Search for: *“RGB LED Strip Sketches”*

Store them on your computer anywhere you like.

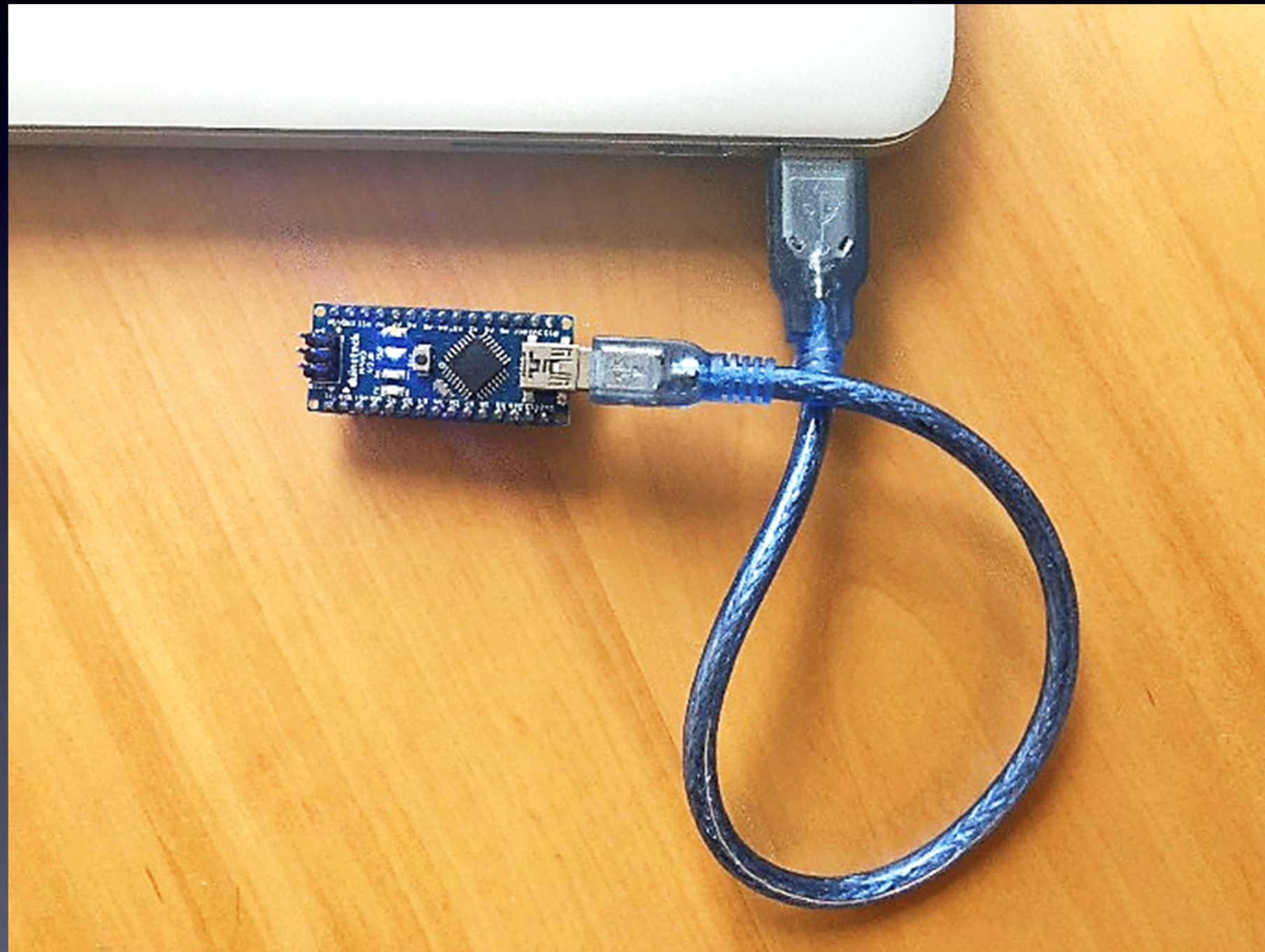




# Connect your Arduino to your computer

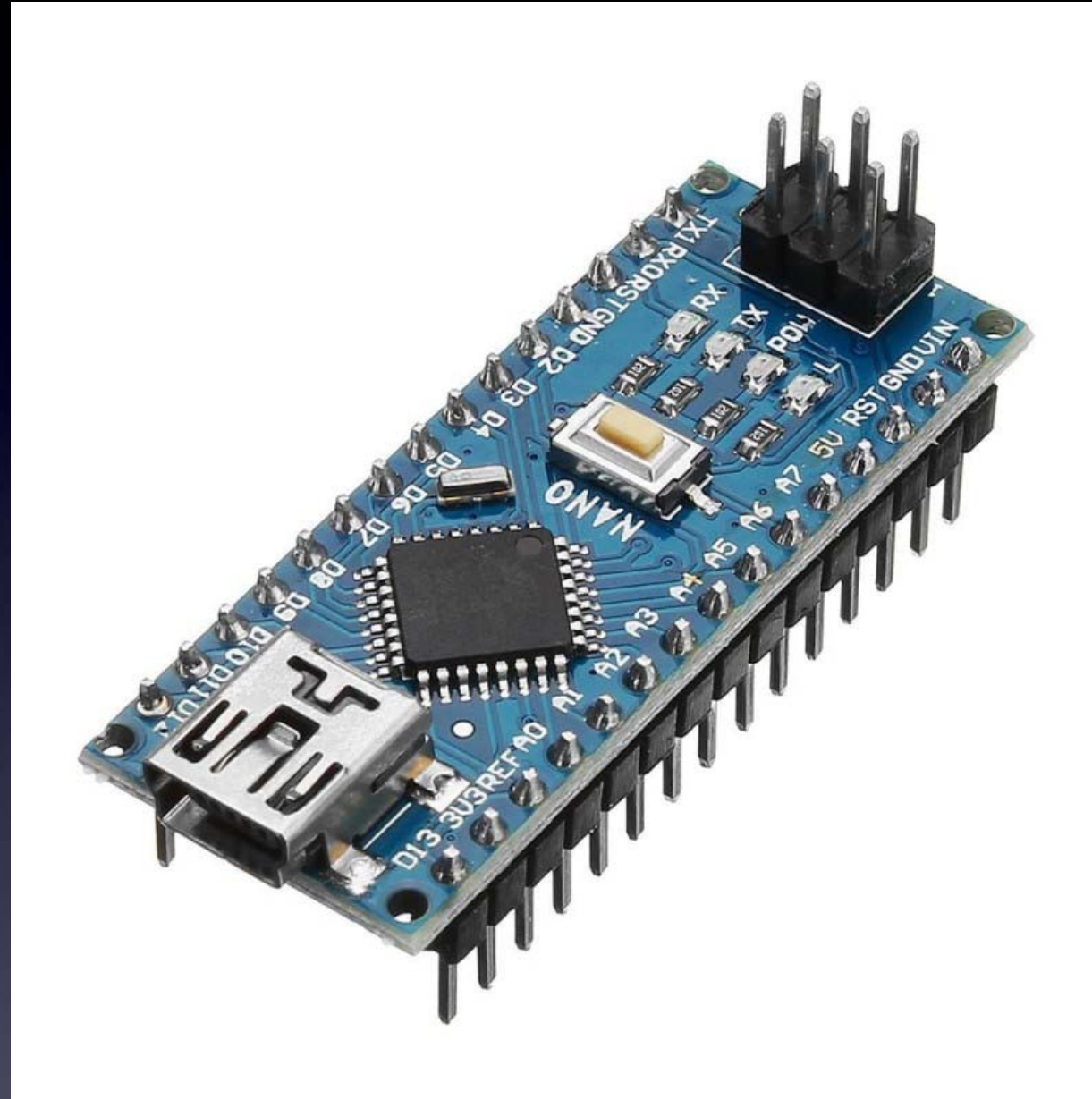


# Connect your Arduino to your computer





# Serial Port Driver

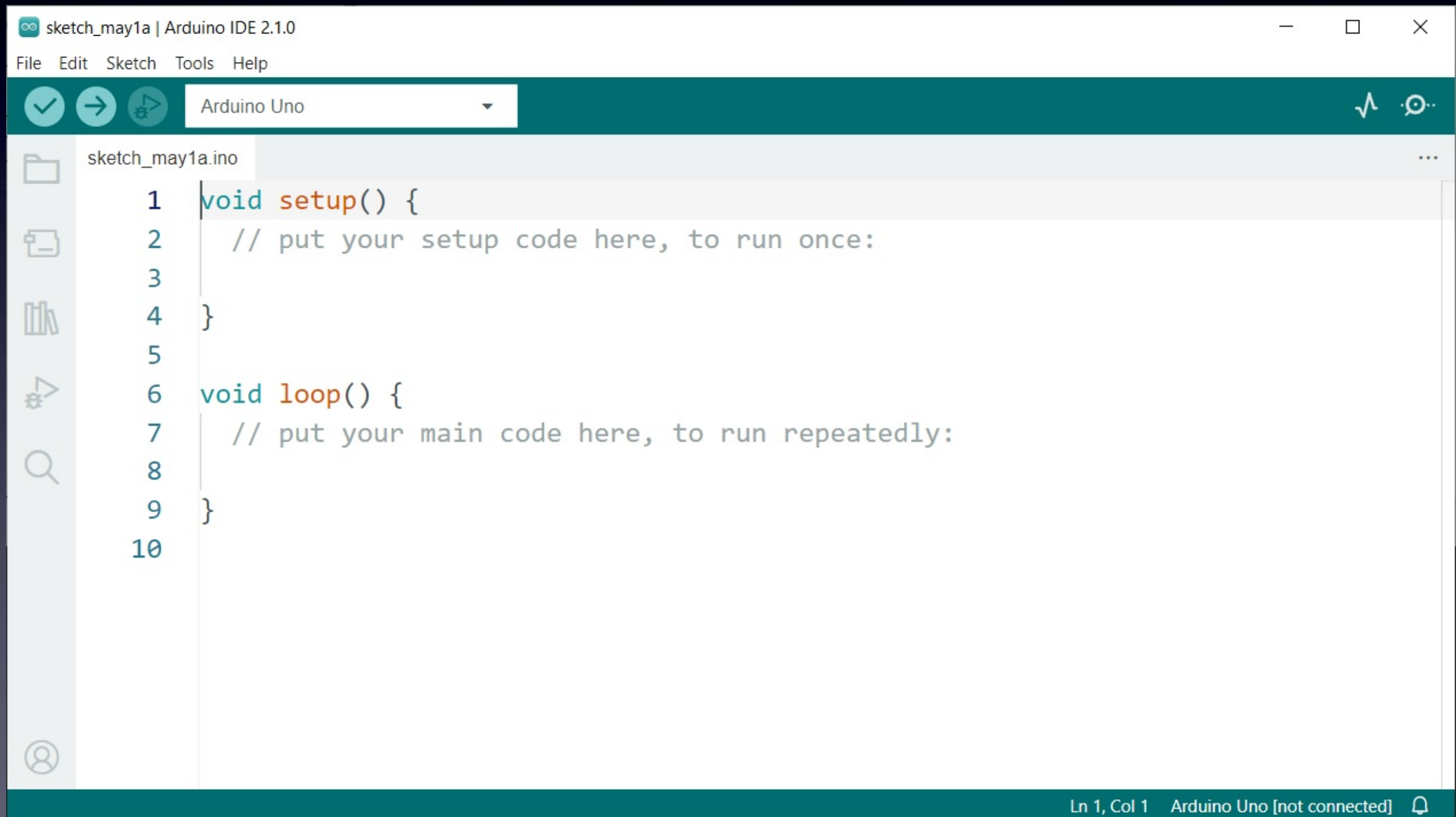


You may need to download and install a driver  
for your Operating System (Windows, MacOS, or Linux):



# Arduino

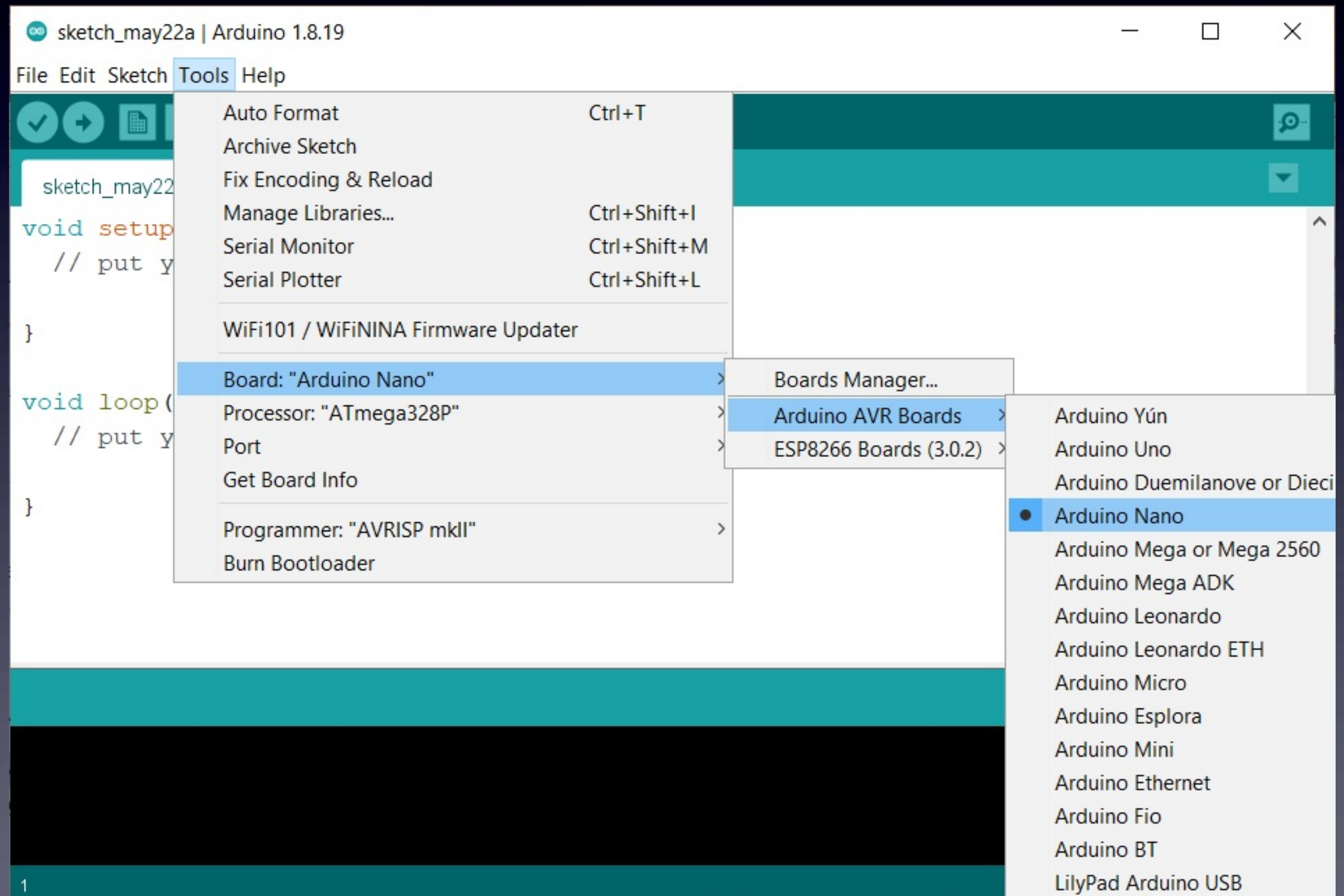
**After you download and install the Arduino software start it, and you will see a screen that looks like this:**



# Arduino

The first time you start your Arduino software you need to set things up

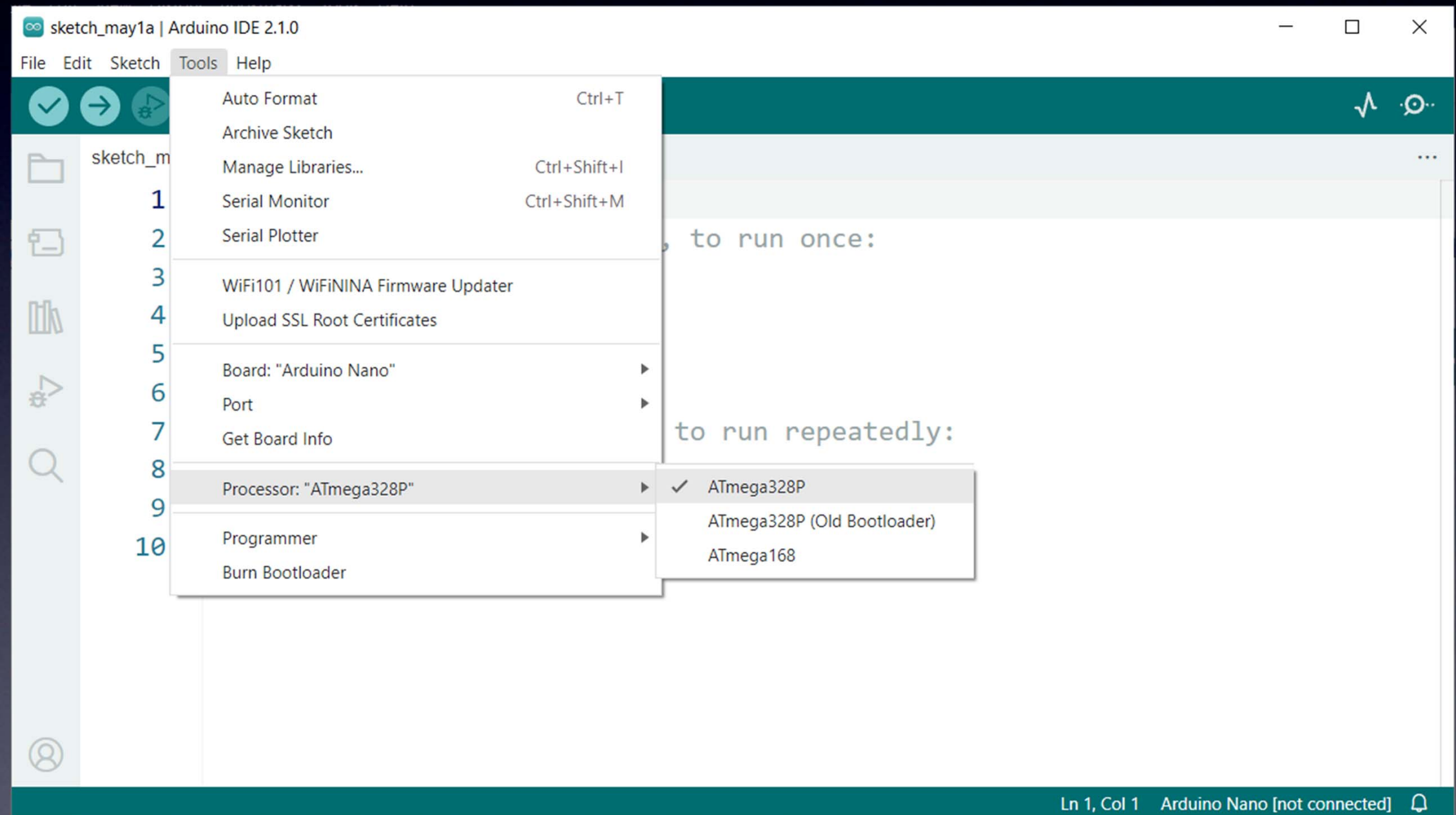
(1)  
Choose  
“Arduino Nano”  
as the Board



# Arduino

The first time you start your Arduino software you need to set things up

(2)  
Choose  
your Processor  
as the Board



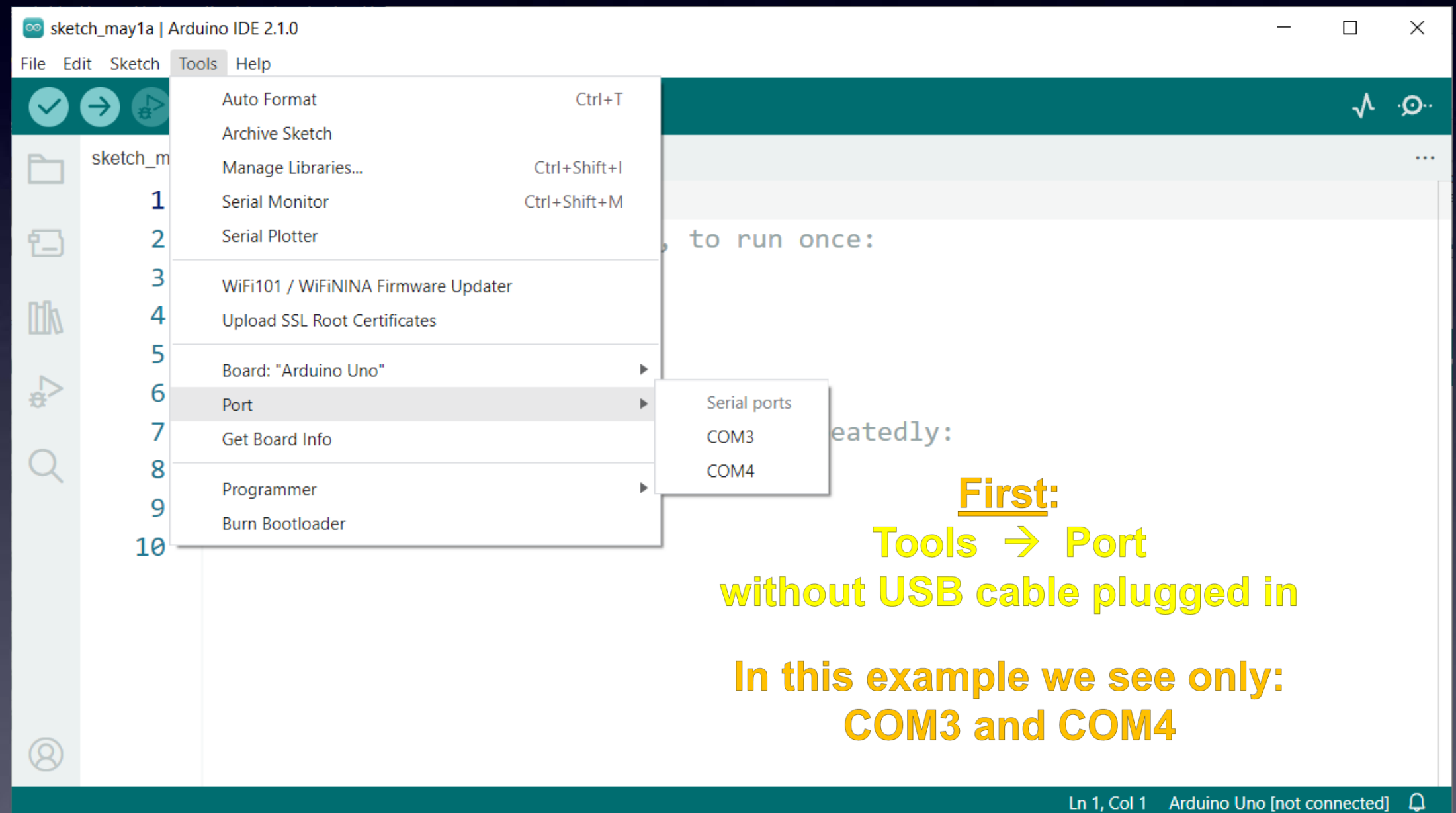
If this one doesn't work,  
then  
choose  
“ATmega328P (Old Bootloader)”



# Arduino

The first time you start your Arduino software you need to set things up

(3)  
Choose  
the Port  
(this will be  
different  
depending on  
your Operating  
System)



First:  
Tools → Port  
without USB cable plugged in

In this example we see only:  
COM3 and COM4

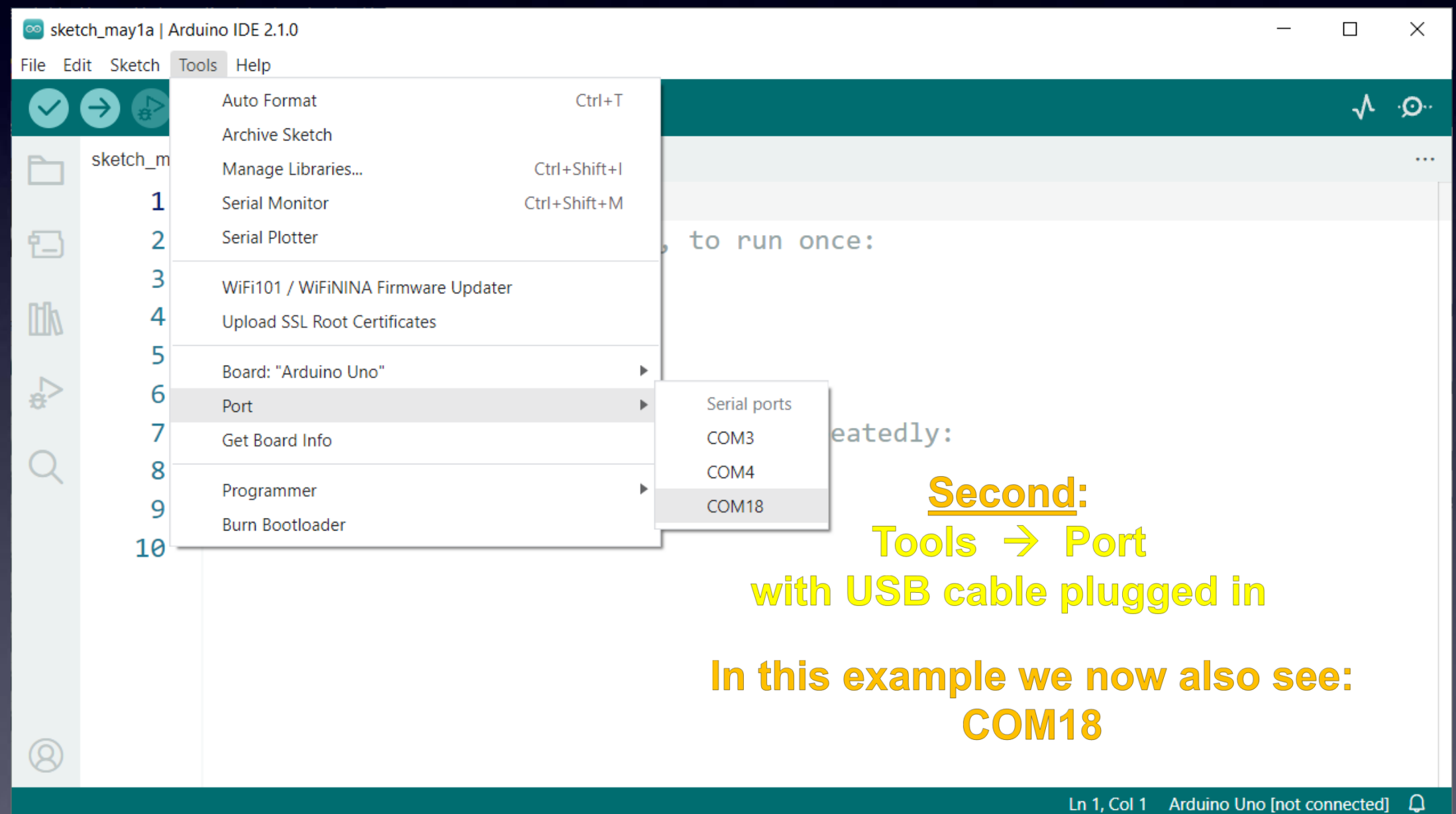
# Arduino

The first time you start your Arduino software you need to set things up

(3)

Choose the Port (this will be different depending on your Operating System)

(After installing the driver for your Arduino (USB-Serial adapter), with your Arduino plugged in, your operating system will see a serial port and it appears here.)



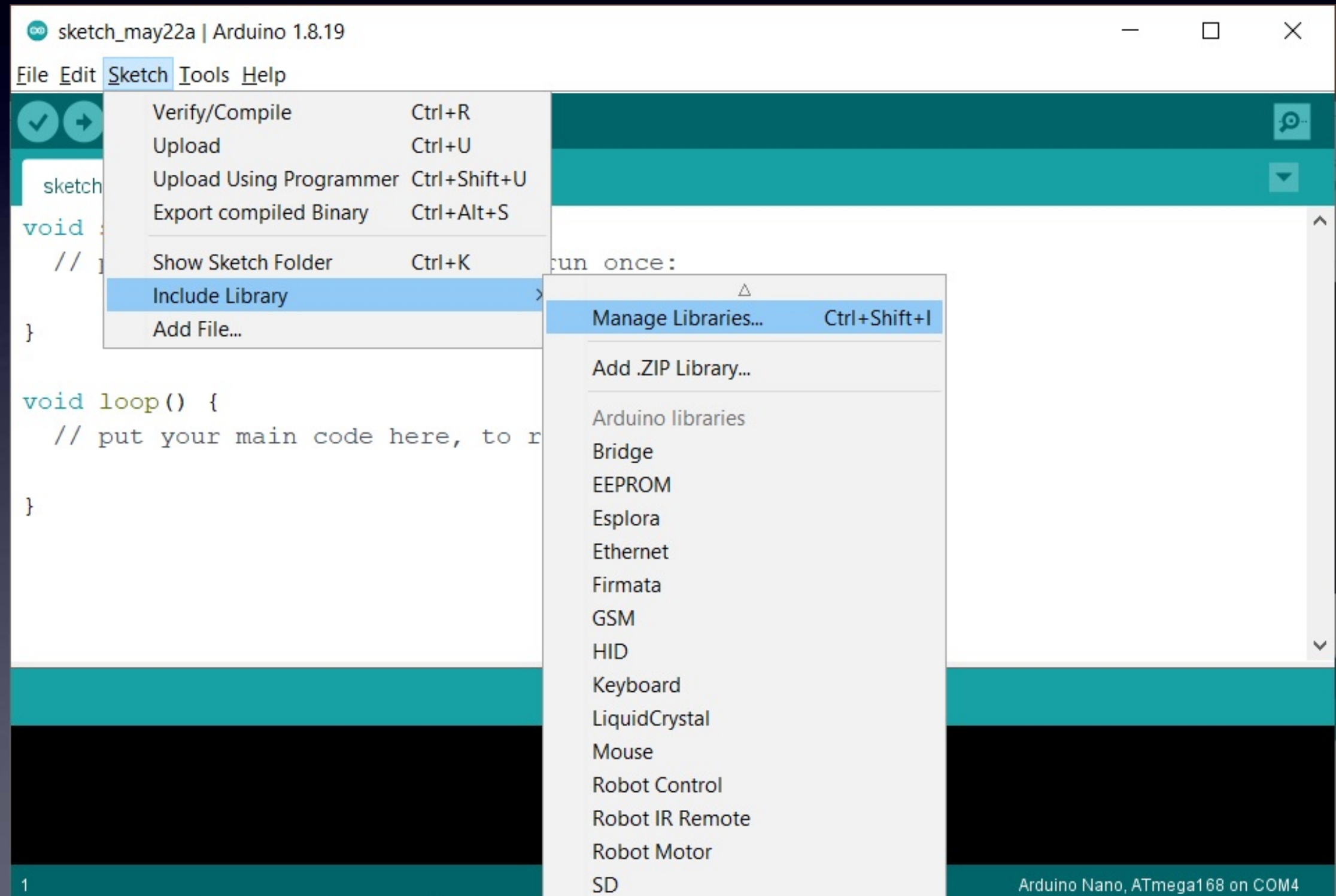
Second:  
Tools → Port  
with USB cable plugged in

In this example we now also see:  
**COM18**

# Arduino

The first time you start your Arduino software  
you need to set things up

(4a)  
Install  
the  
Neopixel  
library

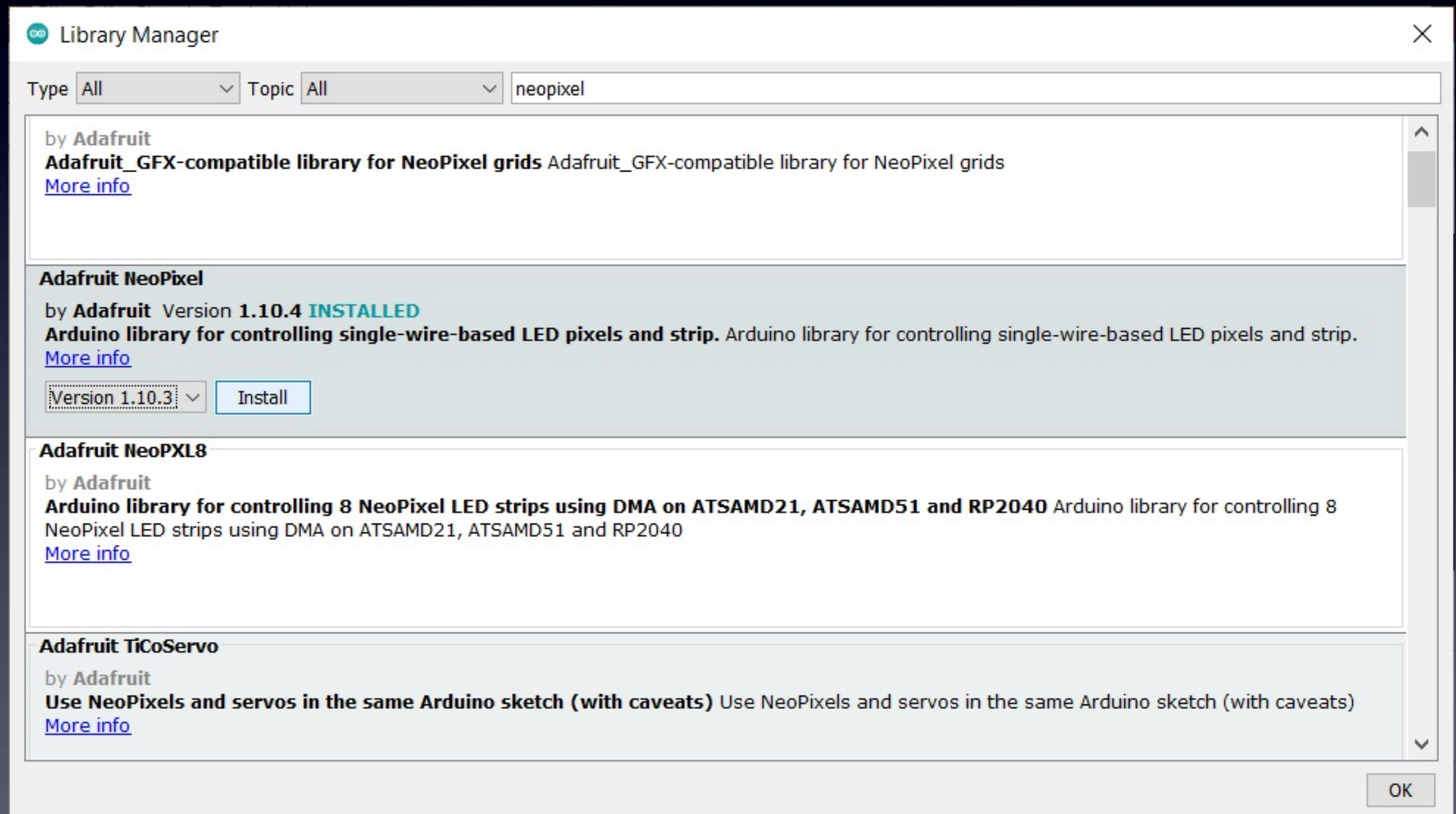




# Arduino

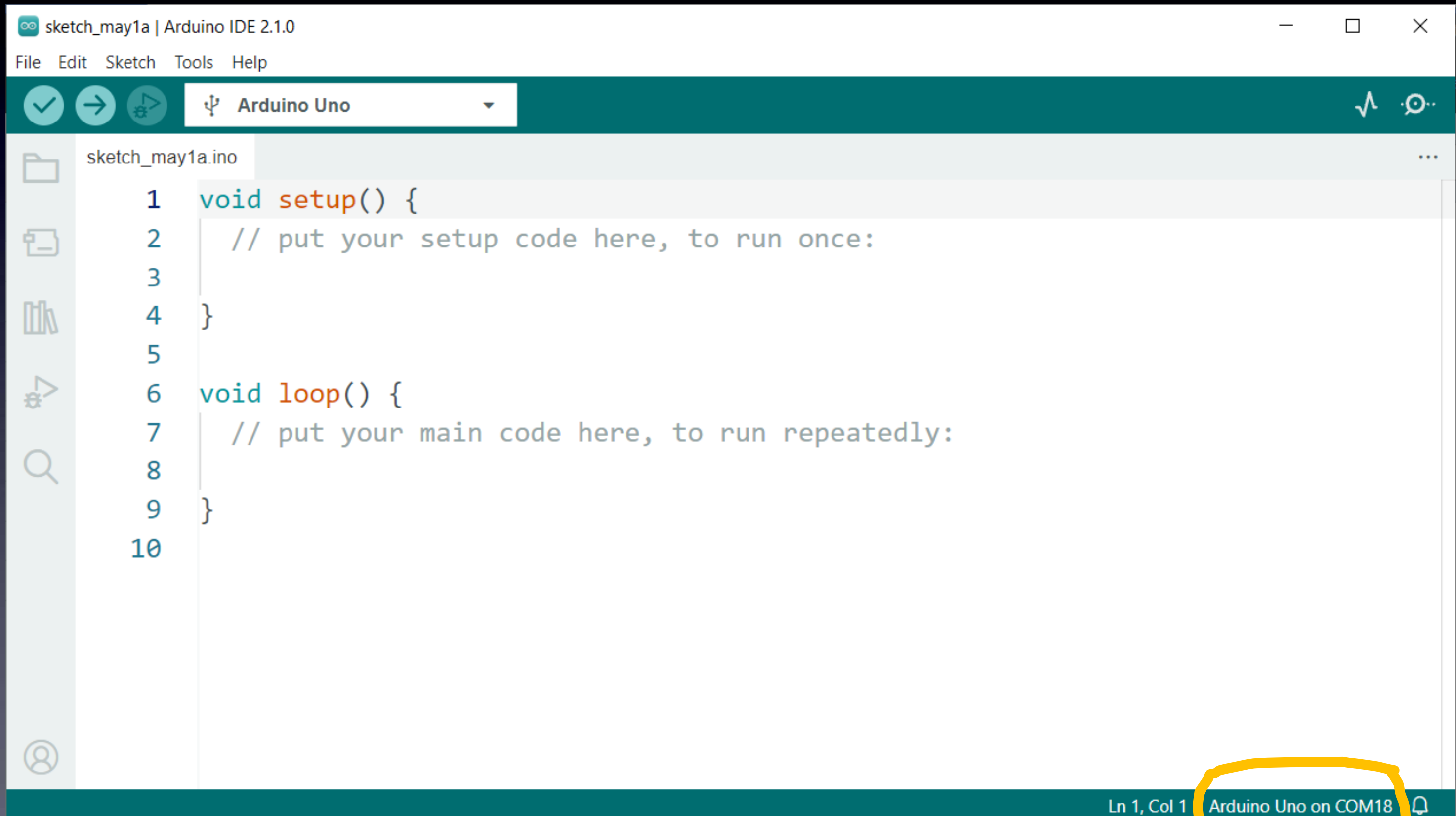
The first time you start your Arduino software  
you need to set things up

(4b)  
Install  
the  
Neopixel  
library



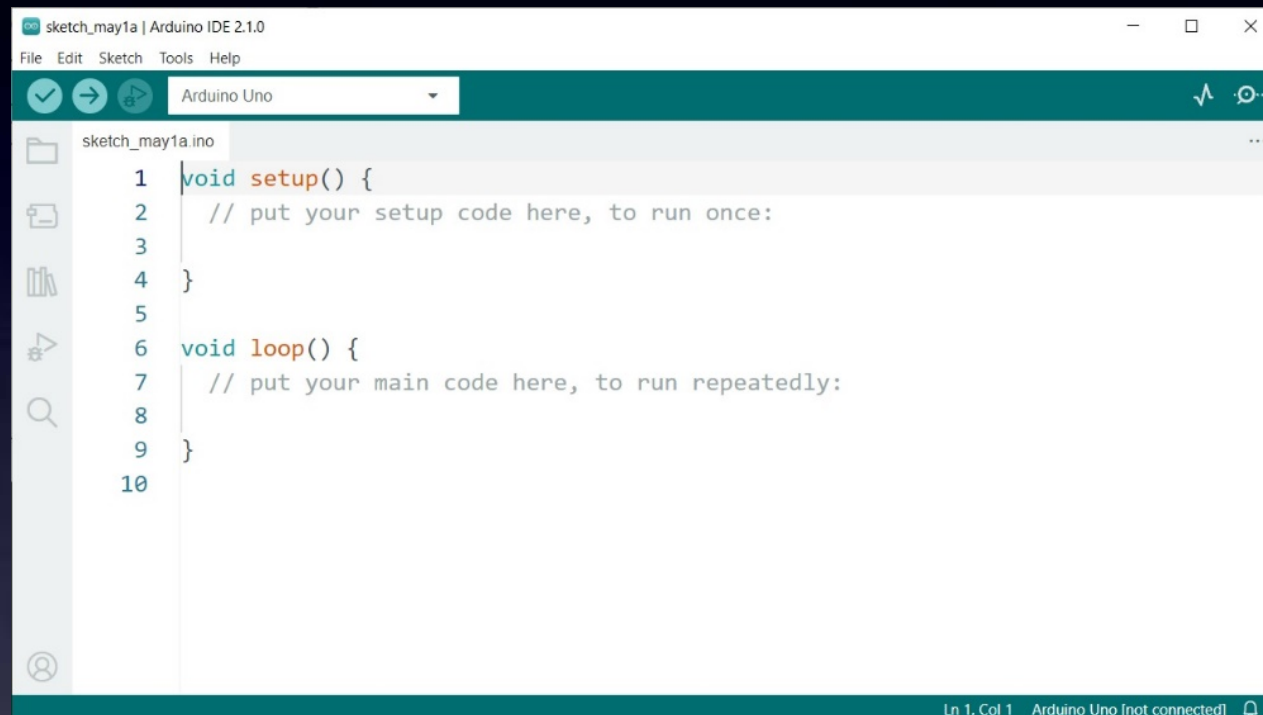
# Arduino

**Your Arduino software is now ready to program your Arduino board!**



# Arduino

Designed for non-geeky artists



```
1 void setup() {  
2   // put your setup code here, to run once:  
3  
4 }  
5  
6 void loop() {  
7   // put your main code here, to run repeatedly:  
8  
9 }  
10
```

“Sketch” :

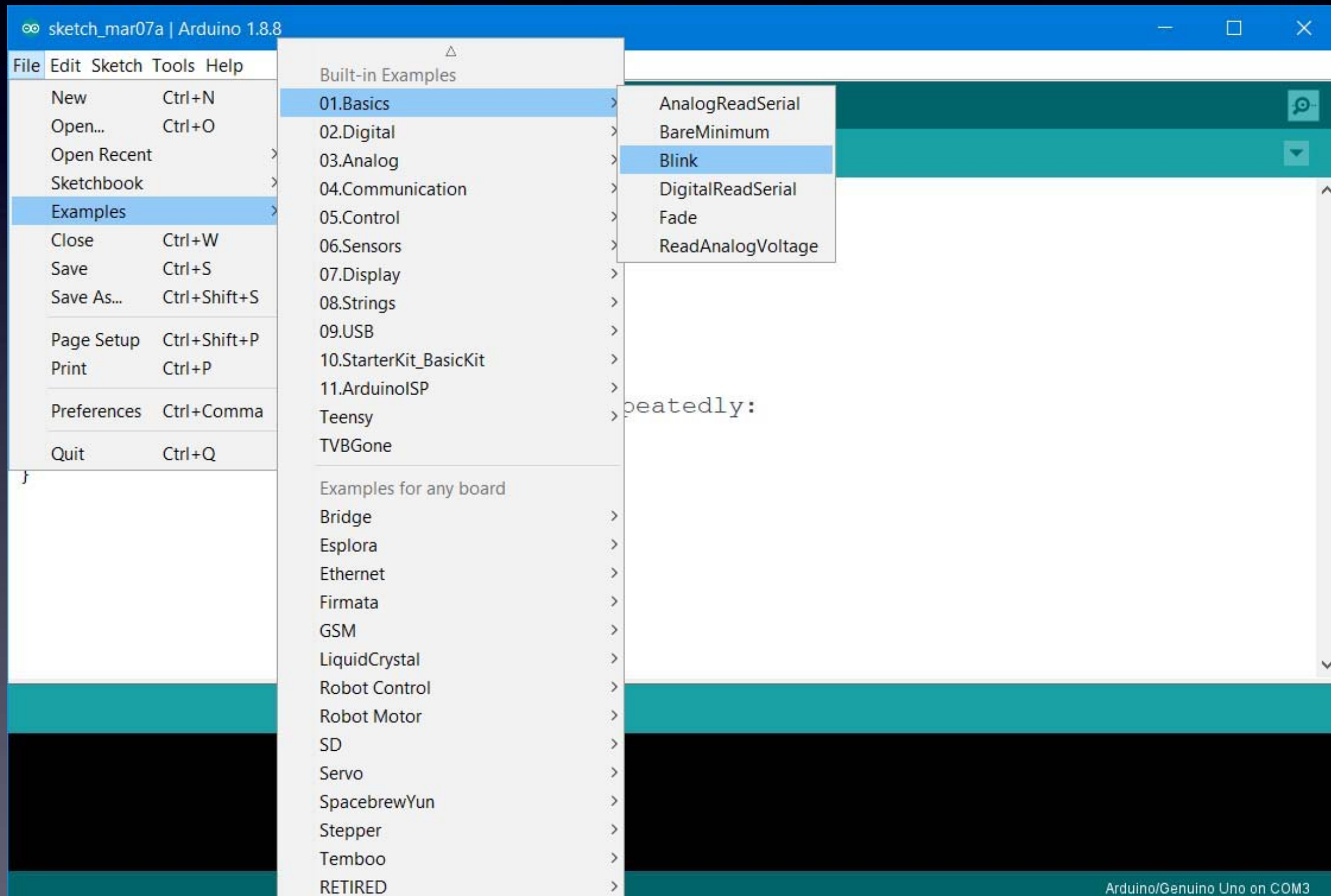
an Arduino program



# Arduino

Let's start simple!

Let's all make an LED blink!



# Arduino

## Example “sketch”: Blink

A screenshot of the Arduino IDE interface. The title bar reads "Blink | Arduino 1.8.19". The menu bar includes "File", "Edit", "Sketch", "Tools", and "Help". Below the menu bar is a toolbar with icons for checking, running, serial monitor, and uploading/downloading. The main text area shows the "Blink" sketch. It includes a header comment explaining the sketch's purpose and providing a link to the Arduino website. The code itself consists of a setup function to initialize the LED pin and a loop function to toggle the LED on and off with a one-second delay. The status bar at the bottom indicates "1" on the left and "Arduino Nano, ATmega168 on COM4" on the right.

```
Blink

Turns an LED on for one second, then off for one second, repeatedly.

Most Arduinos have an on-board LED you can control. On the UNO, MEGA and ZERO
it is attached to digital pin 13, on MKR1000 on pin 6. LED_BUILTIN is set to
the correct LED pin independent of which board is used.
If you want to know what pin the on-board LED is connected to on your Arduino
model, check the Technical Specs of your board at:
https://www.arduino.cc/en/Main/Products

modified 8 May 2014
by Scott Fitzgerald
modified 2 Sep 2016
by Arturo Guadalupi
modified 8 Sep 2016
by Colby Newman

This example code is in the public domain.

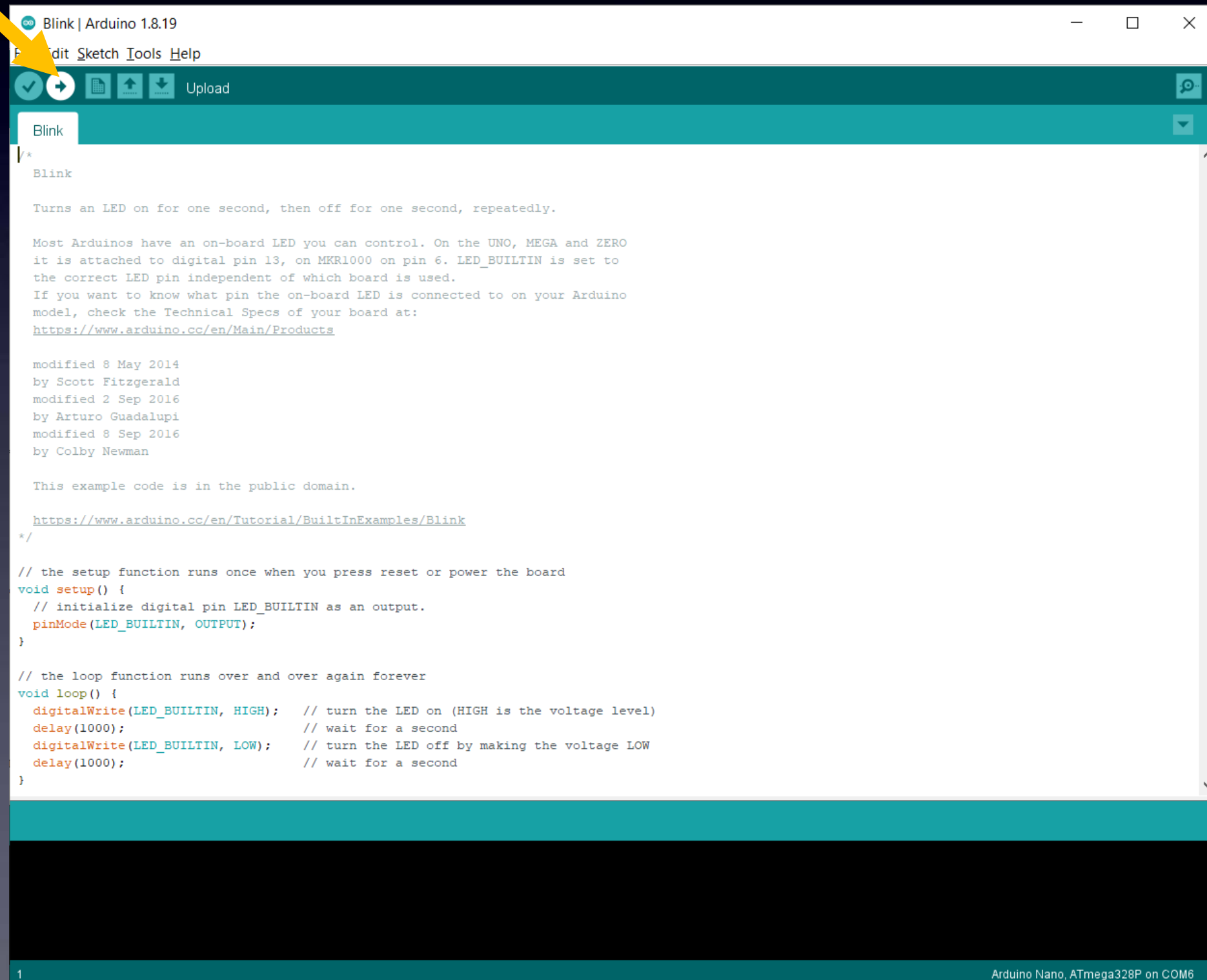
https://www.arduino.cc/en/Tutorial/BuiltInExamples/Blink
*/

// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH); // turn the LED on (HIGH is the voltage level)
  delay(1000); // wait for a second
  digitalWrite(LED_BUILTIN, LOW); // turn the LED off by making the voltage LOW
  delay(1000); // wait for a second
}
```

# Arduino

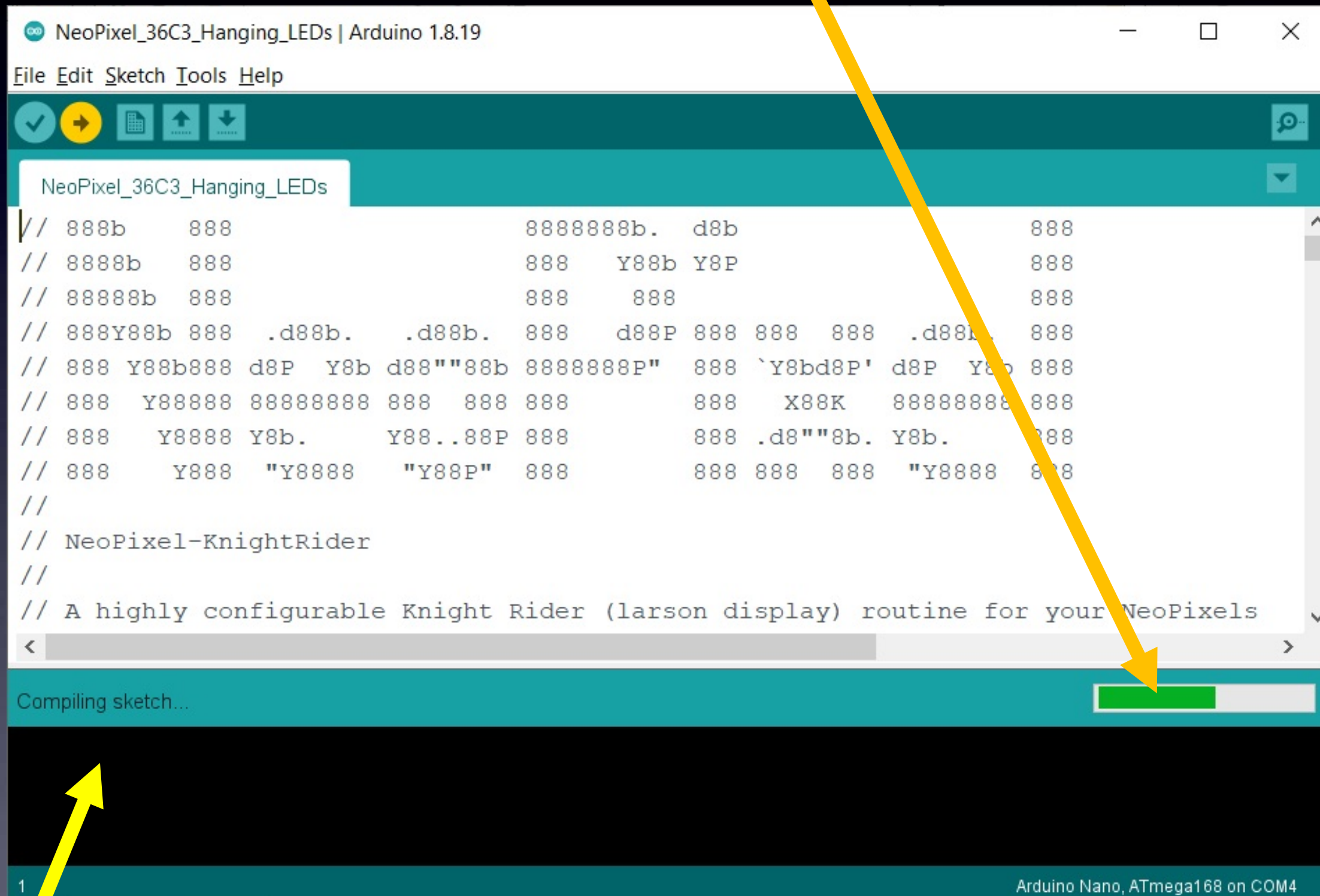
With the USB cable connected to your Arduino board  
press the Upload button





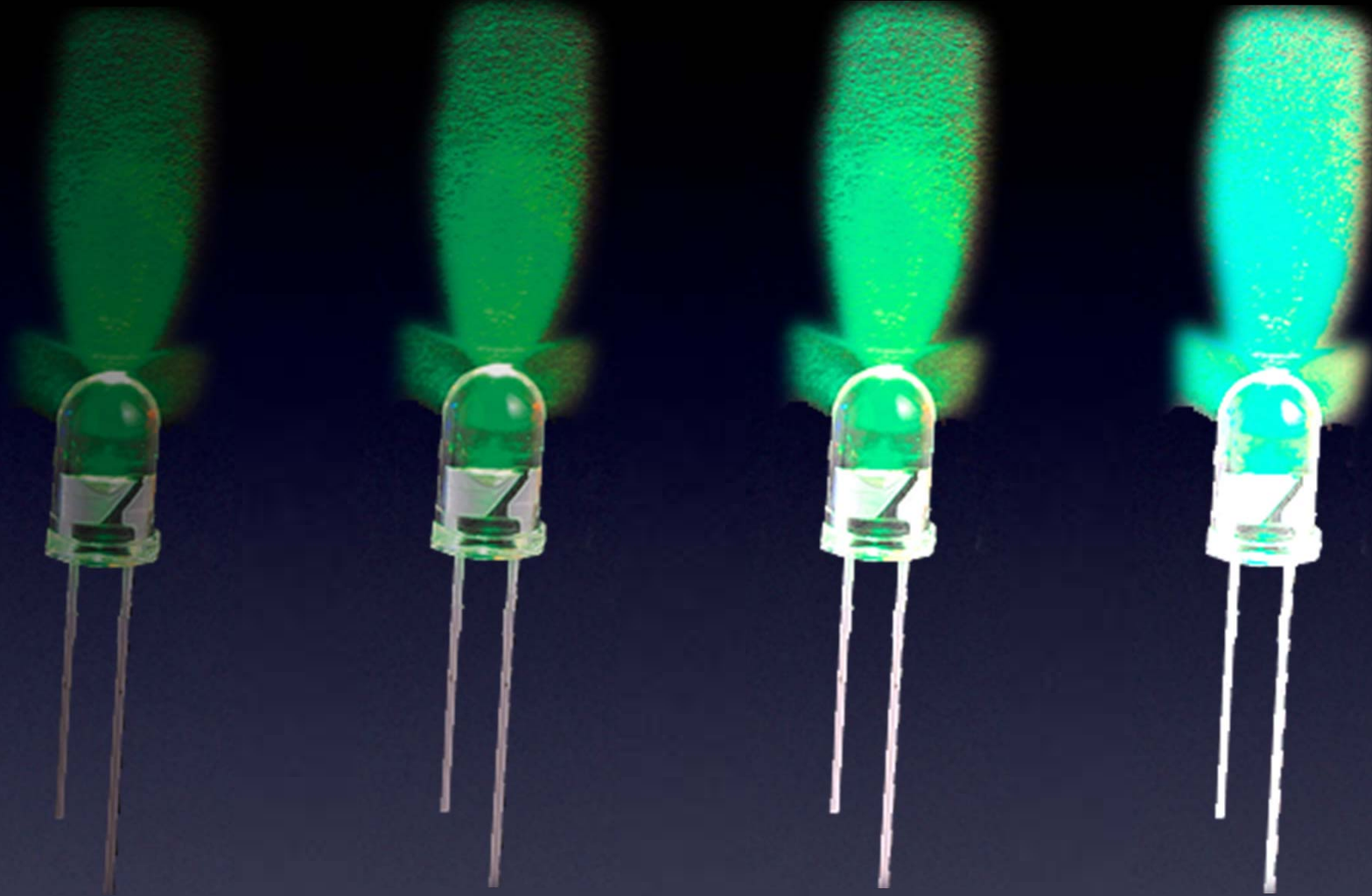
# Arduino

While uploading, you will see a progress bar...



...and when it's completed successfully, it says: "Upload done"

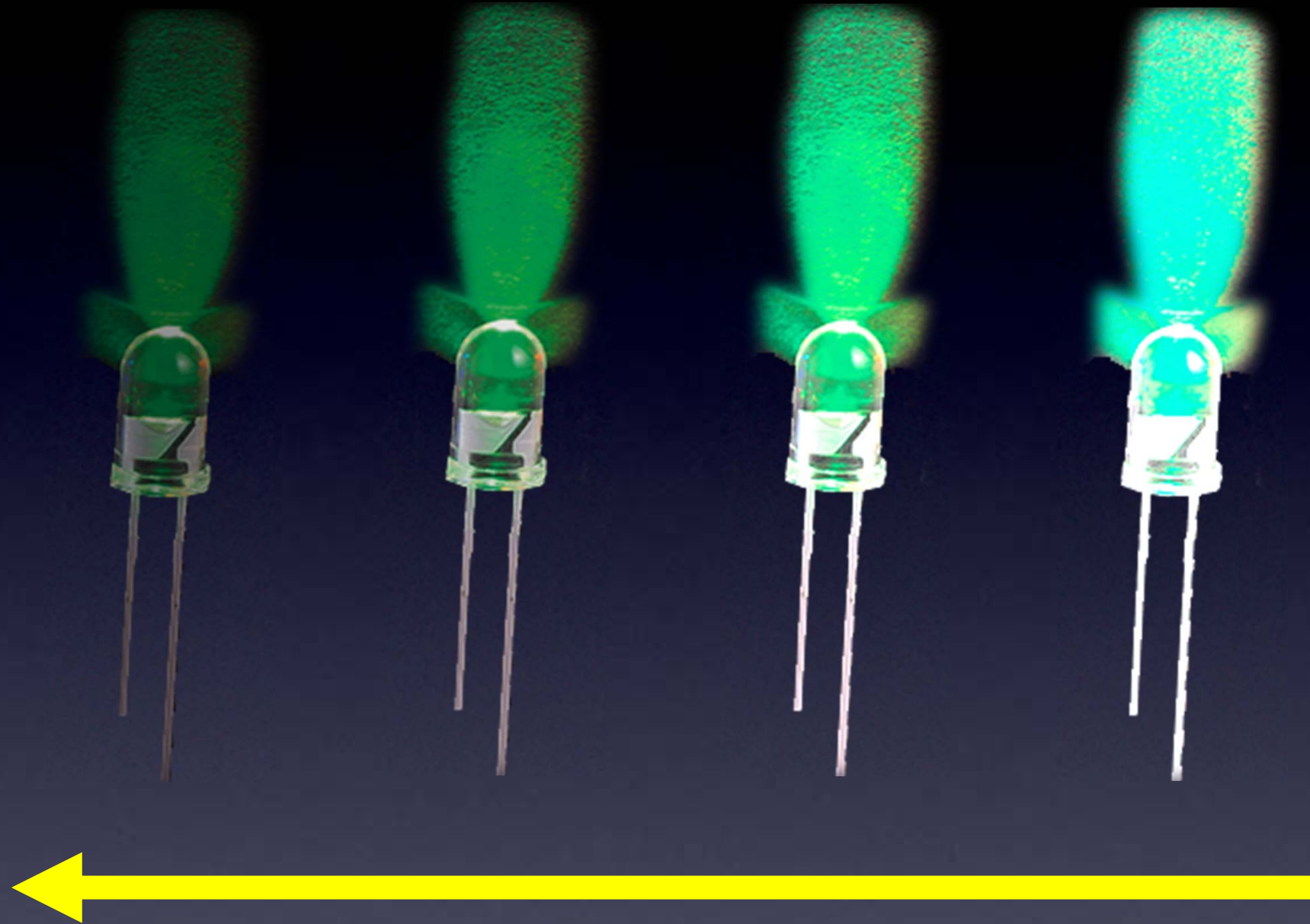
# LED Brightness



More resistance (less current)

(one way to change brightness)

# LED Brightness



Less average current

This is how we do it with a microcontroller

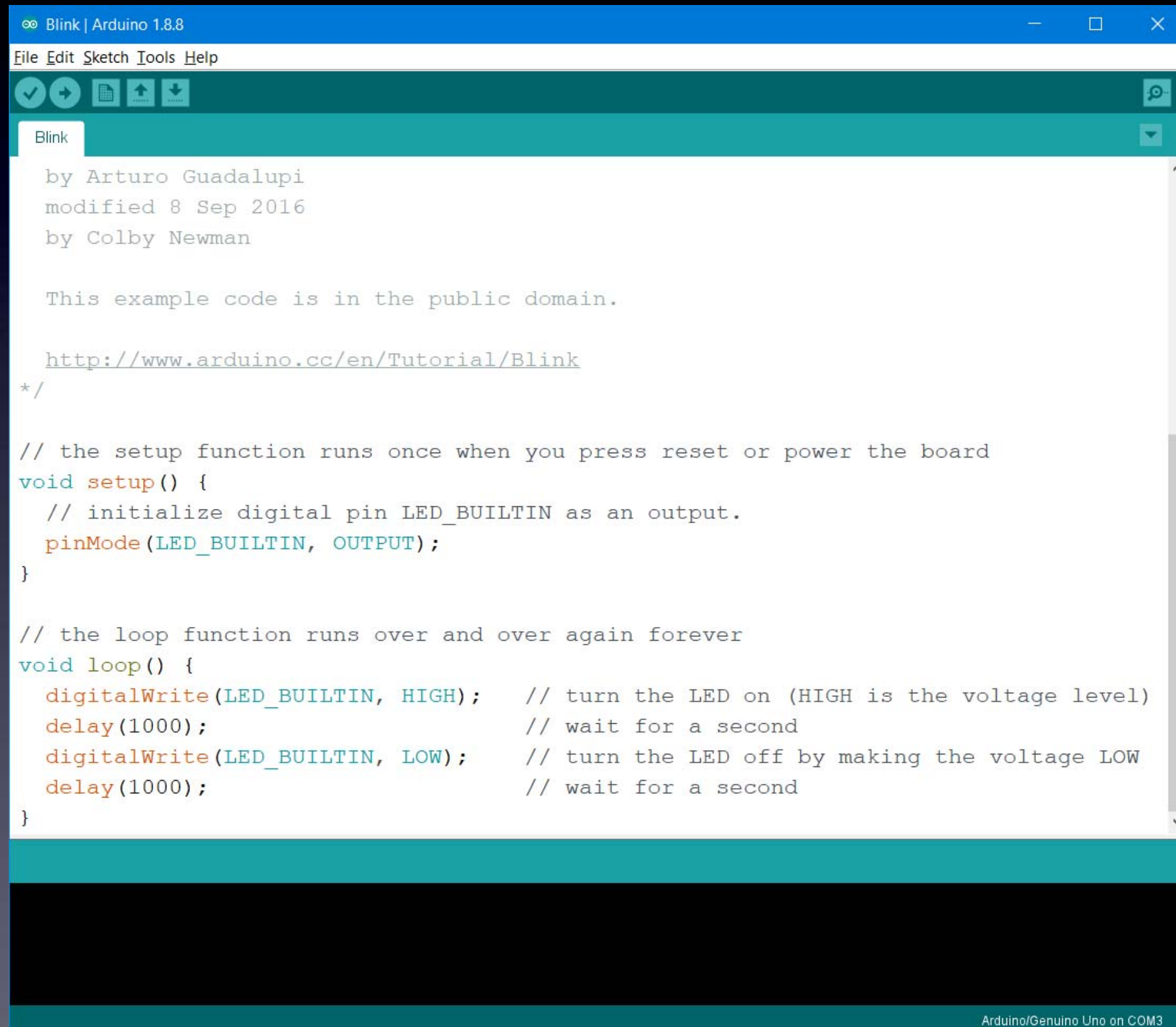


# LED Brightness

## PWM

# Arduino

## Hacking the Blink sketch

A screenshot of the Arduino IDE interface. The title bar reads "Blink | Arduino 1.8.8". The menu bar includes "File", "Edit", "Sketch", "Tools", and "Help". The toolbar contains icons for opening, saving, and uploading files. A tab labeled "Blink" is active. The code editor displays the following text:

```
by Arturo Guadalupi  
modified 8 Sep 2016  
by Colby Newman  
  
This example code is in the public domain.  
  
http://www.arduino.cc/en/Tutorial/Blink  
*/  
  
// the setup function runs once when you press reset or power the board  
void setup() {  
  // initialize digital pin LED_BUILTIN as an output.  
  pinMode(LED_BUILTIN, OUTPUT);  
}  
  
// the loop function runs over and over again forever  
void loop() {  
  digitalWrite(LED_BUILTIN, HIGH); // turn the LED on (HIGH is the voltage level)  
  delay(1000); // wait for a second  
  digitalWrite(LED_BUILTIN, LOW); // turn the LED off by making the voltage LOW  
  delay(1000); // wait for a second  
}
```

The status bar at the bottom right indicates "Arduino/Genuino Uno on COM3".

# LED Brightness

PWM



**Square Wave:**

ON half the time / OFF half of the time



# LED Brightness

PWM



## Square Wave:

ON half the time / OFF half of the time

*(half the energy of ON all the time)*

# Digital Signal Processing

PWM ?



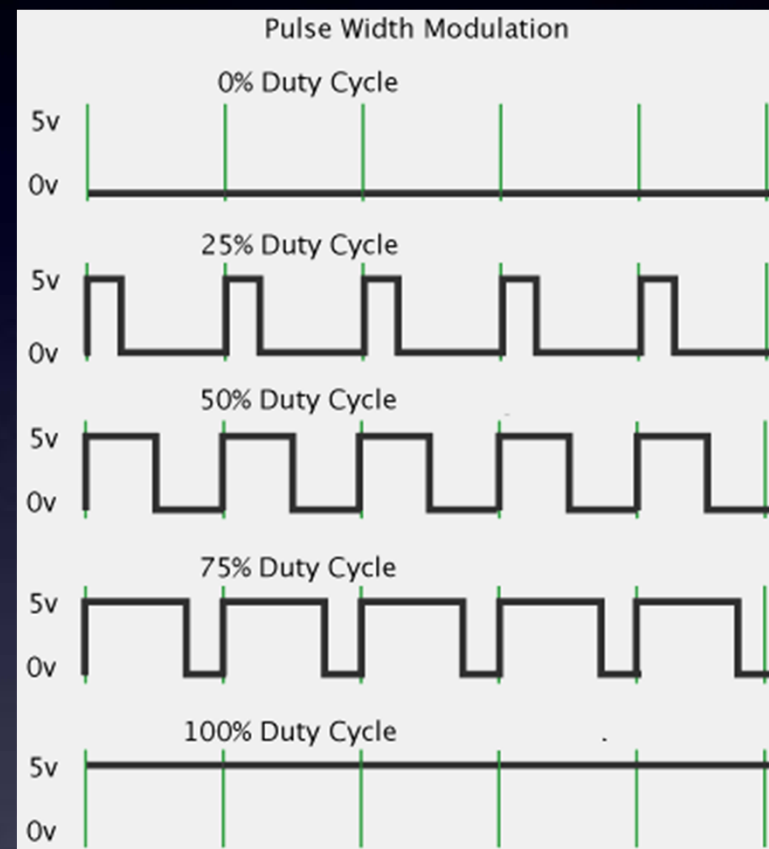
## Pulse Wave:

ON and OFF at any ratio you like

This waveform: ON for 25% of the time / OFF for 75% of the time

# LED Brightness

PWM

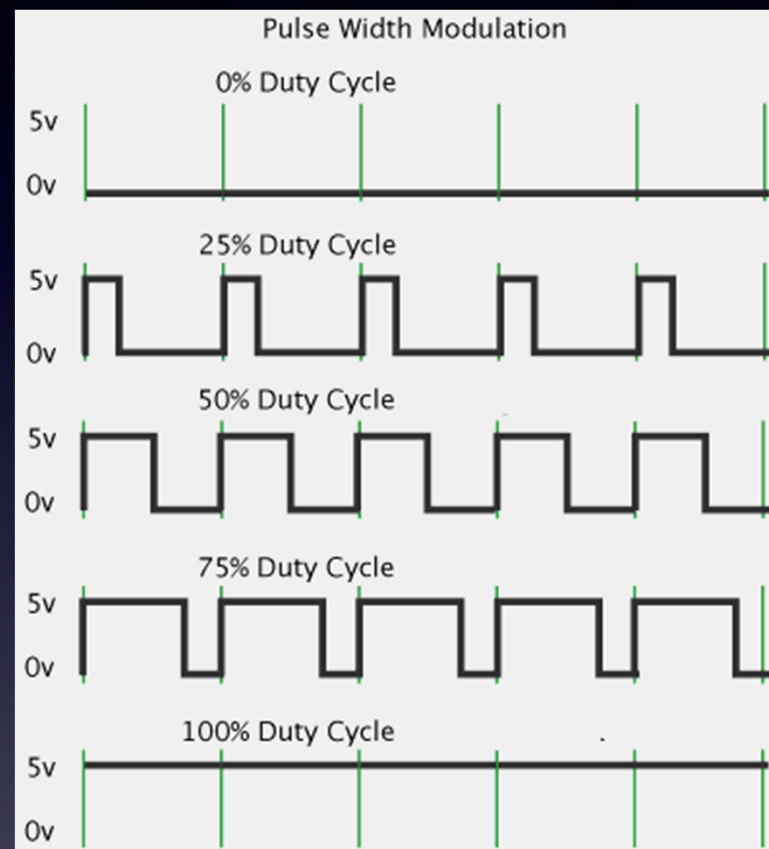


**Pulse Wave:**

ON and OFF at any ratio you like



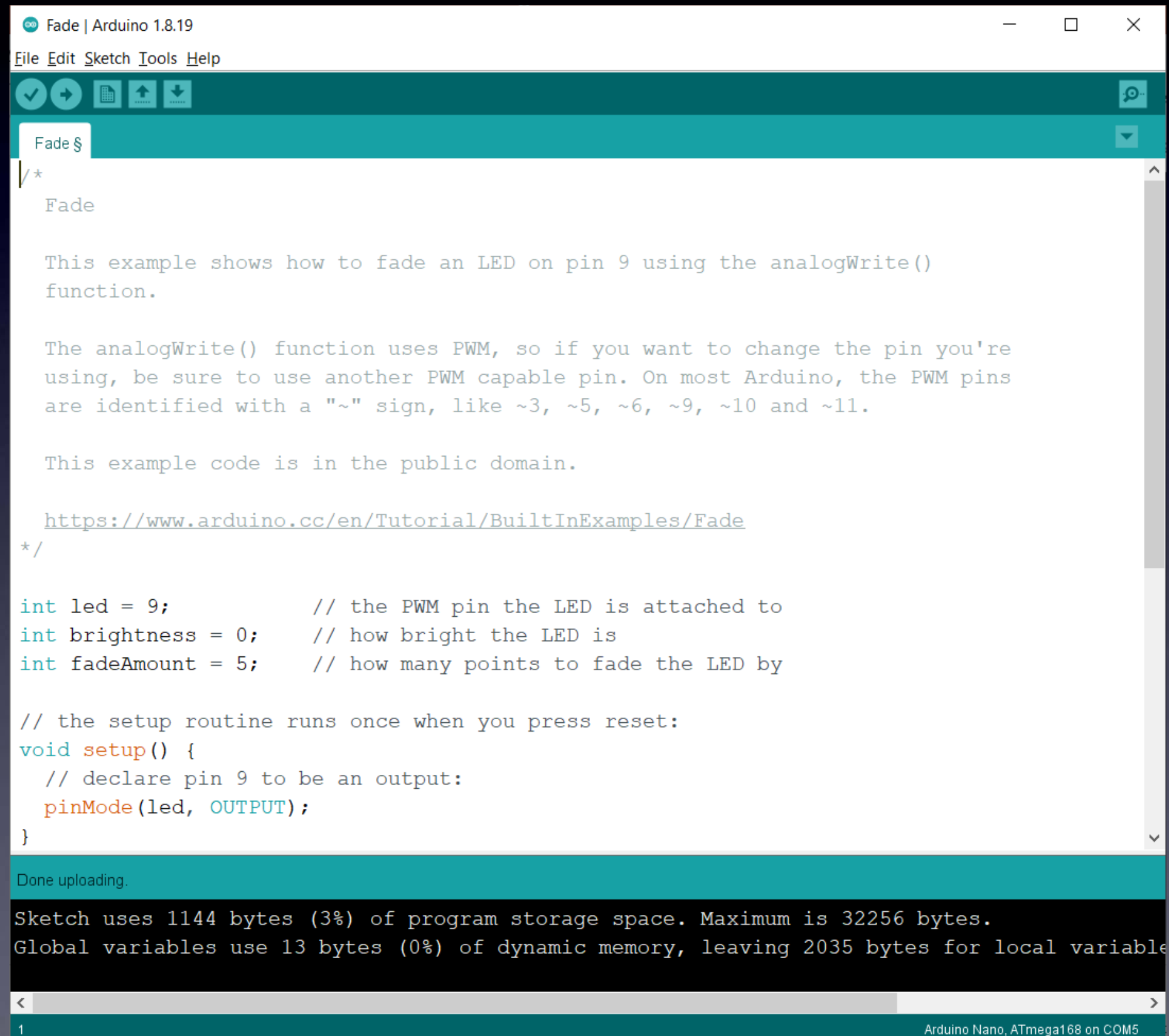
# LED Brightness



**PWM**  
**Pulse Width Modulation**

# Arduino

## Example “sketch”: Fade



```
Fade | Arduino 1.8.19
File Edit Sketch Tools Help
✓ → 📄 ⬆ ⬇
Fade $
/*
  Fade

  This example shows how to fade an LED on pin 9 using the analogWrite()
  function.

  The analogWrite() function uses PWM, so if you want to change the pin you're
  using, be sure to use another PWM capable pin. On most Arduino, the PWM pins
  are identified with a "~" sign, like ~3, ~5, ~6, ~9, ~10 and ~11.

  This example code is in the public domain.

  https://www.arduino.cc/en/Tutorial/BuiltInExamples/Fade
*/

int led = 9;           // the PWM pin the LED is attached to
int brightness = 0;    // how bright the LED is
int fadeAmount = 5;    // how many points to fade the LED by

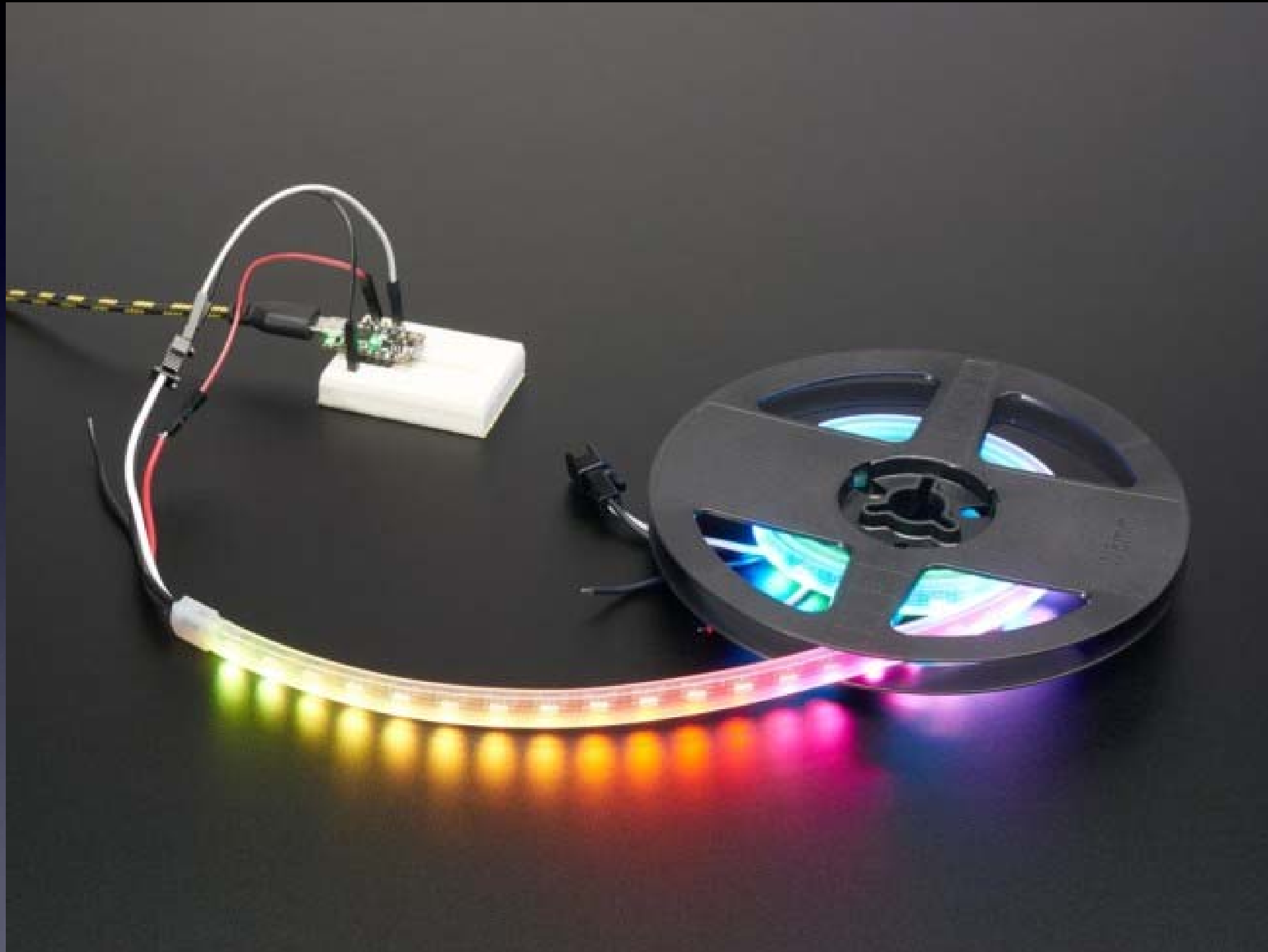
// the setup routine runs once when you press reset:
void setup() {
  // declare pin 9 to be an output:
  pinMode(led, OUTPUT);
}

Done uploading.

Sketch uses 1144 bytes (3%) of program storage space. Maximum is 32256 bytes.
Global variables use 13 bytes (0%) of dynamic memory, leaving 2035 bytes for local variables.

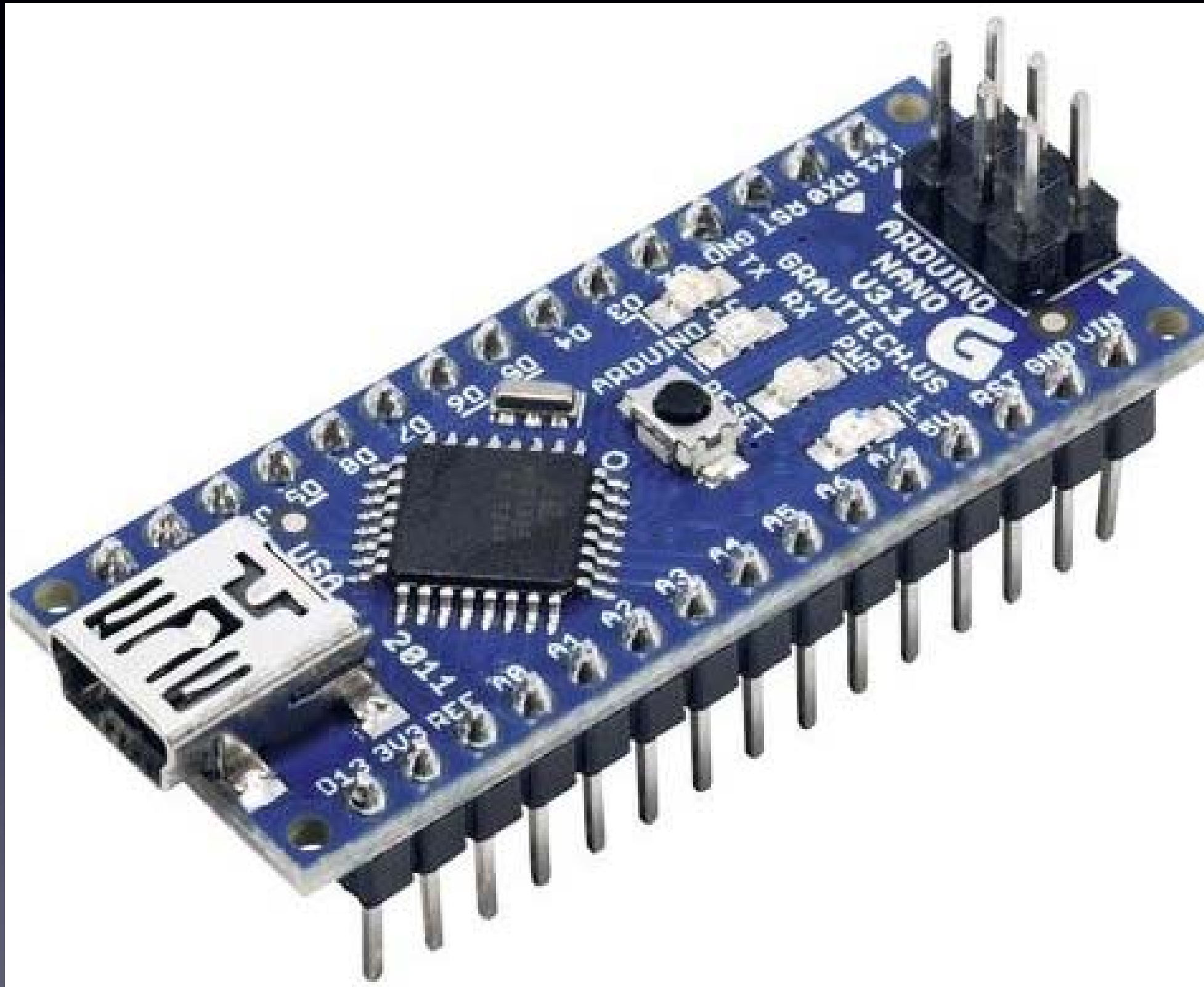
1 Arduino Nano, ATmega168 on COM5
```

# Let's Program Some LED Strips!





# Arduino

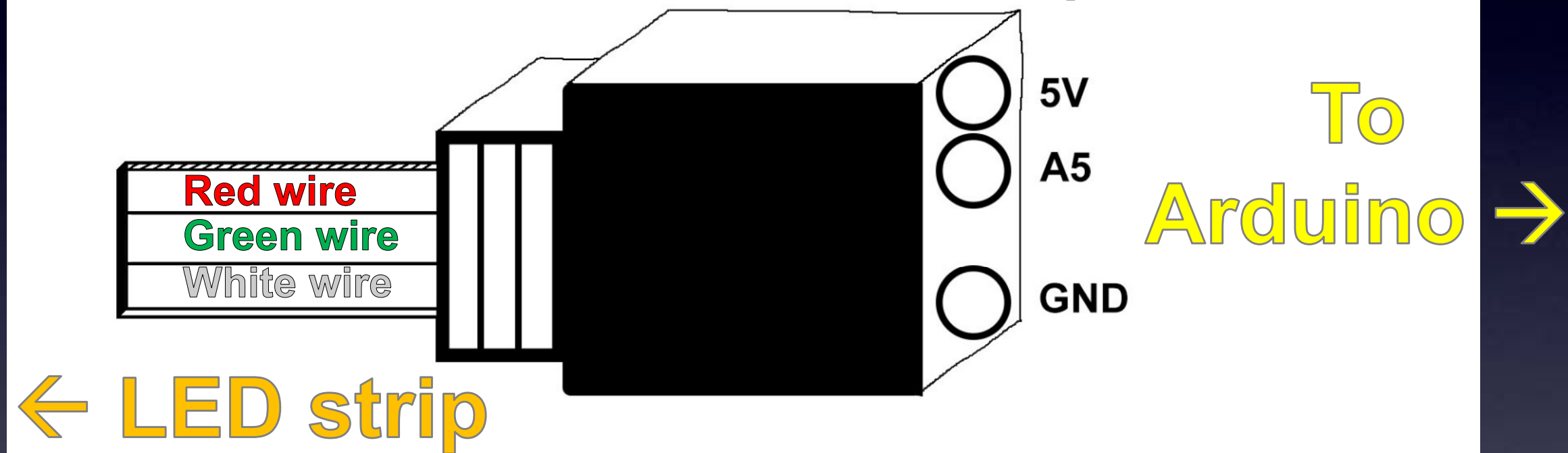


# Arduino



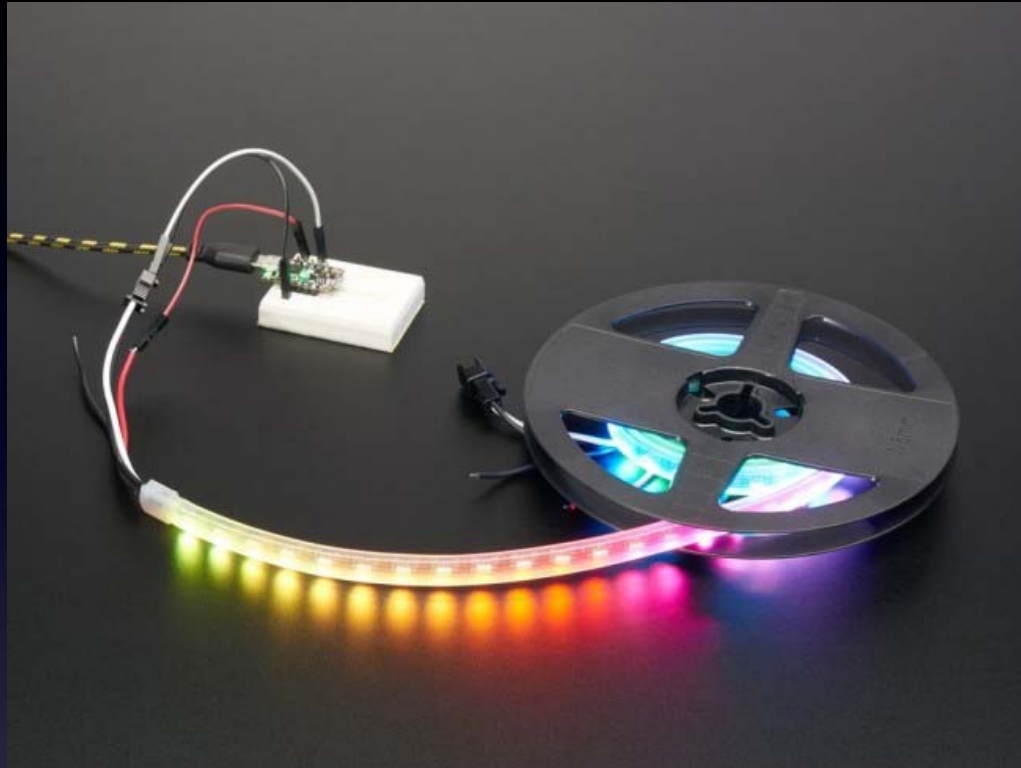
# Let's Program Some LED Strips!

Connector at end of Cable from LED strip





# Let's Program Some LED Strips!

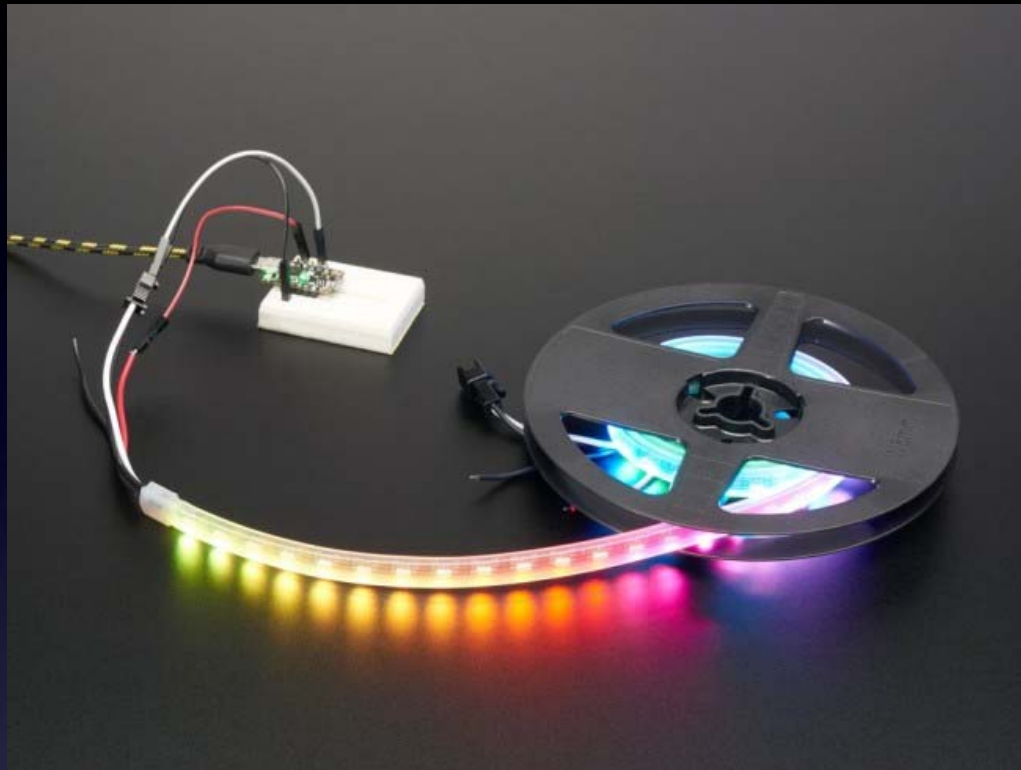


**Download some Arduino “sketches”:**

**Search for:** *“RGB LED Strip Sketches”*

Store them on your computer anywhere you like.

# Let's Program Some LED Strips!

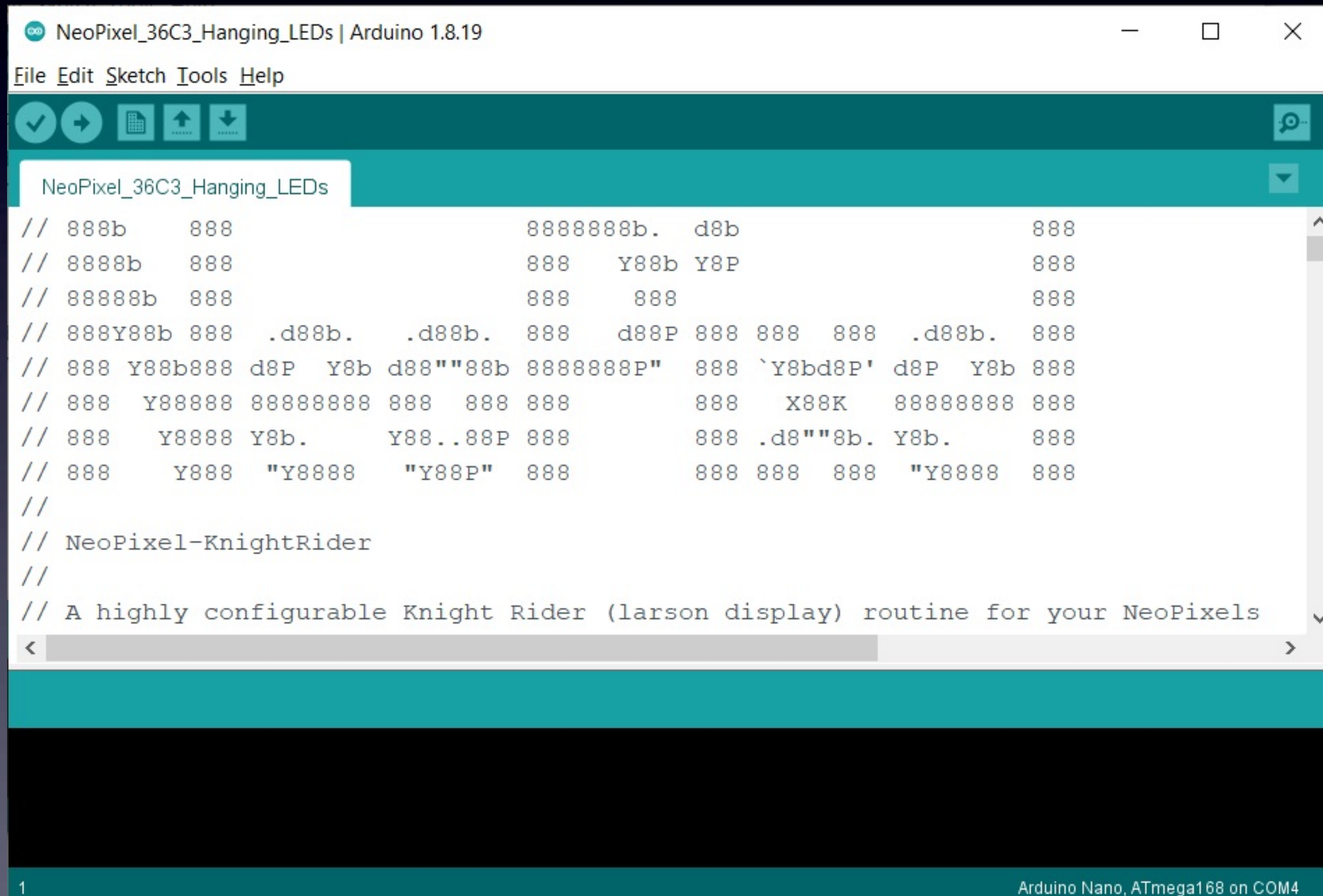


**Download some Arduino “sketches”:**

**<https://CornfieldElectronics.com/cfe/projects.php#ledstrips>**

# Let's Program Some LED Strips!

Open the “sketch” you want to program



The screenshot shows the Arduino IDE interface. The title bar reads "NeoPixel\_36C3\_Hanging\_LEDs | Arduino 1.8.19". The menu bar includes "File", "Edit", "Sketch", "Tools", and "Help". The toolbar contains icons for opening, saving, and running. The sketch editor displays the following code:

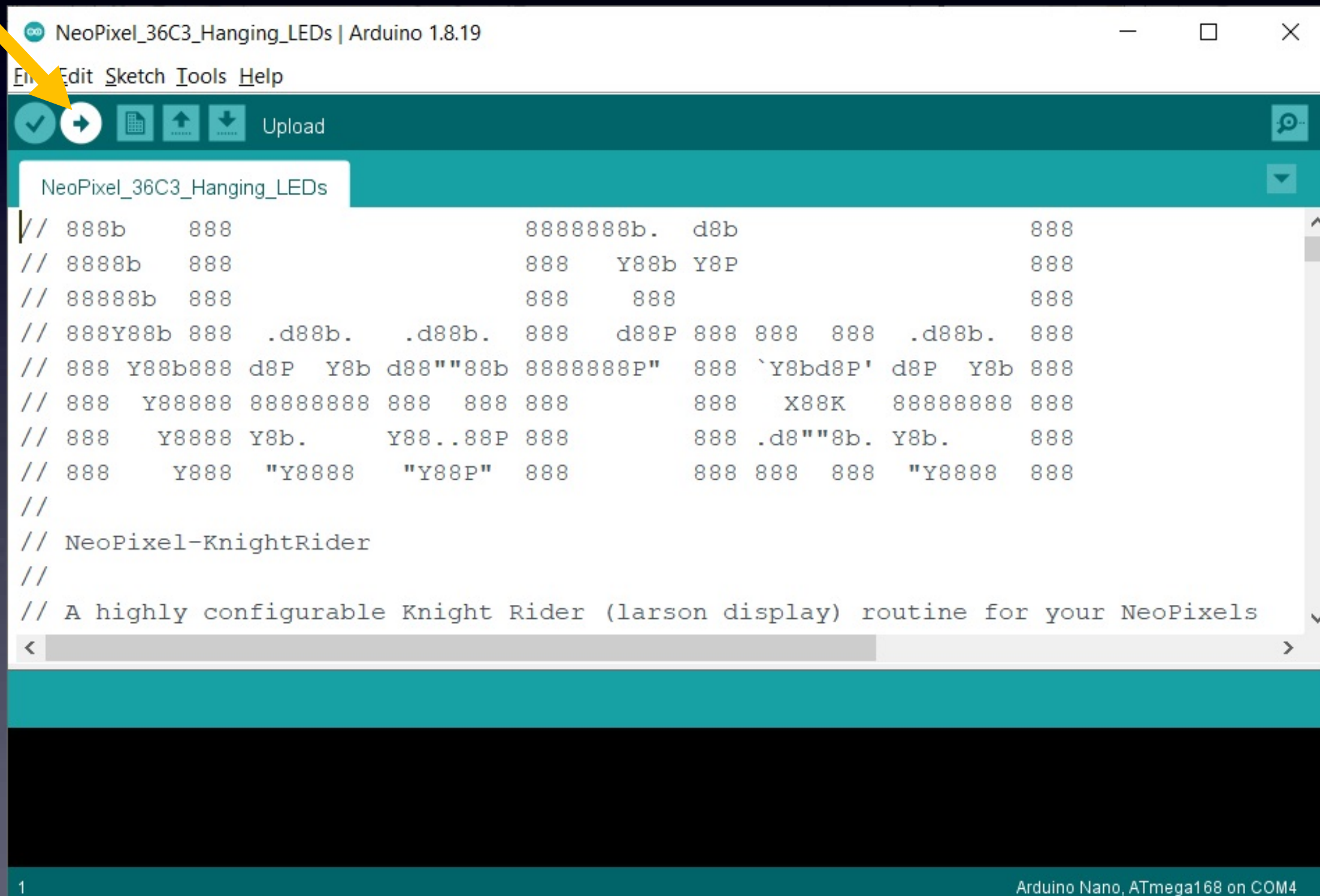
```
// 888b      888                88888888b.  d8b                888
// 8888b      888                888  Y88b Y8P                888
// 88888b      888                888      888                888
// 888Y88b 888  .d88b.  .d88b.  888  d88P 888 888 888  .d88b.  888
// 888 Y88b888 d8P  Y8b d88""88b 88888888P" 888 `Y8bd8P' d8P  Y8b 888
// 888  Y88888 888888888 888 888 888                888  X88K  888888888 888
// 888  Y8888 Y8b.      Y88..88P 888                888 .d8""8b. Y8b.  888
// 888  Y888  "Y8888  "Y88P" 888                888 888 888  "Y8888 888
//
// NeoPixel-KnightRider
//
// A highly configurable Knight Rider (larson display) routine for your NeoPixels
```

The status bar at the bottom indicates "1" on the left and "Arduino Nano, ATmega168 on COM4" on the right.



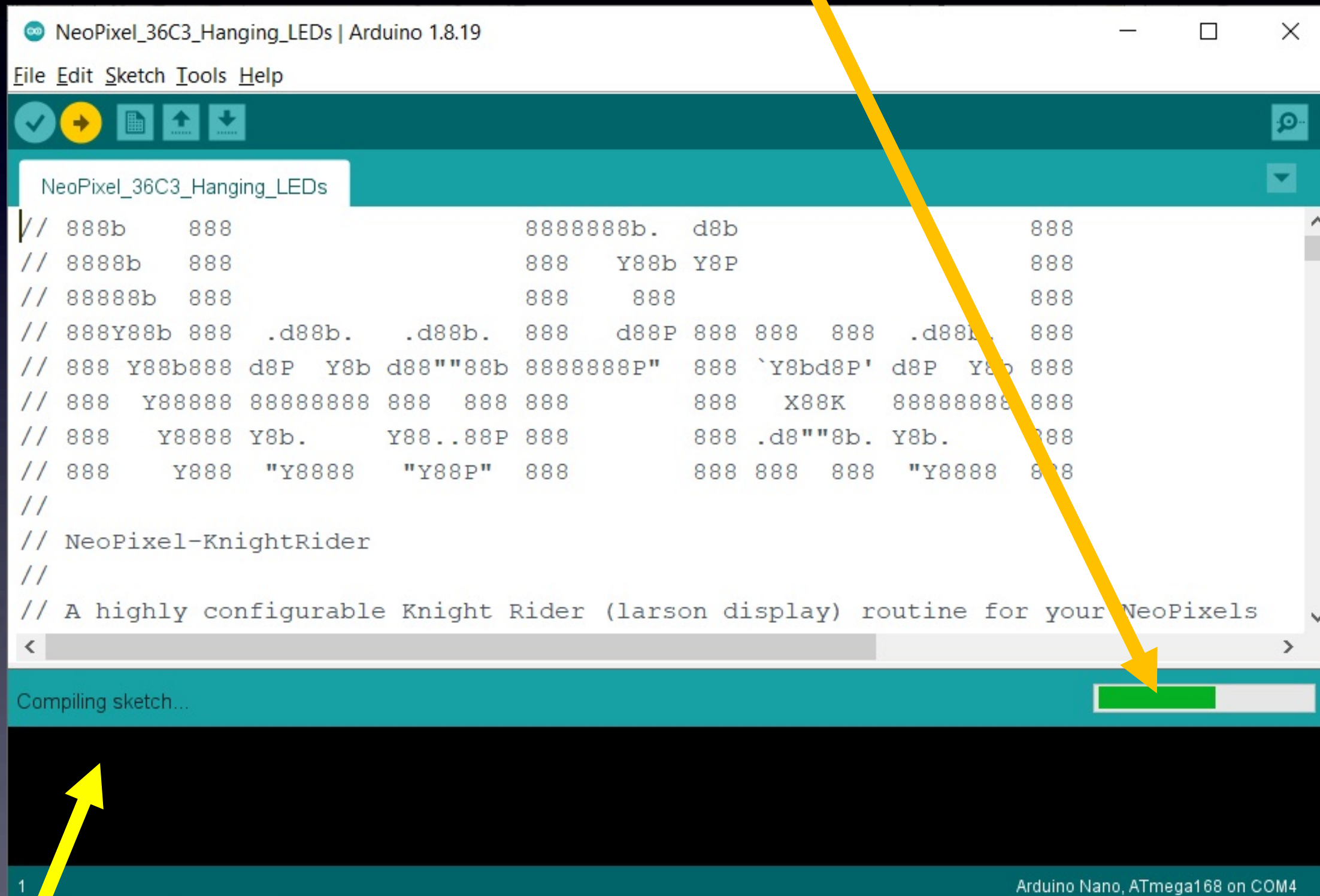
# Let's Program Some LED Strips!

With the USB cable connected to your Arduino board  
press the Upload button



# Let's Program Some LED Strips!

While uploading, you will see a progress bar...



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**WS2812**



Not waterproof IP30  
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1M 30 IP30

2M 30 IP30

3M 30 IP30

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1M 30 IP65

2M 30 IP65

3M 30 IP65

4M 30 IP65

5M 30 IP65

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2M 30 IP67

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4M 60 IP65

5M 60 IP65

1M 60 IP67

2M 60 IP67

3M 60 IP67

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1M 74 IP65

1M 74 IP67

1M 96 IP30

1M 96 IP65

1M 96 IP67

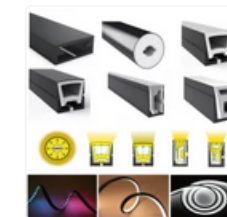
1M 144 IP30

1M 144 IP65

1M 144 IP67

Quantity:

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You



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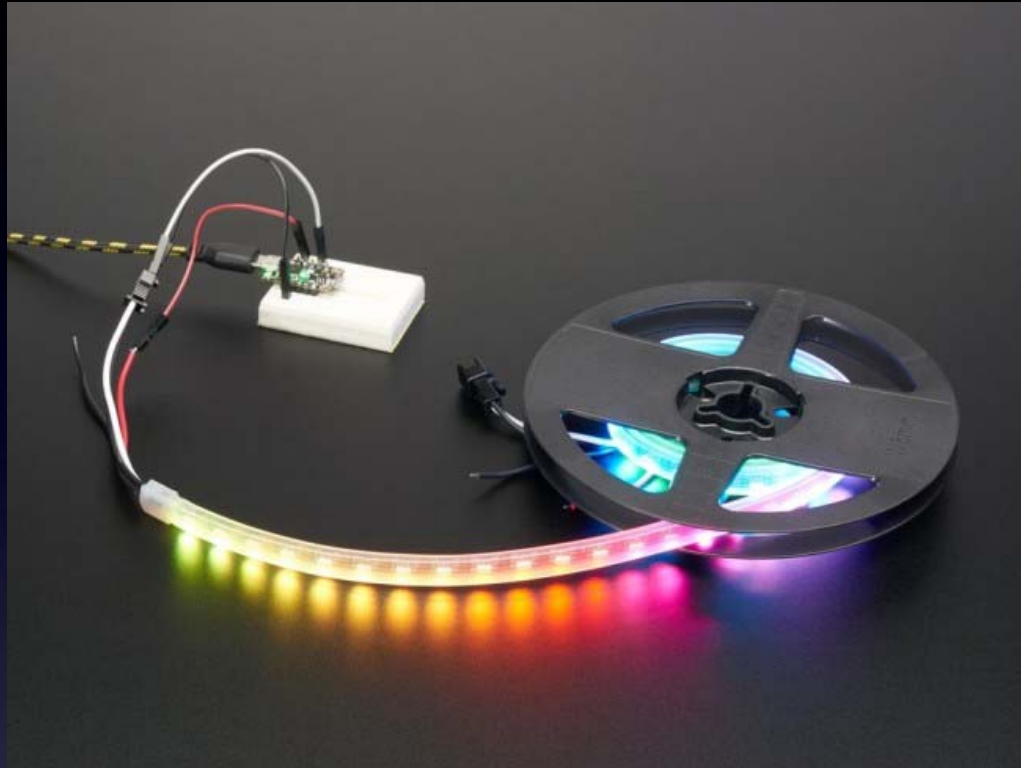
€ 4,95



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# *LED Strips for Everyone Everywhere*



**These slides are also available at:**

**<https://CornfieldElectronics.com/cfe/projects.php#ledstrips>**

# *LED Strips for Everyone Everywhere*

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Co-founder of **3Ware** (successful Silicon Valley startup)

Pioneer of **VR** (in the mid-1980s)

Founding mentor at **HAX** (1<sup>st</sup> and biggest hardware accelerator)

Co-founder of **Noisebridge** (San Francisco hackerspace)

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