

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** (1st and biggest hardware accelerator)

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

email: mitch@CornfieldElectronics.com

site: www.CornfieldElectronics.com

facebook: maltman23

flickr: maltman23

WeChat: mitchaltman

Fediverse: [@maltman23@mastodon.social](https://maltman23@mastodon.social)

Patreon: mitchaltman



CORNFIELD ELECTRONICS

LED Strips for Everyone Everywhere



Syllabus

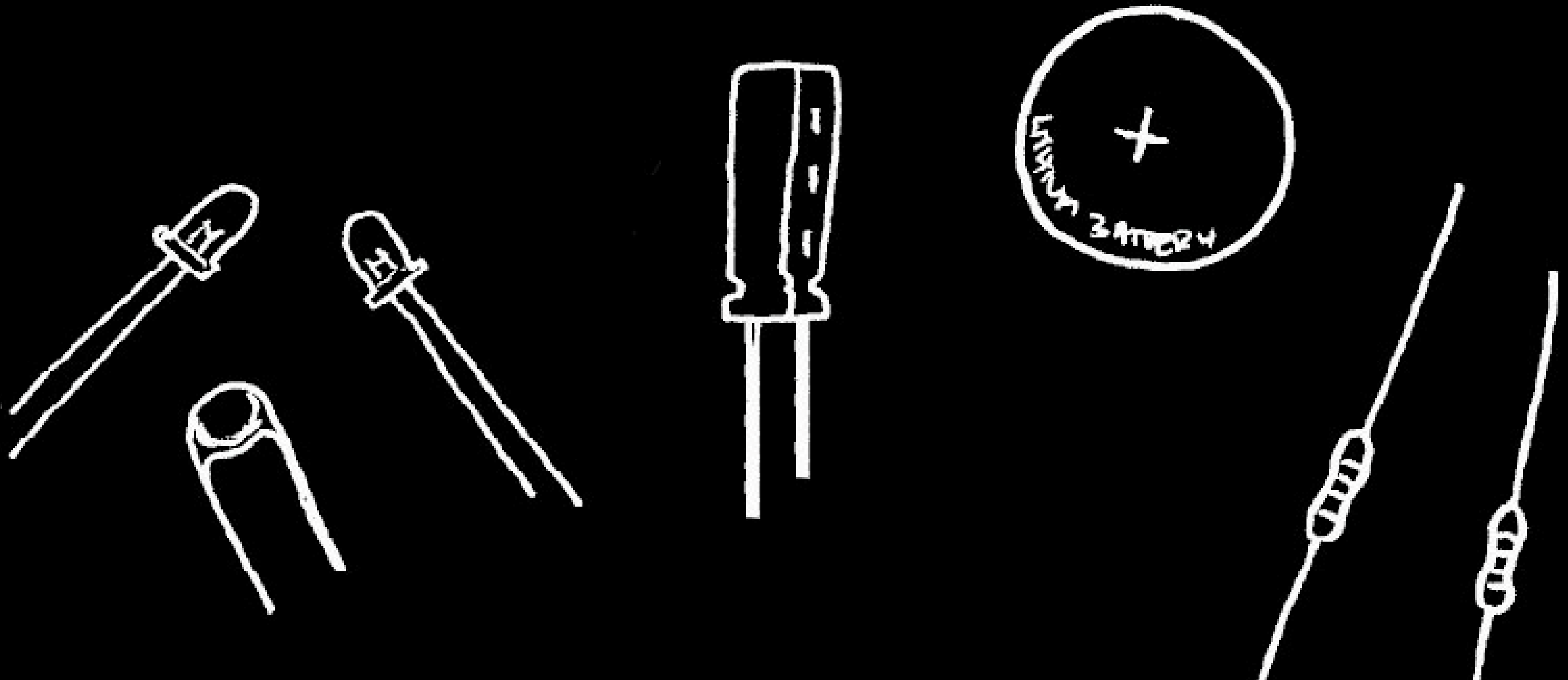
- Intro to LEDs
- A bit about electronics
- RGB color theory
- A bit about Arduino
- PWM basics
- Programming RGB LED strips
- Ordering RGB LED strips

LEDs

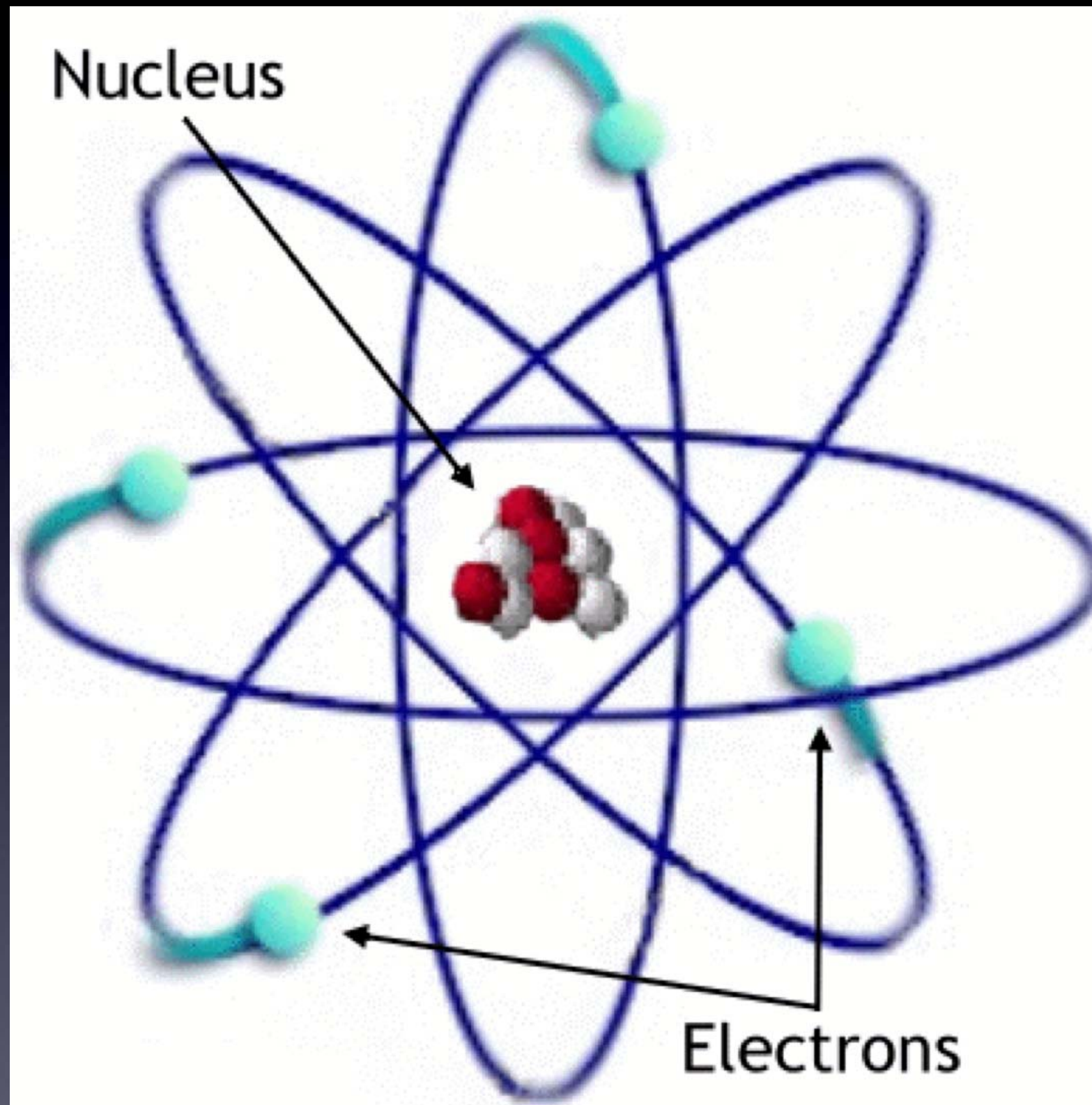


Lots of different colored LEDs!

A Little About Electronics

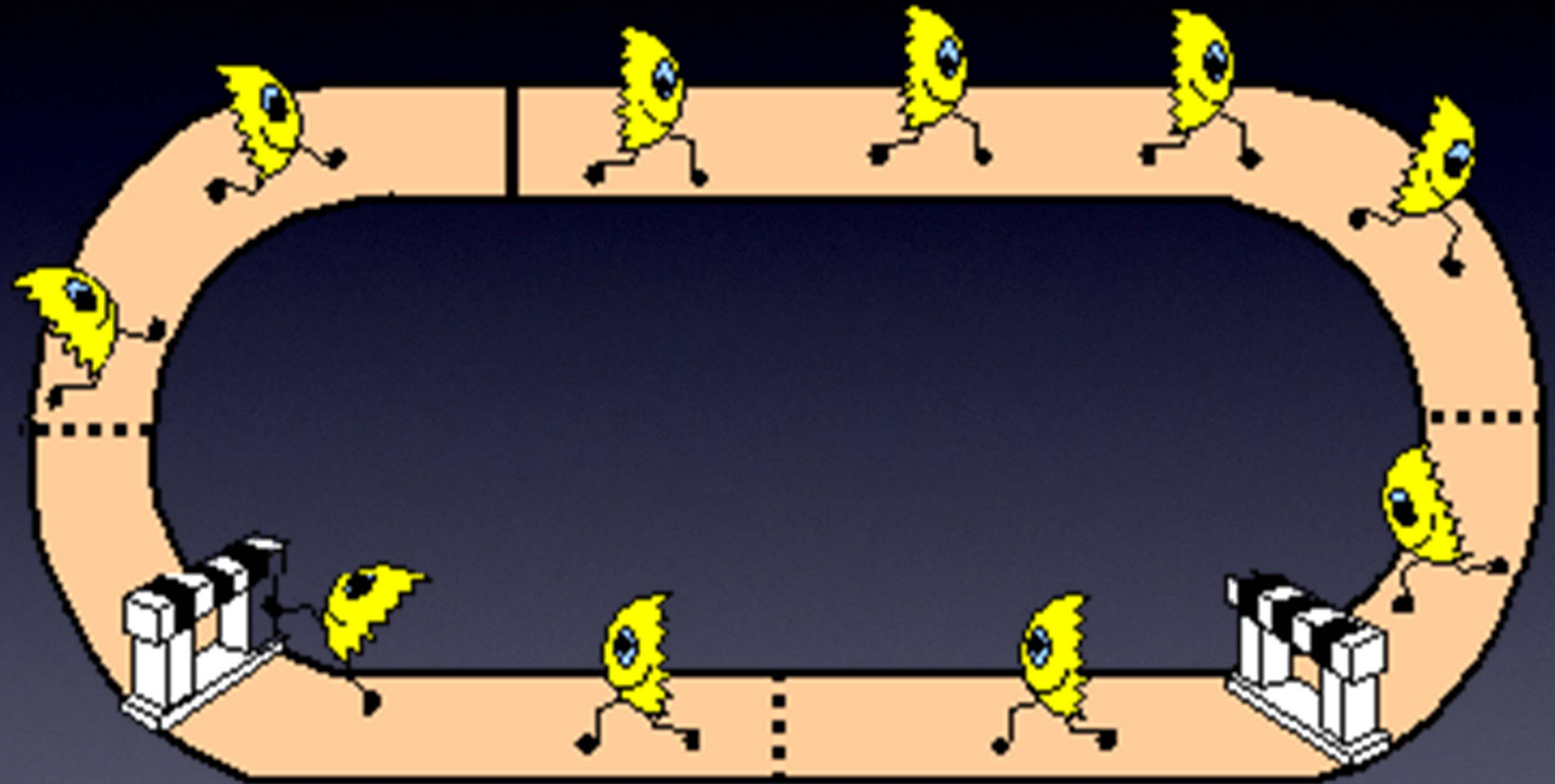


A Little About Electronics



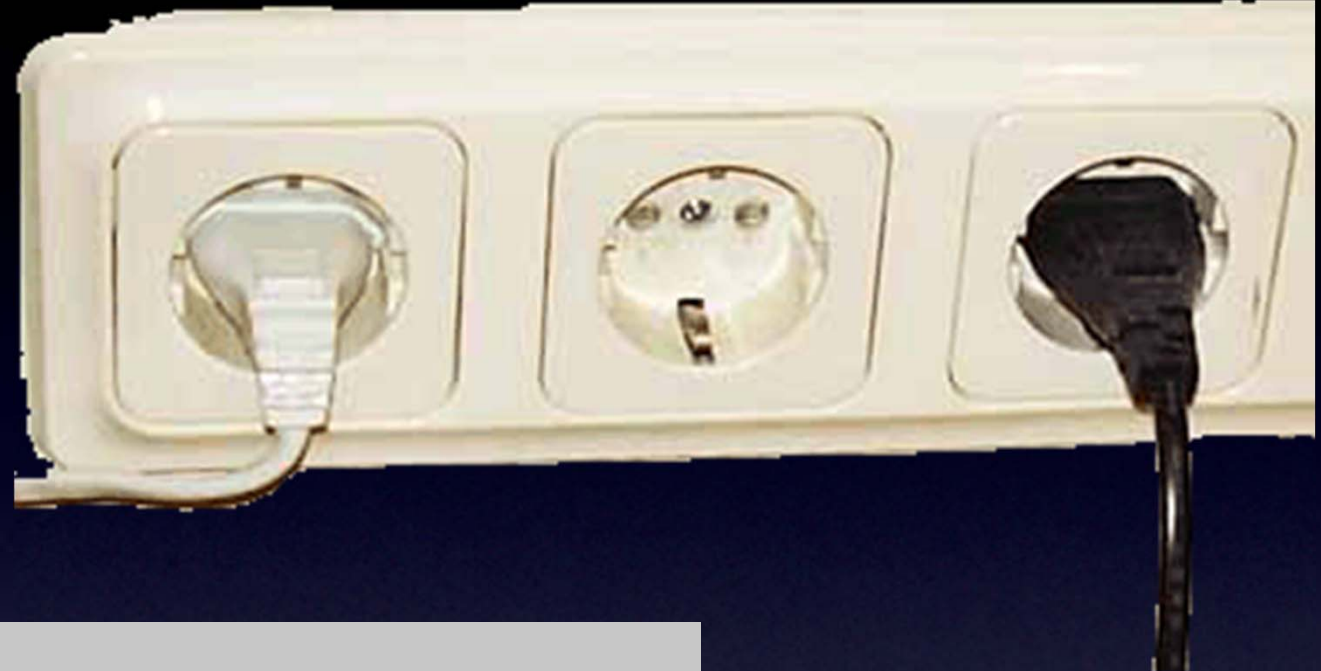
Electrons

A Little About Electronics



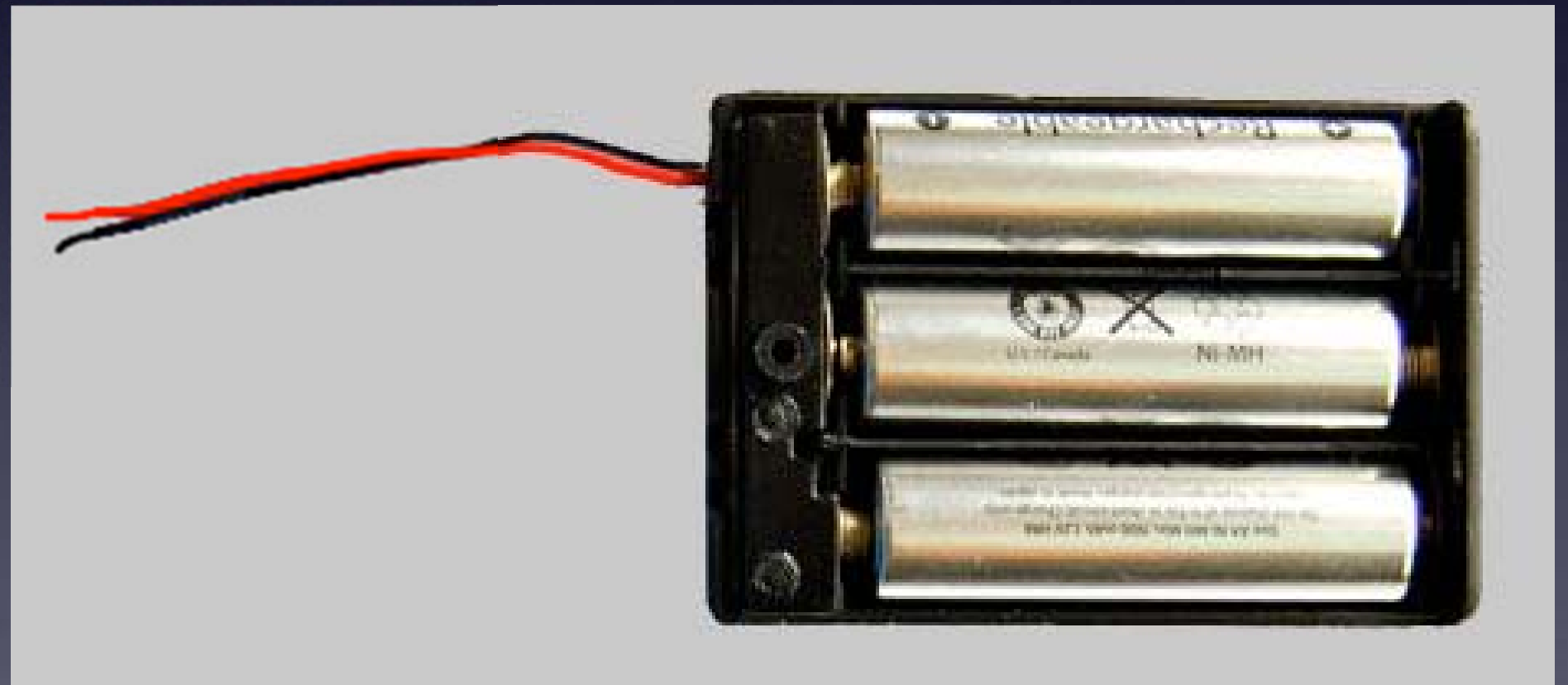
Circuit = Electrons going in complete circle = Magic!

A Little About Electronics



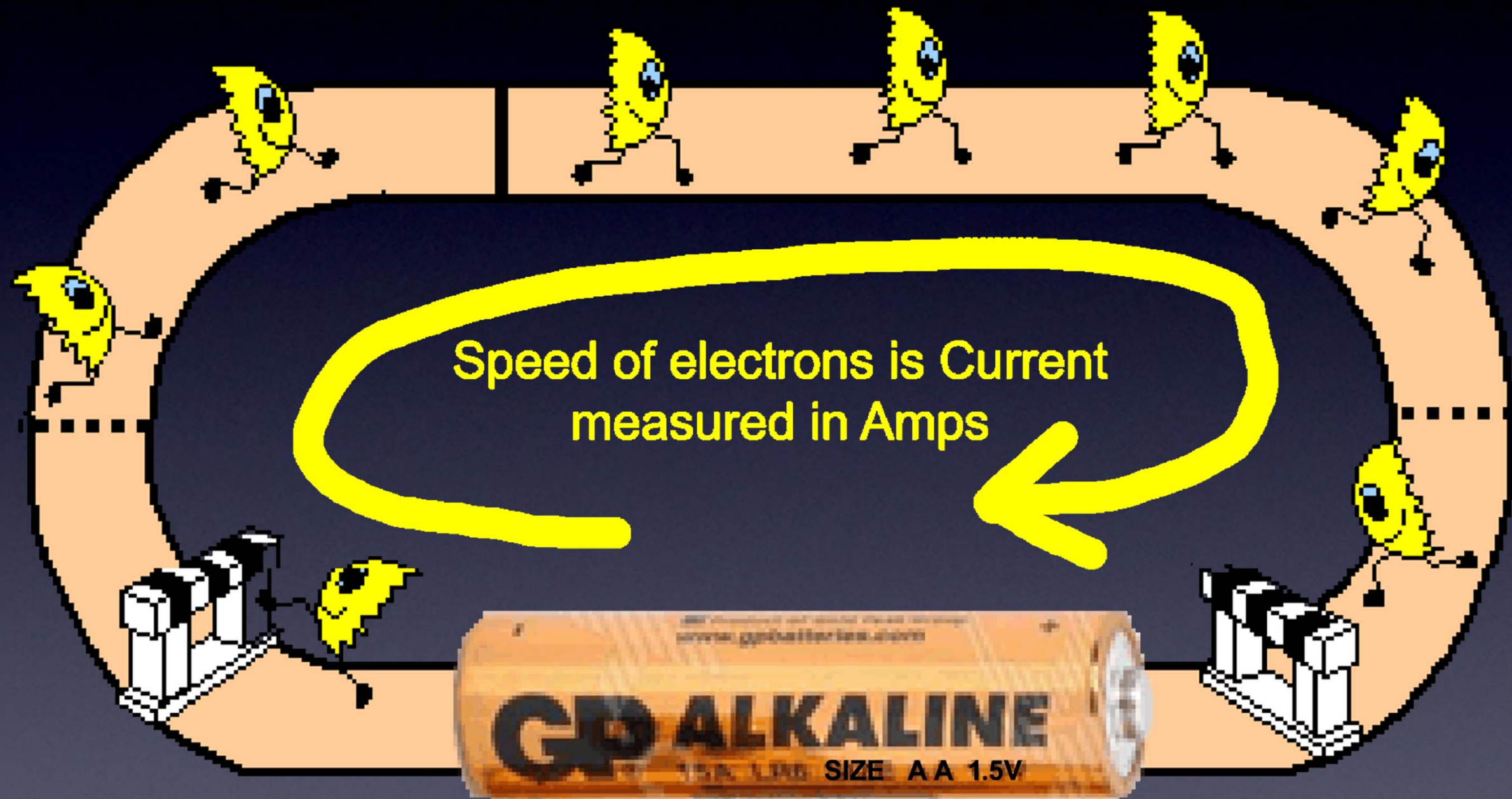
Power Supplies

Everything You Need to Know About Electronics



Voltage / Volts

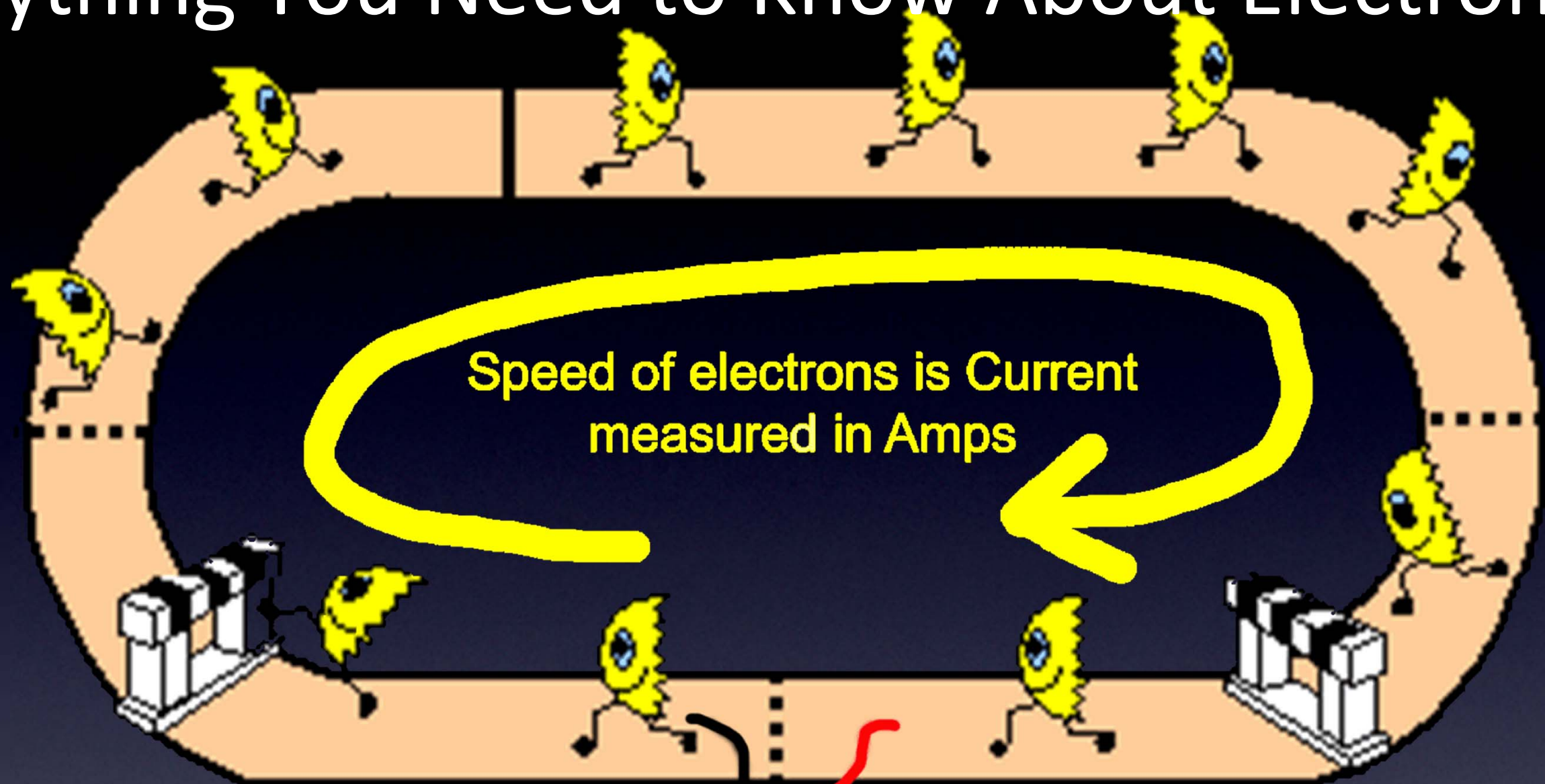
Everything You Need to Know About Electronics



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

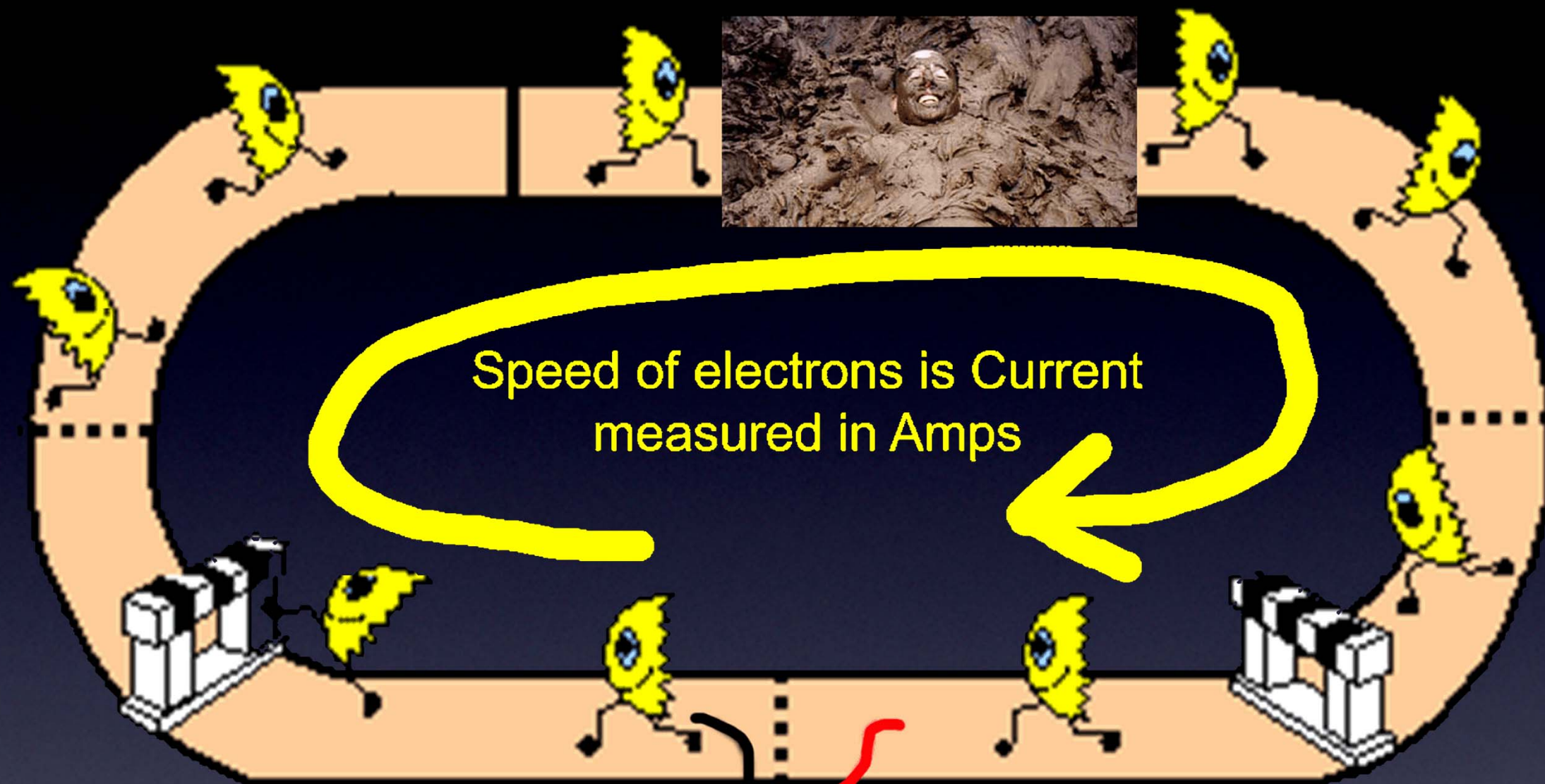
Everything You Need to Know About Electronics

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**

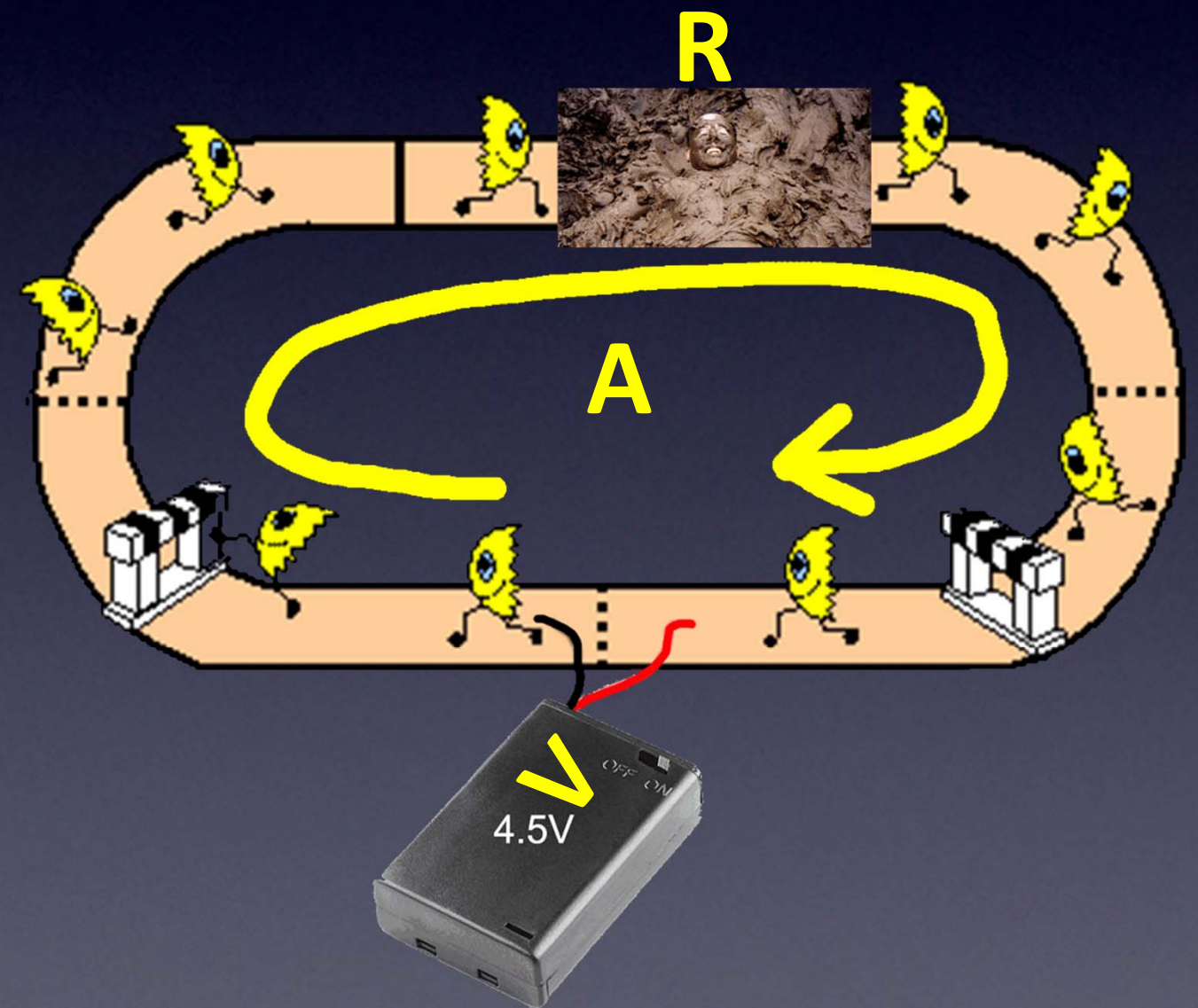
A Little About Electronics

Ohm's Law

Volts -- *force* pushing electrons

Amps -- *speed* of electrons

Ohms -- *Resistance* to flow of electrons



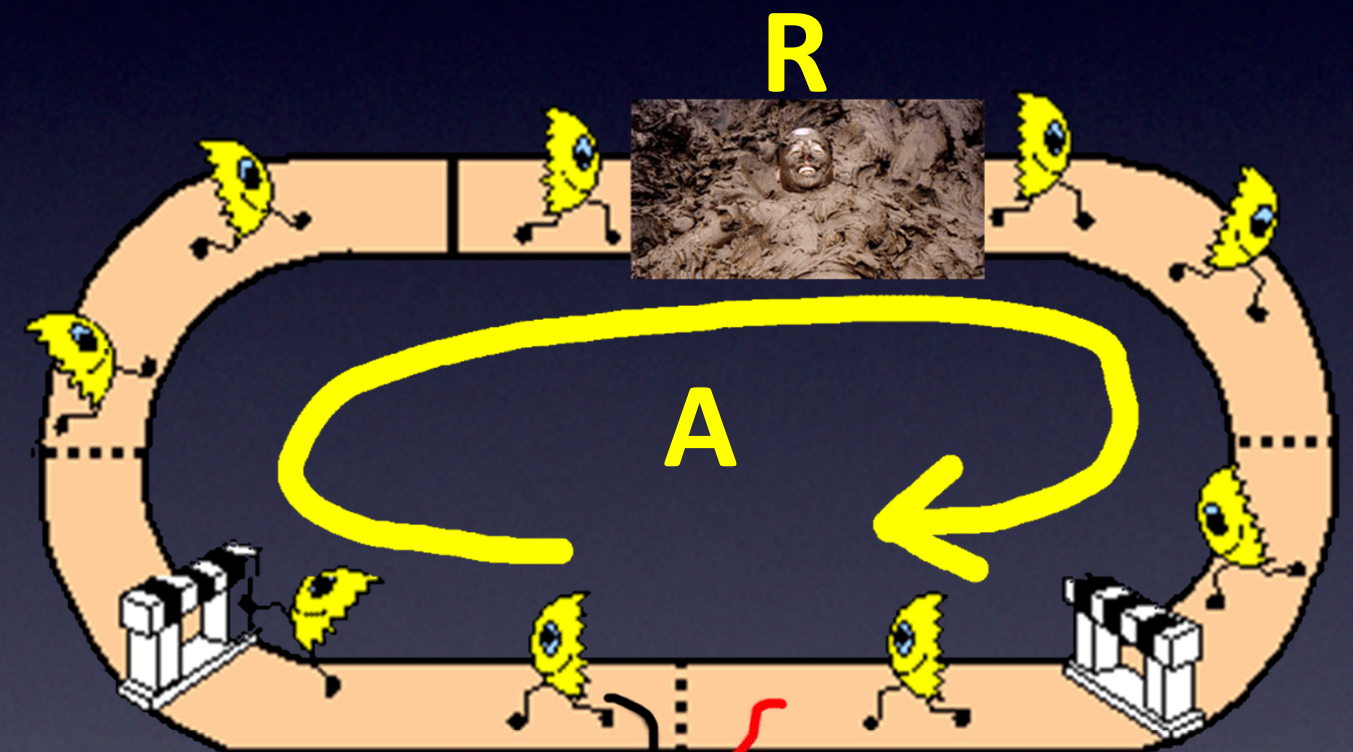
A Little About Electronics

Ohm's Law

Volts -- *force* pushing electrons

Amps -- *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!

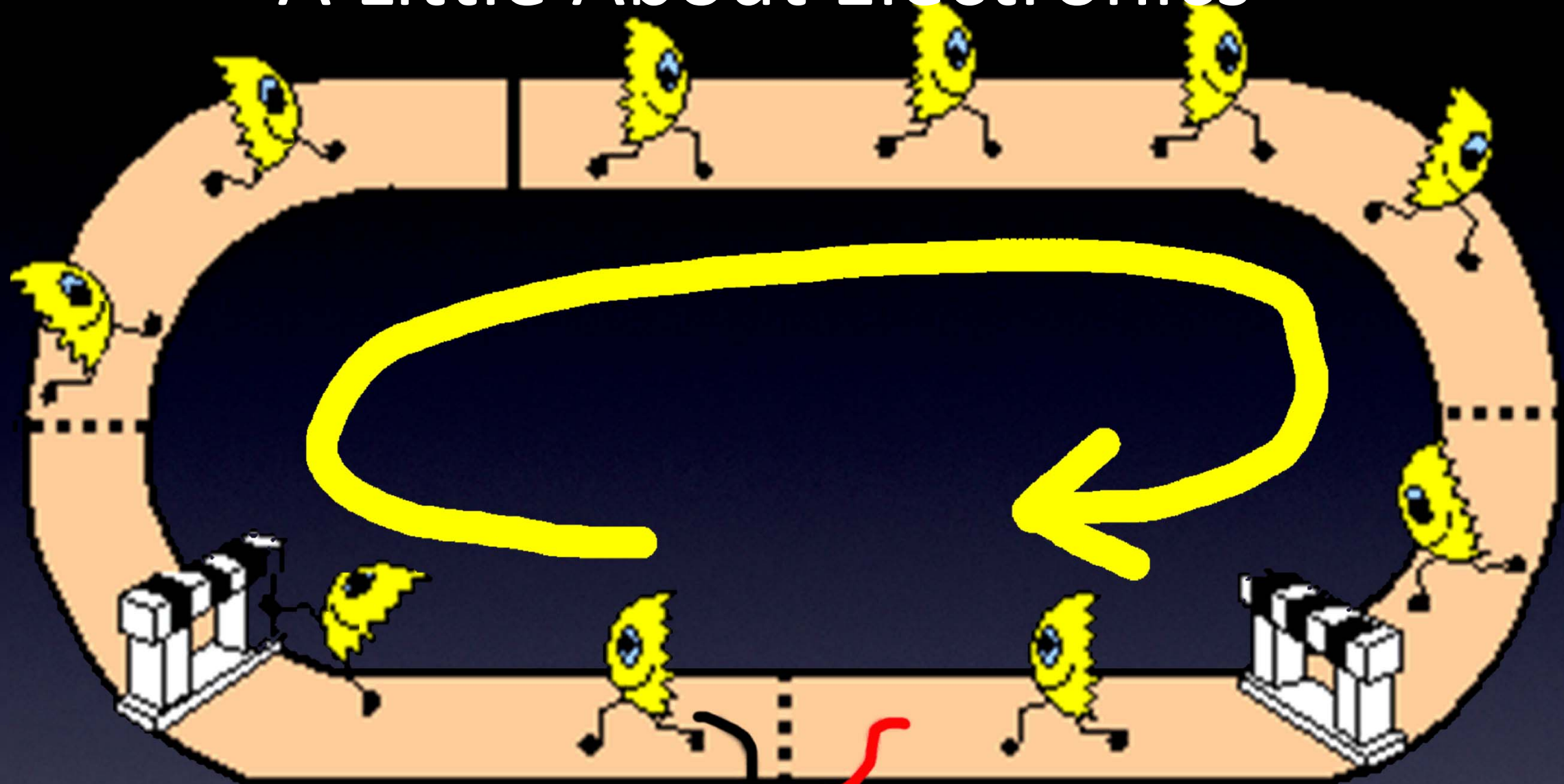
LED



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!

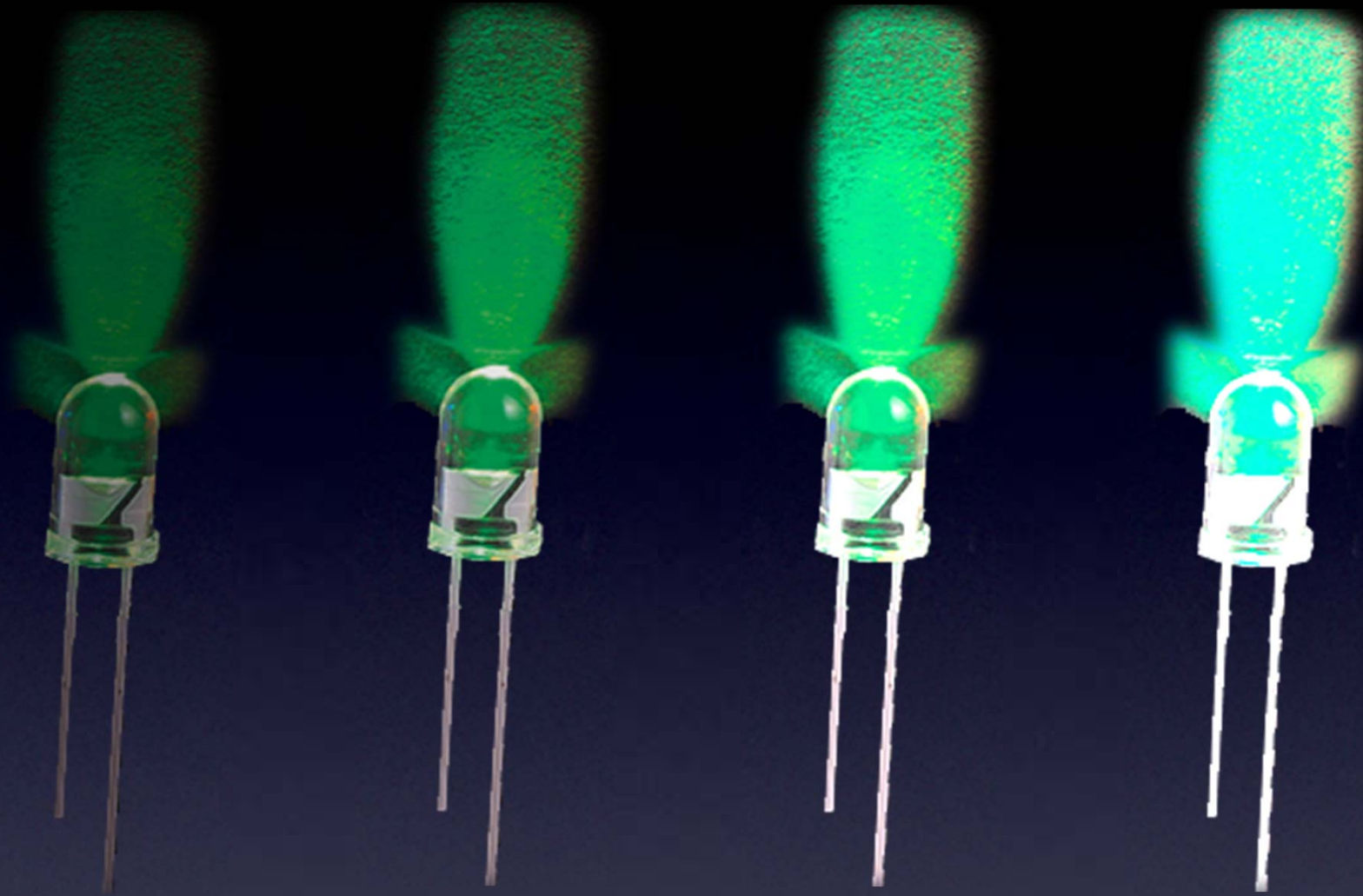
A Little About Electronics



Lots of different colored LEDs!

LED

Everything You Need to Know About Electronics



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

LED

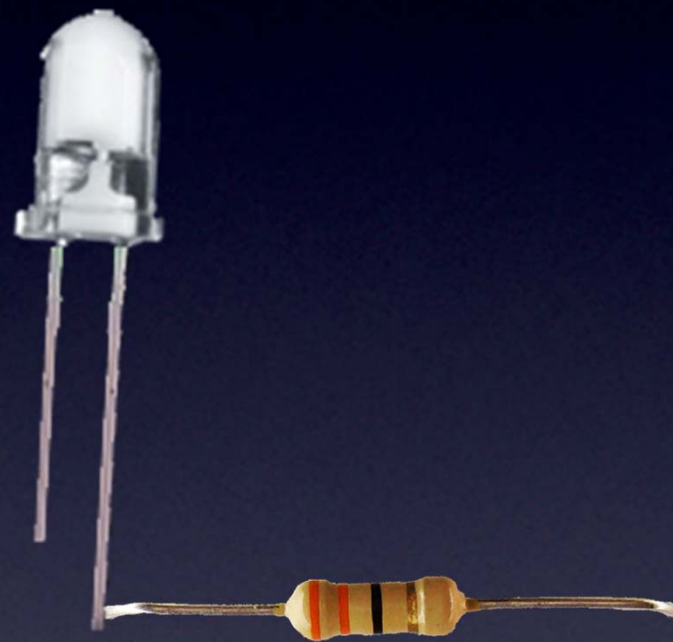
Everything You Need to Know About Electronics



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

LED

Everything You Need to Know About Electronics

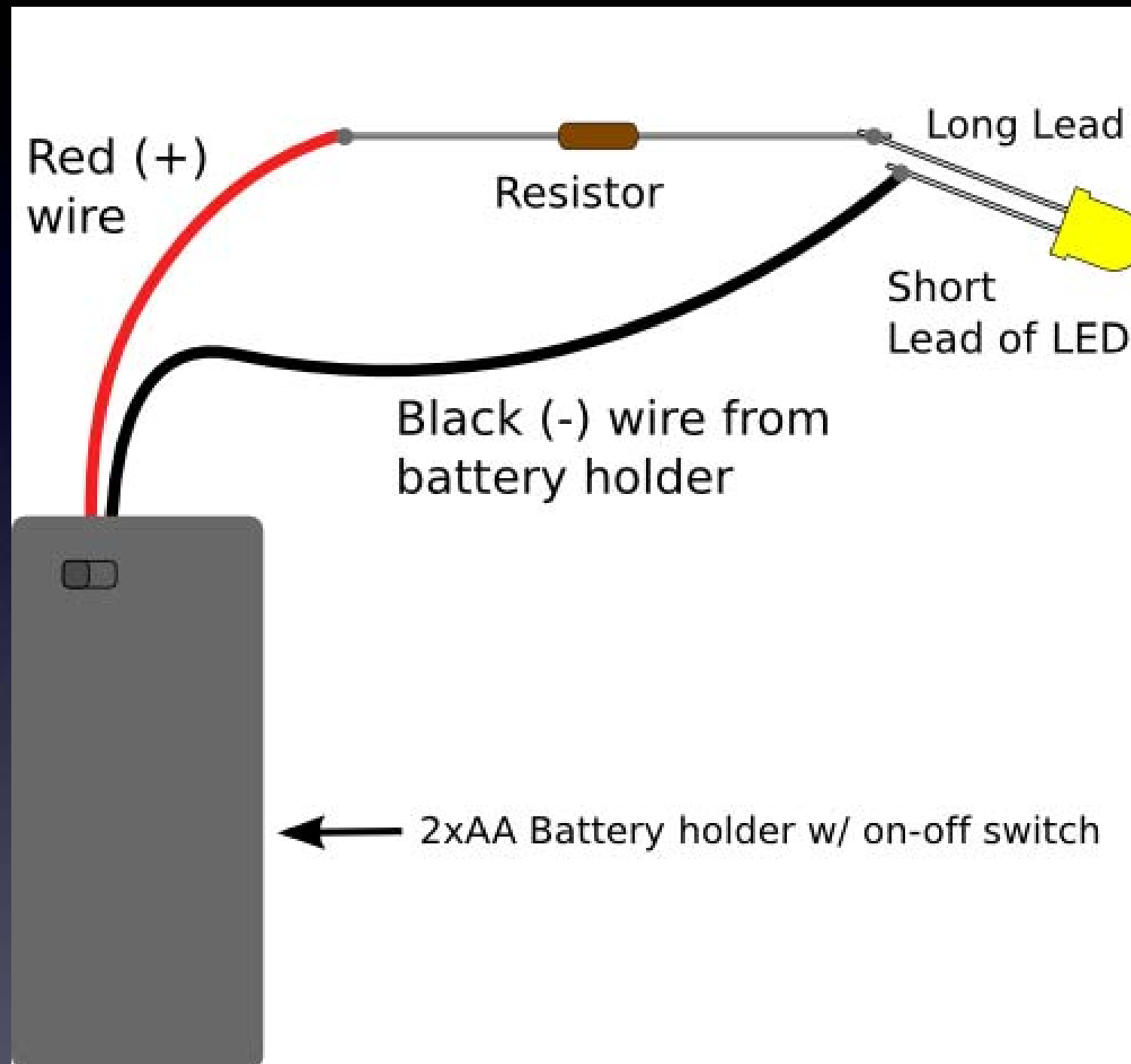


*(with a resistor
so no magic smoke goes away)*

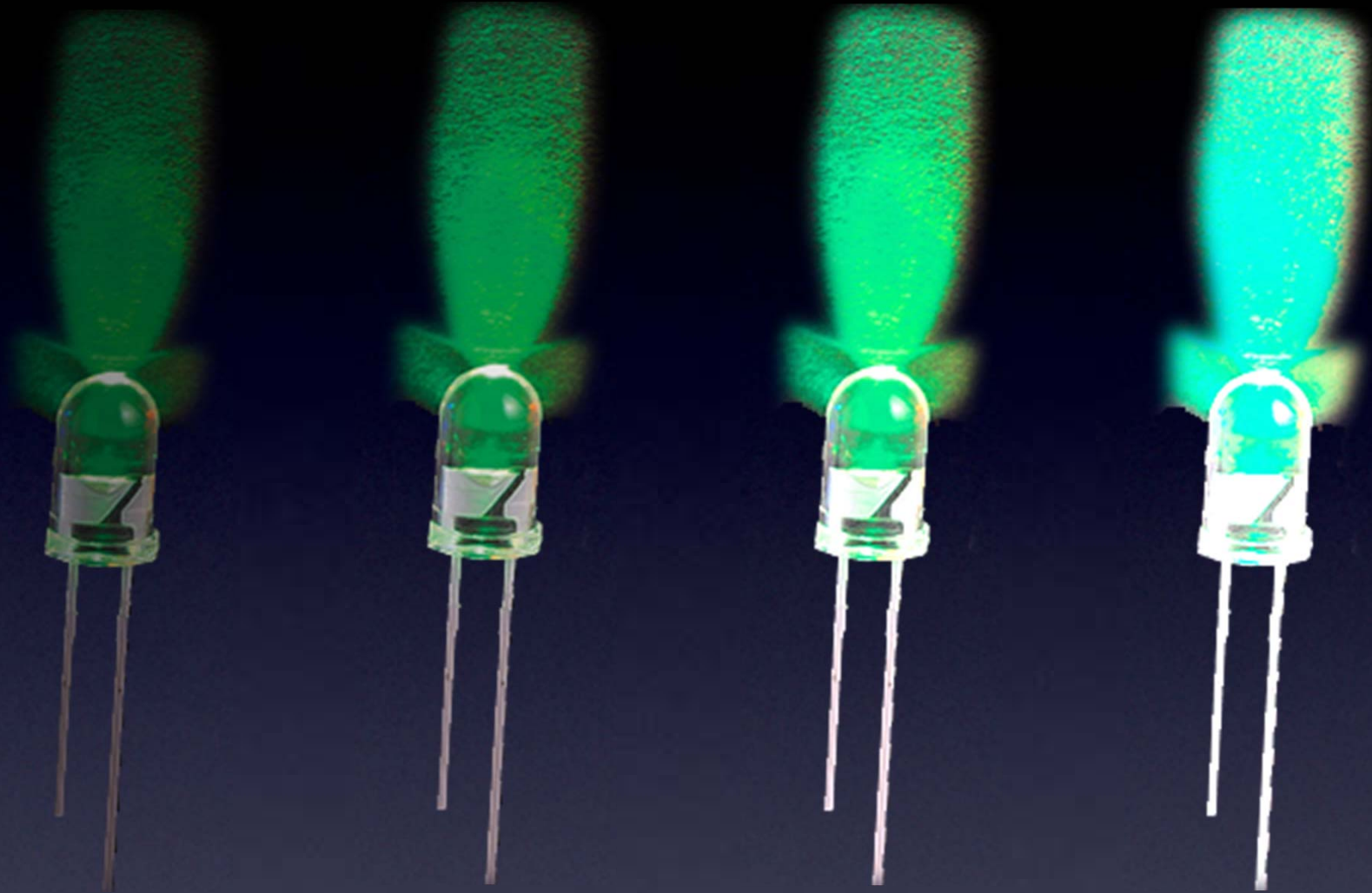
This is why we put a resistor in line with an LED

LED

LED Brightness



LED Brightness



Less resistance

LED Brightness

But, we will use:

PWM

(coming soon)

Lighting an LED



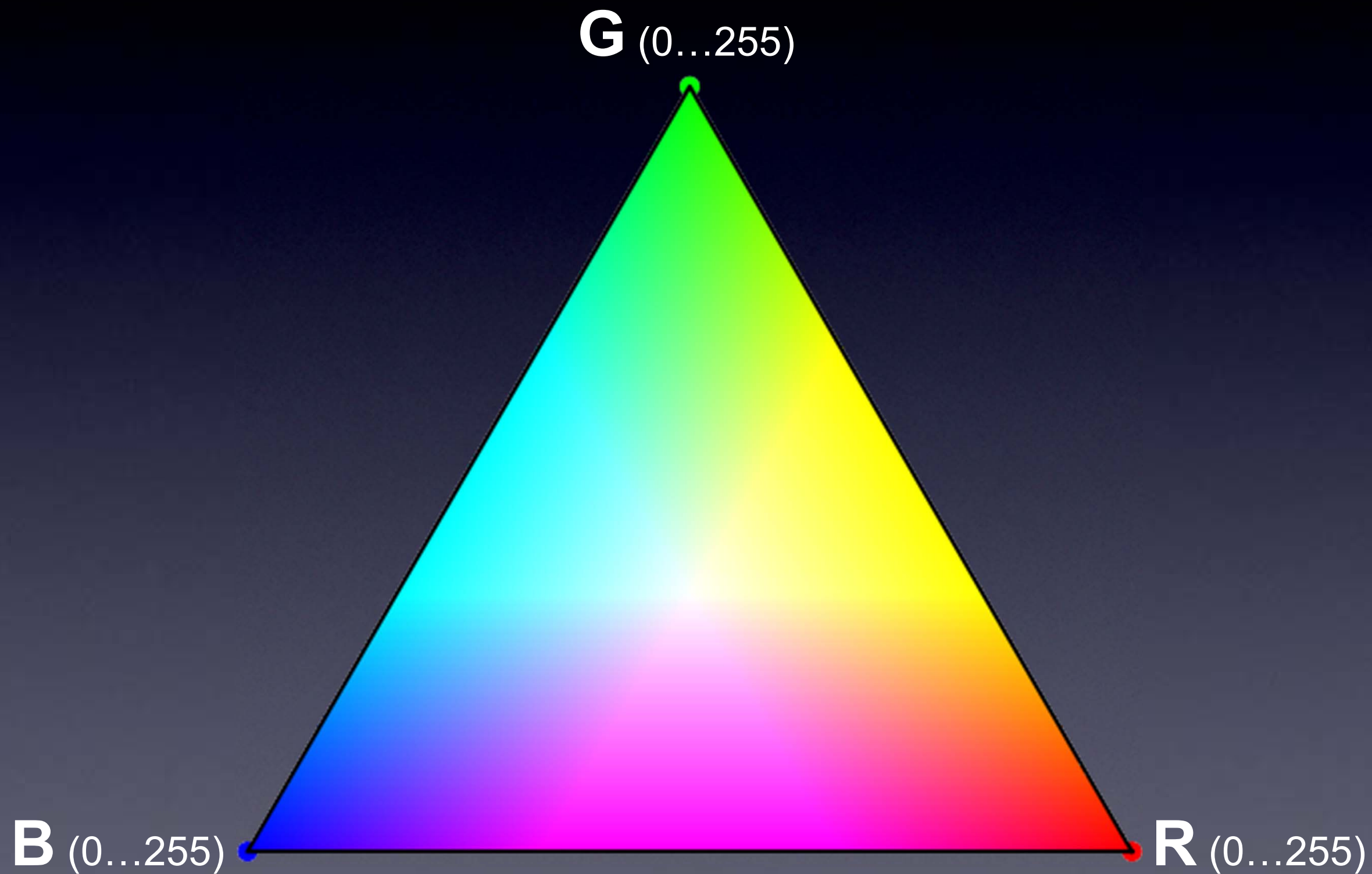
LED & battery

Light Color Mixing



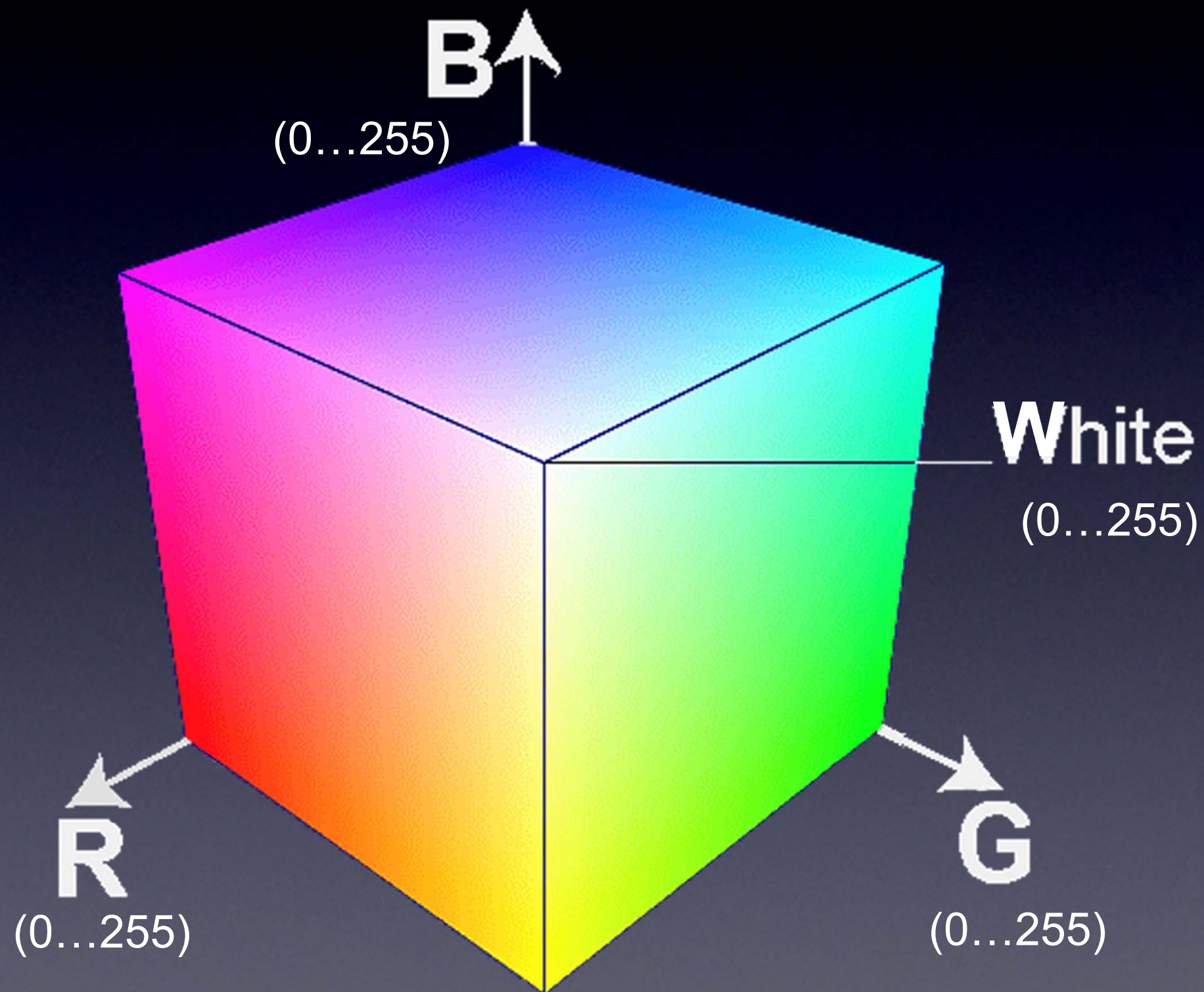
Light Color Mixing

RGB Color Triangle

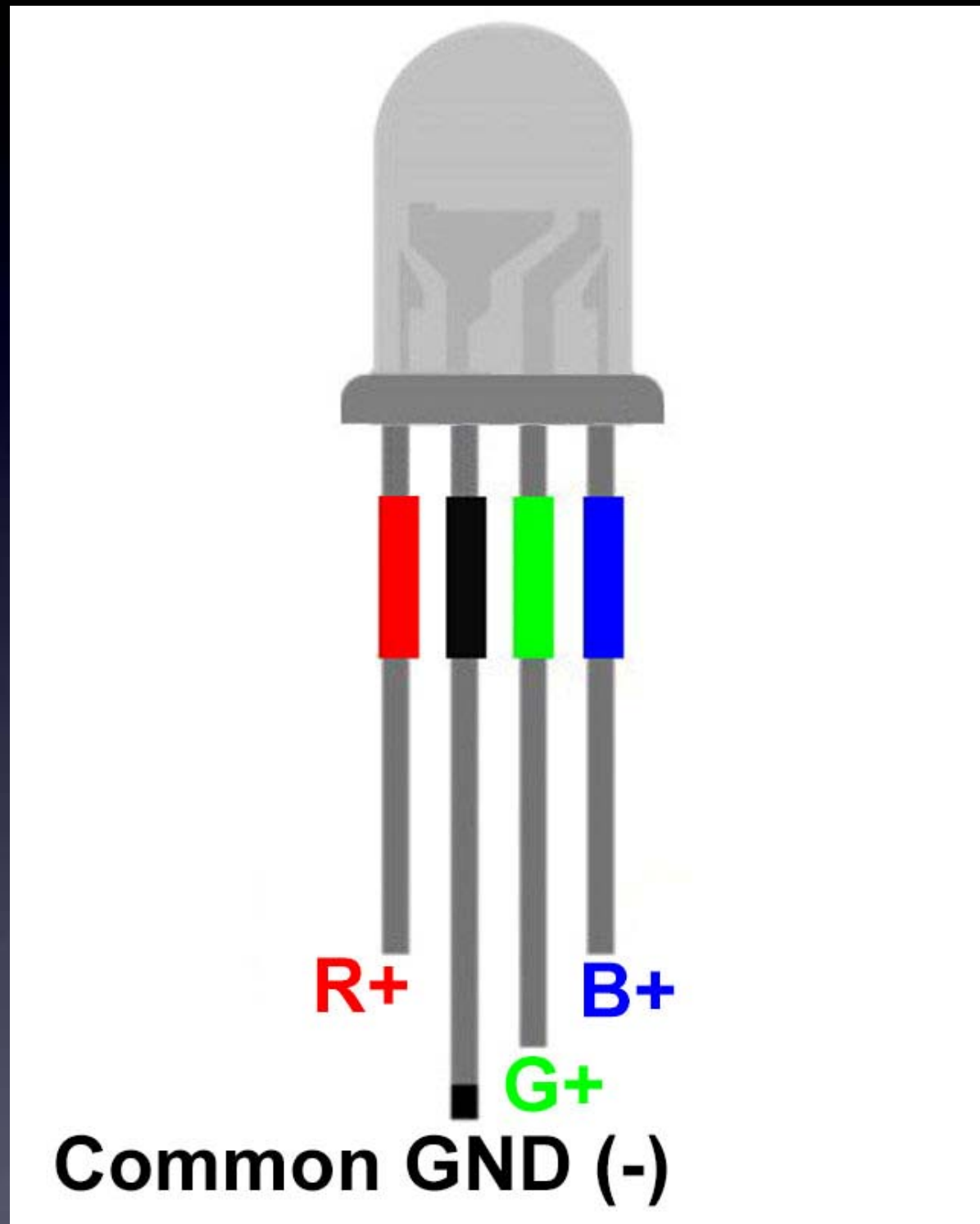


Light Color Mixing

RGBW Color Cube



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

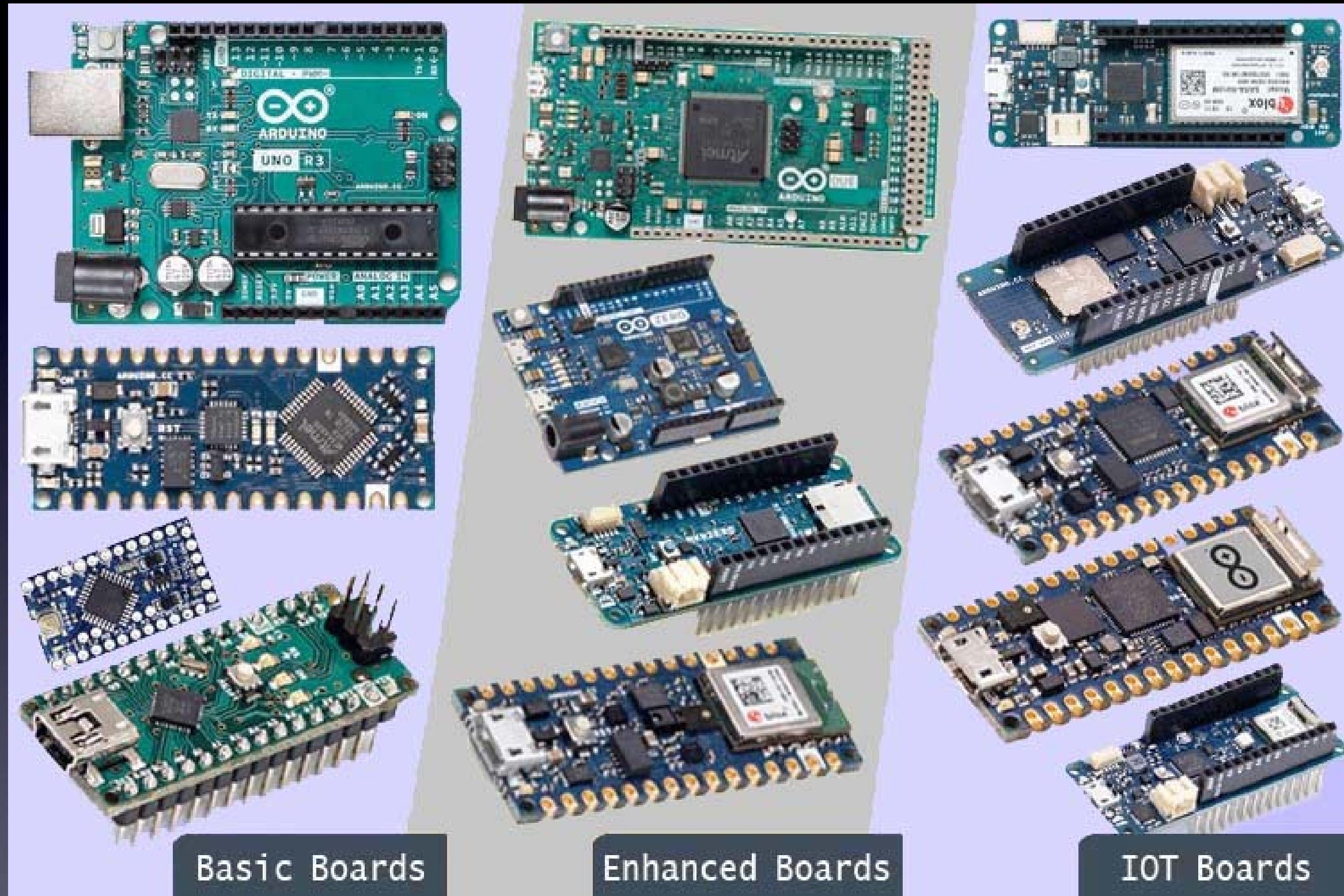


Super easy to
connect parts
to its microcontroller's pins

Use an Arduino board

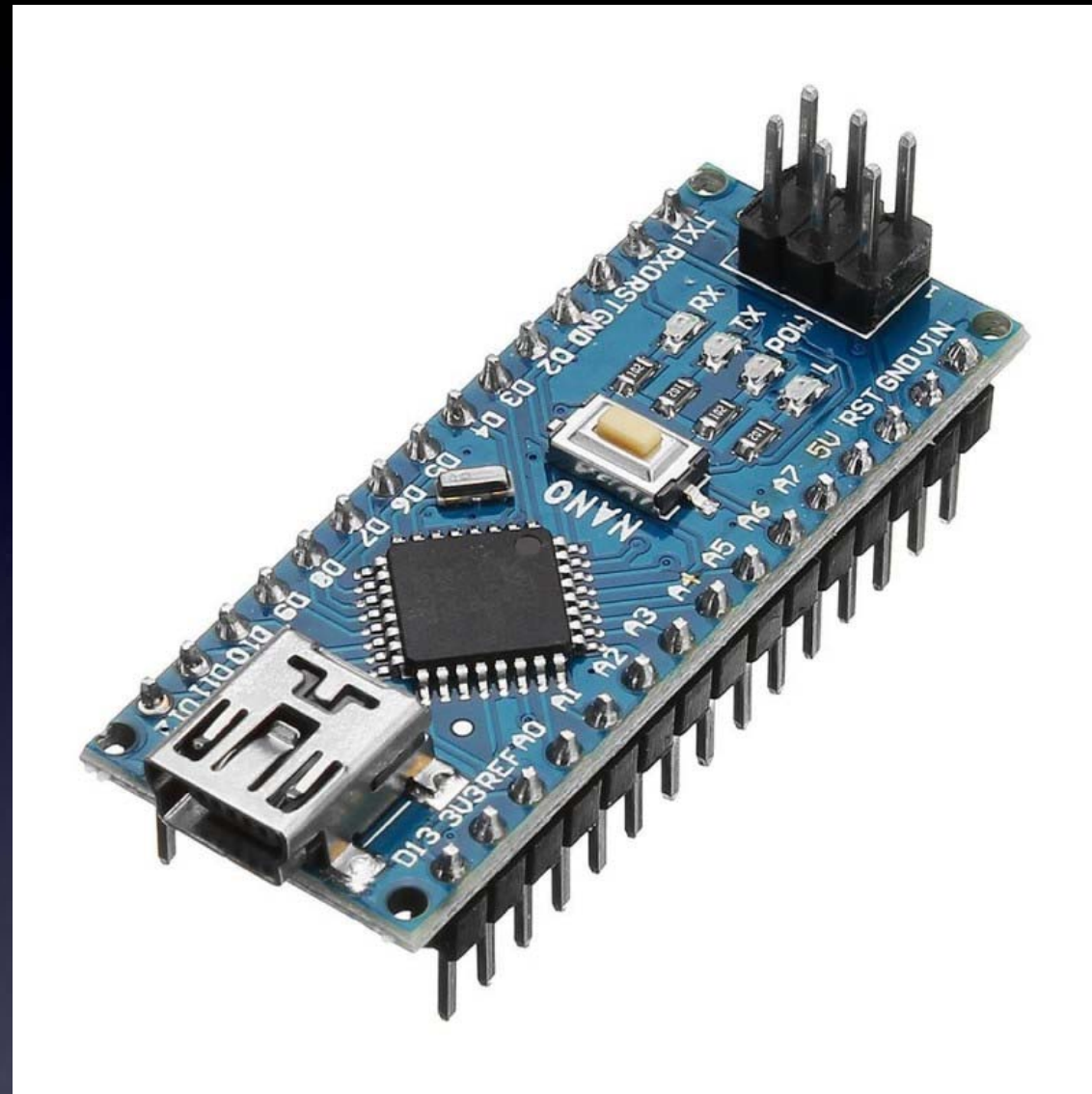
Super easy to
create and upload a program
to control the parts

Intro to Arduino



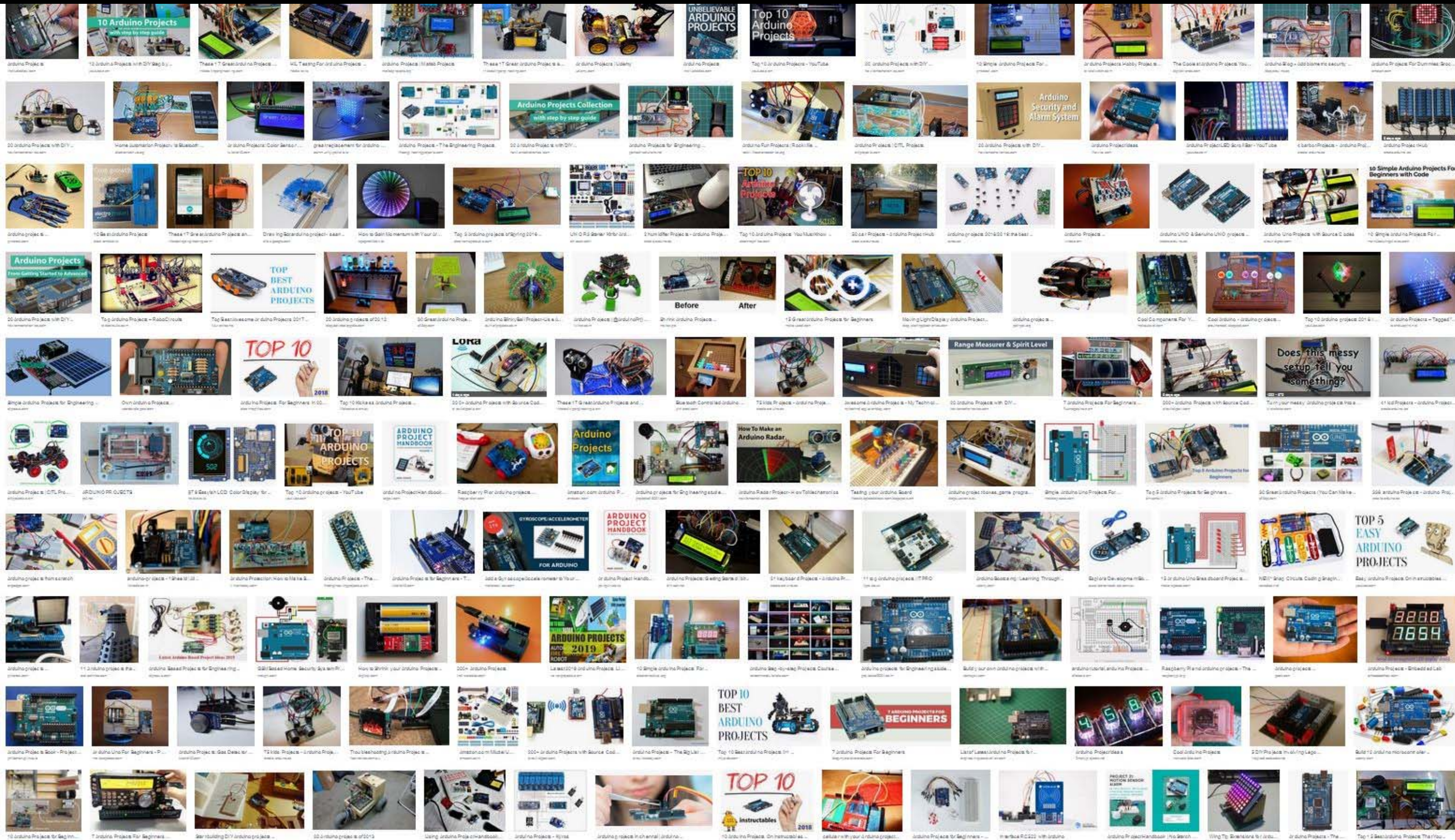
Open Source

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:

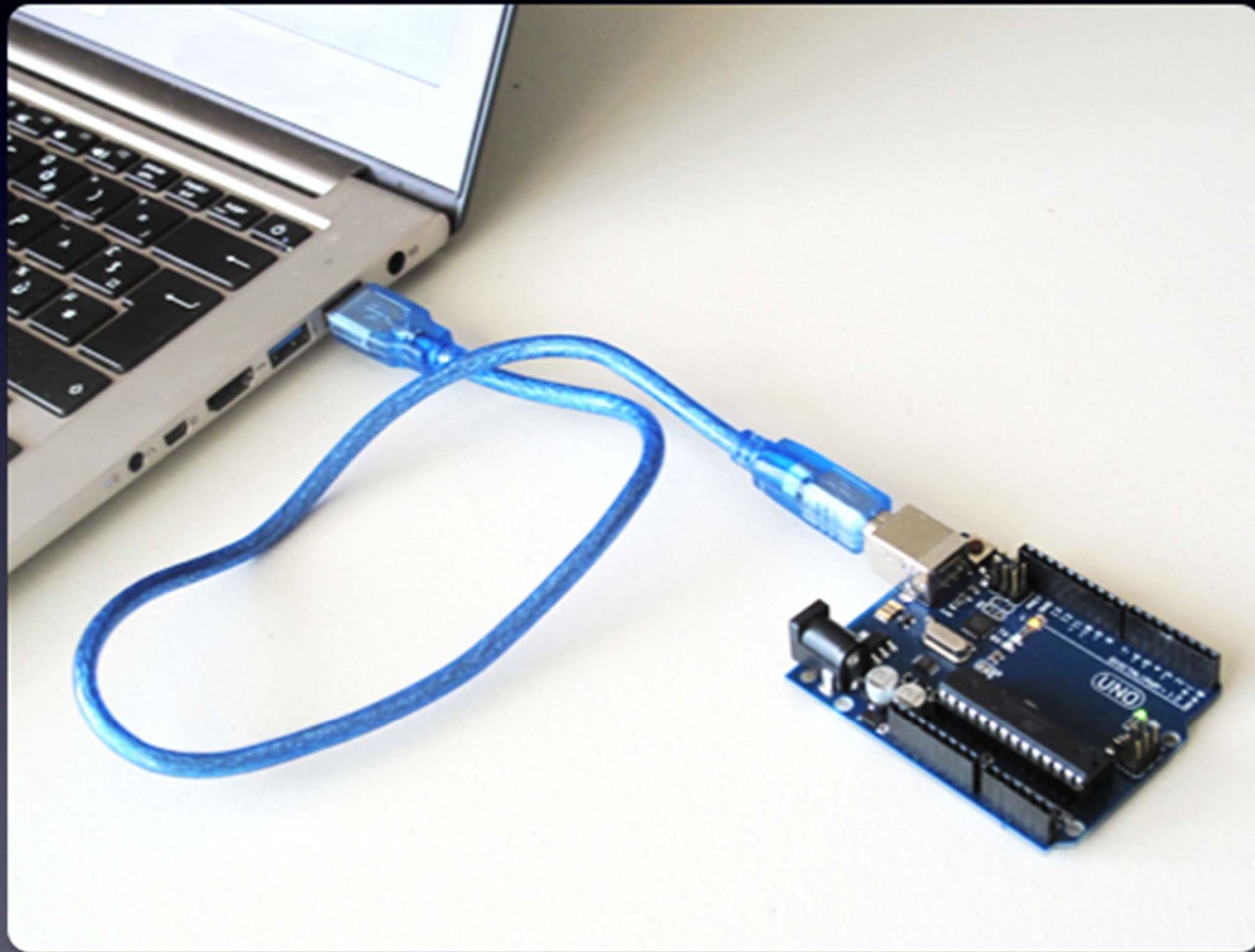
Download Arduino sketches

Search for: *“RGB LED Strip Sketches”*

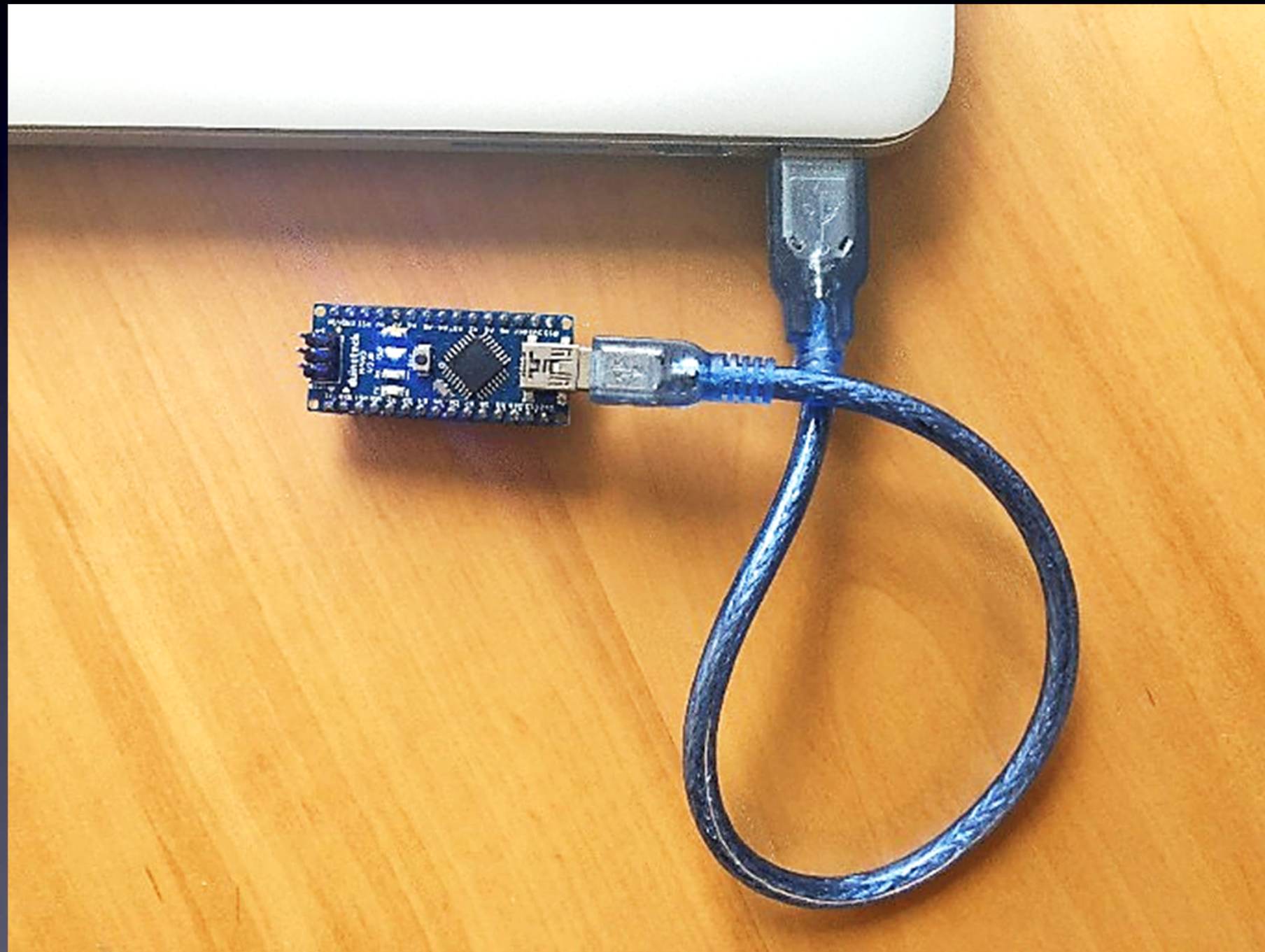
Store them on your computer anywhere you like.



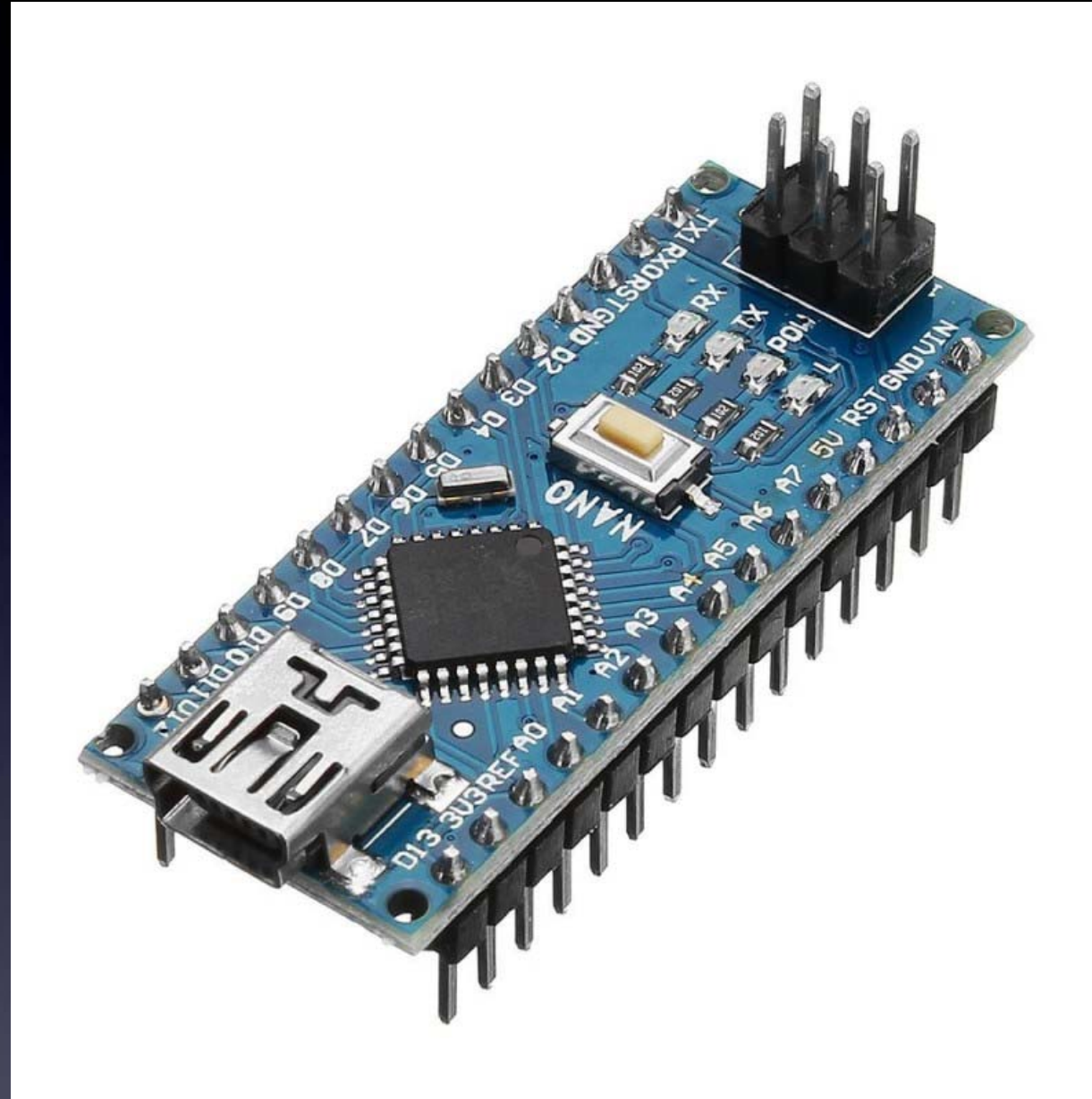
Connect your Arduino to your computer



Connect your Arduino to your computer



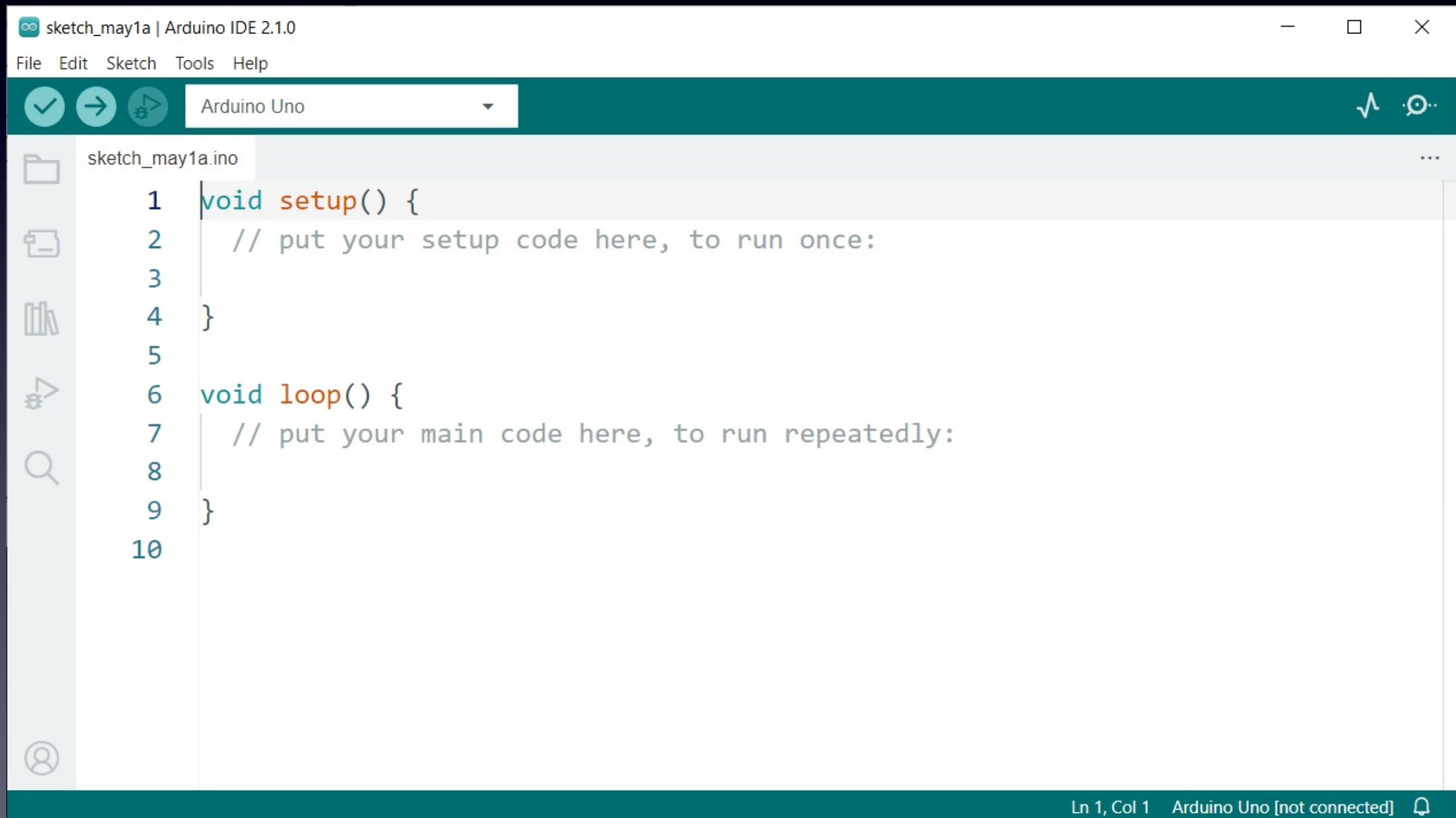
Serial Port Driver



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

Arduino

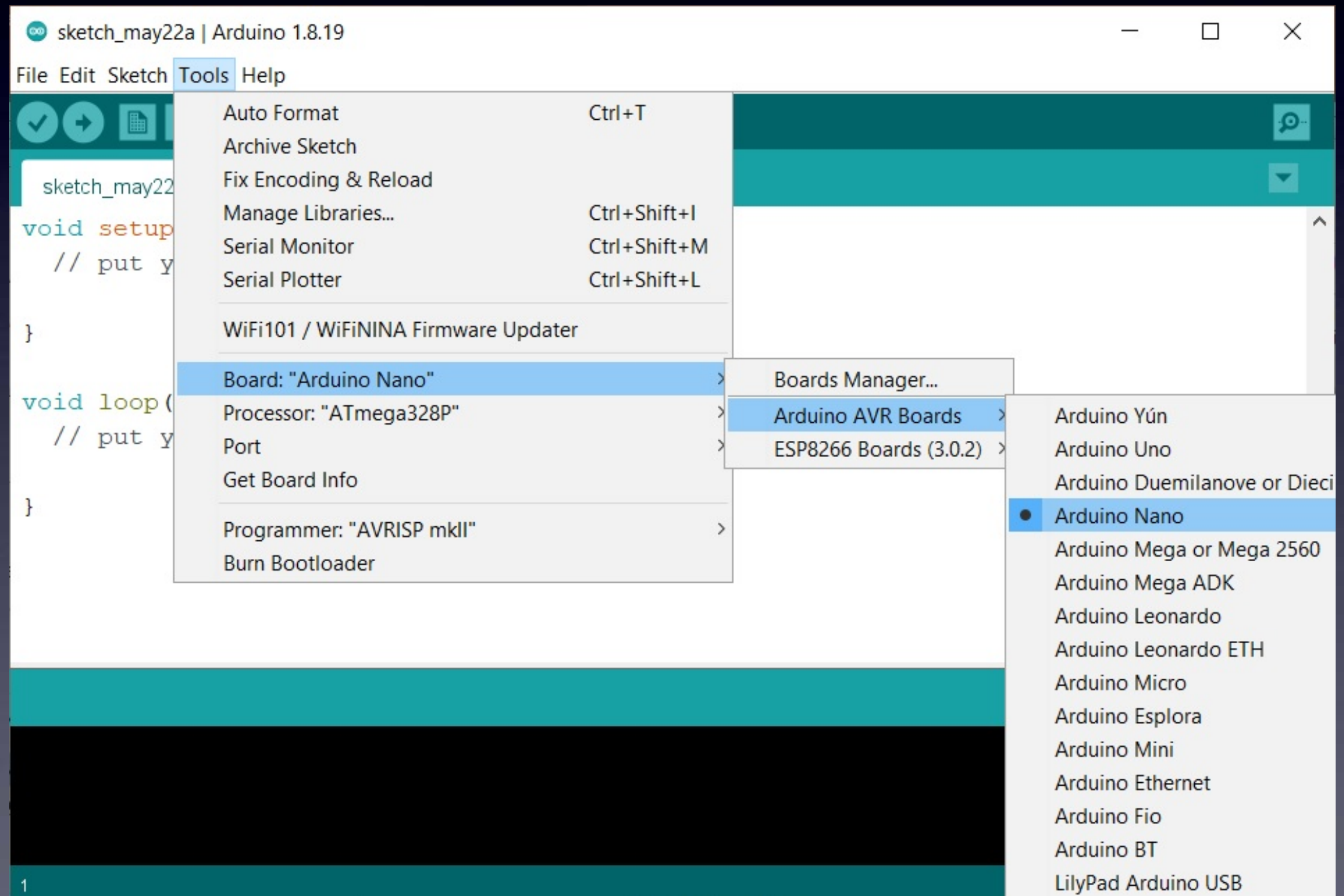
After you download and install the Arduino software start it, and you will see a screen that looks like this:



Arduino

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

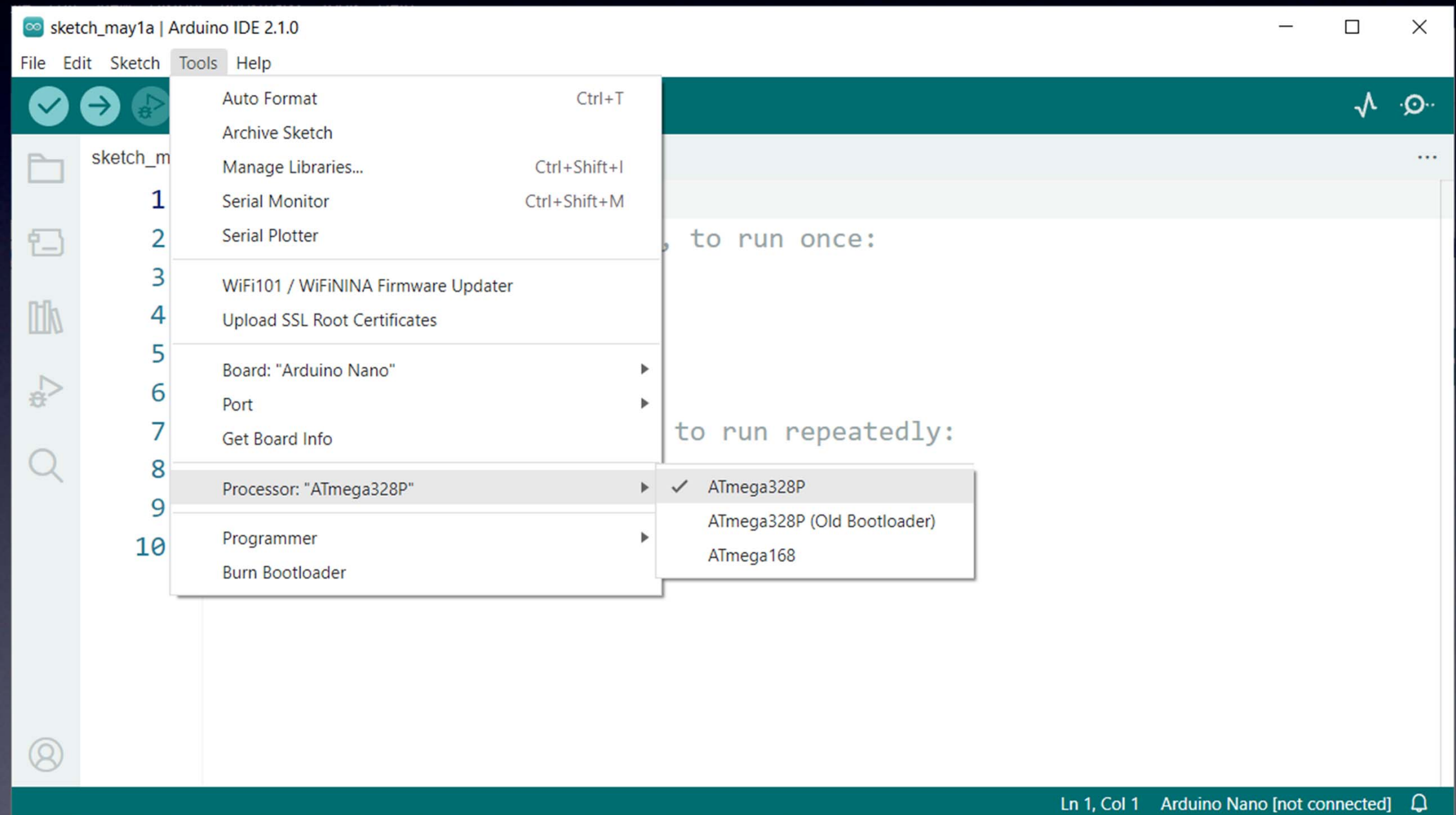
(1)
Choose
“Arduino Nano”
as the Board



Arduino

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

(2)
Choose
your Processor
as the Board

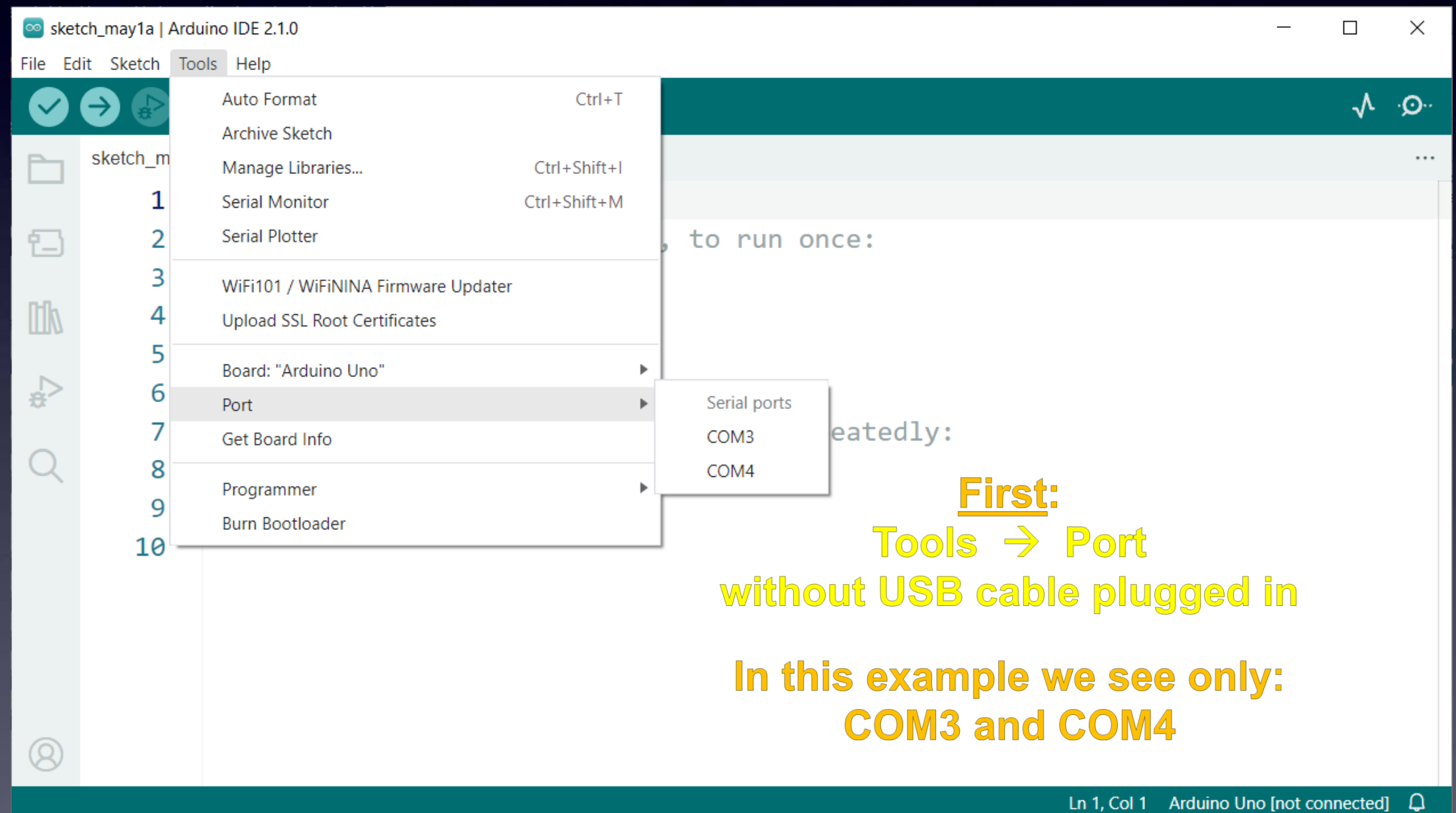


If this one doesn't work,
then
choose
"ATmega328P (Old Bootloader)"

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

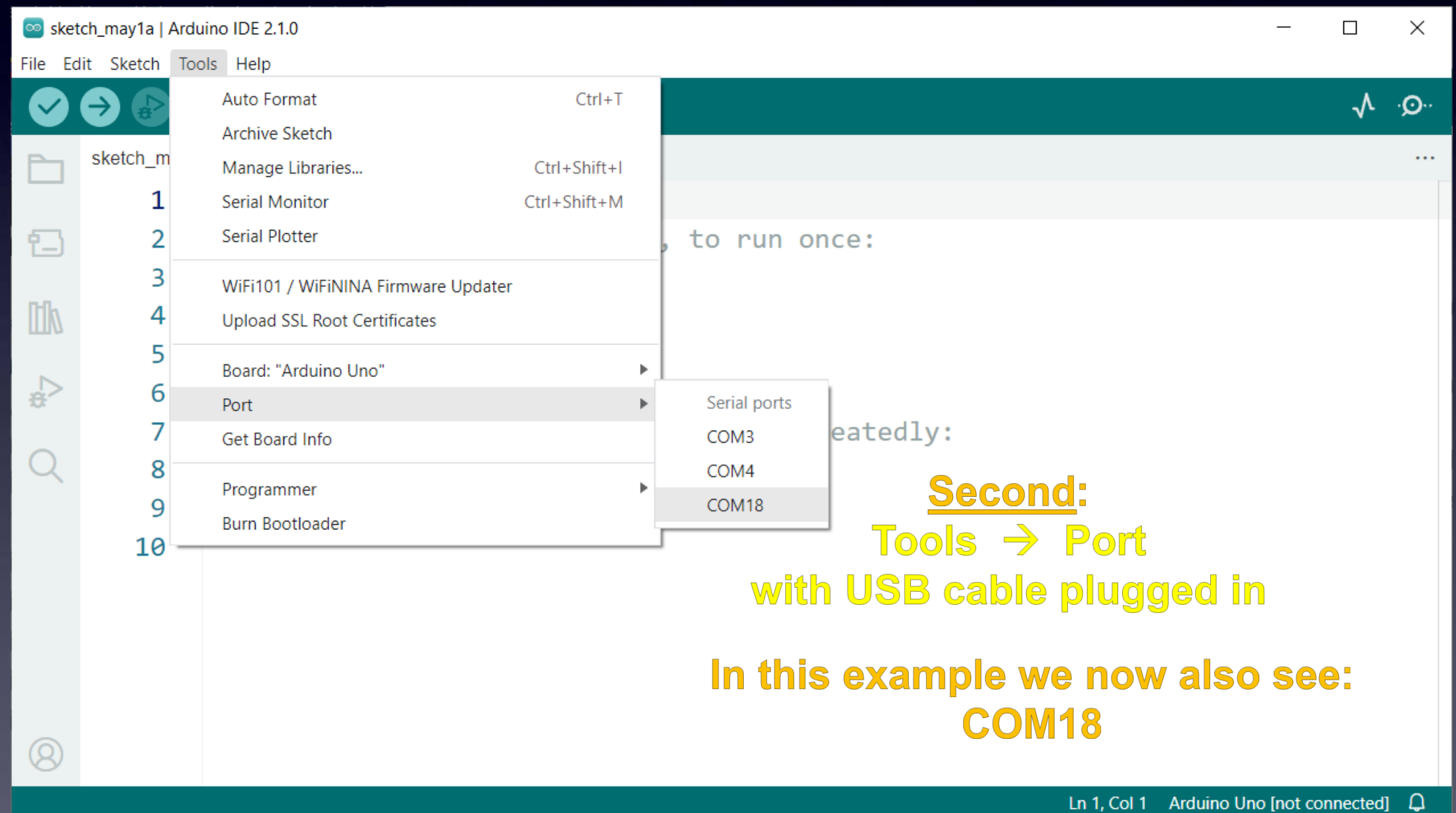
Arduino

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.)



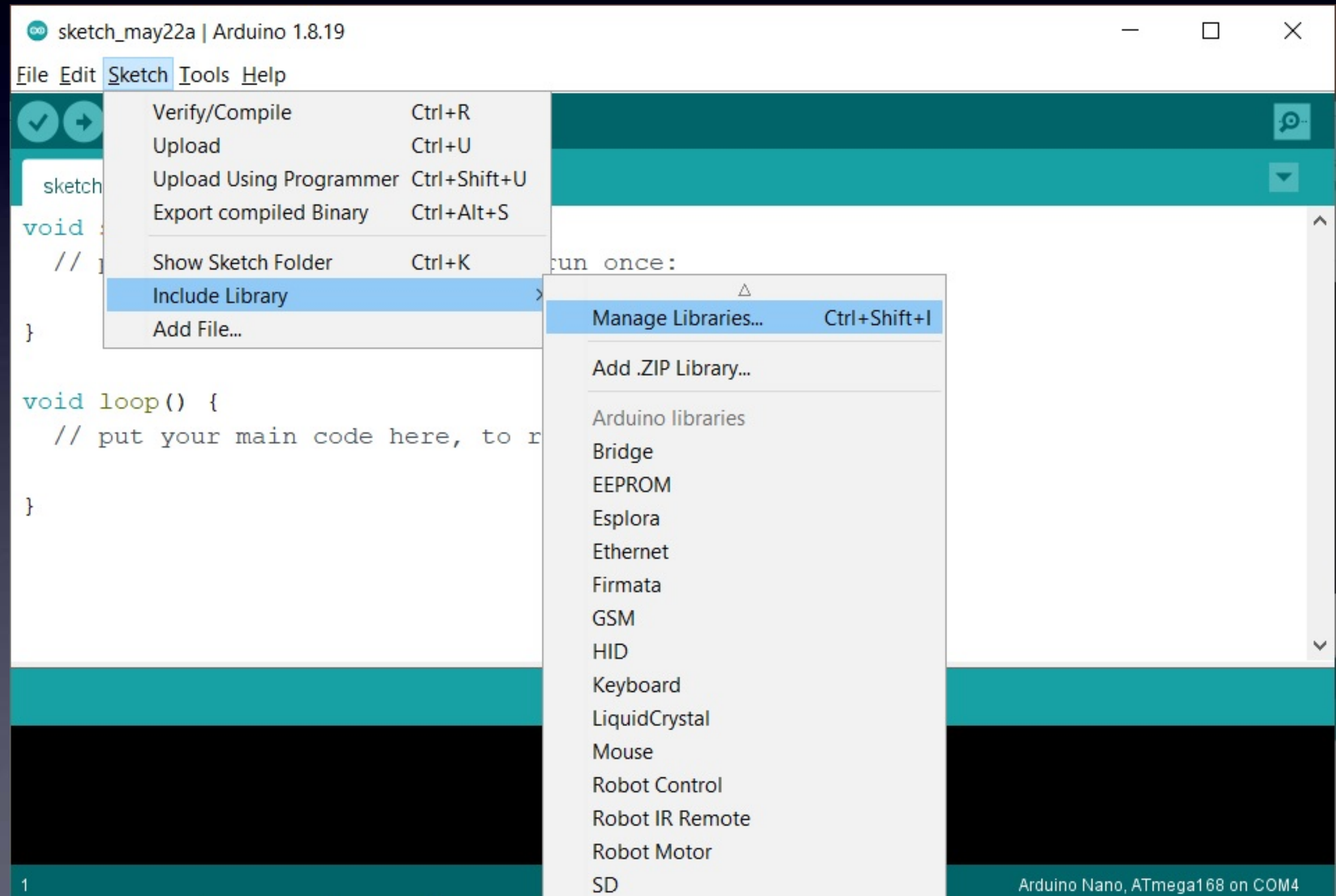
Second:
Tools → Port
with USB cable plugged in

In this example we now also see:
COM18

Arduino

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

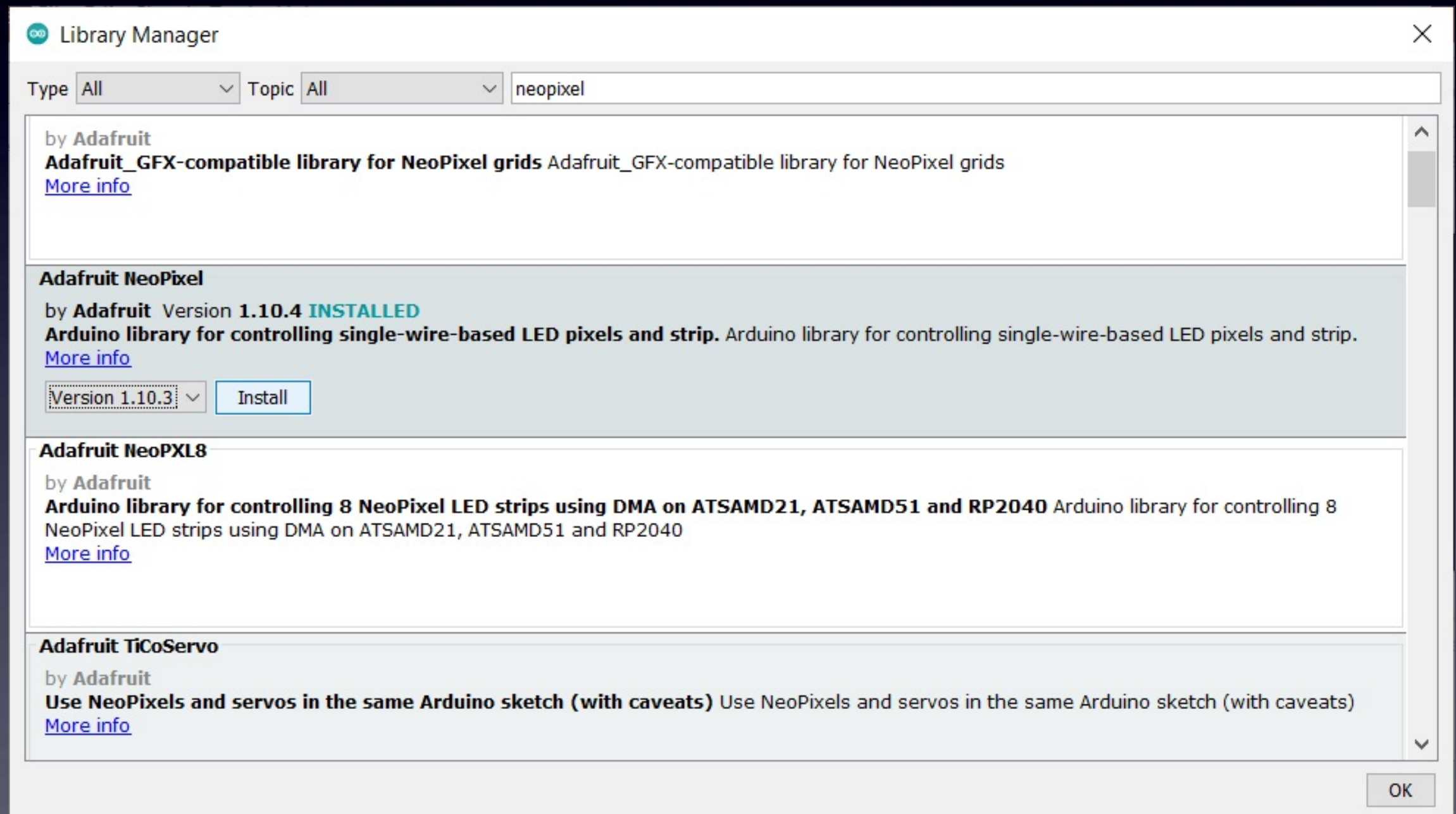
(4a)
Install
the
Neopixel
library



Arduino

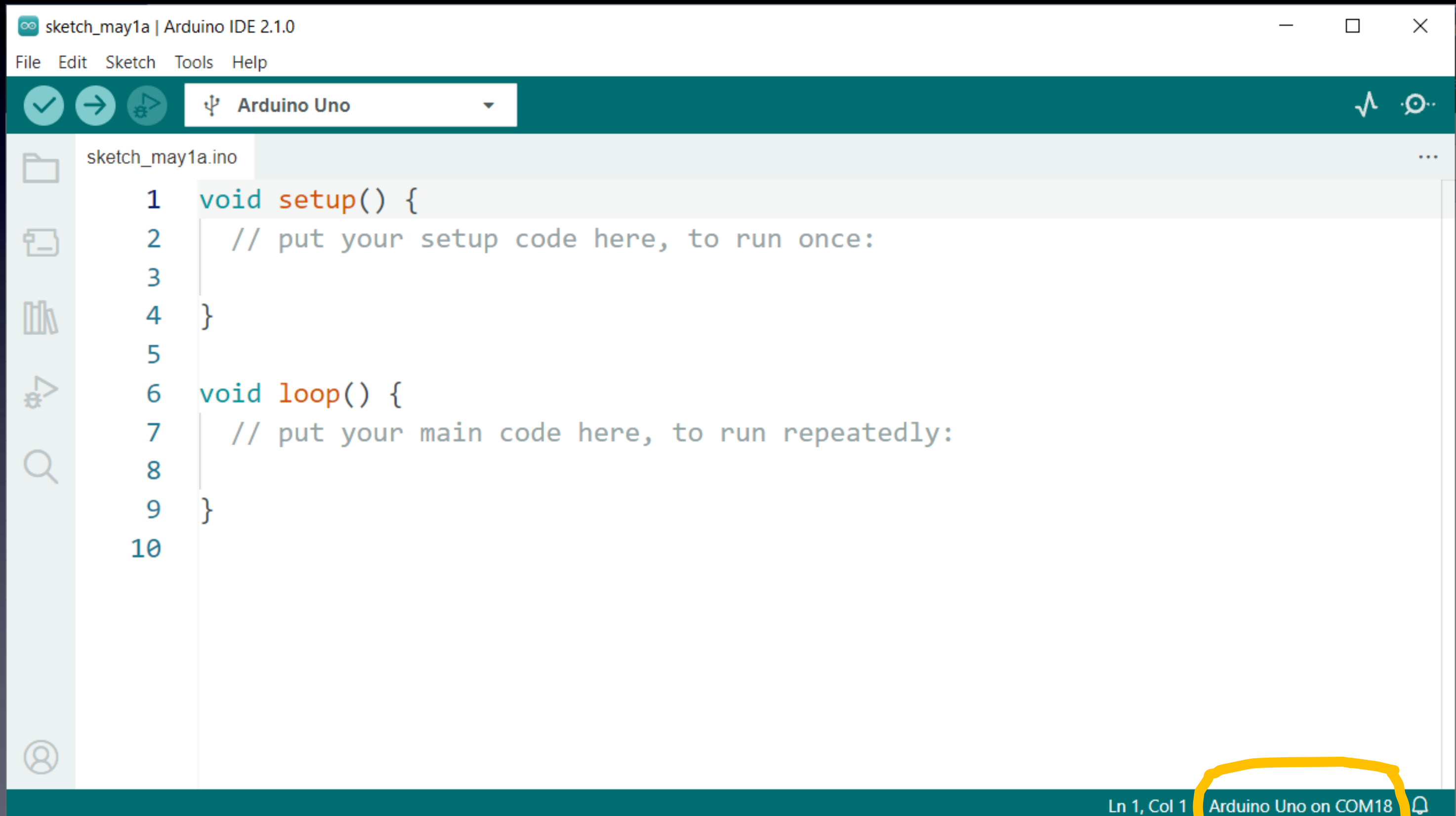
The first time you start your Arduino software
you need to set things up

(4b)
Install
the
Neopixel
library



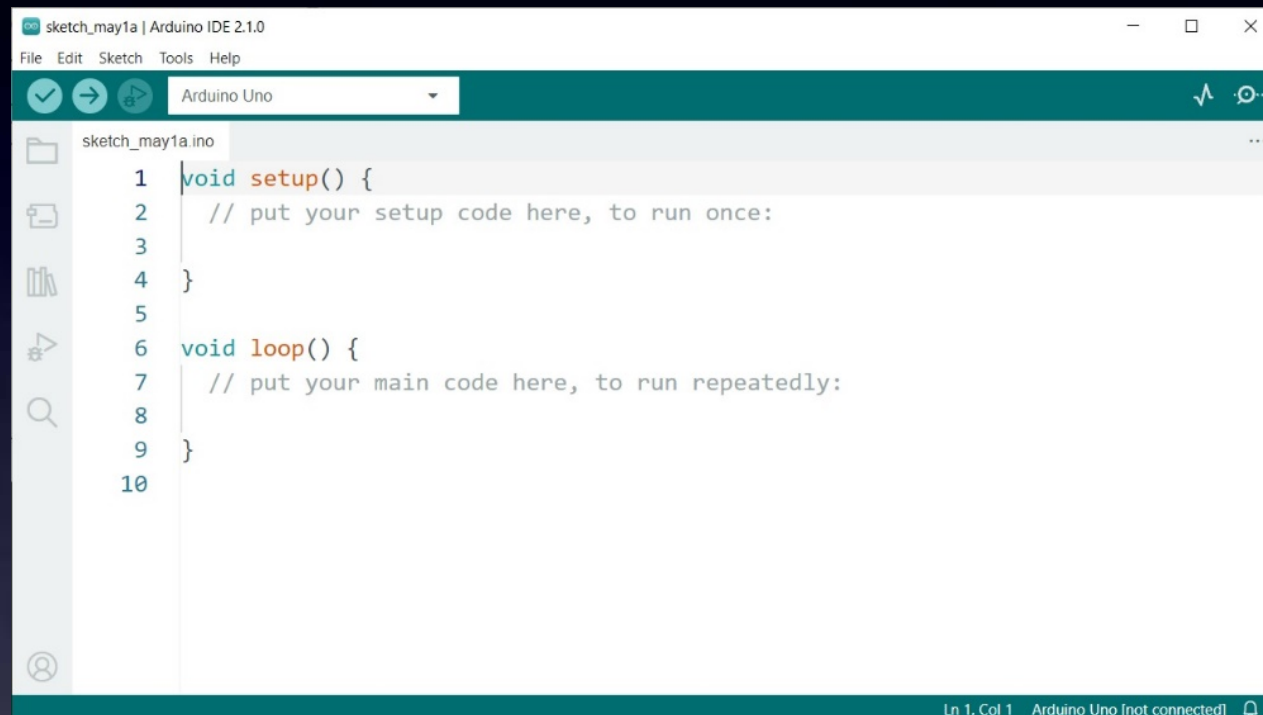
Arduino

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
```

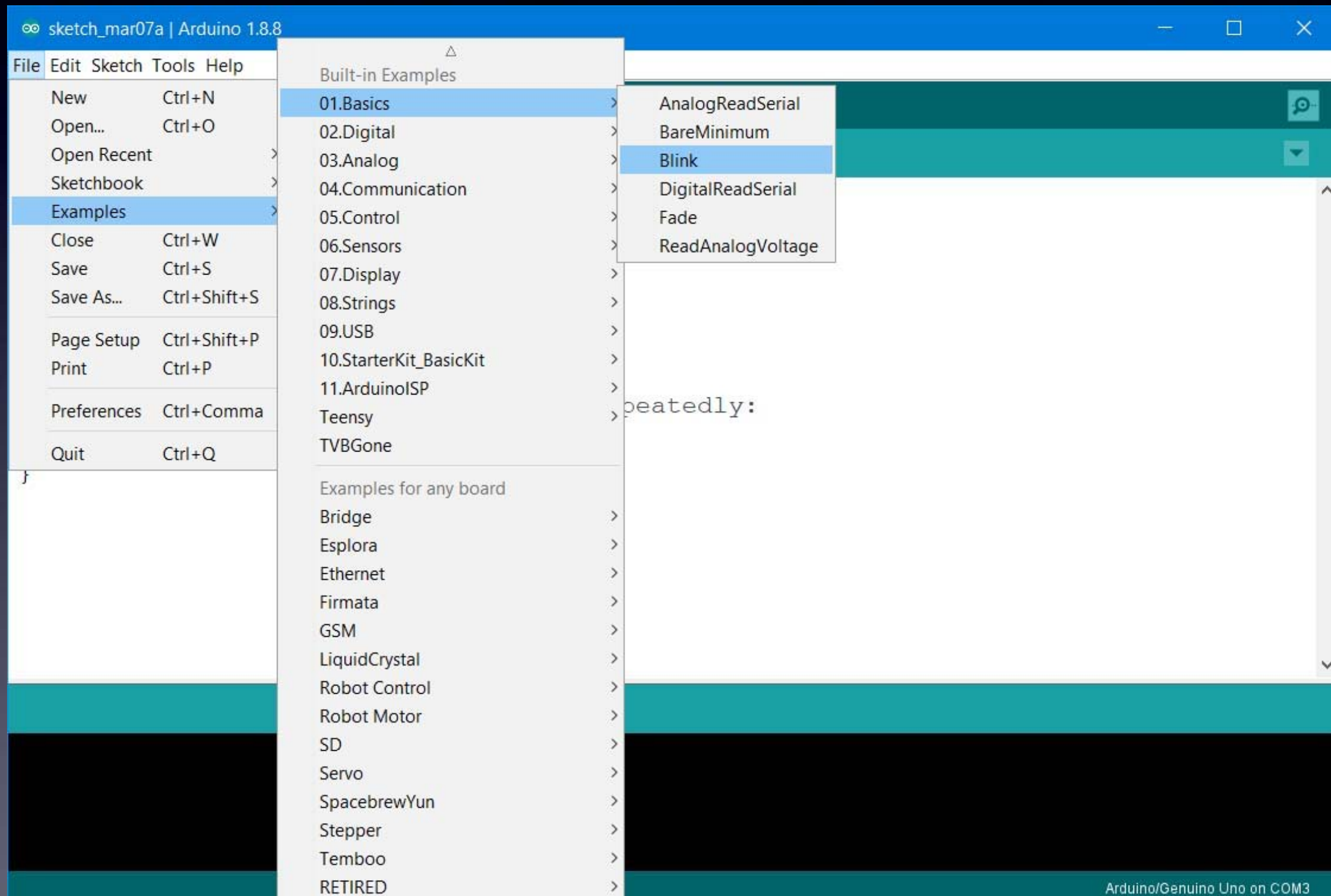
“Sketch” :

an Arduino program

Arduino

Let's start simple!

Let's all make an LED blink!



Arduino

Example “sketch”: Blink

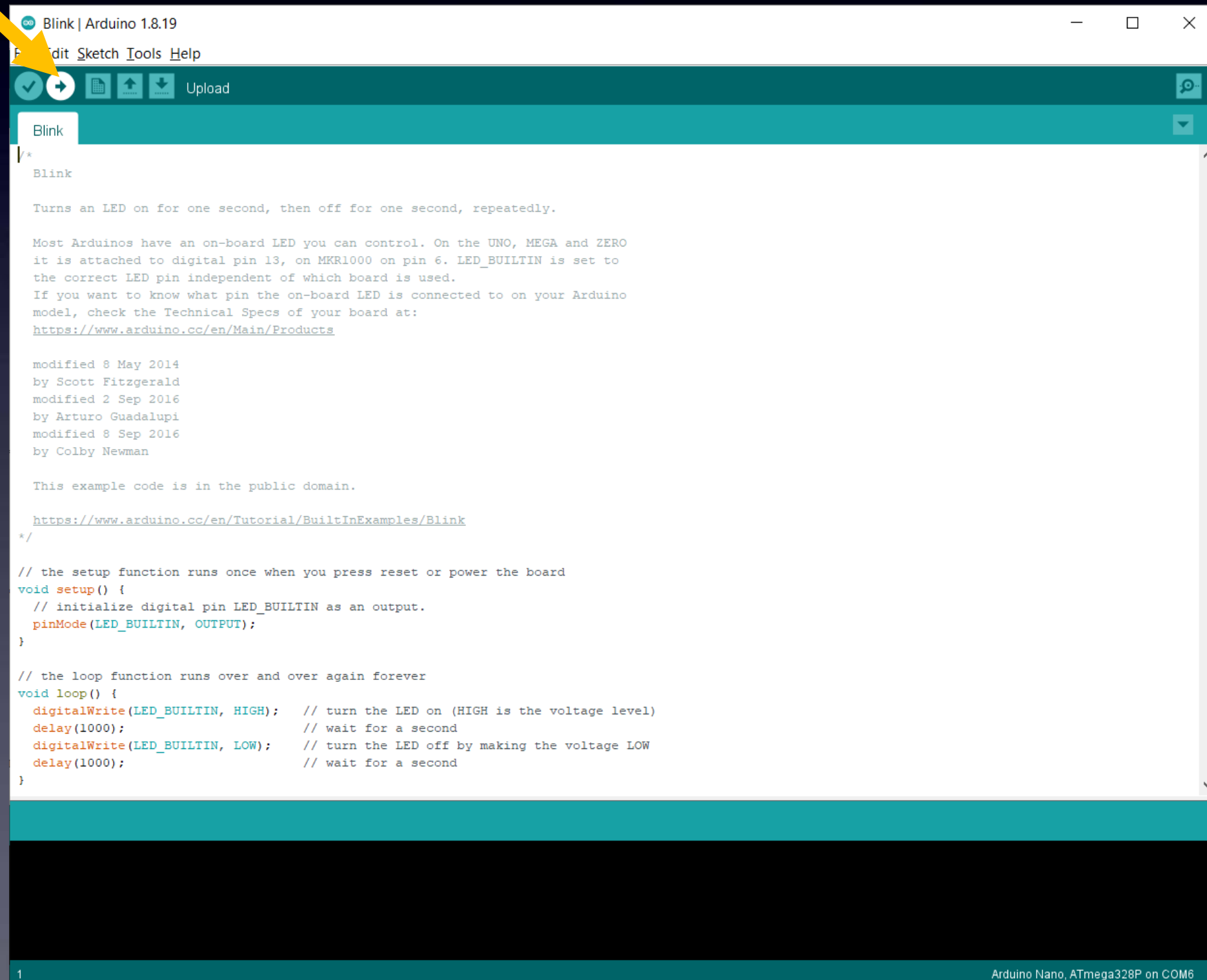
A screenshot of the Arduino IDE interface. The title bar reads "Blink | Arduino 1.8.19". The menu bar includes "File", "Edit", "Sketch", "Tools", and "Help". Below the menu bar is a toolbar with icons for checking, running, serial monitor, and uploading/downloading. The main text area shows the "Blink" sketch. It includes a description: "Turns an LED on for one second, then off for one second, repeatedly." and a note about the on-board LED pin (pin 13 for UNO, MEGA, and ZERO; pin 6 for MKR1000). It also lists the authors: Scott Fitzgerald (modified 8 May 2014), Arturo Guadalupi (modified 2 Sep 2016), and Colby Newman (modified 8 Sep 2016). The code is in the public domain. The code itself is as follows:

```
/*  
 * 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  
}
```

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

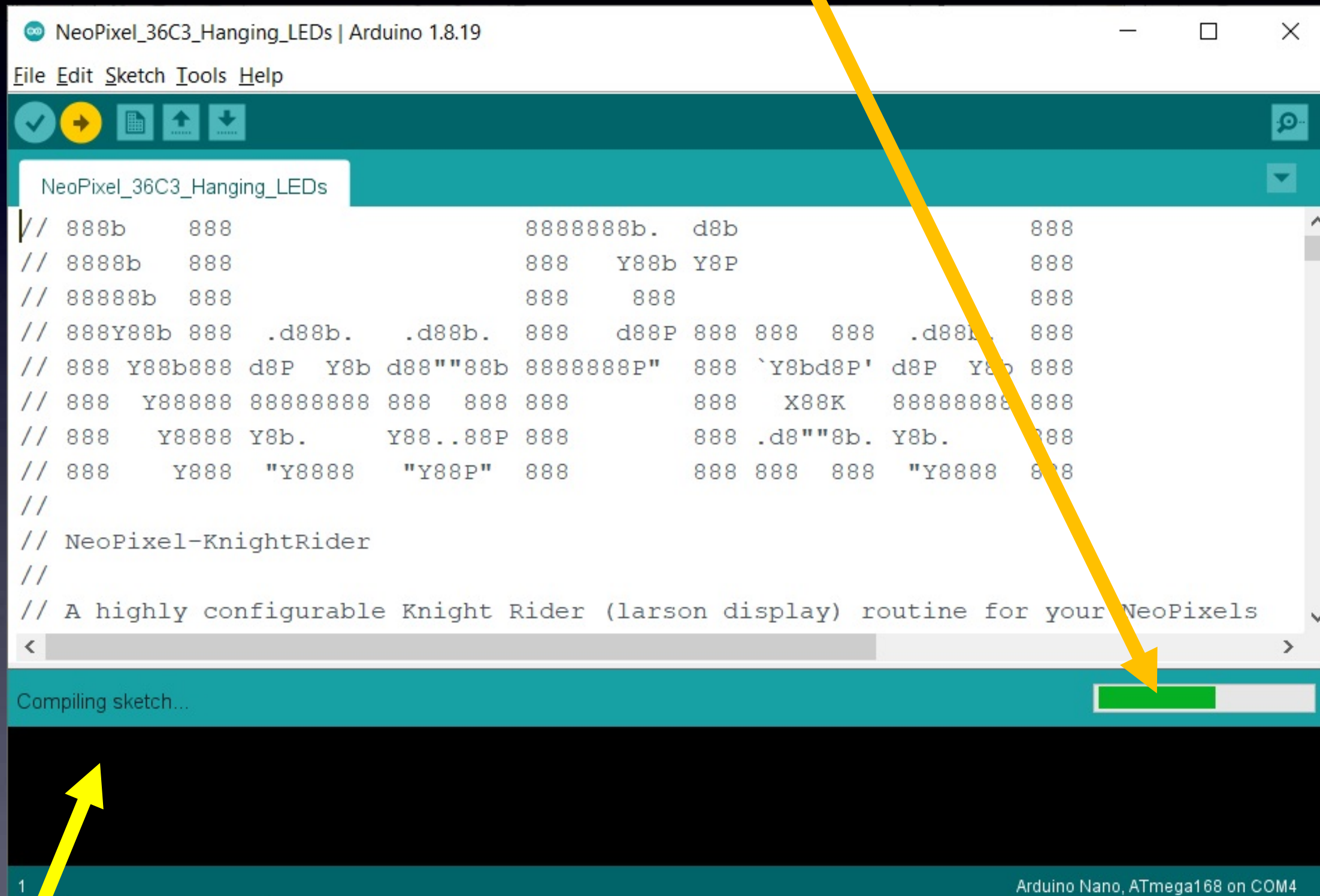
Arduino

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



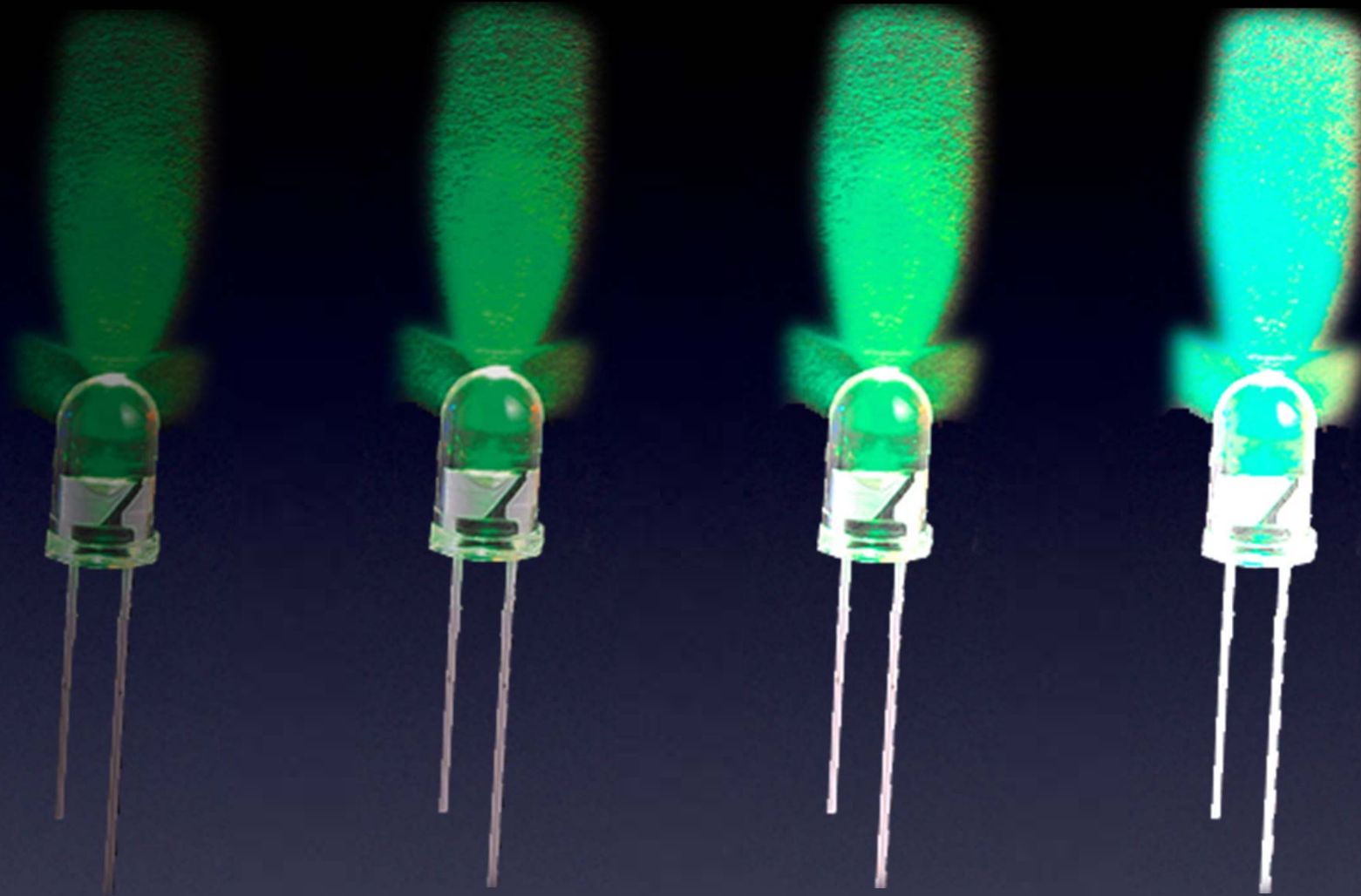
Arduino

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



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

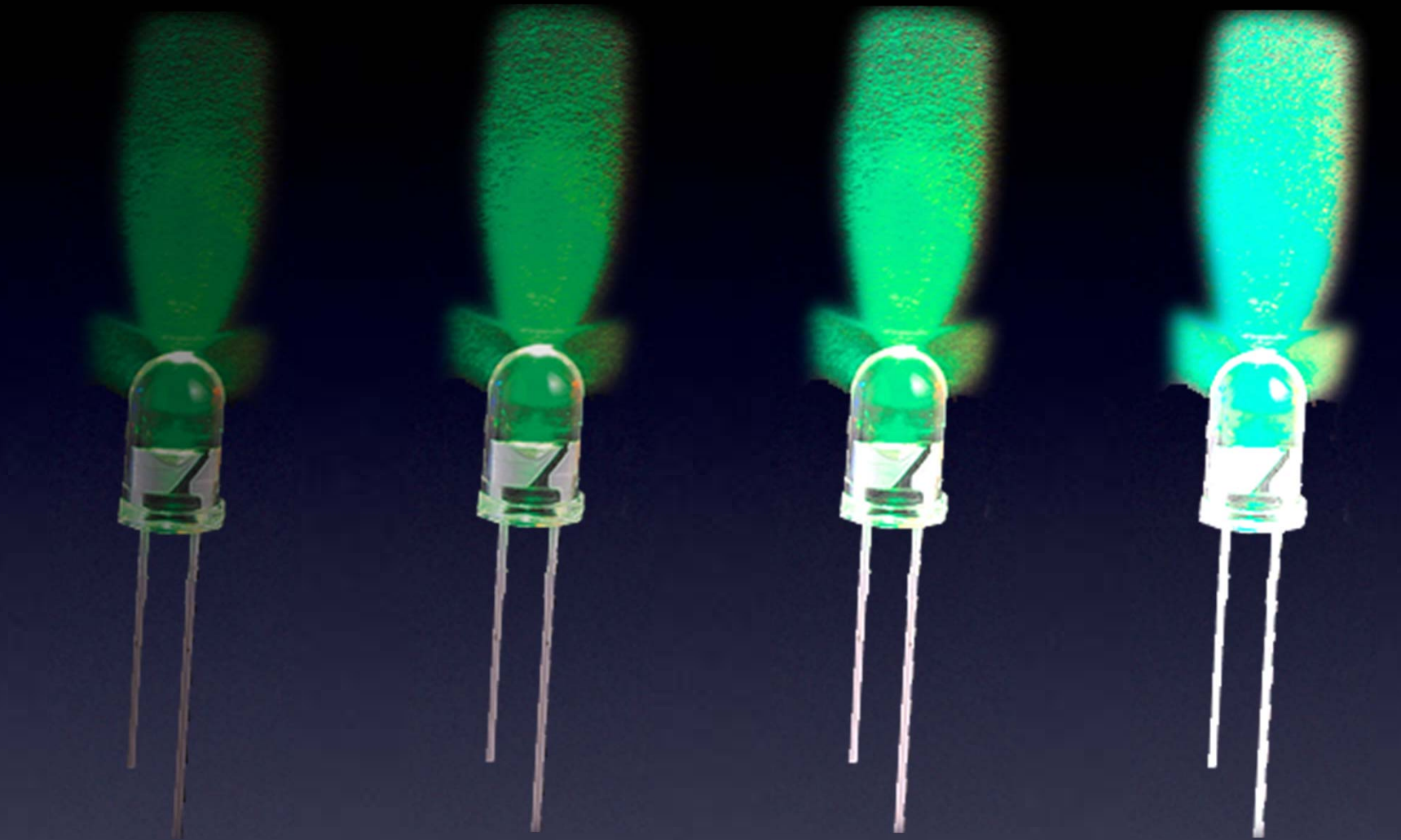
LED Brightness



More resistance (less current)

(one way to change brightness)

LED Brightness



Less average current

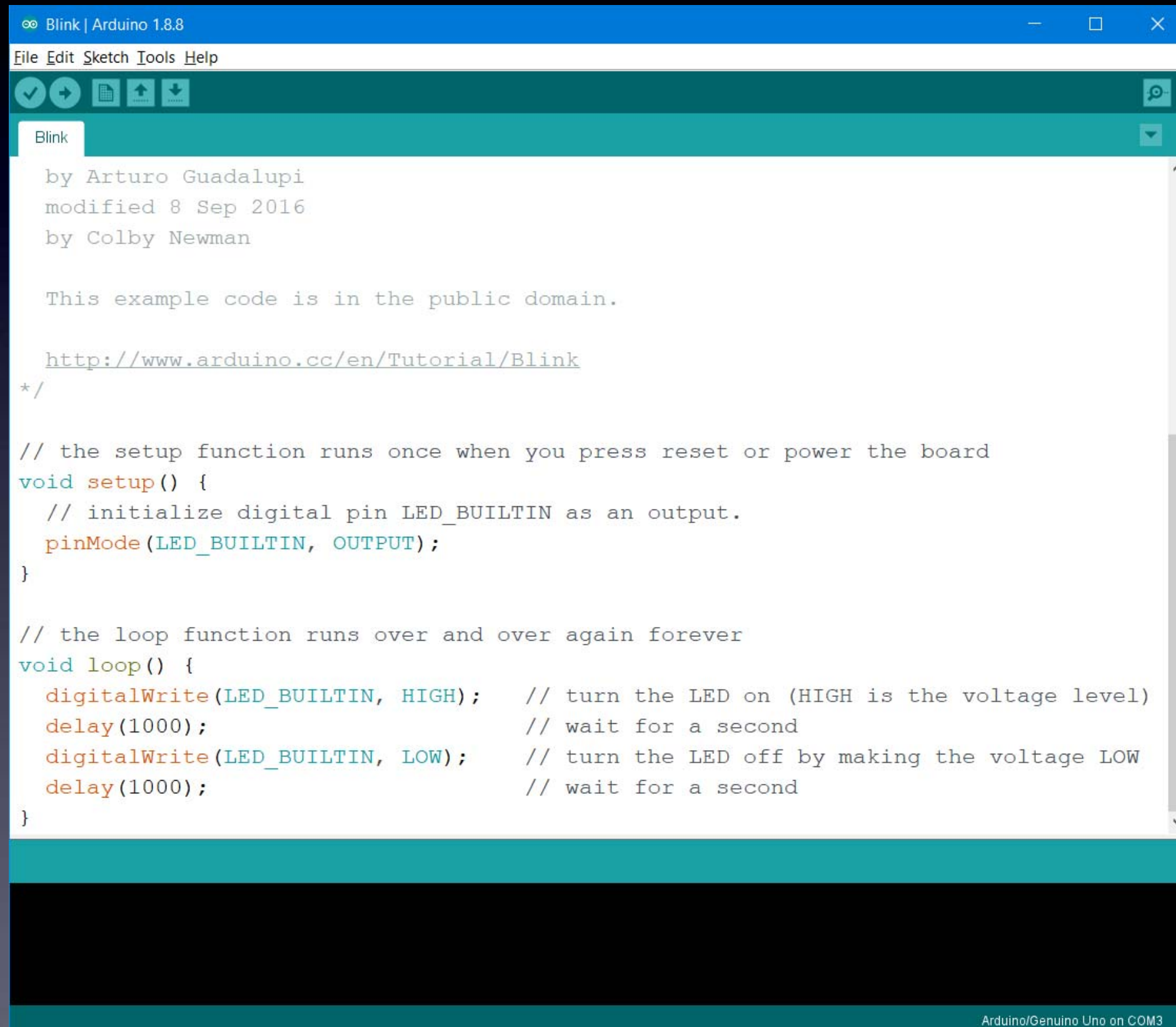
This is how we do it with a microcontroller

LED Brightness

PWM

Arduino

Hacking the Blink sketch



The screenshot shows the Arduino IDE interface with the Blink sketch loaded. 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. The sketch name "Blink" is shown in the top left. 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 ?



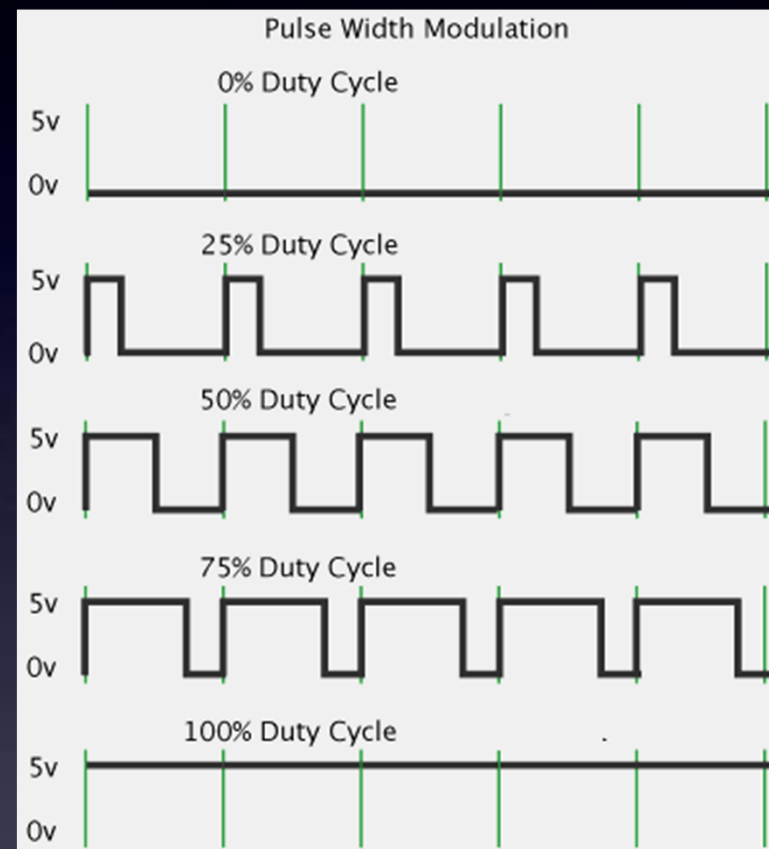
Pulse Wave:

ON and OFF at any ratio you like

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

LED Brightness

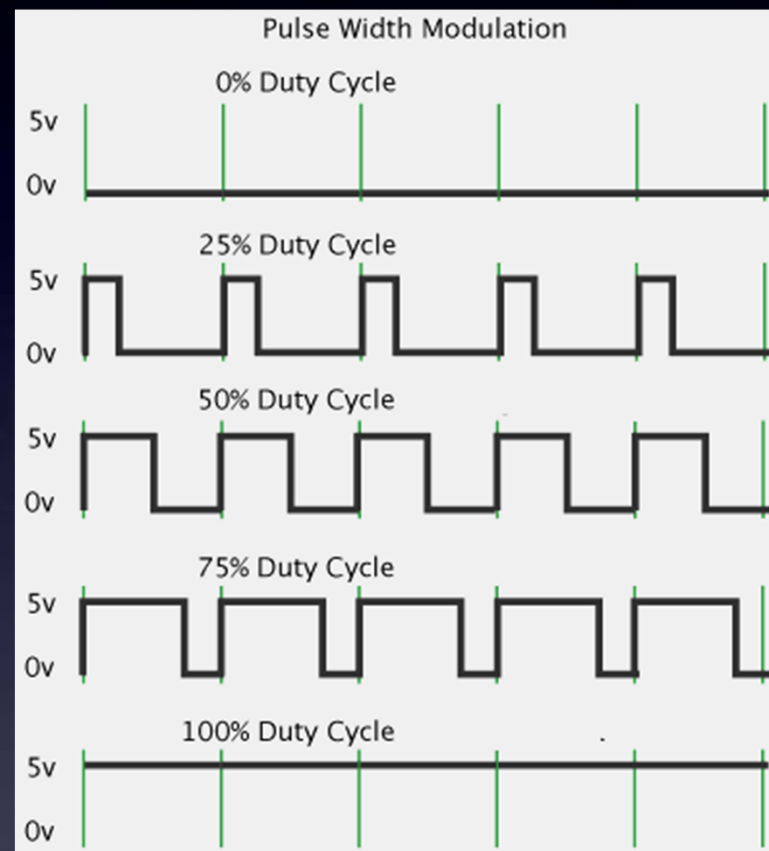
PWM



Pulse Wave:

ON and OFF at any ratio you like

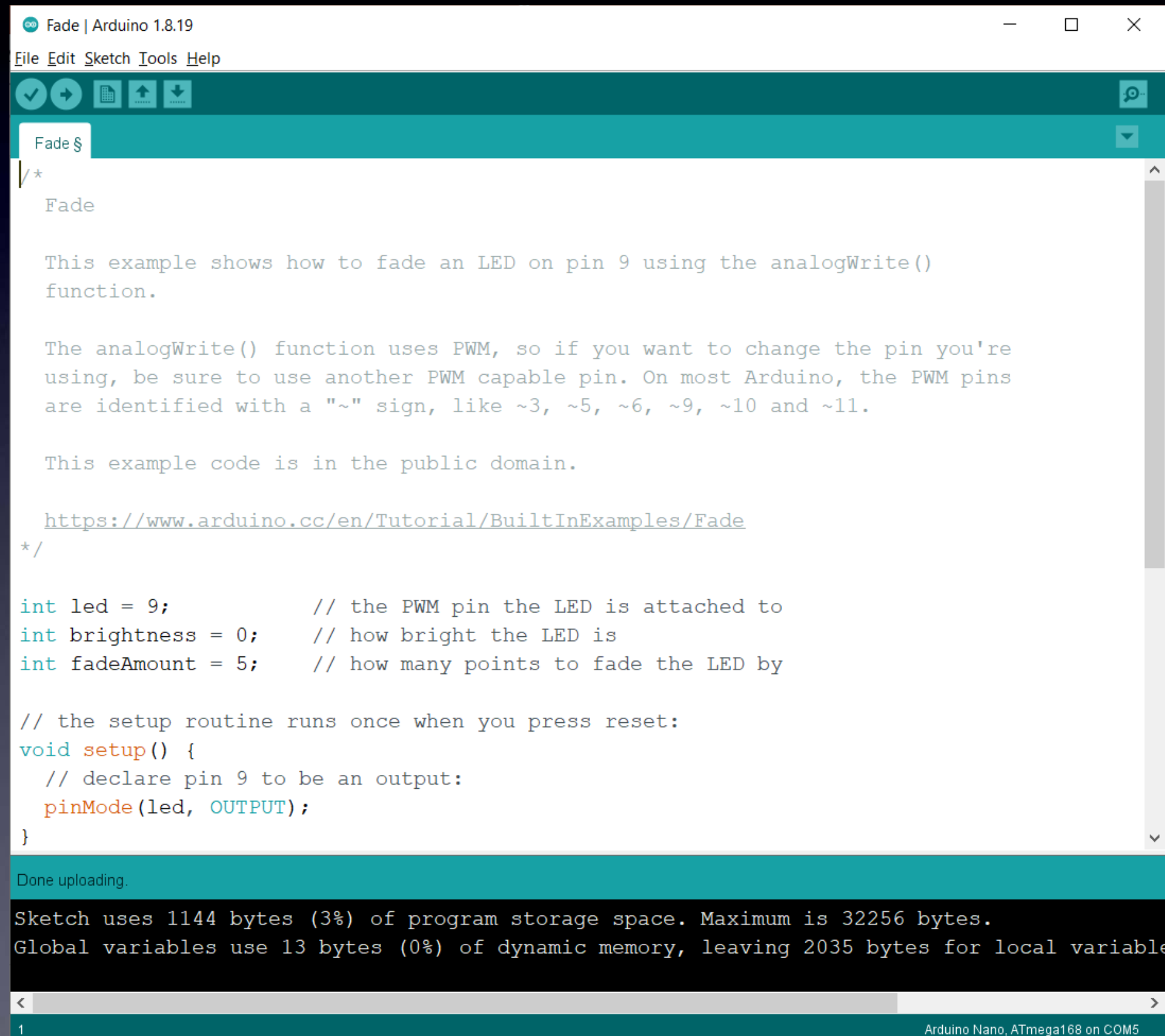
LED Brightness



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

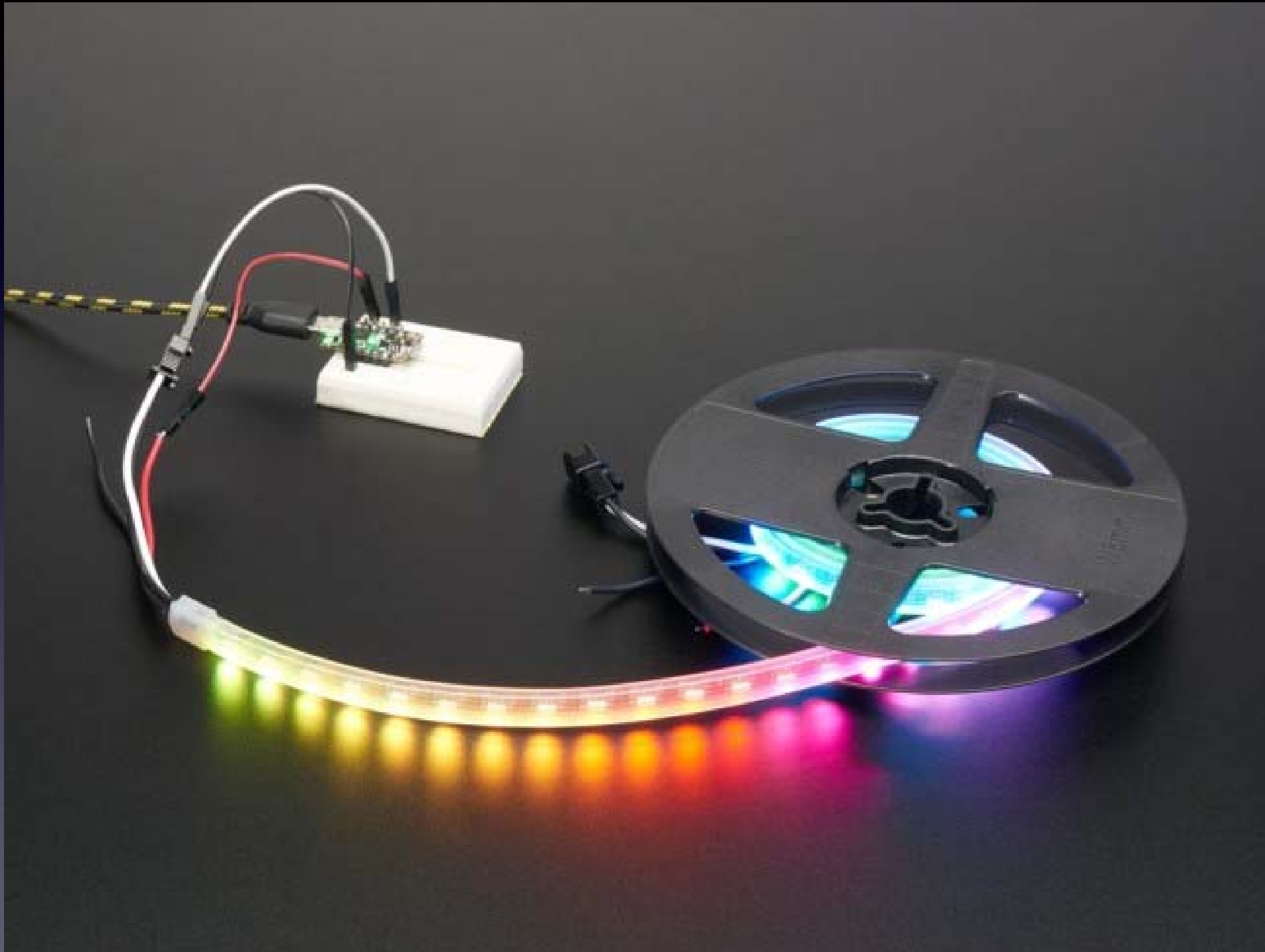
// the setup routine runs once when you press reset:
void setup() {
  // declare pin 9 to be an output:
  pinMode(led, OUTPUT);
}

Done uploading.

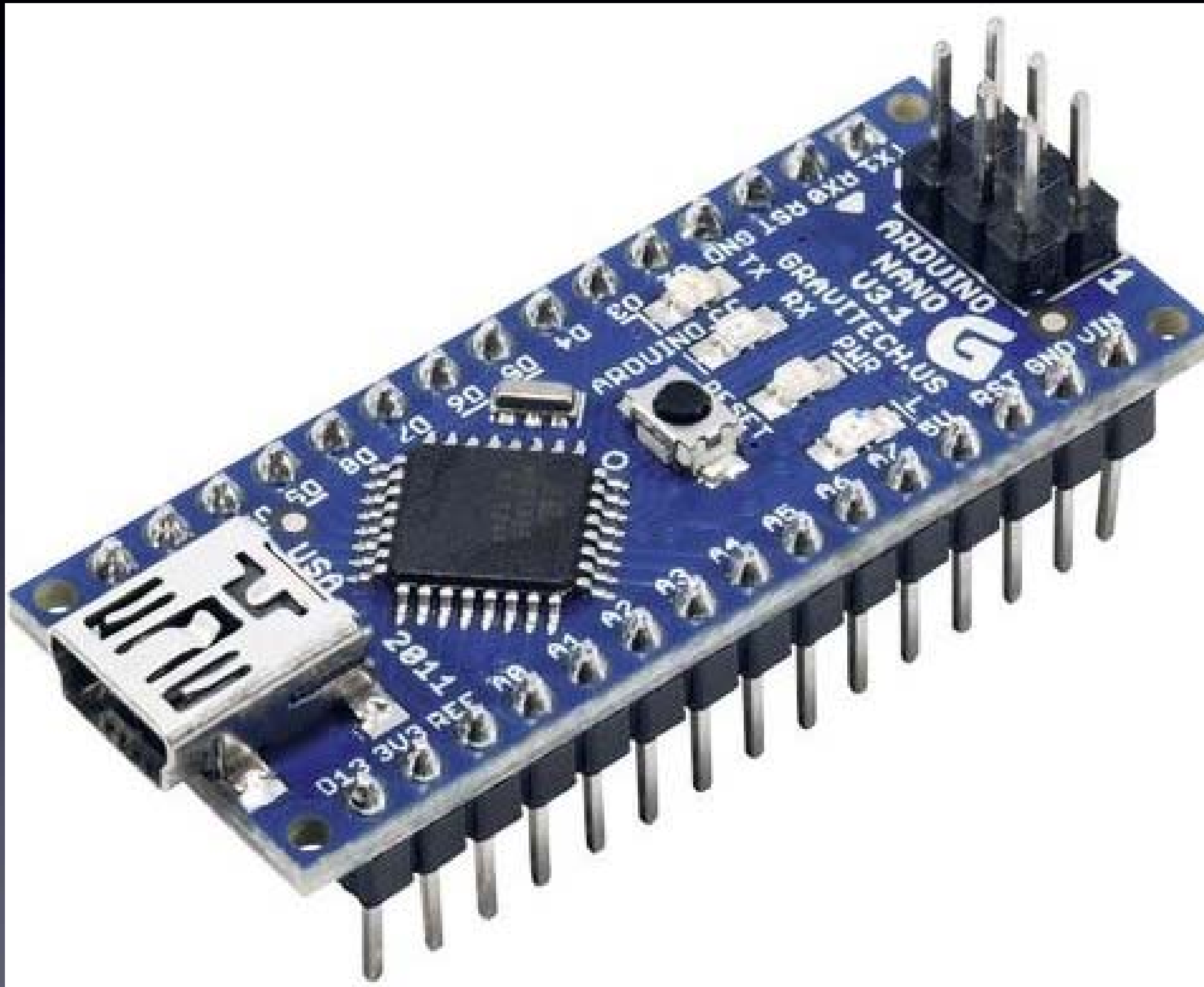
Sketch uses 1144 bytes (3%) of program storage space. Maximum is 32256 bytes.
Global variables use 13 bytes (0%) of dynamic memory, leaving 2035 bytes for local variables.

1 Arduino Nano, ATmega168 on COM5
```

Let's Program Some LED Strips!



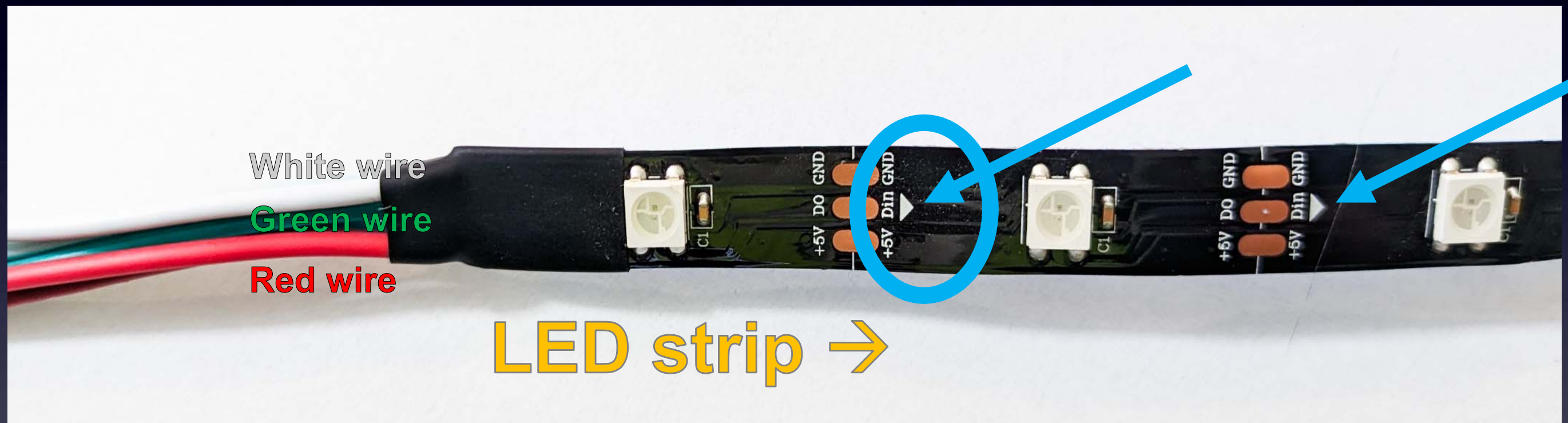
Arduino Nano



Arduino Uno



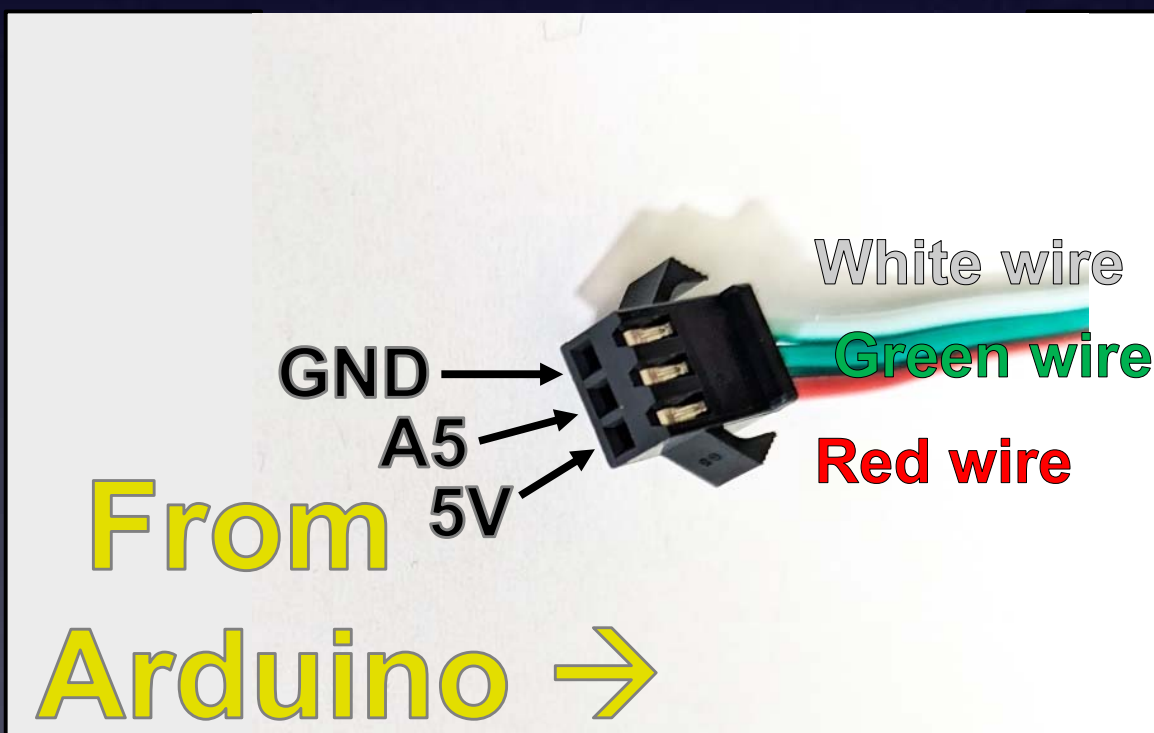
Let's Program Some LED Strips!



The Input side of the LED Strip
has arrows at each LED pointing into the strip

Let's Program Some LED Strips!

The Input side of the LED Strip:



The Input connector
of the LED Strip

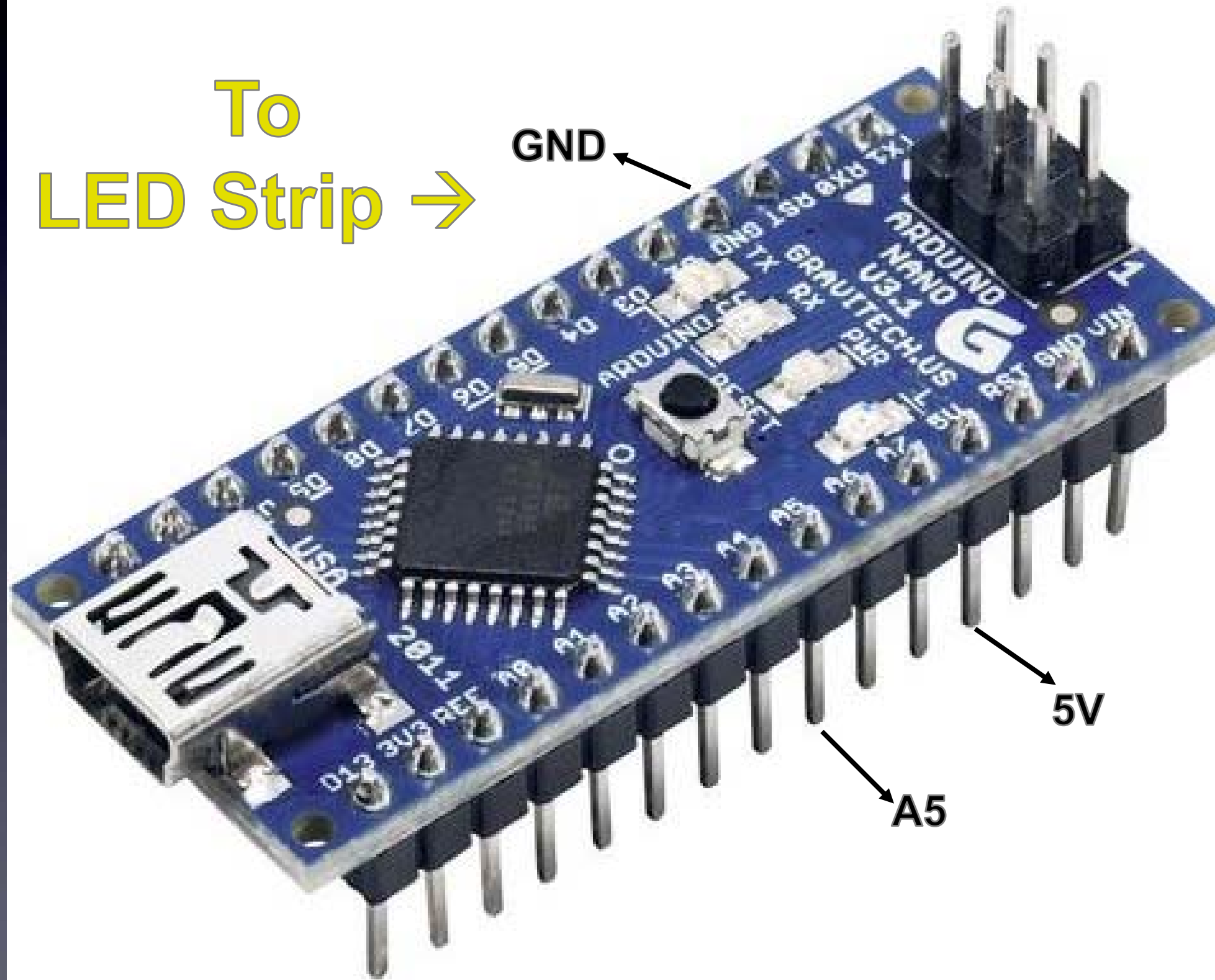


The Input side of the LED Strip

Let's Program Some LED Strips!

Arduino Nano

To
LED Strip →



Let's Program Some LED Strips!

Arduino Uno

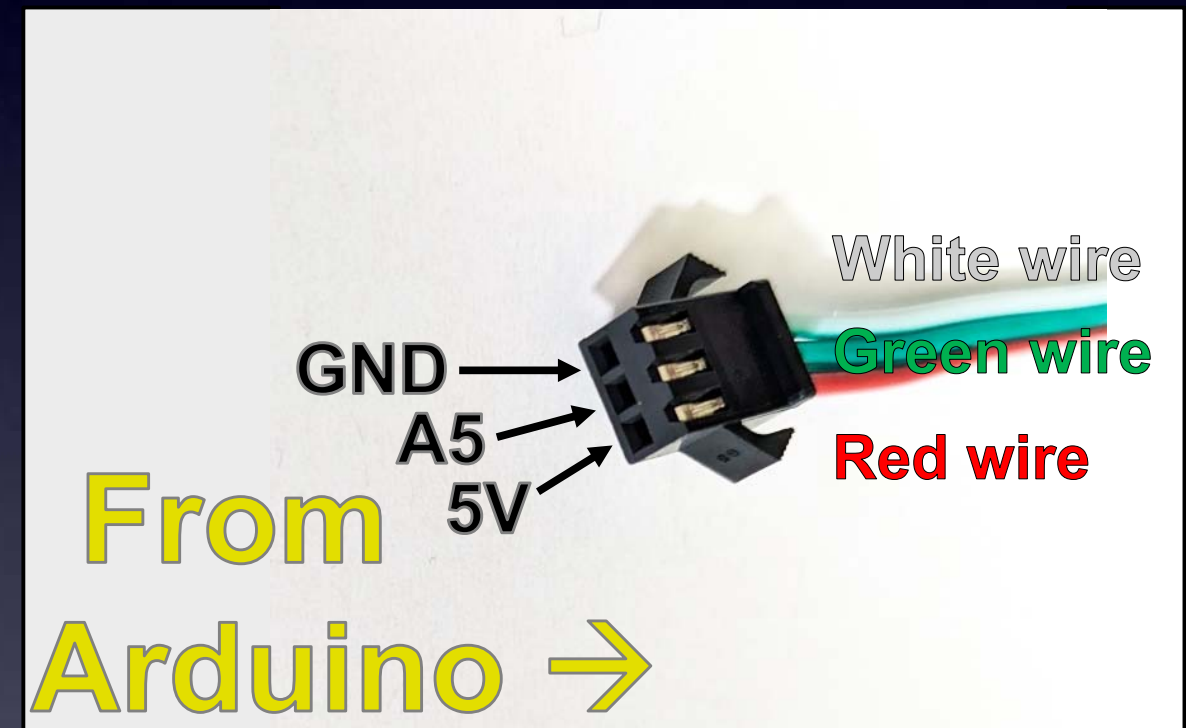
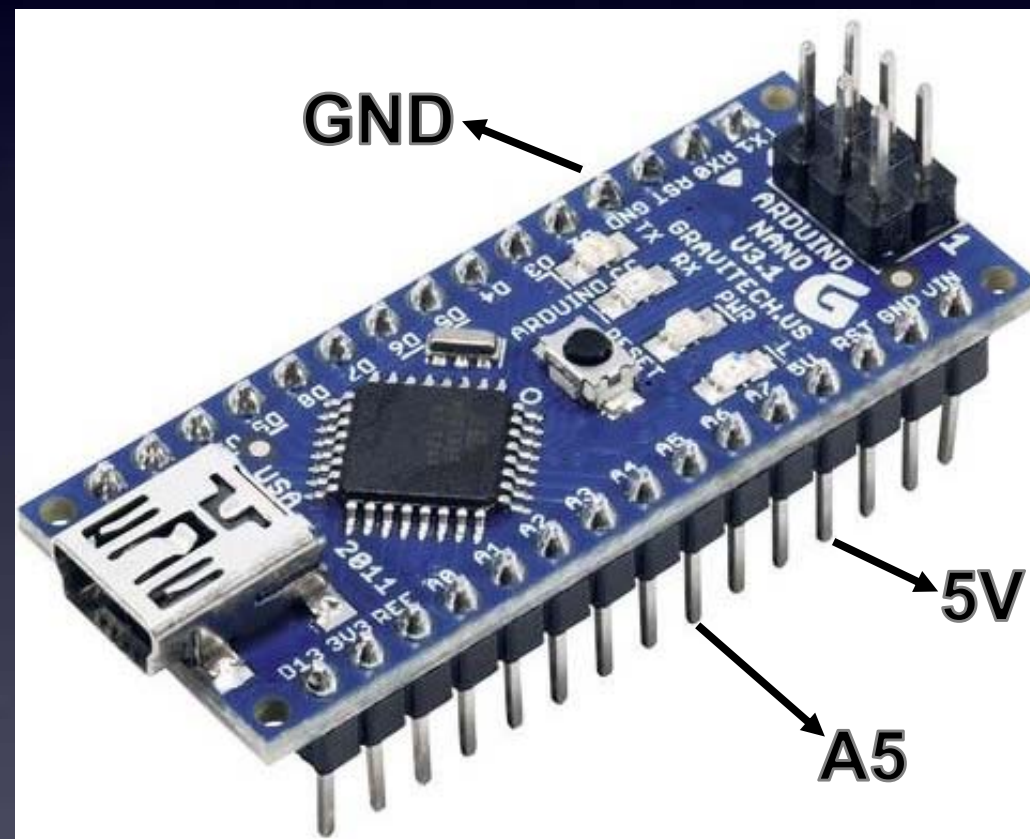


To LED Strip →

5V GND A5

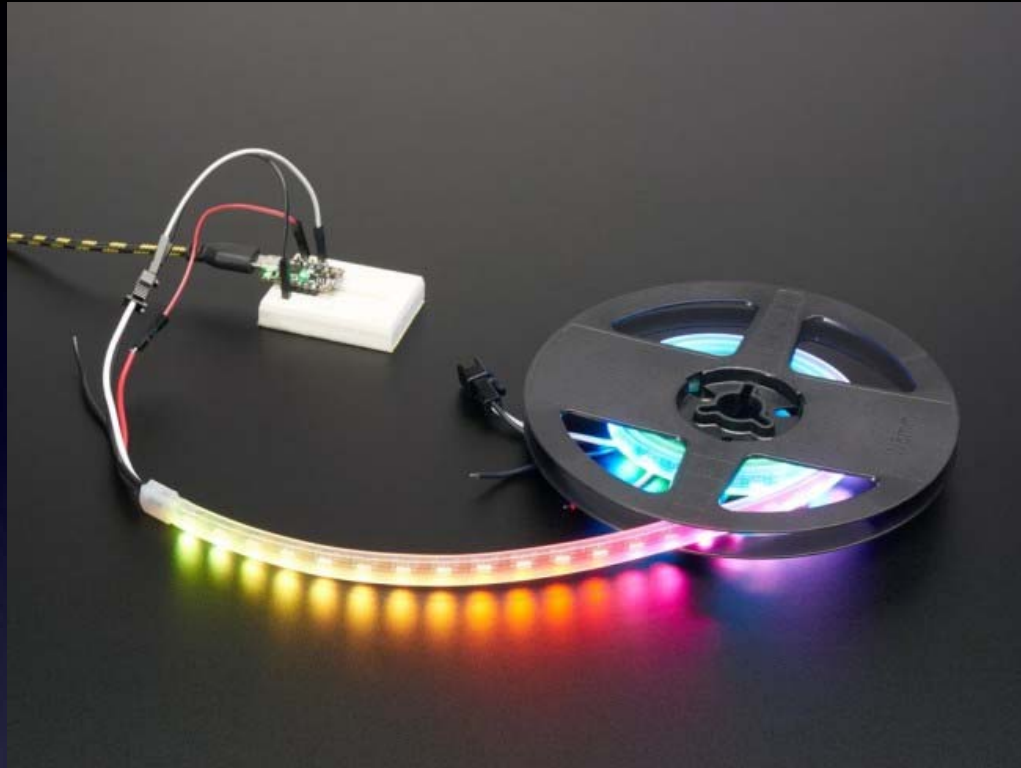
Let's Program Some LED Strips!

Arduino Nano



The Input connector
of the LED Strip

Let's Program Some LED Strips!

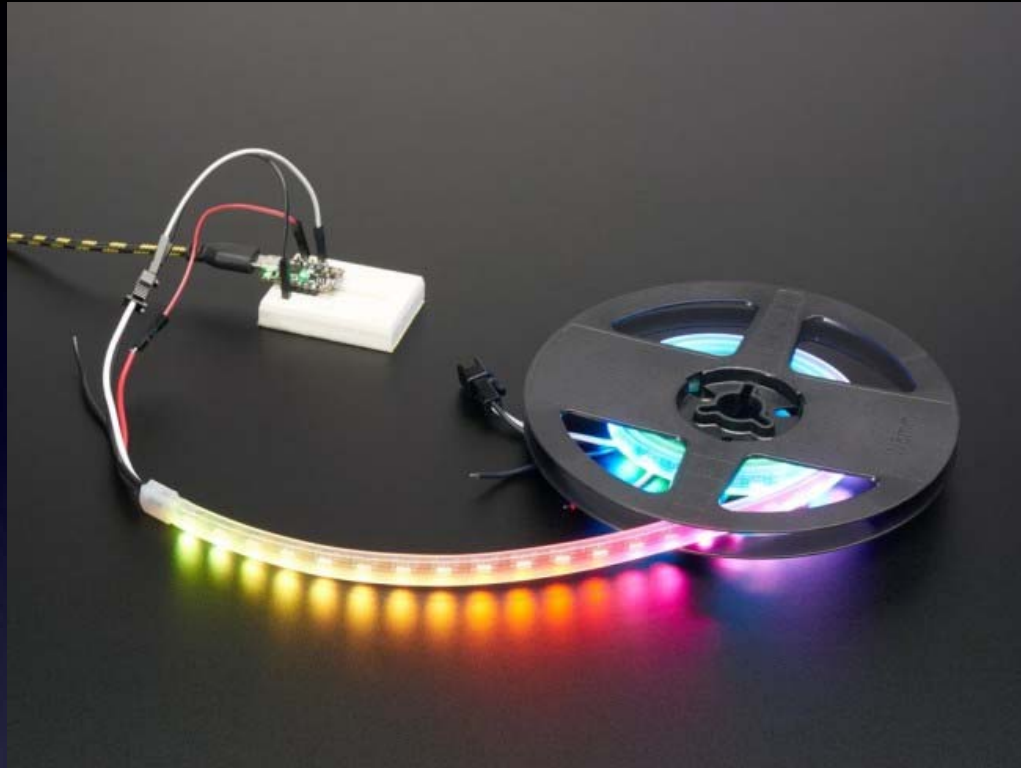


Download some Arduino “sketches”:

Search for: *“RGB LED Strip Sketches”*

Store them on your computer anywhere you like.

Let's Program Some LED Strips!

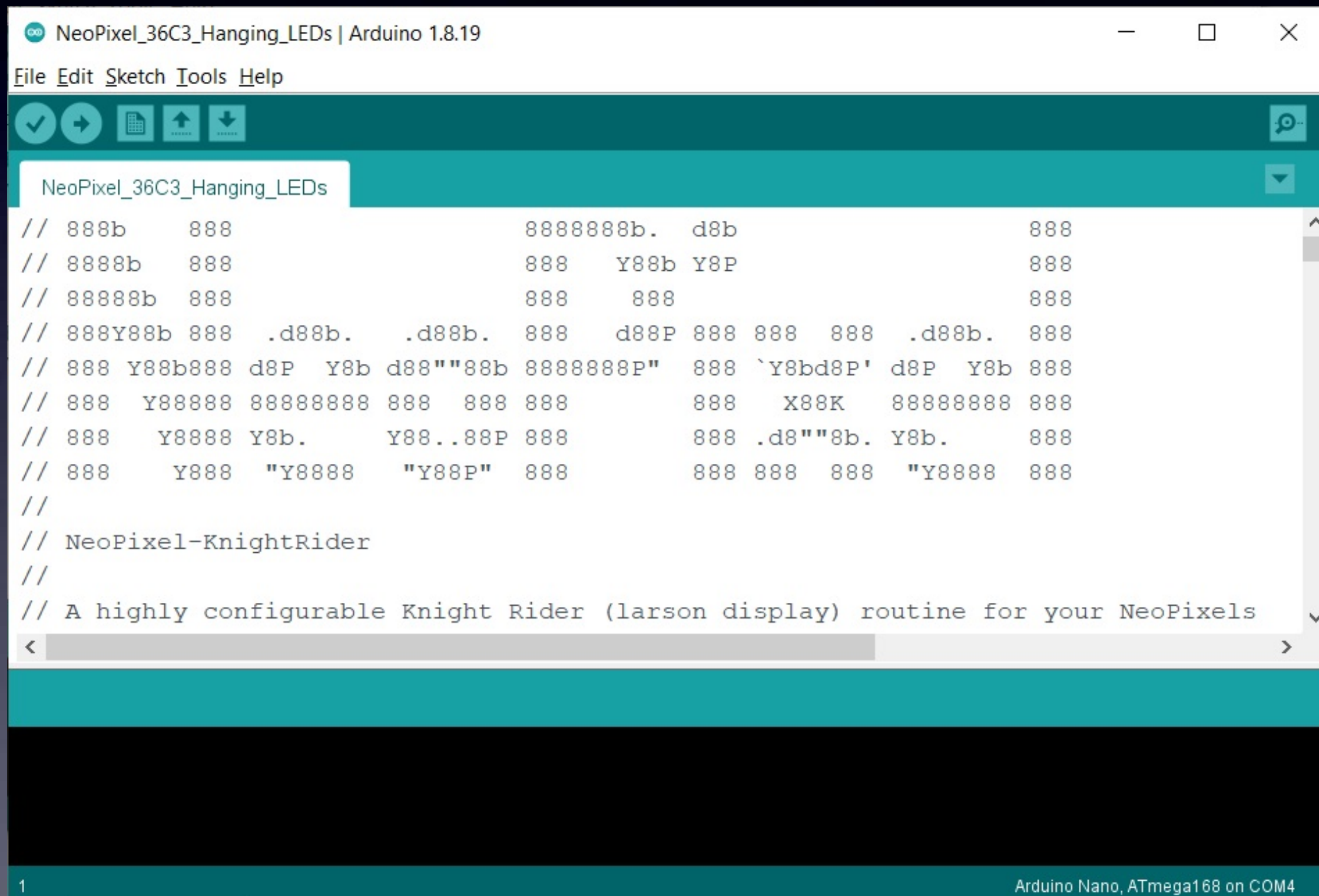


Download some Arduino “sketches”:

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

Let's Program Some LED Strips!

Open the “sketch” you want to program



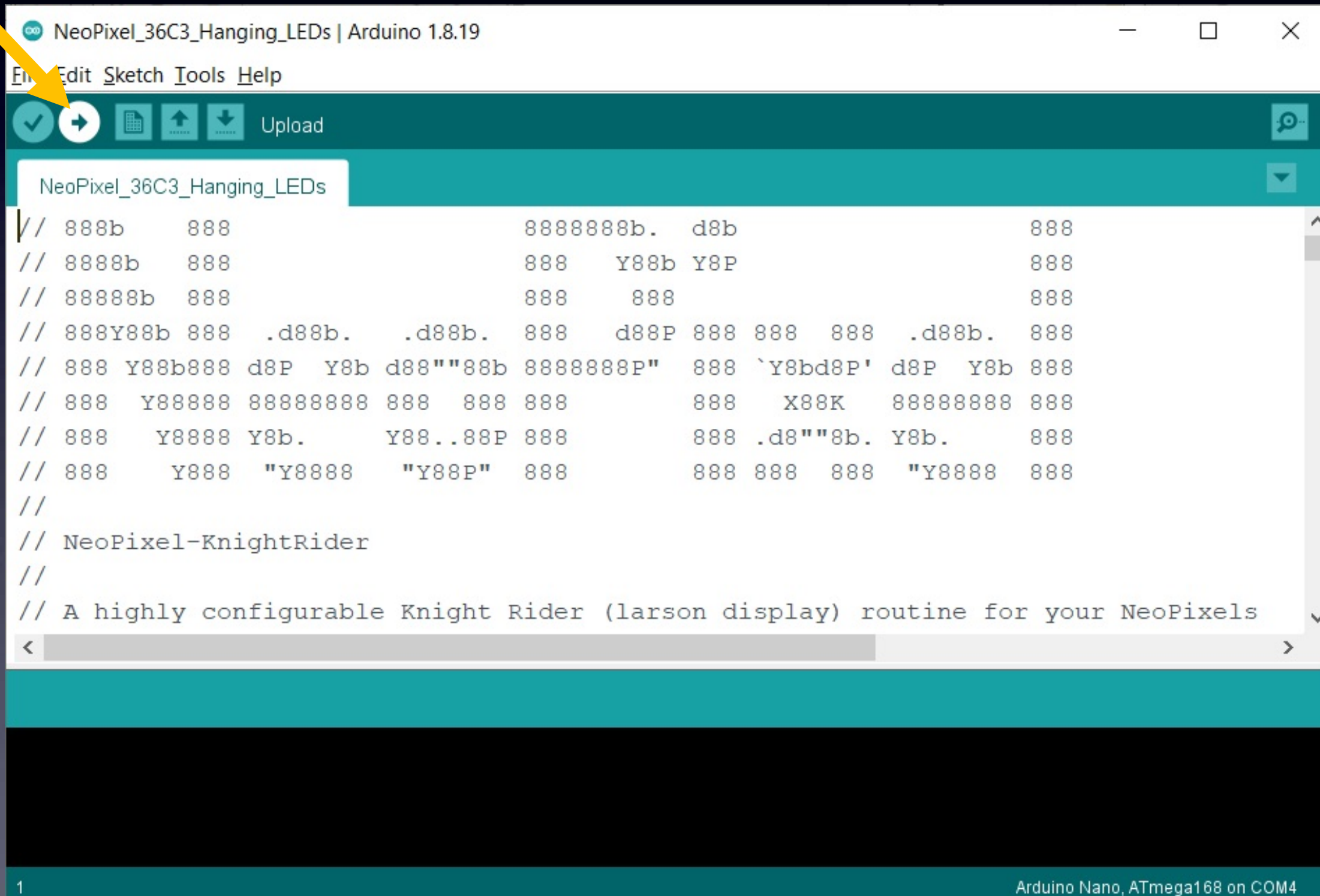
The screenshot shows the Arduino IDE interface. The title bar reads "NeoPixel_36C3_Hanging_LEDs | Arduino 1.8.19". The menu bar includes "File", "Edit", "Sketch", "Tools", and "Help". The toolbar contains icons for opening, saving, and running. The sketch editor displays the following code:

```
// 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.

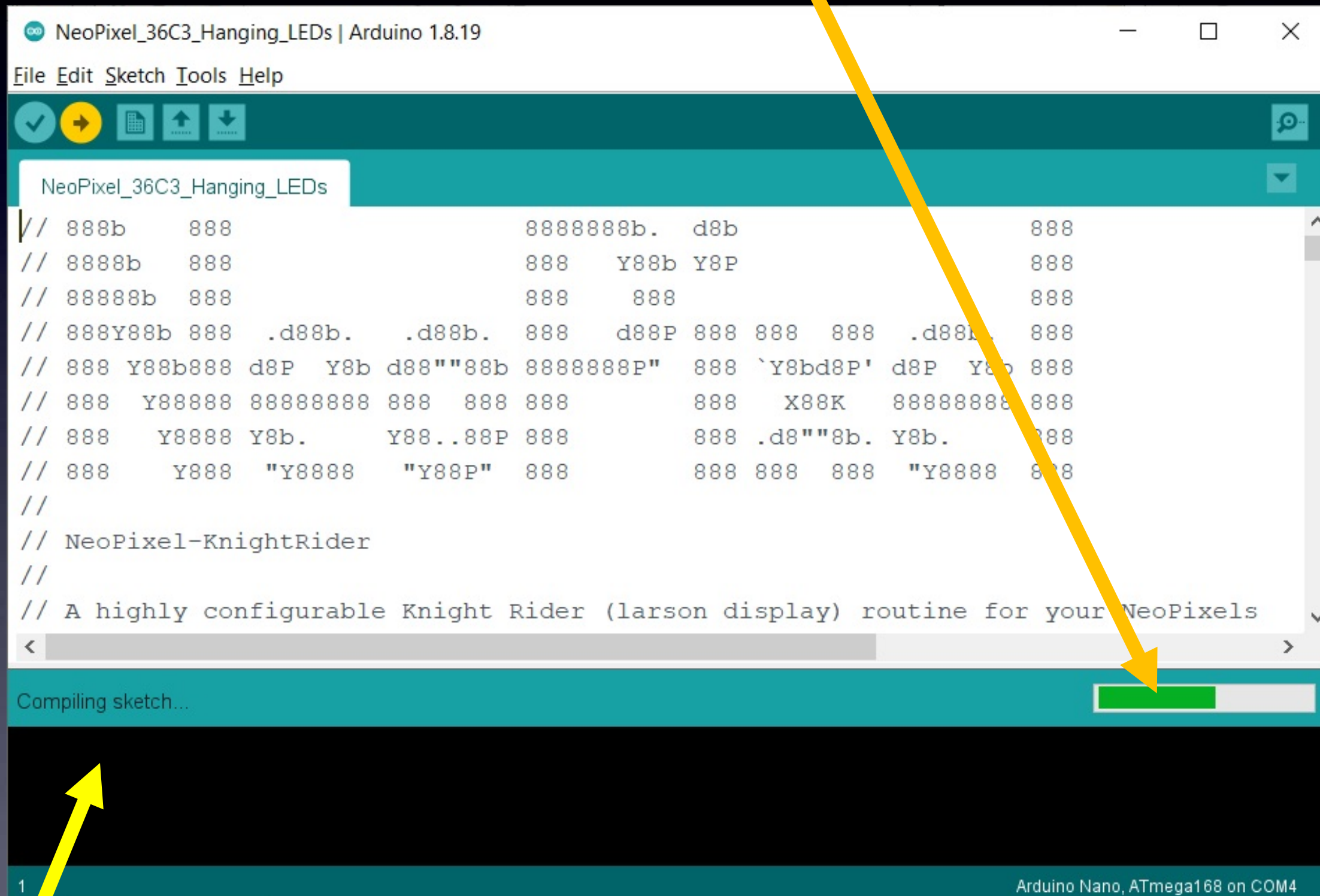
Let's Program Some LED Strips!

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...



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

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5M 30 IP30

1M 30 IP65

2M 30 IP65

3M 30 IP65

4M 30 IP65

5M 30 IP65

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5M 60 IP65

1M 60 IP67

2M 60 IP67

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1M 74 IP65

1M 74 IP67

1M 96 IP30

1M 96 IP65

1M 96 IP67

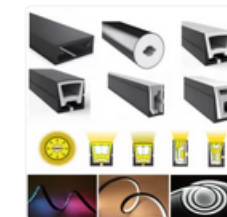
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1M 144 IP65

1M 144 IP67

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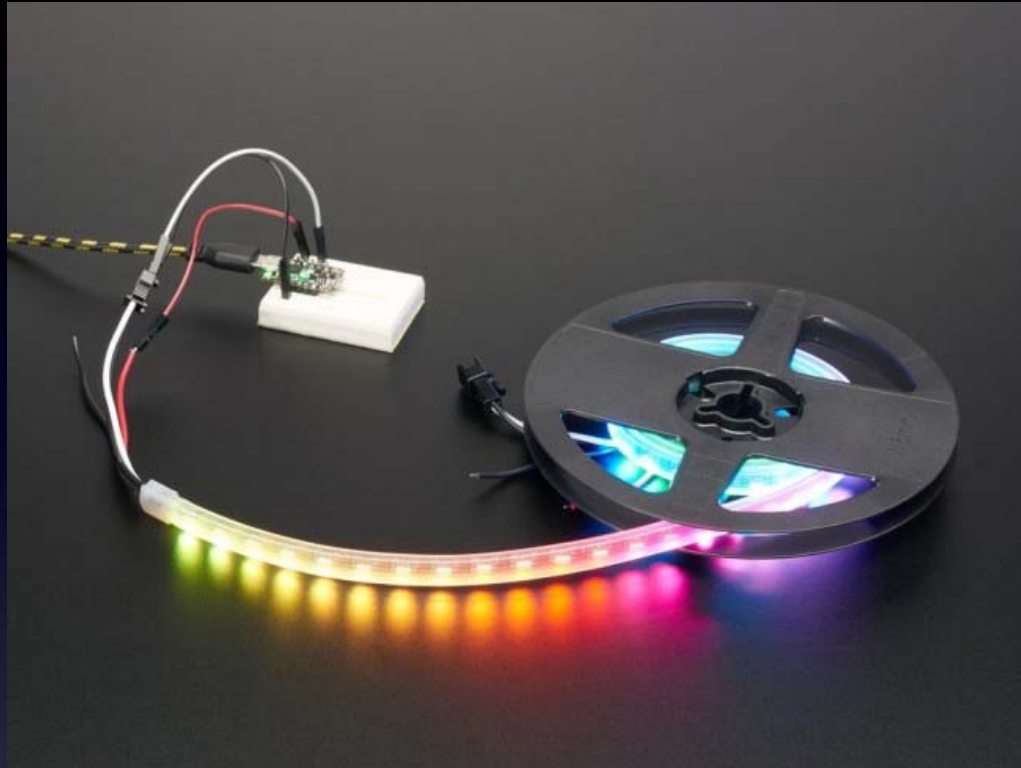
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LED Strips for Everyone Everywhere



These slides are also available at:

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

LED Strips for Everyone Everywhere

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** (1st and biggest hardware accelerator)

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

email: mitch@CornfieldElectronics.com

site: www.CornfieldElectronics.com

facebook: [maltman23](https://www.facebook.com/maltman23)

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