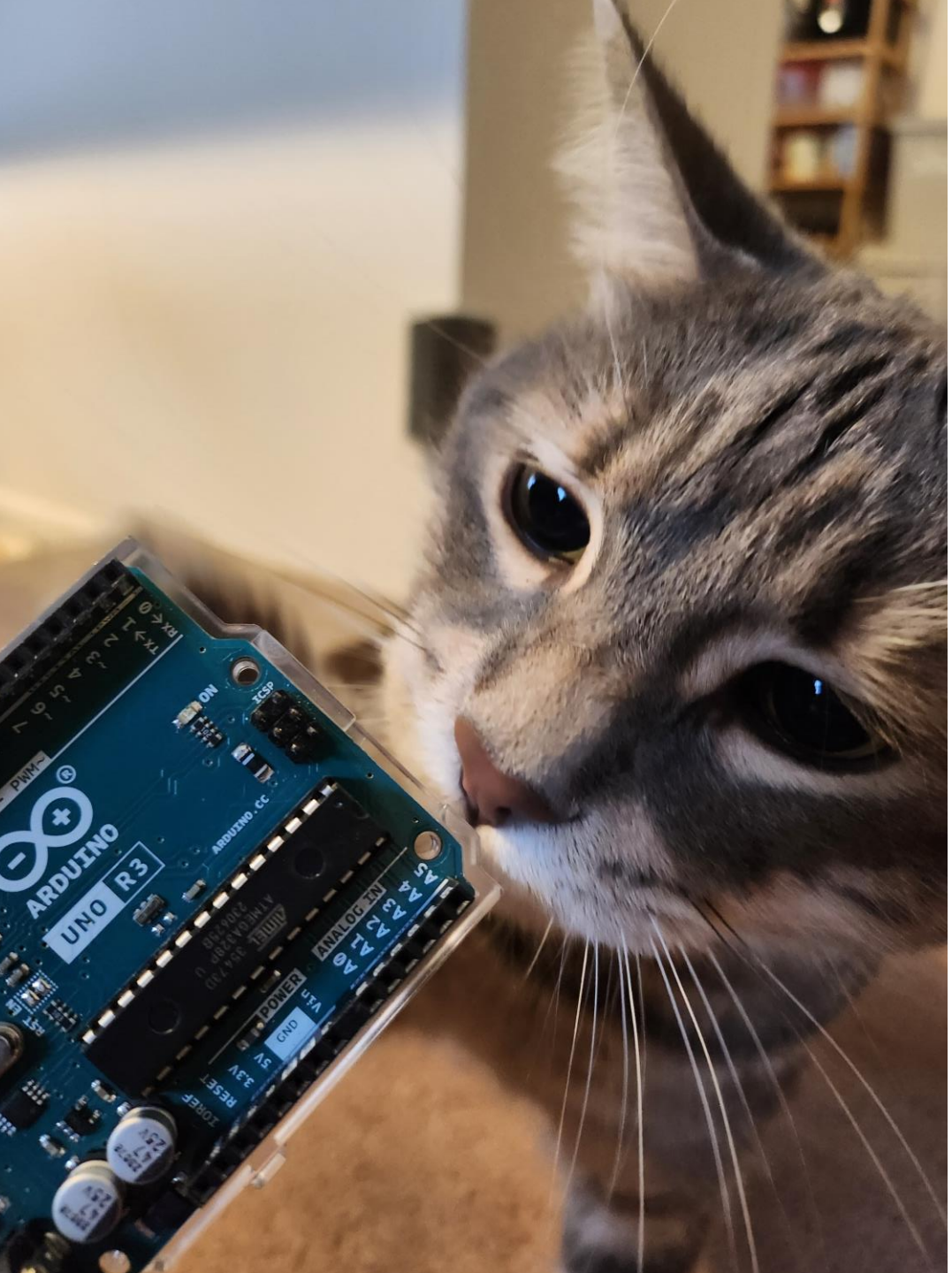


Arduino Programming Fundamentals

Week 4: Microcontroller Programming

Programming Basics

- Languages are made up of several fundamental elements like verbs, nouns, adjectives, etc.
- Programming languages are the same way, except with:
  - Data types
  - Variables
  - Basic operations
  - Conditional statements
  - Loops
  - Functions

Data types

- Tells of the type of data

Data Type	Example
Int	333
Float	0.003
Long	333333333333
Char	K
String	Hello, World!
Bool	TRUE, FALSE

Variables

- Names that you give the microcontroller to store values in
- Variables must be declared before they are used
- Variables can be reassigned many times, but only need to be declared once
- Variables should have names that describe their content
- You need to declare the data type before the variable name

2 yr

6 yr

20 yr

Int CAT = 2

Int DOG = 6

Int CRAB = 20

String CAT_SOUND = “MEOW”

String DOG_SOUND = “WOOF”

Basic Operations

- Operations tells the microcontroller to perform some mathematical, relational, or logical operation
- Arithmetic Operators

Operator	Meaning
+	Addition
-	Subtraction
*	Multiplication
/	Division
%	Modulus (Remainder of Division)
++	[plus] +1 (ex: x = 1; x++; now x=2)
--	[minus] -1 (ex: x = 1; x--; now x=0)
+=	Increment by some # (x+=5 → x=x+5)
-=	Decrement by some # (x-=5 → x=x-5)

Basic Operations

- Relational Operators (useful for conditional statements!)

Operator	Meaning
==	Is equals to
!=	Is not equals to
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to

= (1 equals sign) is an assignment operator. It assigns values to variables

Basic Operations

- Logical Operators (useful for conditional statements!)

Operator	Meaning
&&	AND
||	OR
!	NOT

  - Helps make decisions.

Conditional Statements

- Let you take actions based on if a condition is met or not
- You can also have nested conditional statements
- Pseudo code example:

```
if (button == ON)
        turn LED on
else
        turn LED off
```

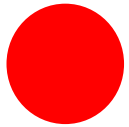
Else is all the other conditions that aren't mentioned. In this case it is button == OFF

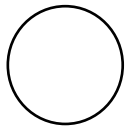
Conditional Statements

- You can have multiple ‘if’ checking statements, with else if!

Pseudocode example:

```
if (button1 == ON)
        make led red
else if (button2 == ON)
        make led blue
else
        turn led off
```



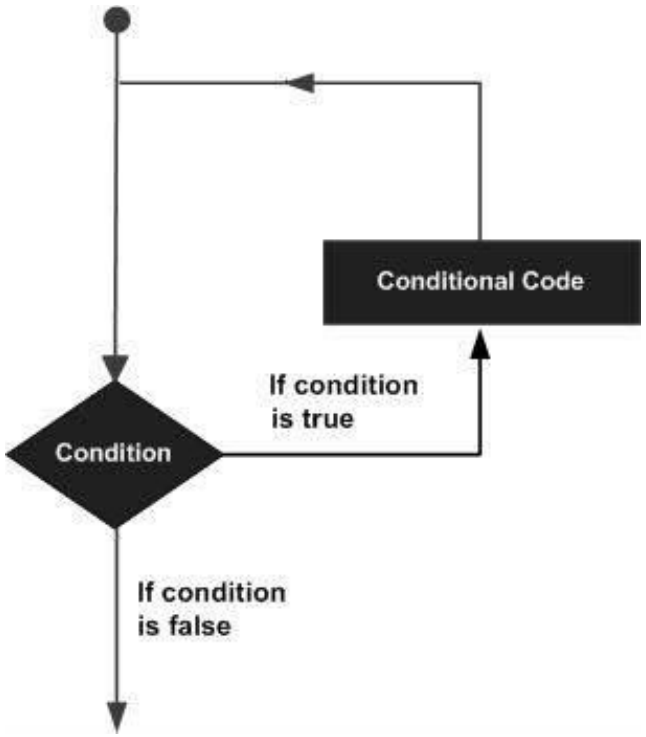


Loops

- Loops are useful for executing lines of code multiple times
- Say I want to add the number 1-9 to 10.
- Hard coding it:
  - 10+1
  - 10+2
  - 10+3
  - … boring
- With a loop

```
For number = 1 thru 9
    10 + number
```

For loop




```
for (int x=1; x<10 ;x++){
  Serial.println(x);
}
```

OUTPUT

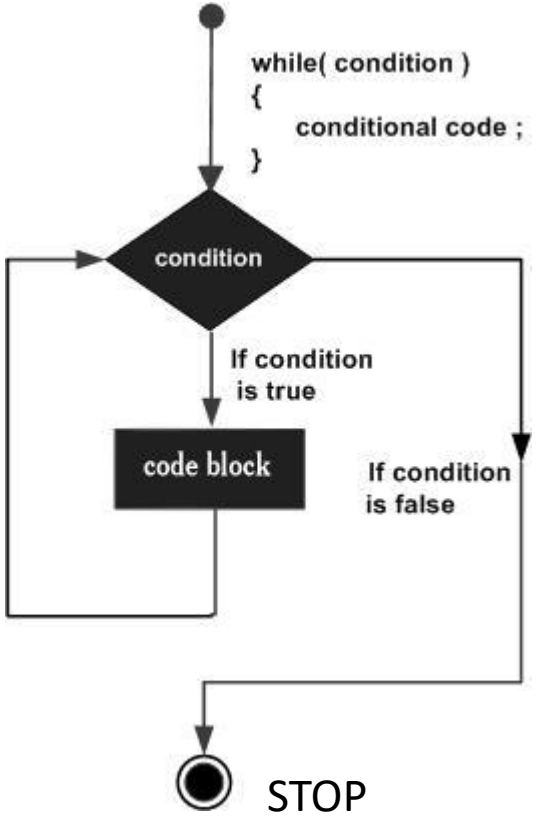
```
1
2
3
4
5
6
7
8
9
```

For (my iterative variable; my condition; go to the next case) {

DO SOMETHING

}

While loop




```
int x = 0;
while(x<5){
  Serial.println("RED PANDAS ARE THE BEST");
  x++;
}
```

While (condition){

DO THIS UNTIL THE CONDITION IS NO LONGER TRUE

}

OUTPUT

```
RED PANDAS ARE THE BEST
RED PANDAS ARE THE BEST
RED PANDAS ARE THE BEST
RED PANDAS ARE THE BEST
RED PANDAS ARE THE BEST
```

Functions

- A block of reusable code
- Allows for non-redundant code

```
1  int slope = 2;
2  int time = 3;
3  int intercept = 1;
4  int value;
5
6  void setup() {
7    // put your setup code here, to run once:
8    Serial.begin(9600);
9    value = slopeCalc(slope,time,intercept);
10   Serial.println(value);
11 }
12
13 void loop() {
14   // put your main code here, to run repeatedly:
15 }
16
17 int slopeCalc(int m,int x, int b){
18   int y;
19   y = m*x + b;
20   return y;
21 }
```

ARDUINO™

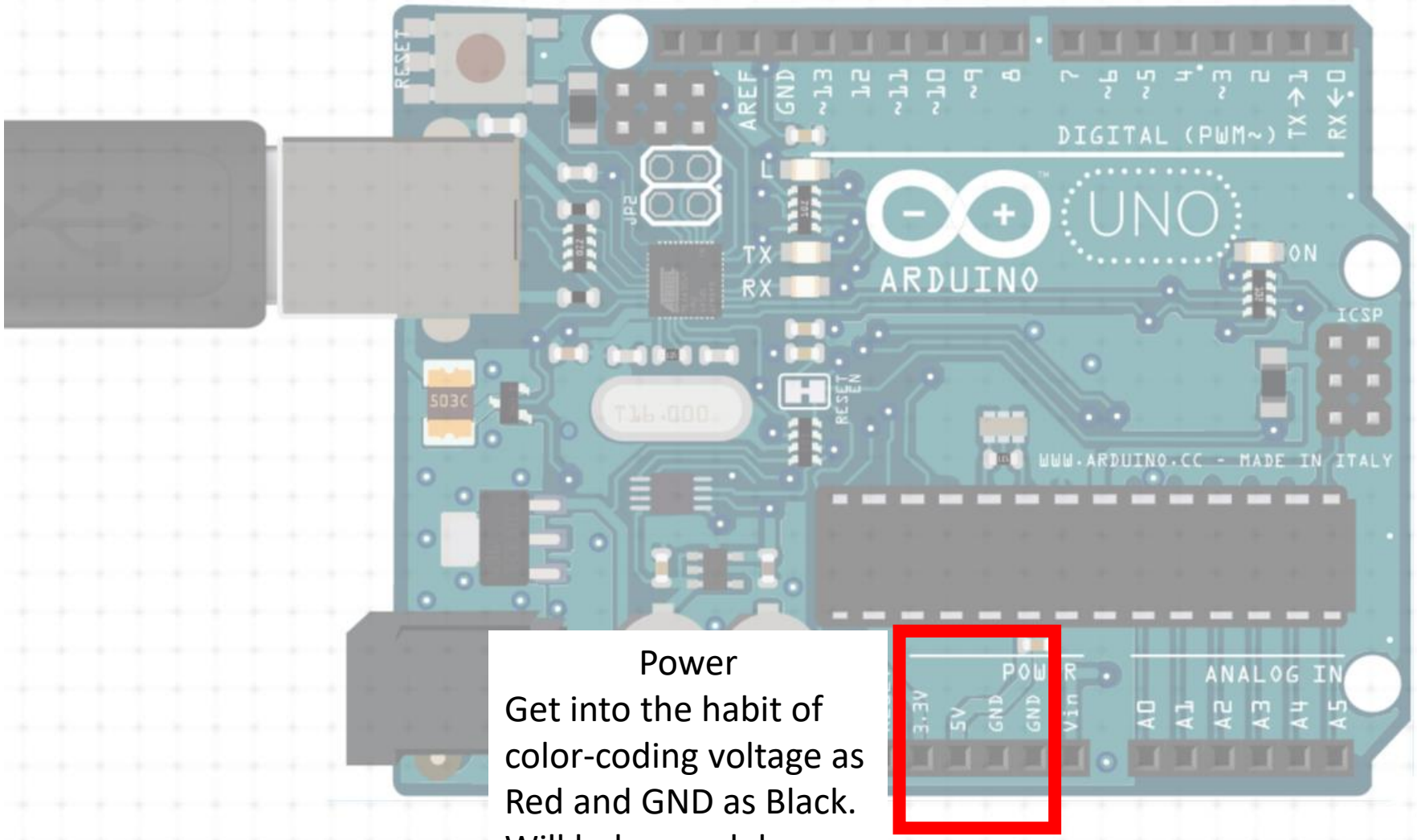
What is Arduino?

Open source platform of hardware and software

Arduino UNO → accessible microcontroller

Microcontroller → like a mini-computer that can take inputs, perform outputs, store a bit of data

Uses a modified version of C/C++

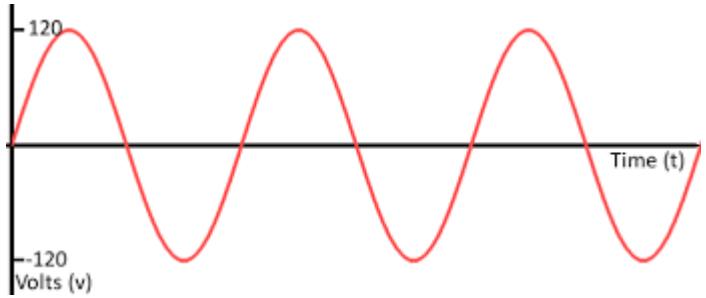


Power

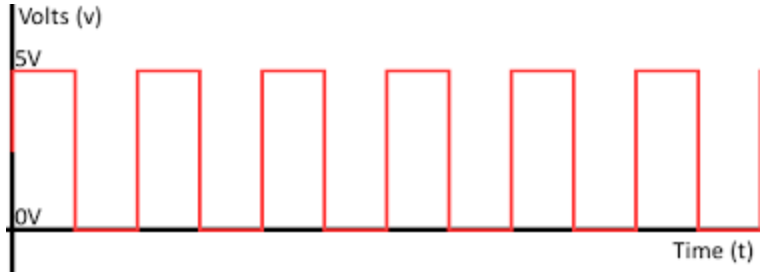
Get into the habit of color-coding voltage as Red and GND as Black. Will help you debug circuits.

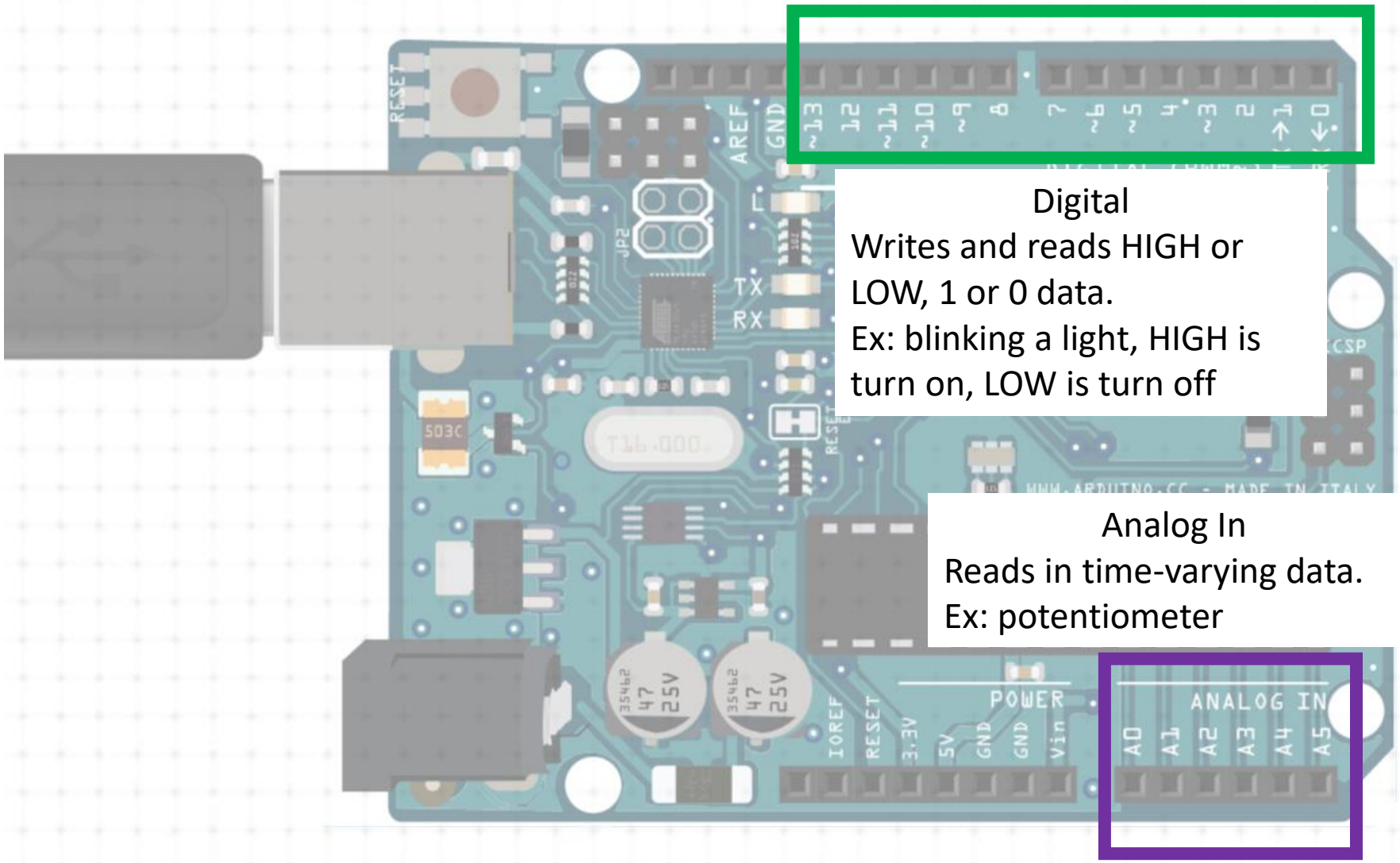
Analog vs. Digital Signals

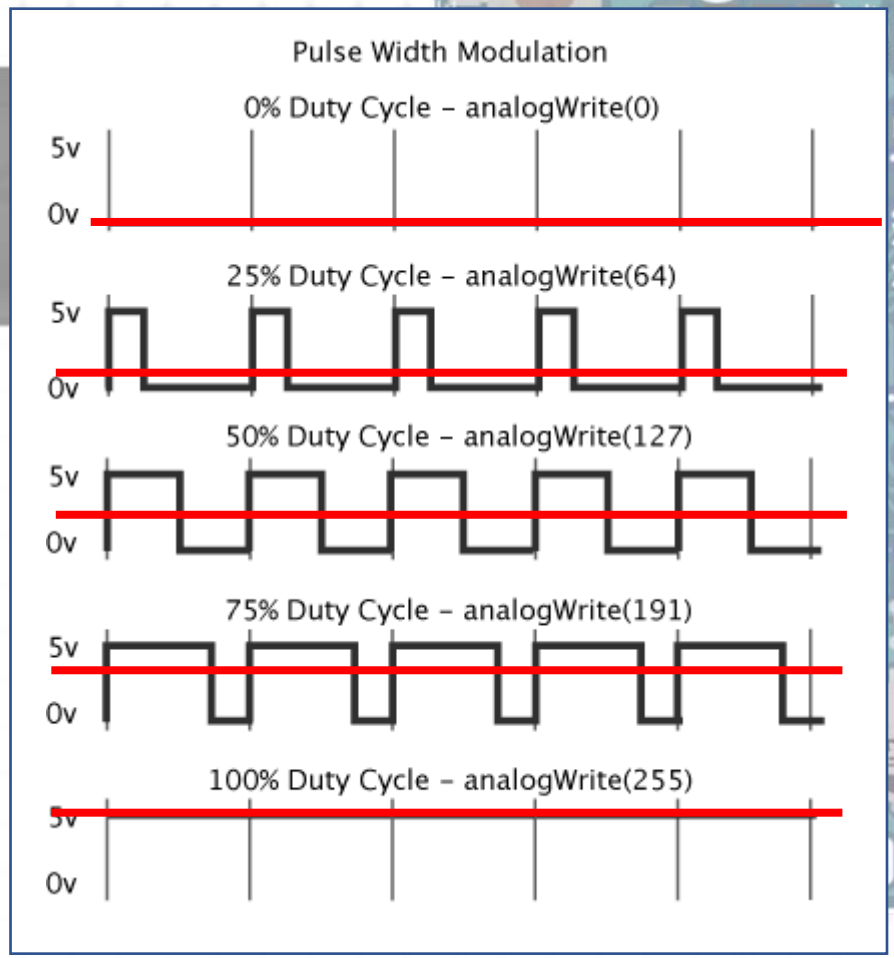
- Analog → data that continuously and infinitely varies over time
- Ex: radio waves, sound waves.



- Digital → data that has discrete values, can only take one value from a finite set of possible values at a given time
- Ex: Binary signal




Digital
Writes and reads HIGH or LOW, 1 or 0 data.
Ex: blinking a light, HIGH is turn on, LOW is turn off
Analog In
Reads in time-varying data.
Ex: potentiometer
RESET
AREF
GND
~13 12 ~11 ~10 ~9 8 7 ~6 ~5 4 ~3 2 1 0
JP2
TX
RX
POWER
IOREF
RESET
3.3V
5V
GND
GND
Vin
ANALOG IN
A0 A1 A2 A3 A4 A5



Squiggly Lines

PWM, Pulse Width Modulation

Technique to get analog results from digital signal

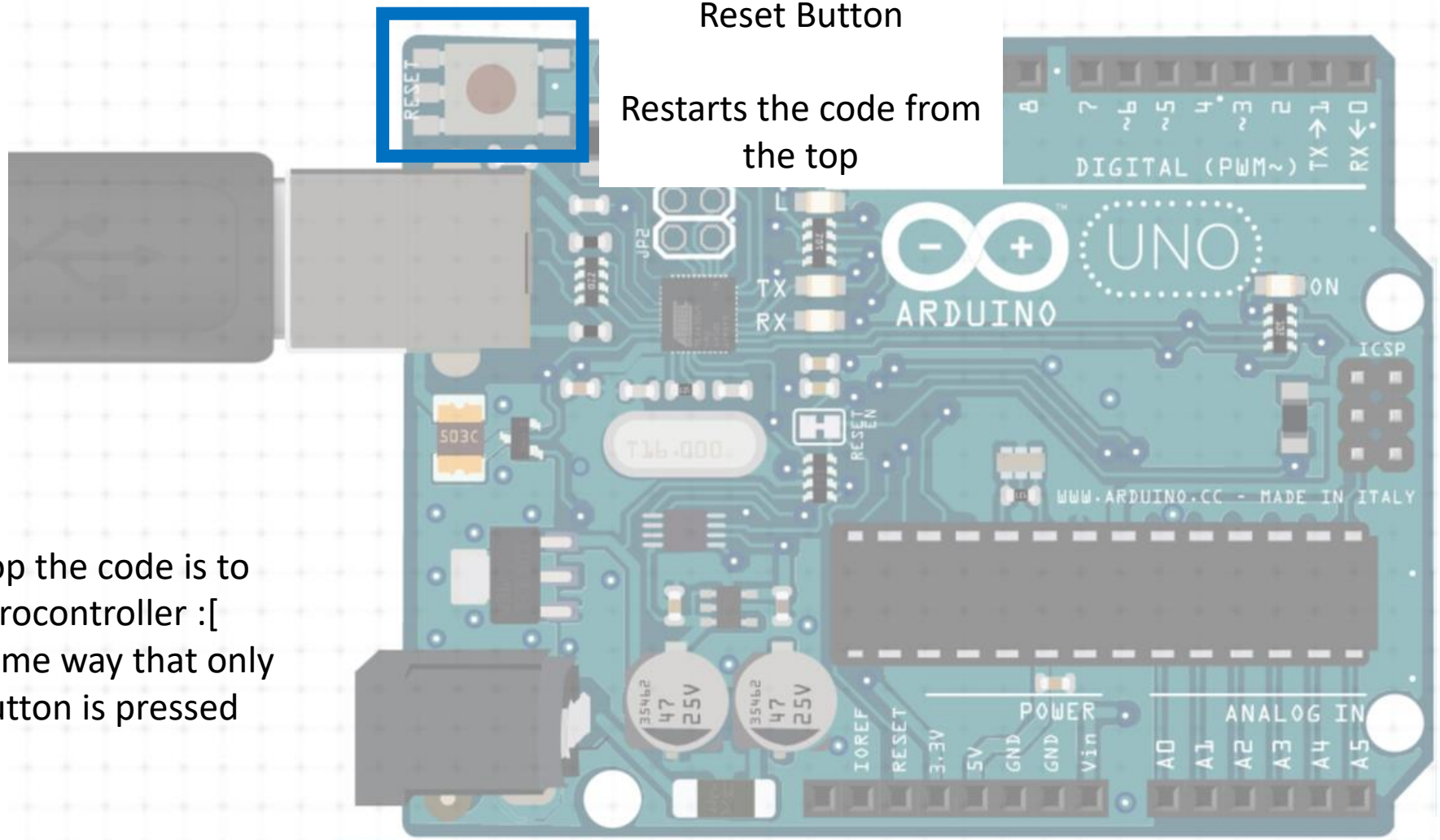
By manipulating the time the signal spends in HIGH an LOW

Examples of use:

- Dimming a LED
- Variable speed control

Reset Button

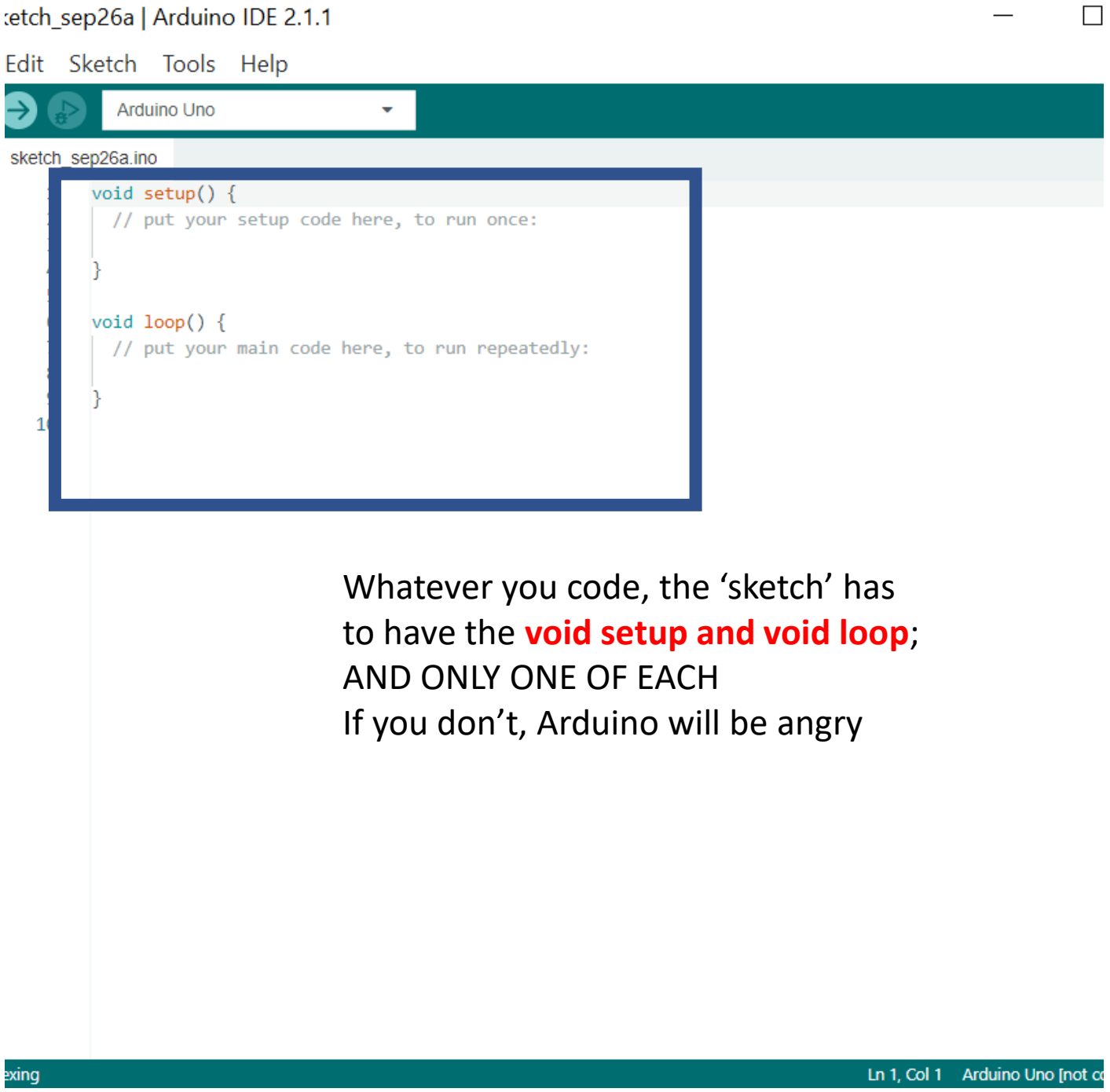
Restarts the code from the top



Only way to stop the code is to unplug the microcontroller :[
Or code it in some way that only runs when a button is pressed

Arduino IDE

Environment where you write your code, upload code, and monitor outputs and inputs with a Serial Monitor



Whatever you code, the ‘sketch’ has to have the **void setup and void loop**; AND ONLY ONE OF EACH
If you don’t, Arduino will be angry

Usual Code Structure

Initialize libraries and variables

What's a library?
Software designed to add functionality to your programs

Code that only gets run once. Start the serial monitor, declare pins, etc.

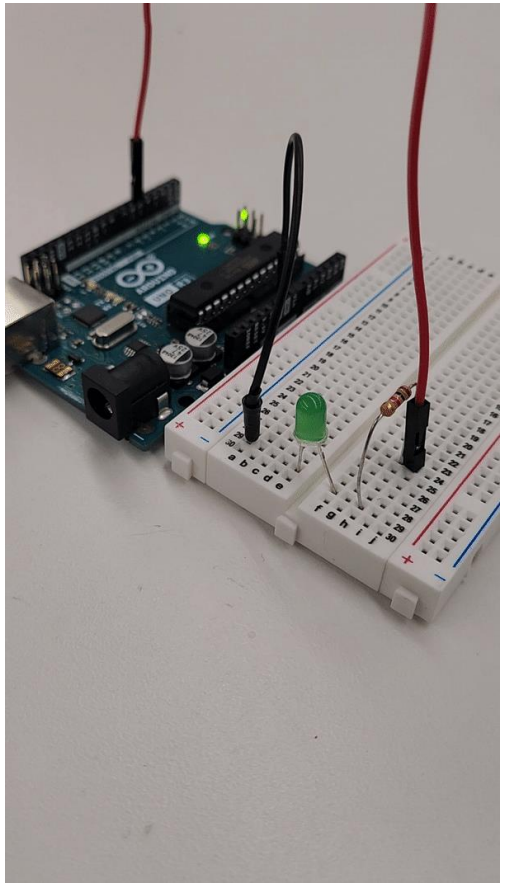
Code that you want to run over and over. Reading input sensors, outputting actions, etc.

```
1   #include library
2
3   int value;
4   int buttonPin = 3;
5   String message = "Hello World";
6
7   void setup() {
8     // put your setup code here, to run once:
9     Serial.begin(9600);
10    pinMode(buttonPin, INPUT);
11    Serial.println(message);
12  }
13
14  void loop() {
15    // put your main code here, to run repeatedly:
16    value = digitalRead(buttonPin);
17    Serial.println(value);
18  }
```

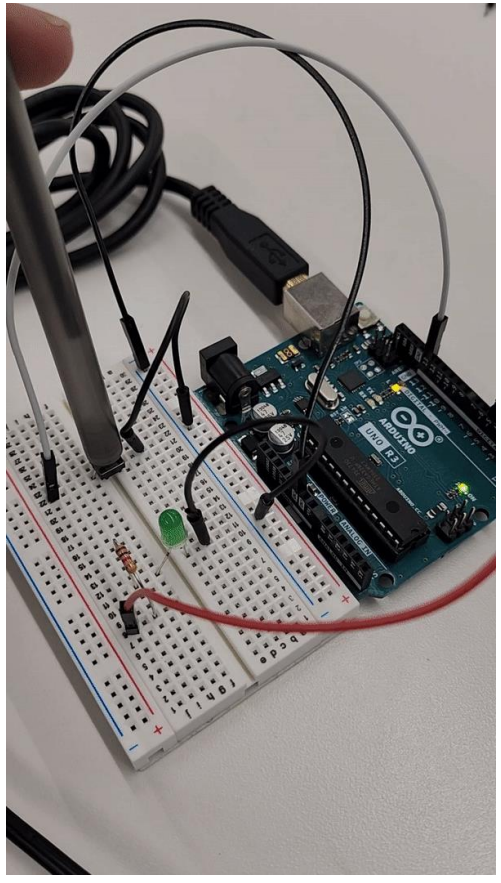
LET’S CODE

Coding Examples

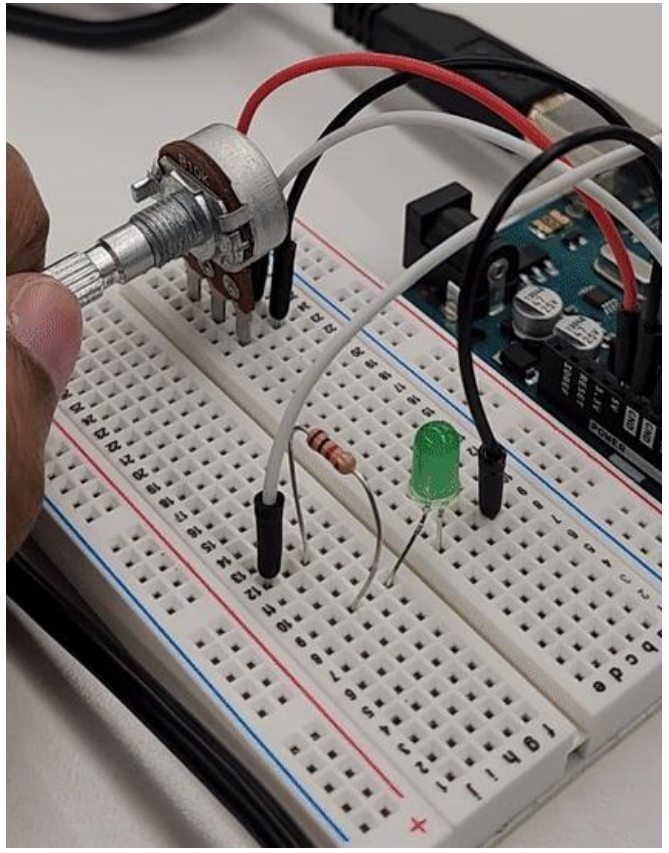
Blinking LED



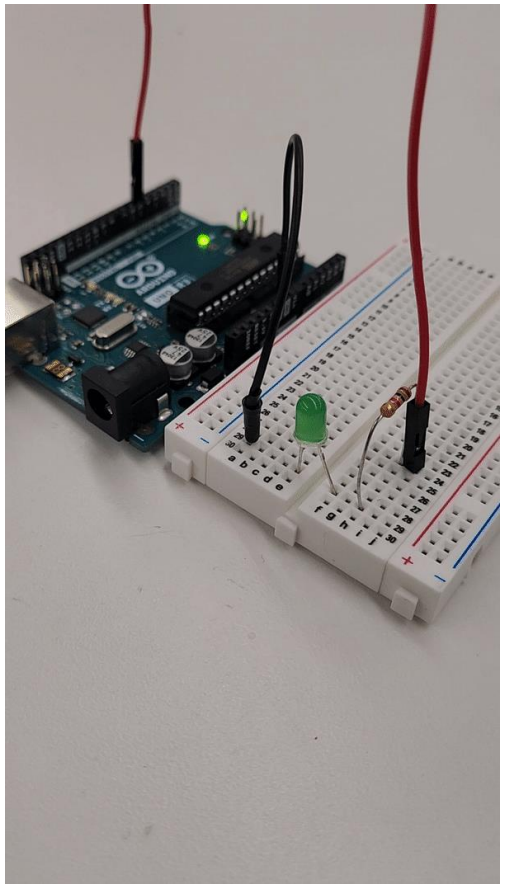
Button Control

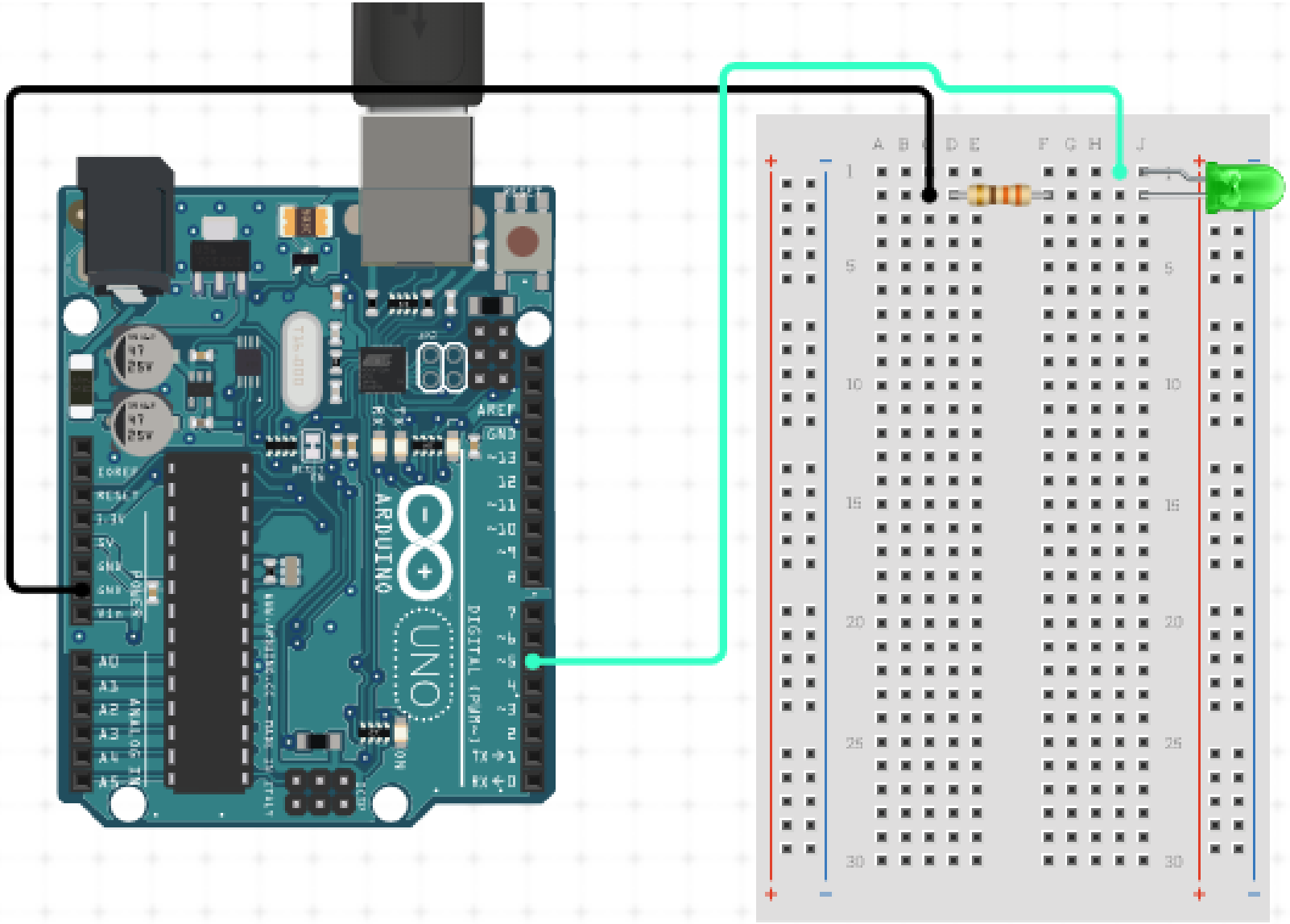


Potentiometer Control



Blinking LED





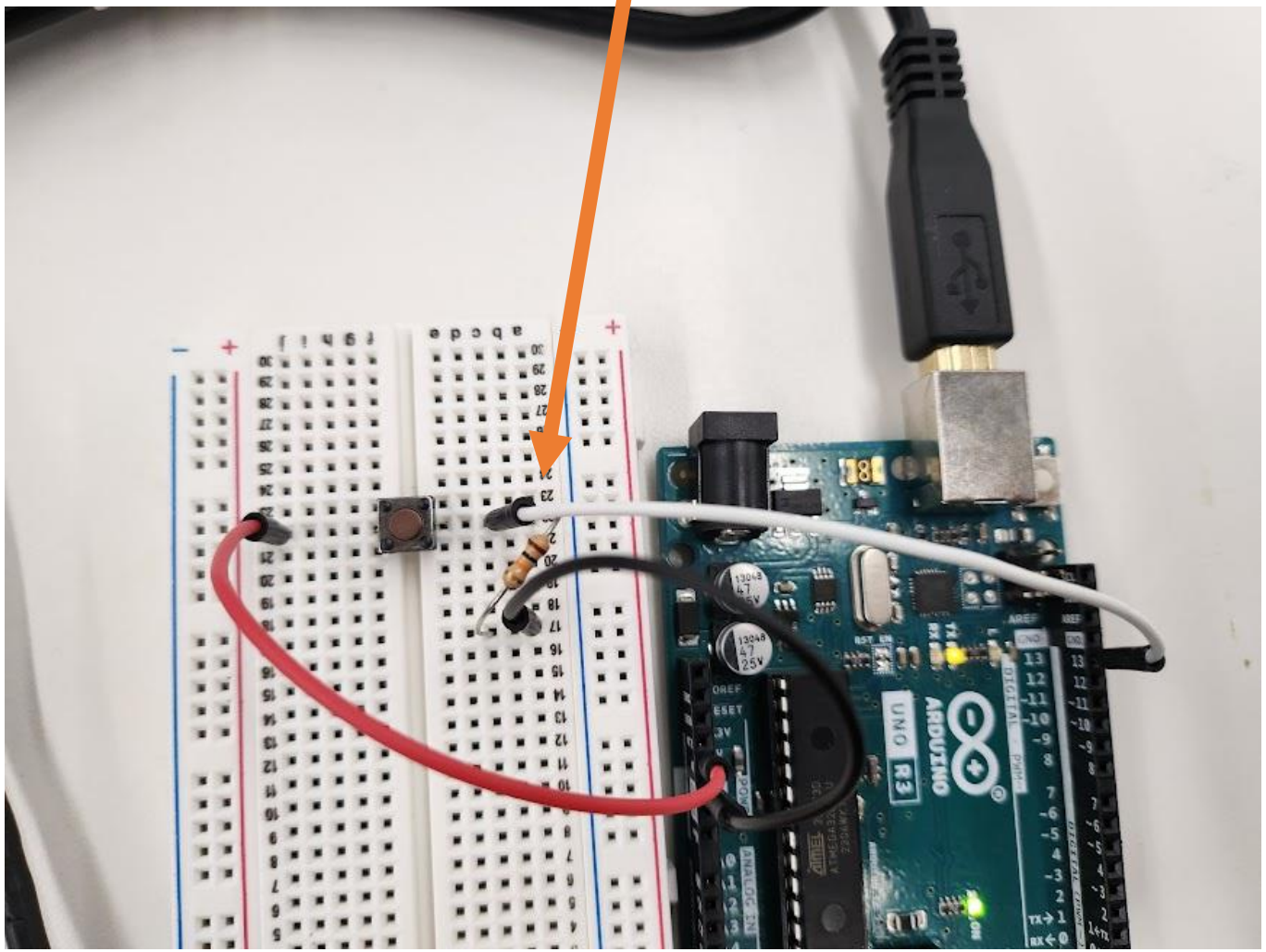
Code Blinking LED

```
int ledPin = 5;
int onTime = 500; //milliseconds
int offTime = 100; //milliseconds

void setup() {
  // put your setup code here, to run once:
  pinMode(ledPin, OUTPUT);

}

void loop() {
  // put your main code here, to run repeatedly:
  digitalWrite(ledPin, HIGH); //turn on
  delay(onTime);
  digitalWrite(ledPin, LOW); //turn off
  delay(offTime);
}
```

Buttons/Switches

PULL_UP Resistor vs PULL_DOWN Resistor

Note that the resistor is on the GND side



Let’s first make a pull-down resistor

When the button is NOT pressed, the value that the pin reads is LOW

The 10kOhm resistor is in between the reading pin and GND

Let’s code!

Code Button

```
int buttonPin = 13;
int val;

void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  pinMode(buttonPin, INPUT);

}

void loop() {
  // put your main code here, to run repeatedly:
  val = digitalRead(buttonPin);
  Serial.println(val);
}
```

Button/Switches

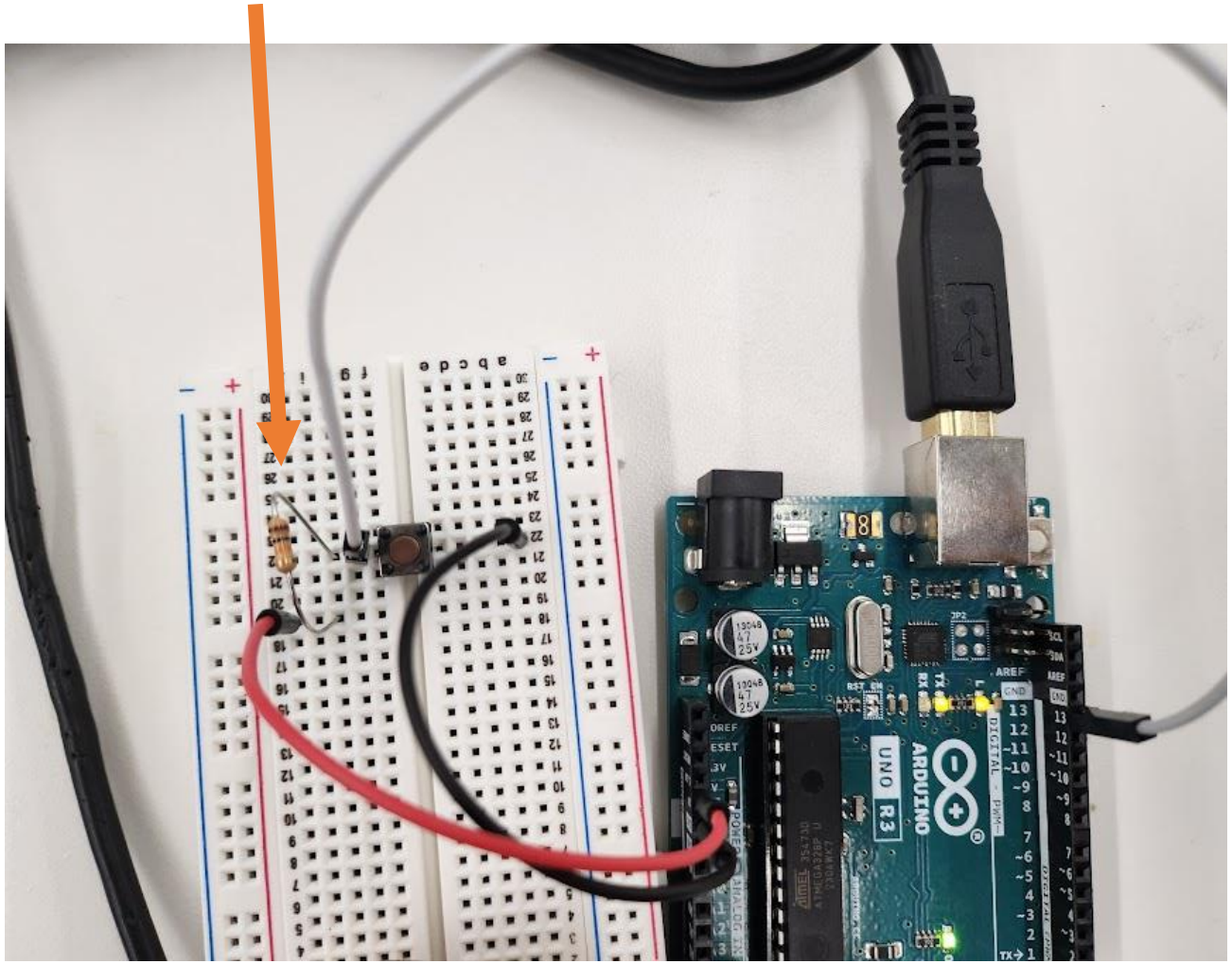
Now make a pull-up resistor

When the button is NOT pressed, the value that the pin reads is HIGH

The 10kOhm resistor is in between the reading pin and POWER (5V/3.3V)

Notice no need to change the code

Note that the resistor is on the Power side

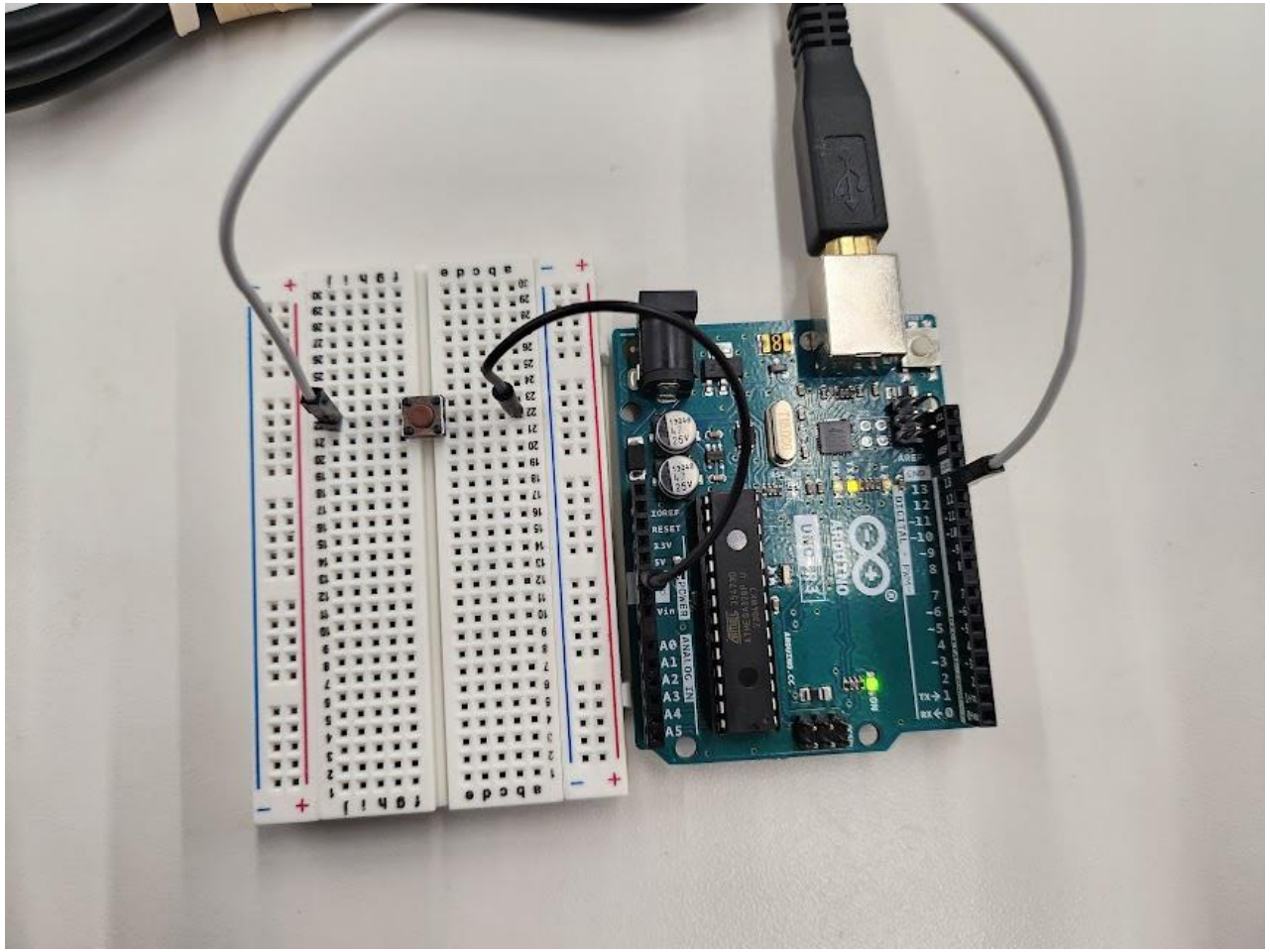


Button/Switches

Arduino pins have an internal pull-up resistor.

```
pinMode(buttonPin,INPUT_PULLUP);
```

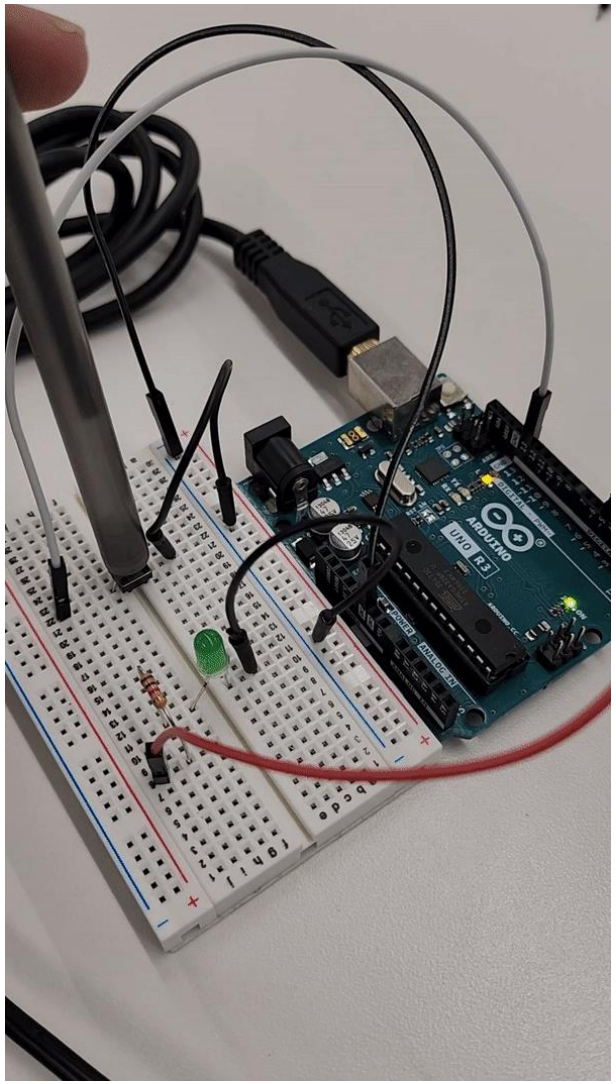
So, we can make a button circuit without the physical resistor!

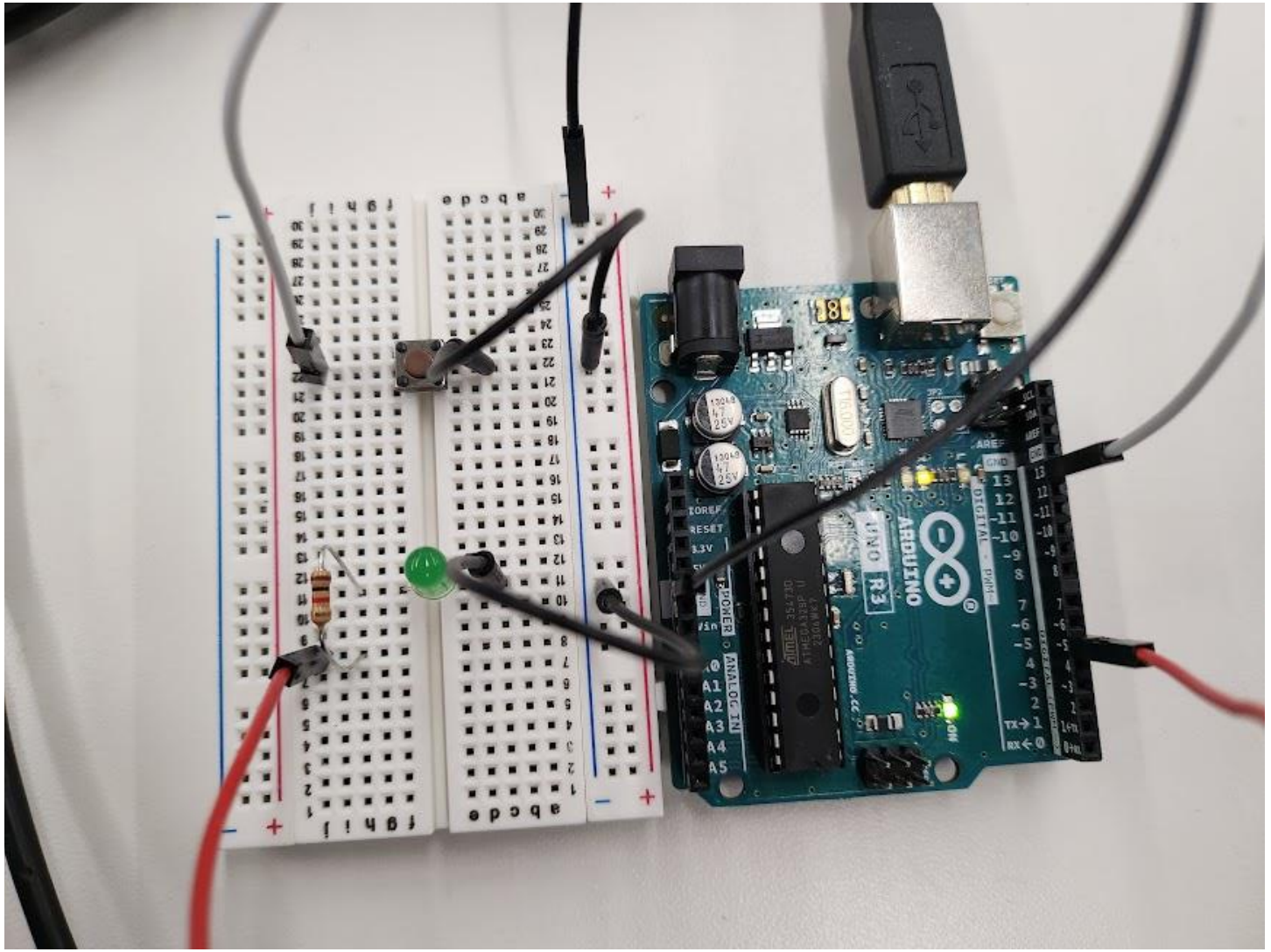


Code
Button
Input Pullup

```
int buttonPin = 13;
int val;

void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  pinMode(buttonPin, INPUT_PULLUP);

}

void loop() {
  // put your main code here, to run repeatedly:
  val = digitalRead(buttonPin);
  Serial.println(val);
}
```

Button Control LED



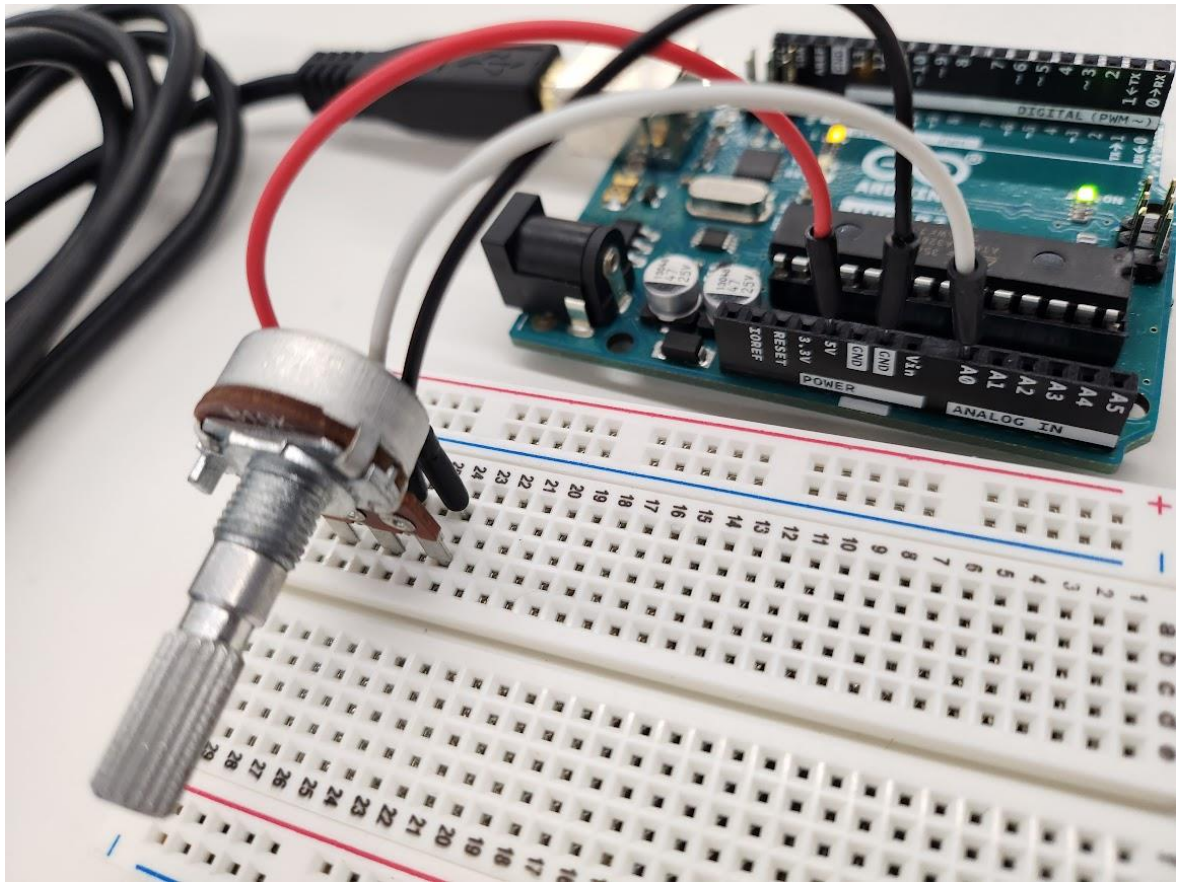


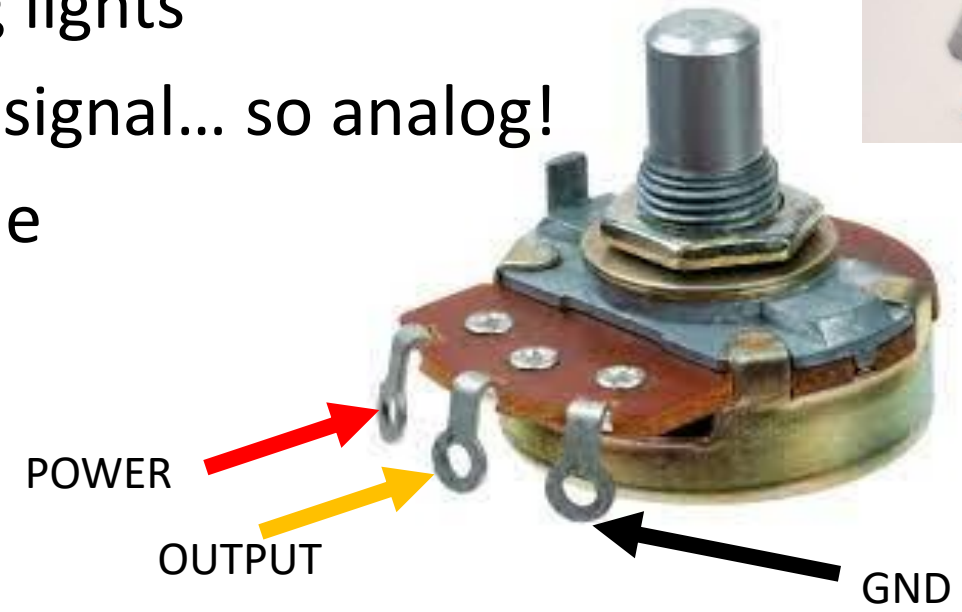
Code
Button Control LED

```
int ledPin = 5;
int buttonPin = 13;
int val;

void setup() {
  // put your setup code here, to run once:
  pinMode(ledPin, OUTPUT);
  pinMode(buttonPin, INPUT_PULLUP);

}

void loop() {
  // put your main code here, to run repeatedly:
  val = digitalRead(buttonPin);
  if(val == LOW){
    digitalWrite(ledPin, HIGH);
  }
  else{
    digitalWrite(ledPin, LOW);
  }

}
```

Potentiometer

- A variable resistor. By turning the knob you vary the resistance which in turn varies the amount of voltage allowed through.
- Can be useful for speed control, dimming lights
- Variable signal… so analog!
- Let’s code

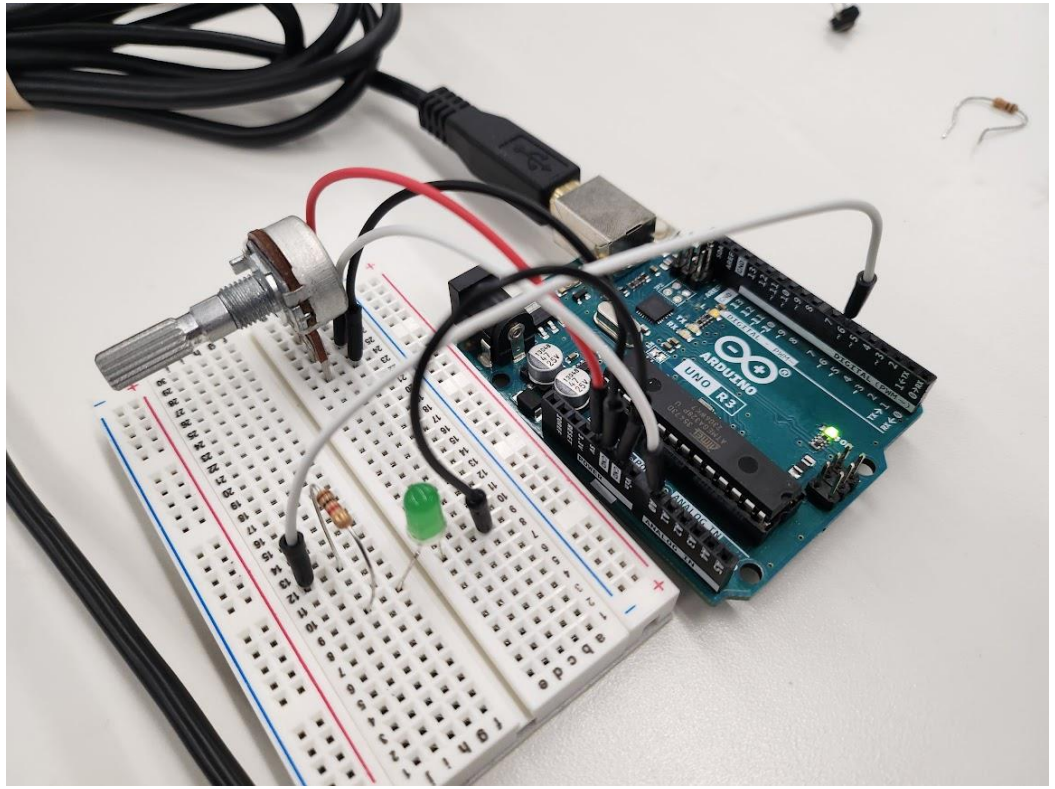


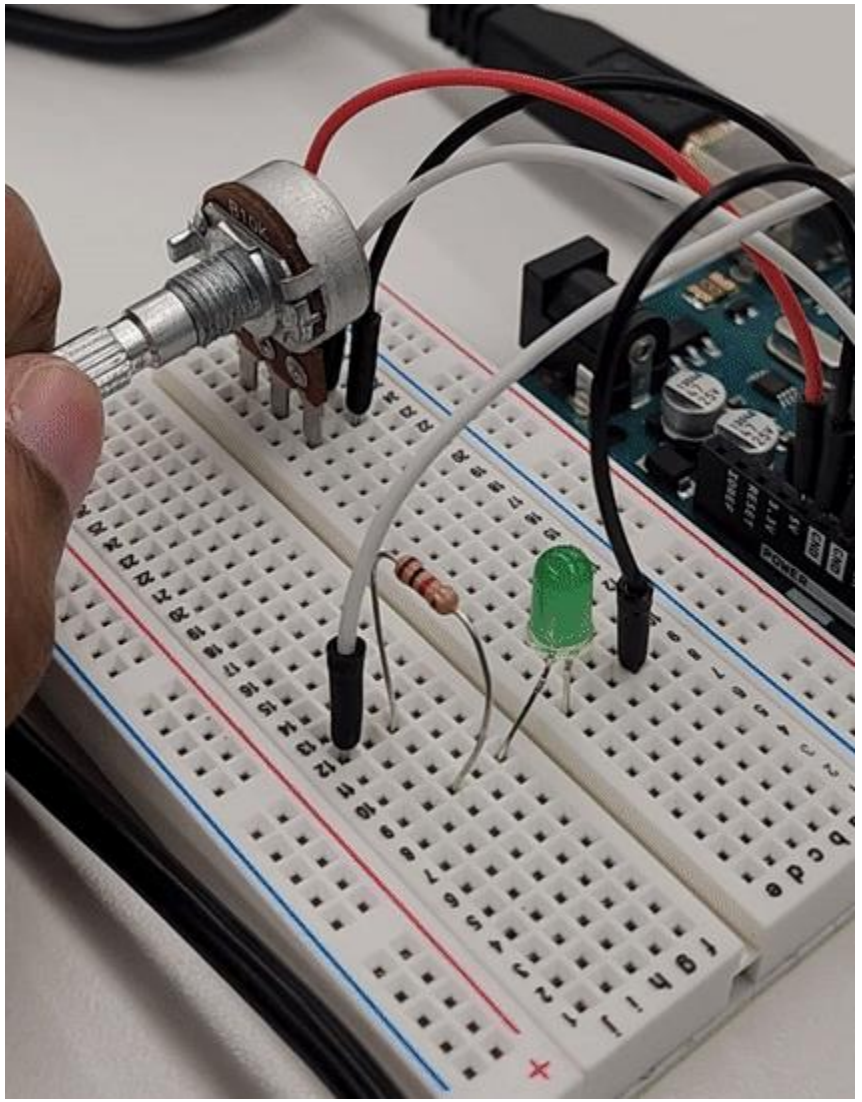


Code Potentiometer

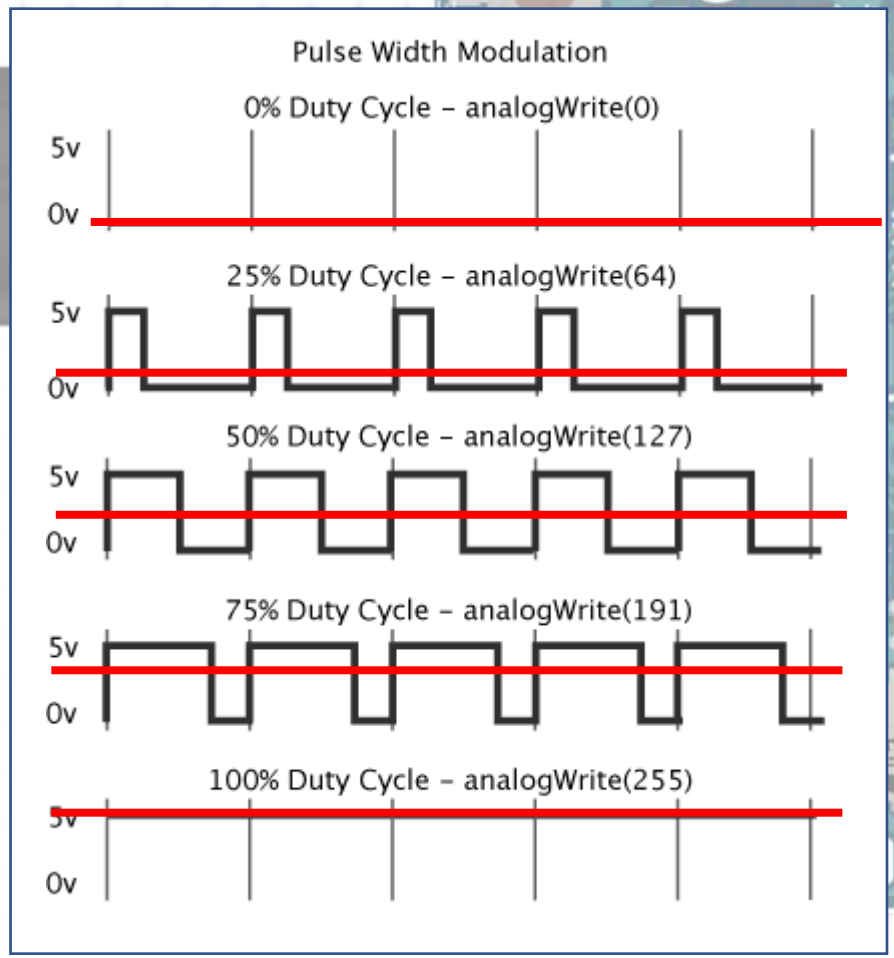
```
int potPin = A0;
int potVal;

void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  pinMode(potPin, INPUT);}

void loop() {
  // put your main code here, to run repeatedly:
  potVal = analogRead(potPin);
  Serial.println(potVal);
}
```

Potentiometer Control LED





Remember PWM signals?



Squiggly Lines

PWM, Pulse Width Modulation

Technique to get analog results from digital signal

By manipulating the time the signal spends in HIGH an LOW

Examples of use:

- Dimming a LED
- Variable speed control

Mapping Values

Arduino has an analogRead range from 0 to 1023, and an analogWrite range only from 0 to 255

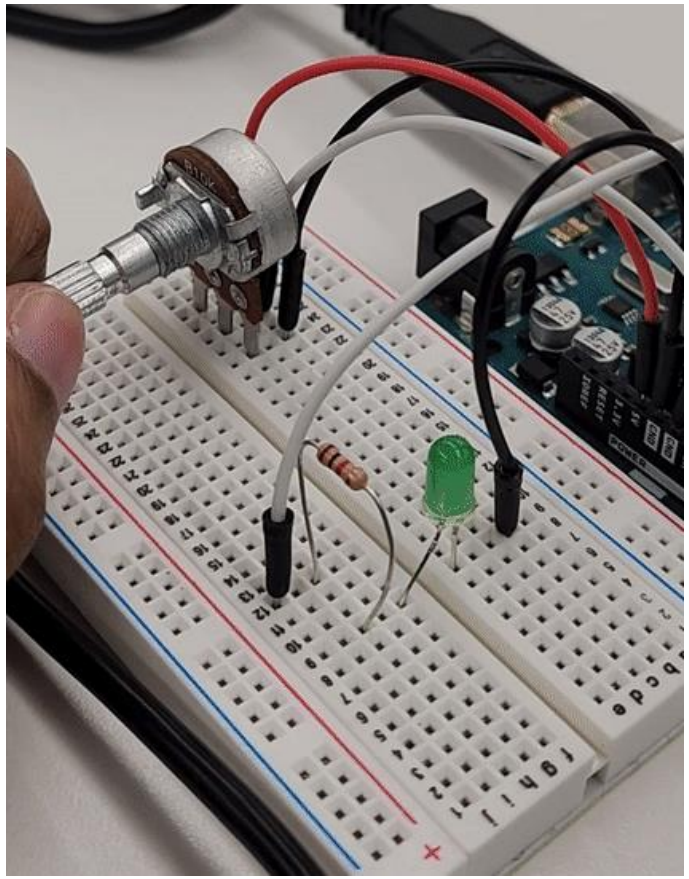
Potentiometer has range of 0 to 1023

LED has range of 0 to 255

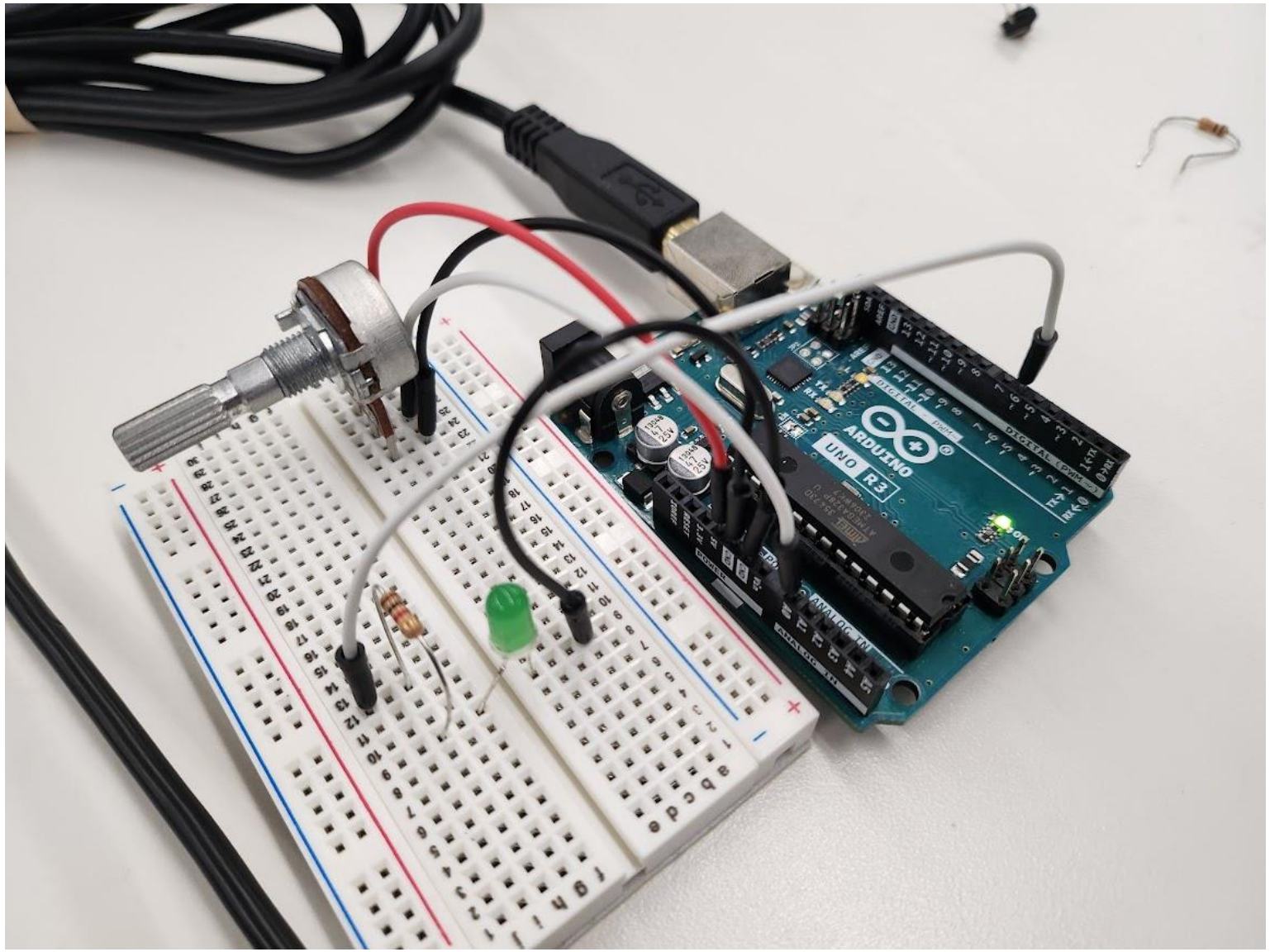
Need to map the values 0 to 1023 to 0 to 255

map(val I want to map, [lowerB, upperB] of the initial, [lowerB, upperB] of the final

Potentiometer Control LED



Let’s code



Code Potentiometer Control LED

```
int potPin = A0;
int potVal;
int ledPin = 6;
int ledVal;

void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  pinMode(potPin, INPUT);
  pinMode(ledPin, OUTPUT);
}

void loop() {
  // put your main code here, to run repeatedly:
  potVal = analogRead(potPin);
  //Serial.println(potVal);
  ledVal = map(potVal, 0, 1023, 0, 255);
  analogWrite(ledPin, ledVal);
}
```

Sources

- Computer Programming Tutorial (tutorialspoint.com)
- Learn | Arduino Documentation
- PS70: Introduction to Digital Fabrication (nathanmelenbrink.github.io)