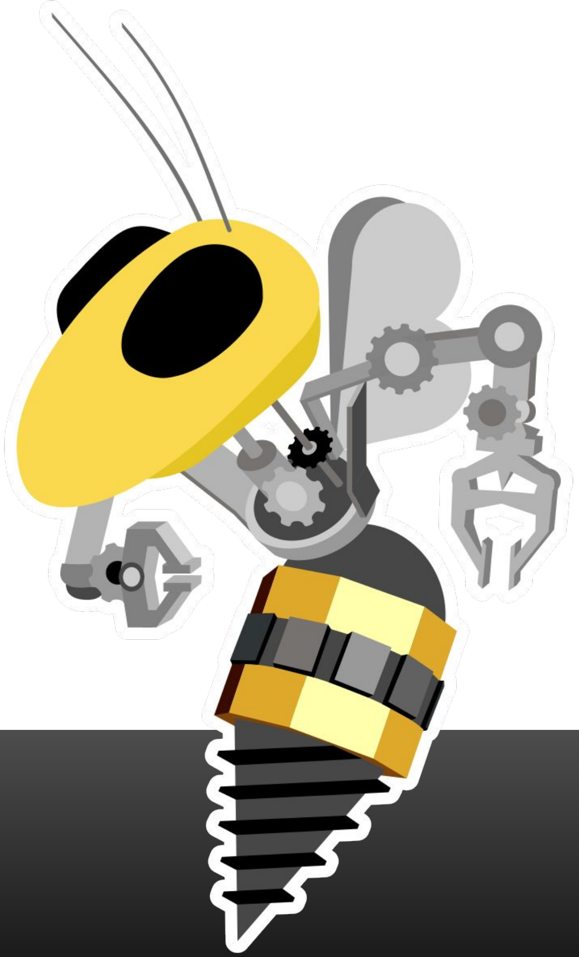
Welcome!

Electrical/Firmware Training
Week 1



RoboJackets
Competitive Robotics at Georgia Tech

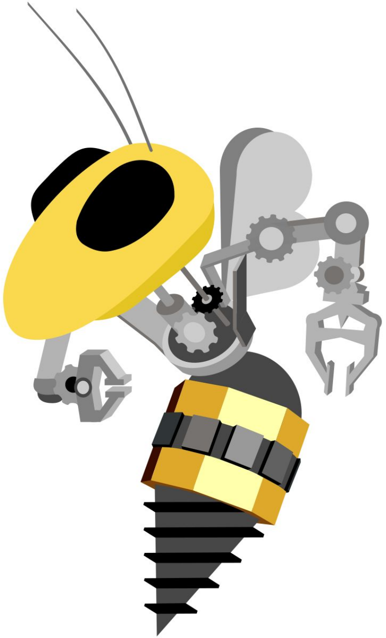
www.robojackets.org

Last Week

- Introductions
- What is RoboJackets Electrical/Firmware?
- Logistics
- Electrical Basics

Agenda

1. Microcontrollers
2. Intro to C++
3. Prototyping
4. Lab

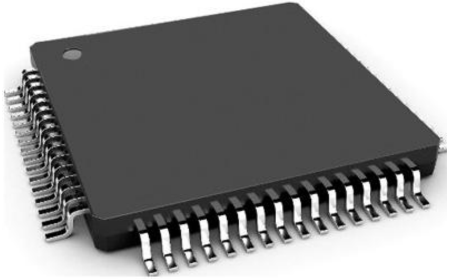


Microcontrollers

aka MCU

What is a Microcontroller?

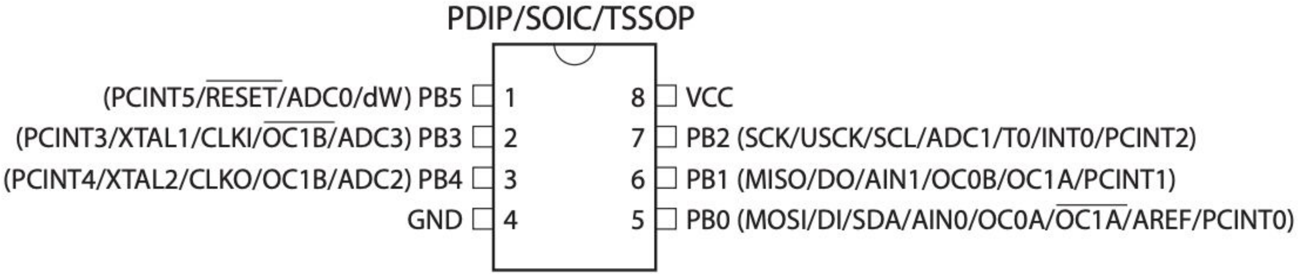
- The microcontroller is like a brain
- It’s a computer on a single electronic chip
- Contains logic gates, capacitors, resistors, etc.
- Functions such as processor, memory, programmable input/output peripherals
- These have pins for power, communication, and input/output connections



Pin config for ATtiny25

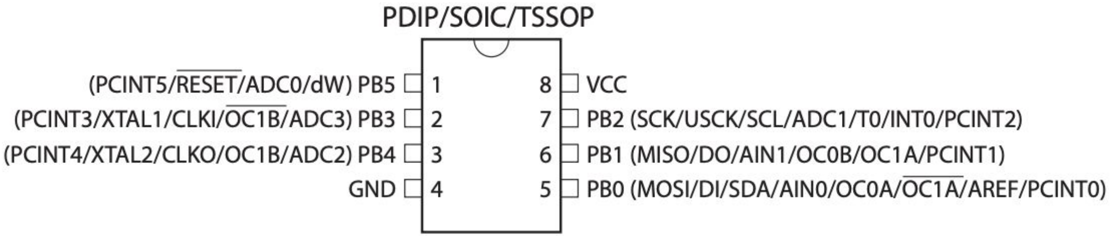
Pin configurations help to identify inputs and outputs for the microcontroller

- A pin is a piece of metal that sticks out in an microcontroller that can be connected electrically to the outside world
- Each pin serves a function, but not all pins need to be connected to something
- The MCU below is an 8-pin microcontroller


PDIP/SOIC/TSSOP
(PCINT5/RESET/ADC0/dW) PB5 1
(PCINT3/XTAL1/CLKI/OC1B/ADC3) PB3 2
(PCINT4/XTAL2/CLKO/OC1B/ADC2) PB4 3
GND 4
8 VCC
7 PB2 (SCK/USCK/SCL/ADC1/T0/INT0/PCINT2)
6 PB1 (MISO/DO/AIN1/OC0B/OC1A/PCINT1)
5 PB0 (MOSI/DI/SDA/AIN0/OC0A/OC1A/AREF/PCINT0)

NOTE: TSSOP only for ATtiny45/V

Pin config for ATtiny25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NOTE: TSSOP only for ATtiny45/V

- **VCC** is used to power the microcontroller
- **GND** is used to connect the MCU to ground
- **RESET** resets the program when its input is *low*
- **CLK**/**SCK** govern the speed at which the processor executes instructions
- **MOSI** and **MISO** let the microcontroller communicate with peripherals by sending and receiving data
- **ADC** is an analog to digital converter

Intro to C++

A programming language

C++ (pronounced ‘see plus plus’) is a programming language respected for its flexibility and low-level functionality.

Used in operating systems, microcontrollers, and elsewhere. C++ files have a .cpp extension.

Like most programming languages, code runs from top to bottom. Before the code is sent to a computer, it is **compiled** into binary code and then **executed**.

More about this in Week 2 of firmware

C++ Variables & Types

- int → integers (12, -17)
- double → floating point or decimal numbers (1.23)
- char → single characters (“s”, “D”)
- string → text (“Hello world”)
- bool → logical values (true/false)

```
//set up and
//assign a
//value like below
int i = 5;
//you can also set
//up a variable
//without initially
//assigning a value
bool rain;
rain = false;
```

C++ Arithmetic Operators

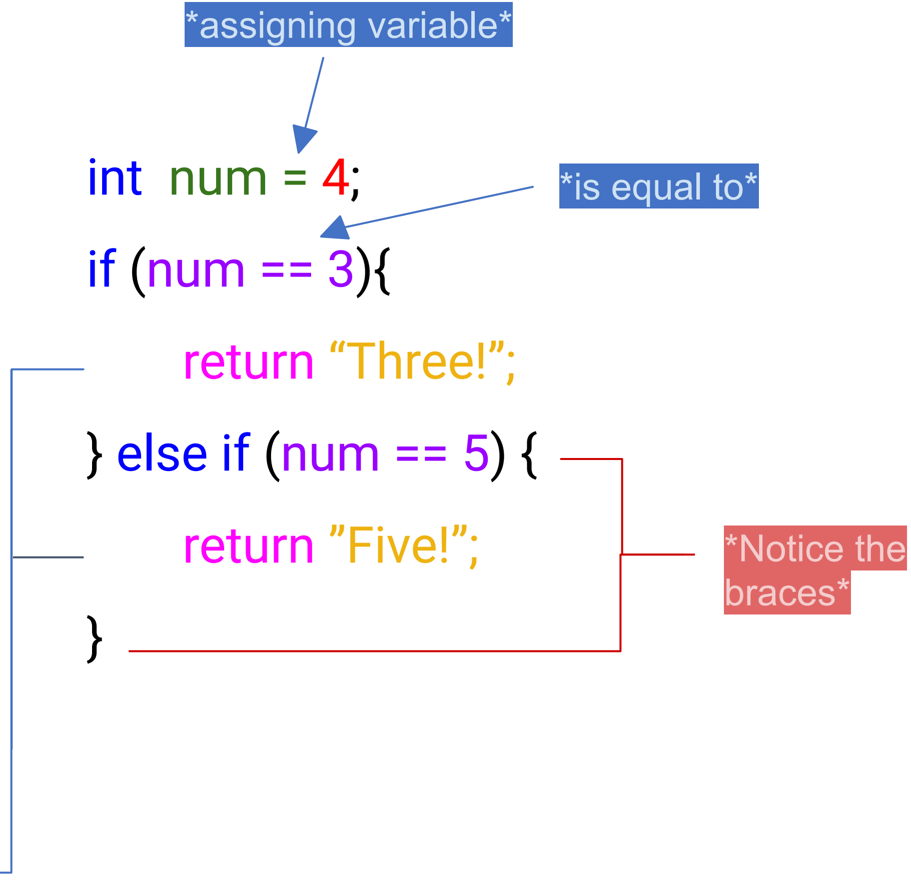
- + → Addition
- - → Subtraction
- * → Multiplication
- / → Division
- % → Modulo (produces the remainder e.g 9 % 4 >> 1)

C++ Relational Operations

- == → Equal to
- != → Not equal to
- > → Greater than
- < → Less than
- >= → greater than or equal to
- <= → less than or equal to

C++ Conditions

- If the condition (within brackets) in the *if* statement is *true*, then the code within the first set of braces will execute and will output “Three!”.
- *Else if* statements can be added in between *if* and *else* to provide additional conditions



assigning variable

is equal to

```
int  num = 4;
if (num == 3){
        return “Three!”;
} else if (num == 5) {
        return ”Five!”;
}
```

Notice the braces

Notice the indentation

C++ Conditions

- The *else* statement will execute when all previous conditions evaluate *false*
- Note that once a condition is met, no further code within the if block will execute

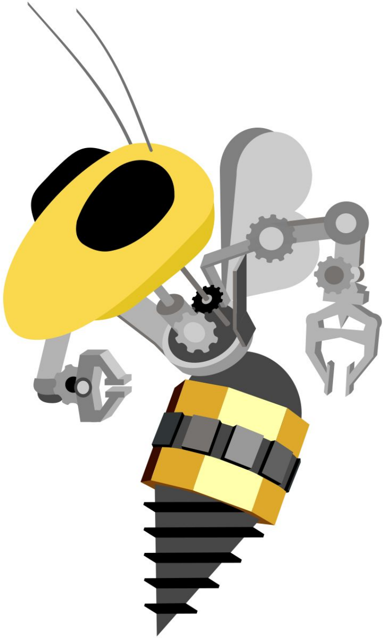
assigning variable

is equal to

```
int  num = 4;
if (num == 3){
        return “Three!”;
} else if (num == 5) {
        return ”Five!”;
} else {
        return num;
}
```

Notice the braces

Notice the indentation



Prototyping

Breadboard and Arduino Uno

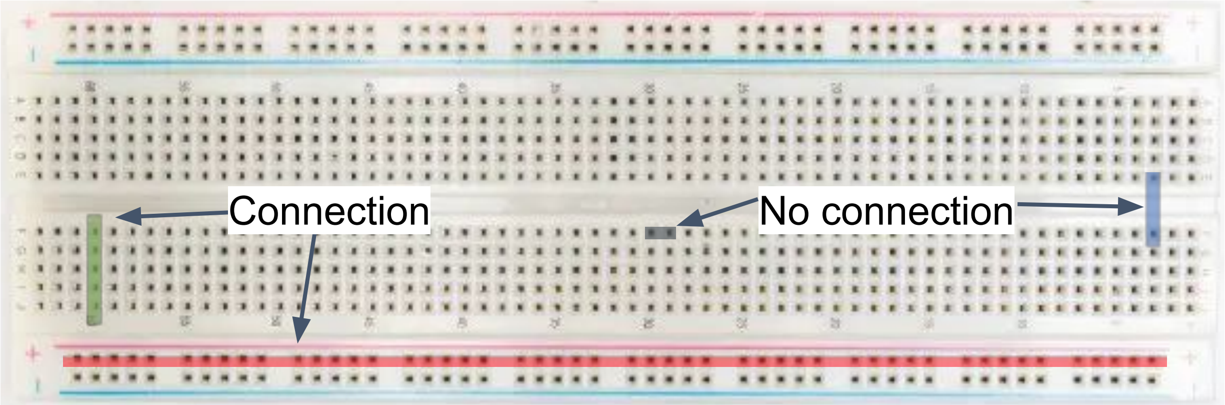
Prototype basic circuit designs with **Breadboards**

Breadboards help you connect electrical components to build basic circuits.

Terminals are the vertical columns. Each terminal is independent from the other

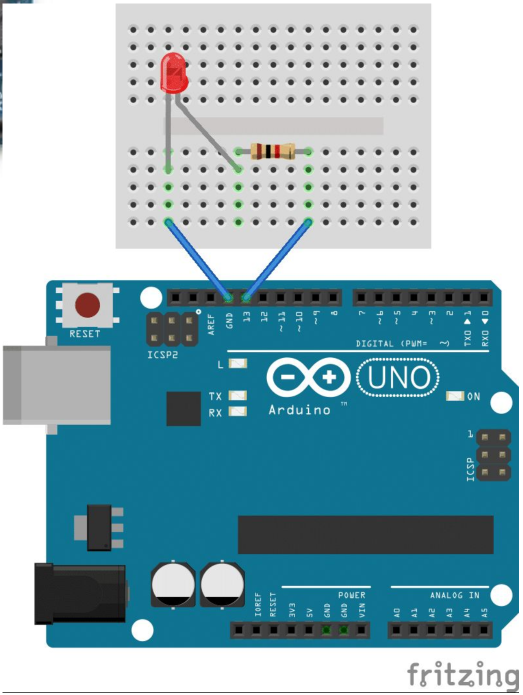
Power rails are use to connect the power supply to the breadboard. The horizontal pins on each power rail are connected.

Top half and bottom half of the breadboard are independent from each other.



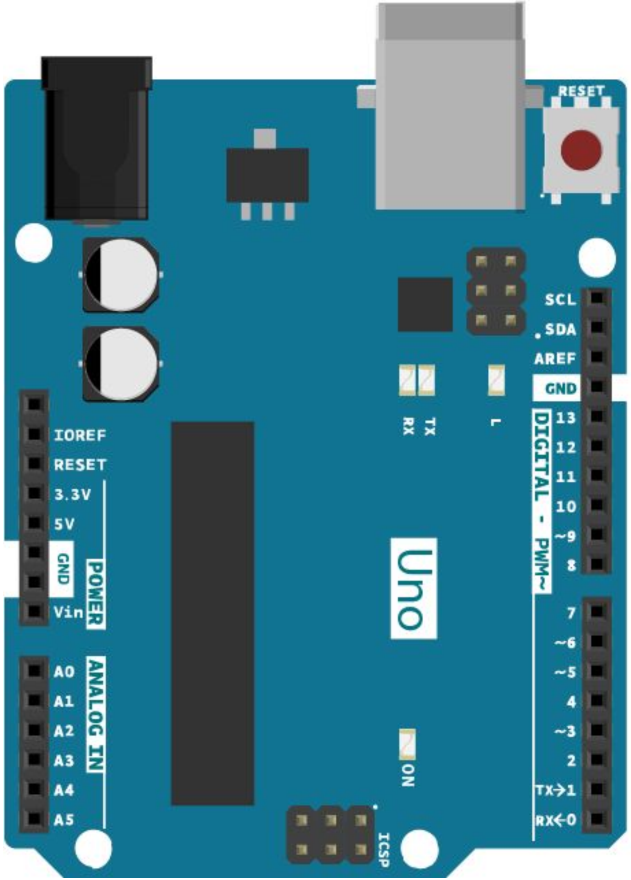
Arduino Uno

Microcontroller with I/O ports to control electronics



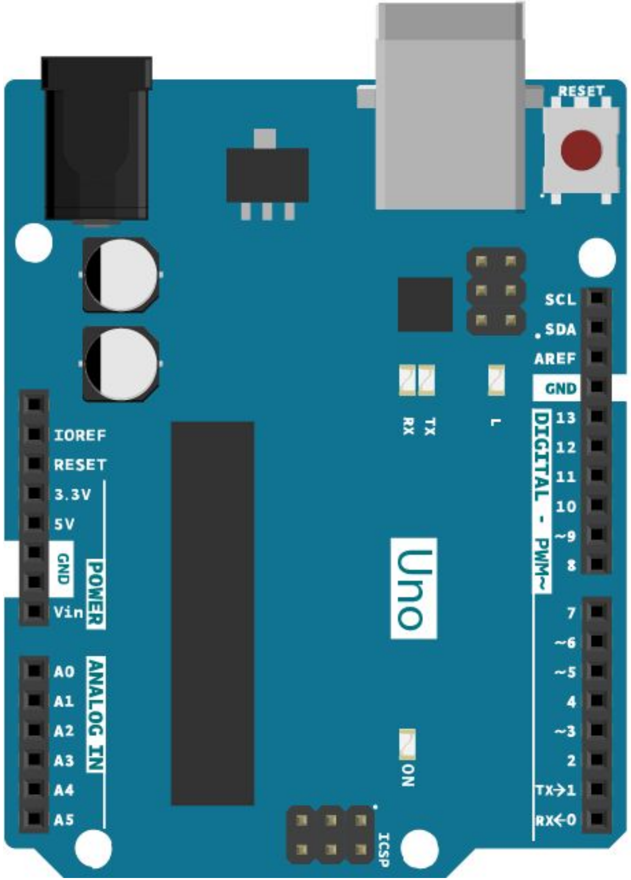
Arduino Board Explained

- **Power**: an Arduino can be powered using a USB cable or a Barrel Jack. Use between 6V and 12V
- **GND** can connect components to Ground
- **5V** & **3.3V**: supplies power to components
- **ANALOG IN**: A0 - A5 pins can read values from analog sensors
- **DIGITAL** pins cans be used as input from components (like switches) or output to components (like LEDs)
- **PWM**: some pins have a tilde (~) symbol next to it for Pulse Width Modulation (PWM) to simulate analog output.



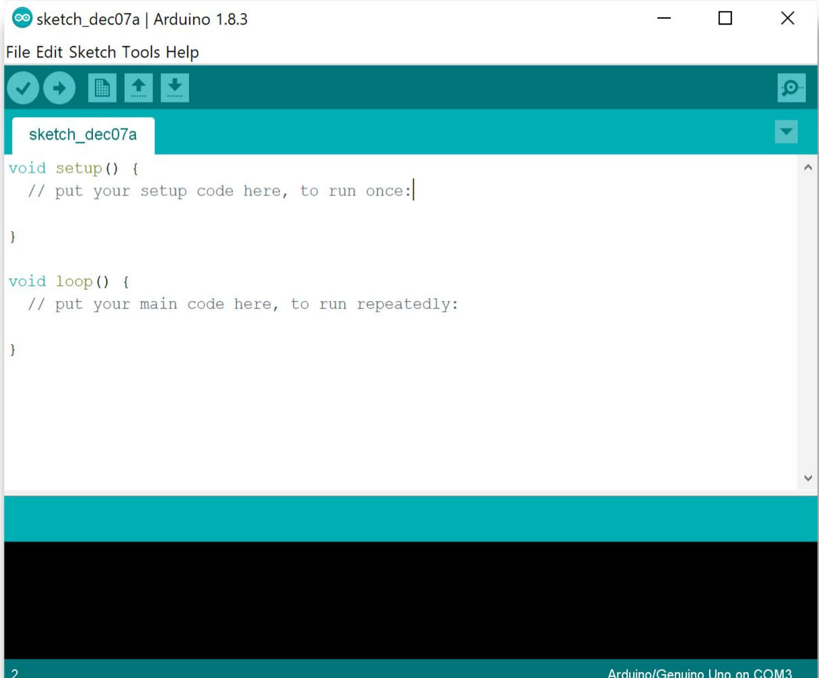
Arduino Board Explained

- **AREF**: used to set external reference voltage between 0V and 5V for analog input. You would mostly ignore this
- **RESET** (button): temporarily connects reset pin to ground to restart code. Useful when you cannot reset with a computer.
- **Built-in LED**: a mounted LED that can be programmed to blink



Arduino IDE Explained

- IDE aka integrated development environment
- Programs written using Arduino Software (IDE) are called **sketches**.


sketch_dec07a | Arduino 1.8.3
File Edit Sketch Tools Help
sketch_dec07a
2
Arduino/Genuino Uno on COM3

```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

Verify checks for errors and *compiles* code

Upload *compiles* and *uploads* code

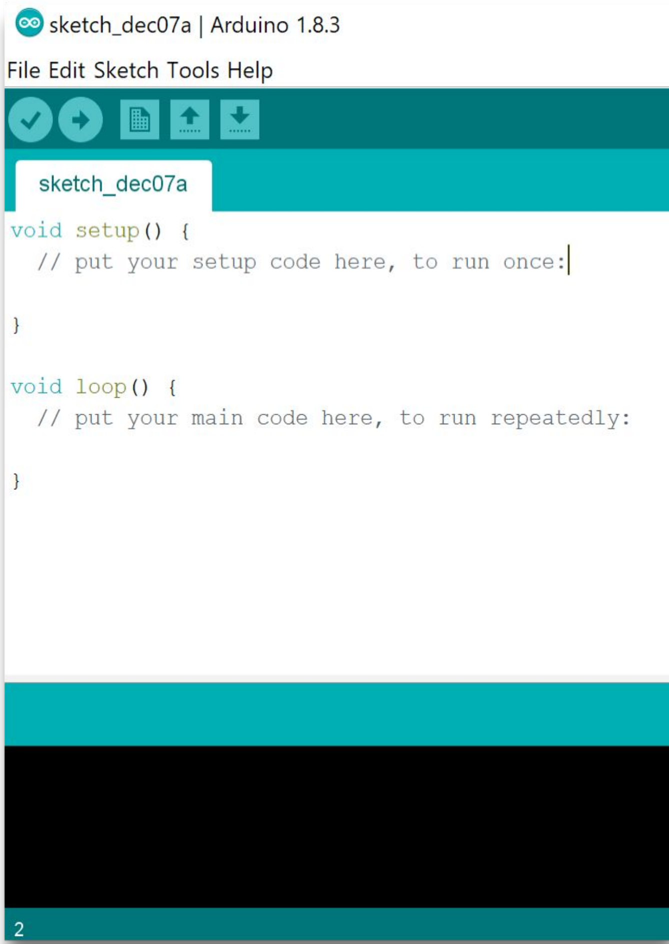
New creates new sketch

Save saves your sketch

Serial Monitor displays print outputs

Arduino IDE Explained

- void setup()
    - *initialize* variables and *define* pins
    - Runs once
- void loop()
    - write code to read from and write to pins
    - Runs multiple times
- The Arduino IDE has a lot of built-in *libraries* that boils down complex tasks into simple functions. You can add libraries to your sketch using #include
    - **Sketch > Import Library**
- The code used in Arduino IDE is very similar to C++



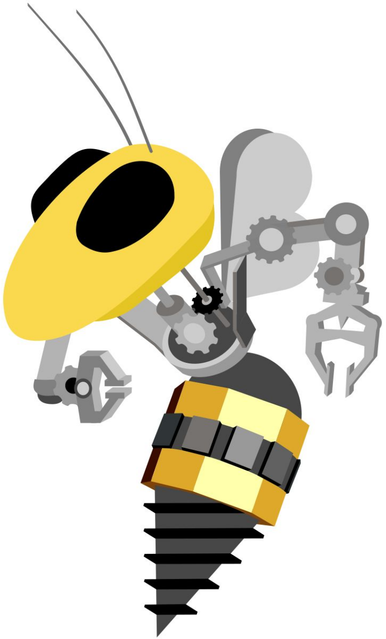
```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

Common Arduino IDE Functions

- pinMode(pin, mode);
  - Configures the specified pin to act as an input or output
- digitalWrite(pin, value);
  - Write a high (5V) or low (0V) value to a specified pin
- digitalRead(pin);
  - Read a high or low value from a specified pin
  - Returns true if voltage is HIGH, or false if it is LOW
- delay(value);
  - Pauses code execution for a value—time in milliseconds

Common Arduino Functions

- analogRead(pin);
  - Returns an analog value from an analog pin
- Serial.print();
  - Used to print values in serial monitor and to see if your code is being executed → Useful for debugging.
  - Requires Serial.begin(value); in void setup



Lab

Blinking LEDs & Thermistor/Heat sensor (Online)

Lab Setup (Online)

This week we will build a simple circuit to light up LEDs and we will use an Arduino Uno to control which LEDs light up.

Afterwards, we will use a temperature sensor to light up LEDs based on the input temperature.