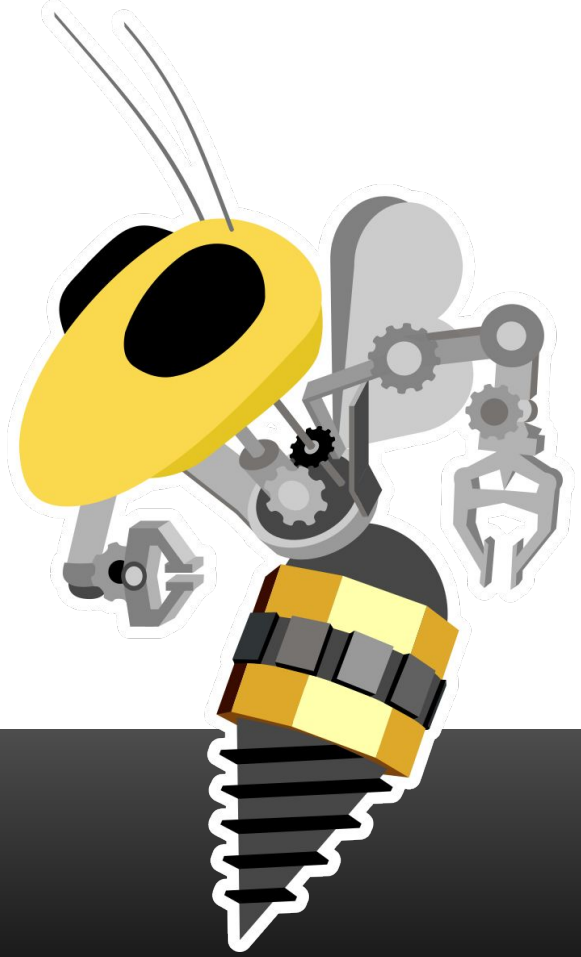
Welcome!

Electrical/Firmware Training
Week 1



RoboJackets
Competitive Robotics at Georgia Tech

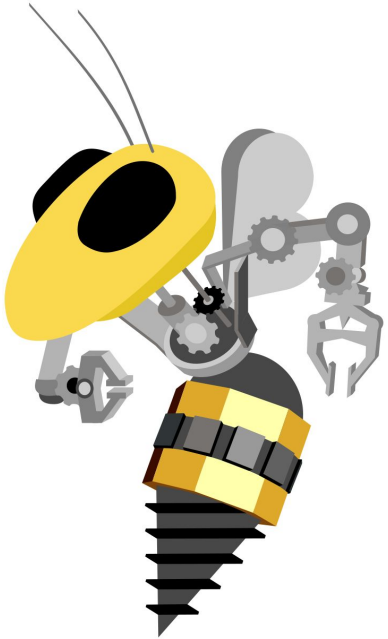
www.robojackets.org

Last Week!

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

This Week!

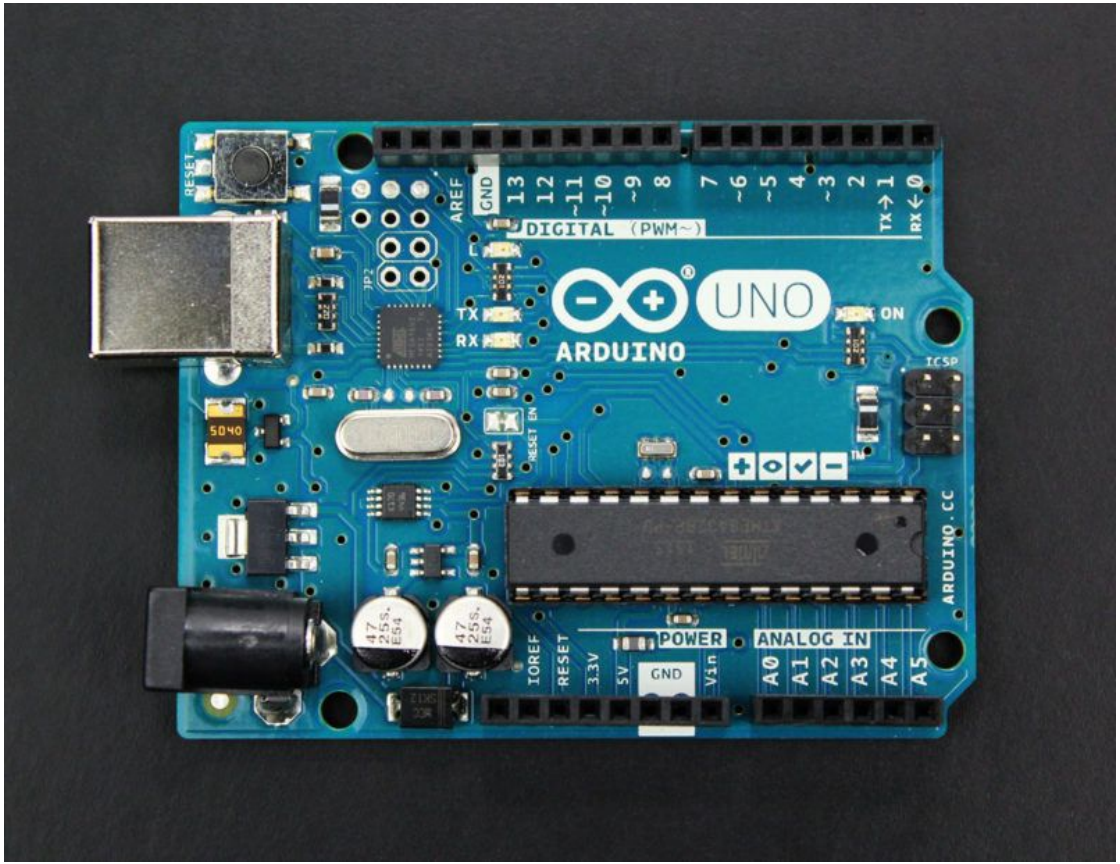
- Microcontrollers & Firmware
- Arduino, Part 1
- Prototyping



Microcontrollers and Firmware

Arduino!

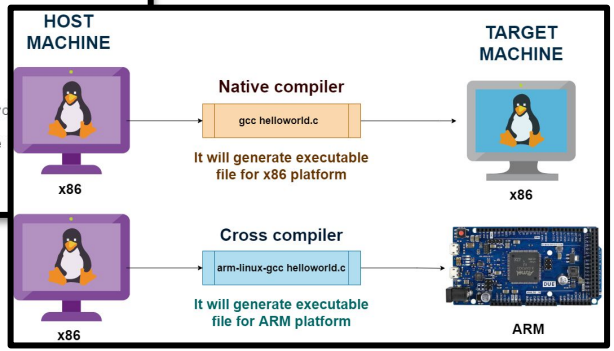
- Arduino is…
  - … a development board (Arduino Uno, Arduino Nano)
  - … a programming language (libraries, compiler, syntax)
- Development board centered around microcontroller



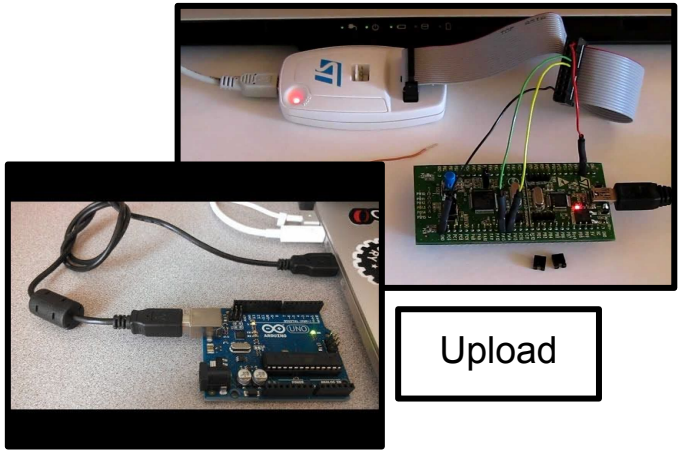
Programming a MCU

```
Blink §
/*
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.

  This example code is in the public domain.
 */
int led = 13;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
}

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

Code



Cross-compilation



Upload

Example: RoboCup

High-level Decisions (Software)

- Where am I in the world?
- Where are my teammates / opponents / goals?
- Where should I move?
- If I have the ball, when and where should I kick it and how hard?

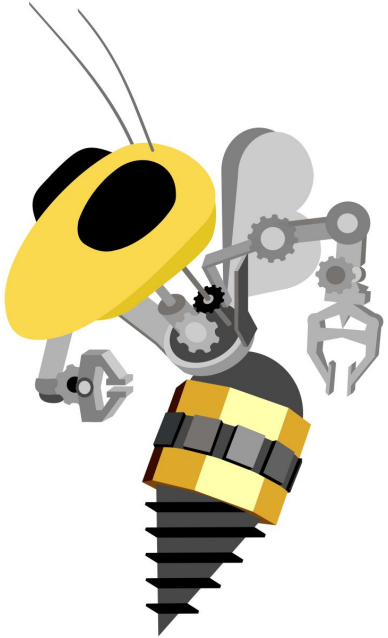
Example: RoboCup

Low-level Decisions (Firmware)

- How do I instruct the motors to spin at the desired speed?
- How do I instruct the kicker to kick at a certain time, in a certain direction, with the desired intensity?

Why aren't Low-level decisions made by a "software computer?"

- Speed
  - Counting encoder ticks <<< Computer vision algorithm
- Space
  - MCUs are small, PCs are not
- Overkill
  - Some robots don't need to make complicated decisions
  - PC would be $$$ to replace
- Convenience
  - Robotics hardware + software APIs cater to MCUs

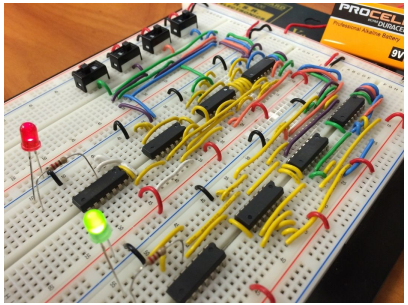


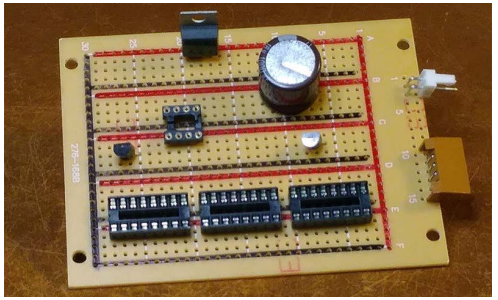
Prototyping

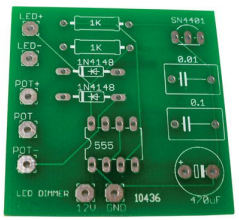
Breadboard and Arduino Uno

From Breadboard to PCB

- Solderless Breadboard (Top)
  - Easy to change
  - Good for initial prototyping
  - Difficult to build large circuits
- Protoboard (Middle)
  - More permanent; solder used
  - Good for mature prototype
  - Changes are doable, but involves re-soldering
- Printed Circuit Board (Bottom)
  - Most permanent; unable to change connections
  - Able to tightly pack components
  - Circuit can span several layers
  - Good for finished product







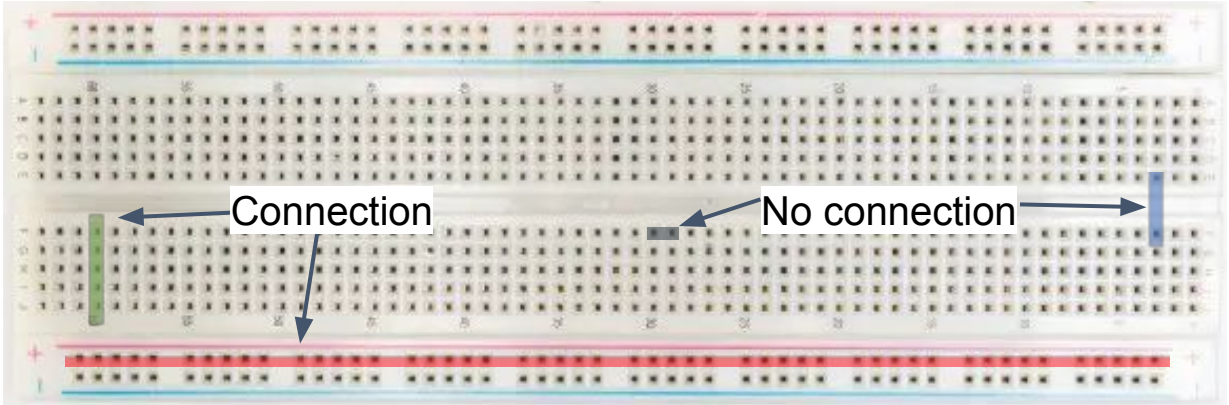
Prototype basic circuit designs with **Breadboards**

Breadboards help you connect electrical components to build basic circuits.

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

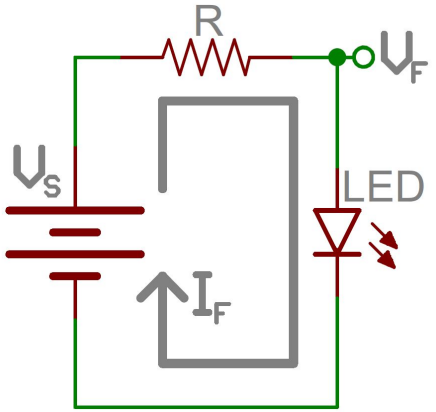
Power rails are use to connect the power supply to the breadboard. The horizontal pins on each power rail are connected.

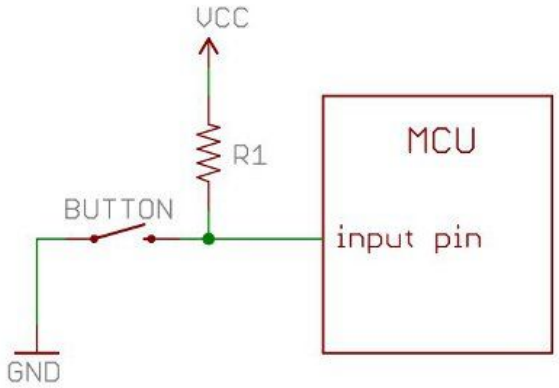
Top half and bottom half of the breadboard are independent from each other.



Prototyping Hardware

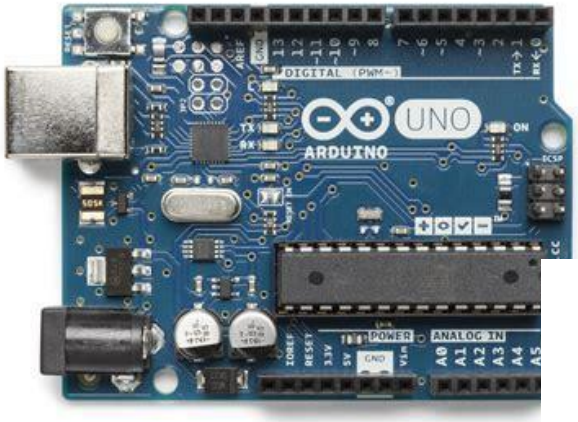
- LEDs
  - Diode: allows lots of current in one direction
  - LED: too much current = blow up
- Buttons
  - Open / close a circuit
  - Problem: High Impedance / “floating” pin
- Resistors
  - Current-limiting resistor + LEDs (I = V / R)
  - Pull-up resistor + Buttons

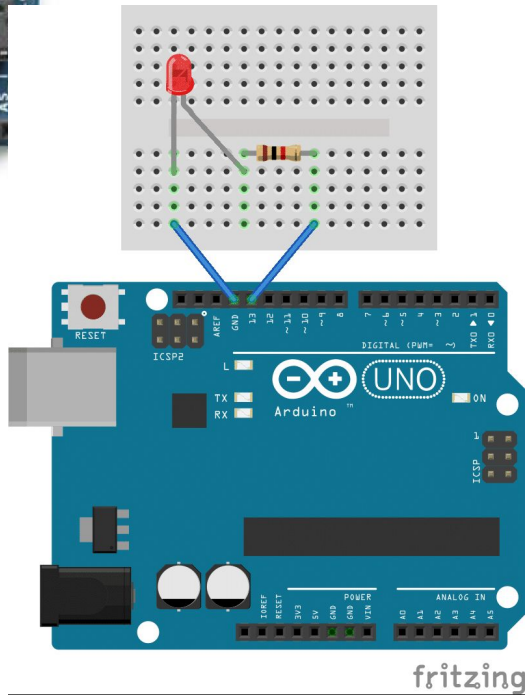




Arduinos!

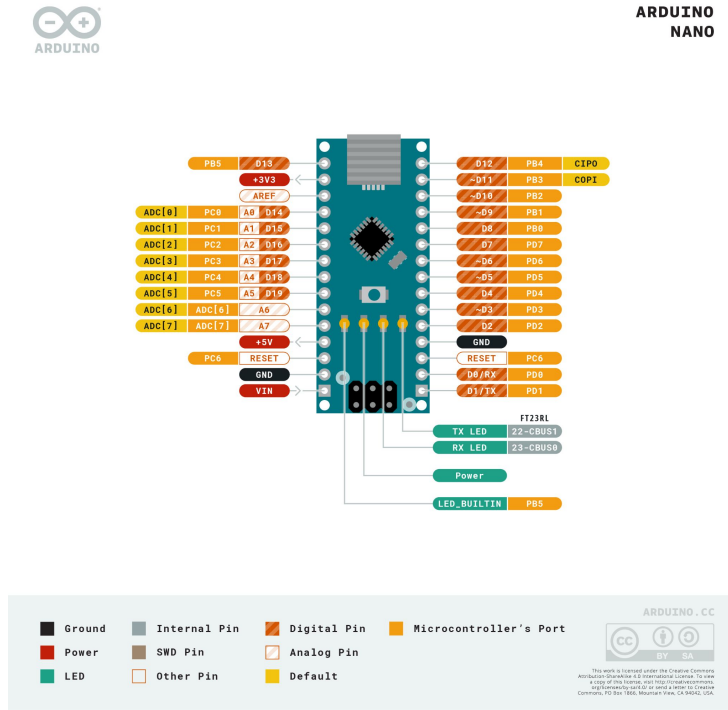
Microcontroller with I/O ports to control electronics





The pinout diagram

- Arduino Nano Pinout
  - Physical pins -> software pins
    - Ex: D2 (hardware)
    - -> “2” (software)
  - Summarizes capabilities of different pins
  - Ex: PWM, ADC, SPI, UART, I2C
- Read the Datasheet!



Arduino IDE Explained

- IDE = “Integrated Development Environment”
- Programs = “sketches”.

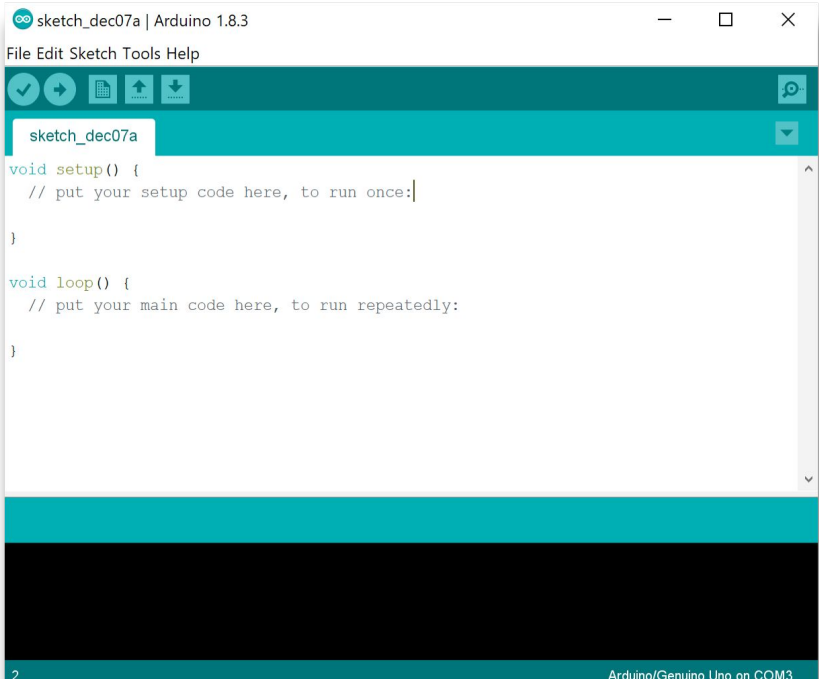

Verify checks for errors and *compiles* code


Upload *compiles* and *uploads* code


New creates new sketch

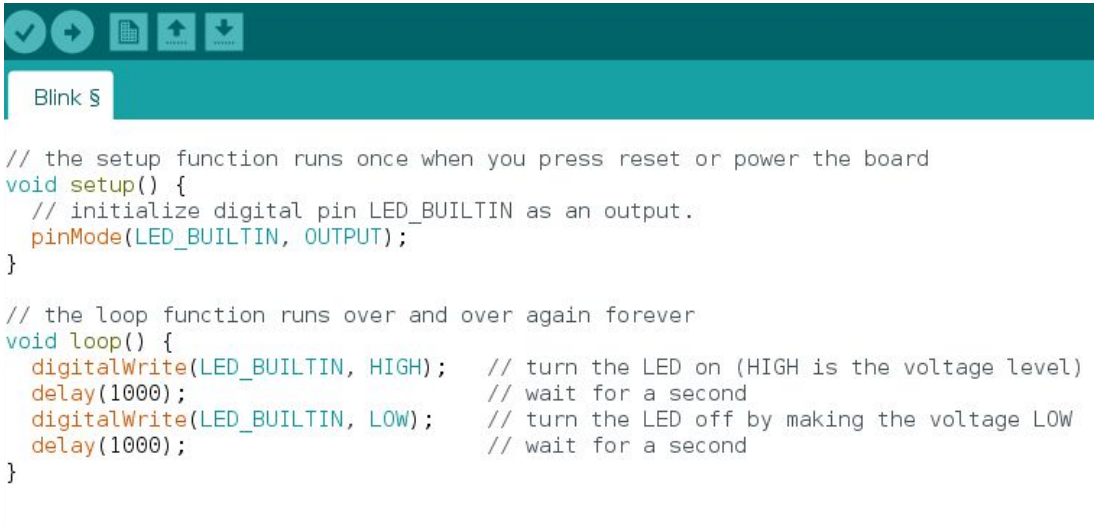

Save saves your sketch


Serial Monitor displays print outputs



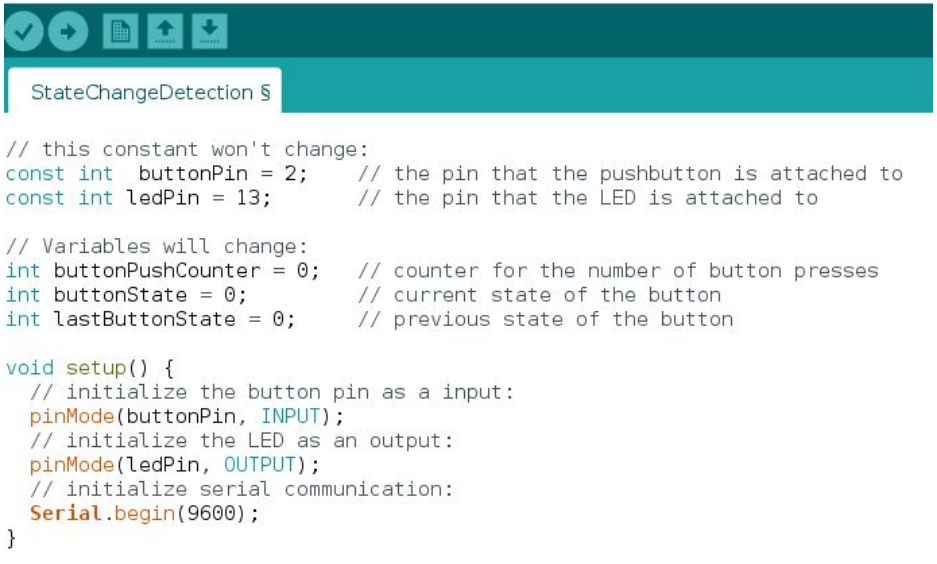
Blink Example

- setup()
- loop()
- pinMode()
- digitalWrite()
- delay()



StateChangeDetection, Part 1

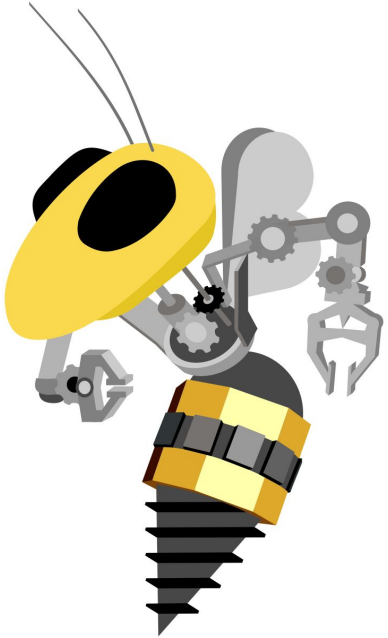
- Variables
  - Pin variables (buttonPin, ledPin)
  - Integer variables (buttonPushCounter, buttonState, lastButtonState)
- pinMode()
- Serial.begin()



StateChangeDetection, Part 2

- digitalRead()
- If /else
- digitalWrite()

```
void loop() {
  // read the pushbutton input pin:
  buttonState = digitalRead(buttonPin);

  // code omitted

  // turns on the LED every four button pushes by checking the modulo of the
  // button push counter. the modulo function gives you the remainder of the
  // division of two numbers:
  if (buttonPushCounter % 4 == 0) {
    digitalWrite(ledPin, HIGH);
  } else {
    digitalWrite(ledPin, LOW);
  }

}
```



Lab

LEDs and Buttons

Lab Time!

- Read the lab setup
  - Legacy Arduino IDE
  - CH340 drivers
- Challenges!
  - Blink
  - Blink + Button
  - Variable Frequency Blink + Button
  - Binary Counter