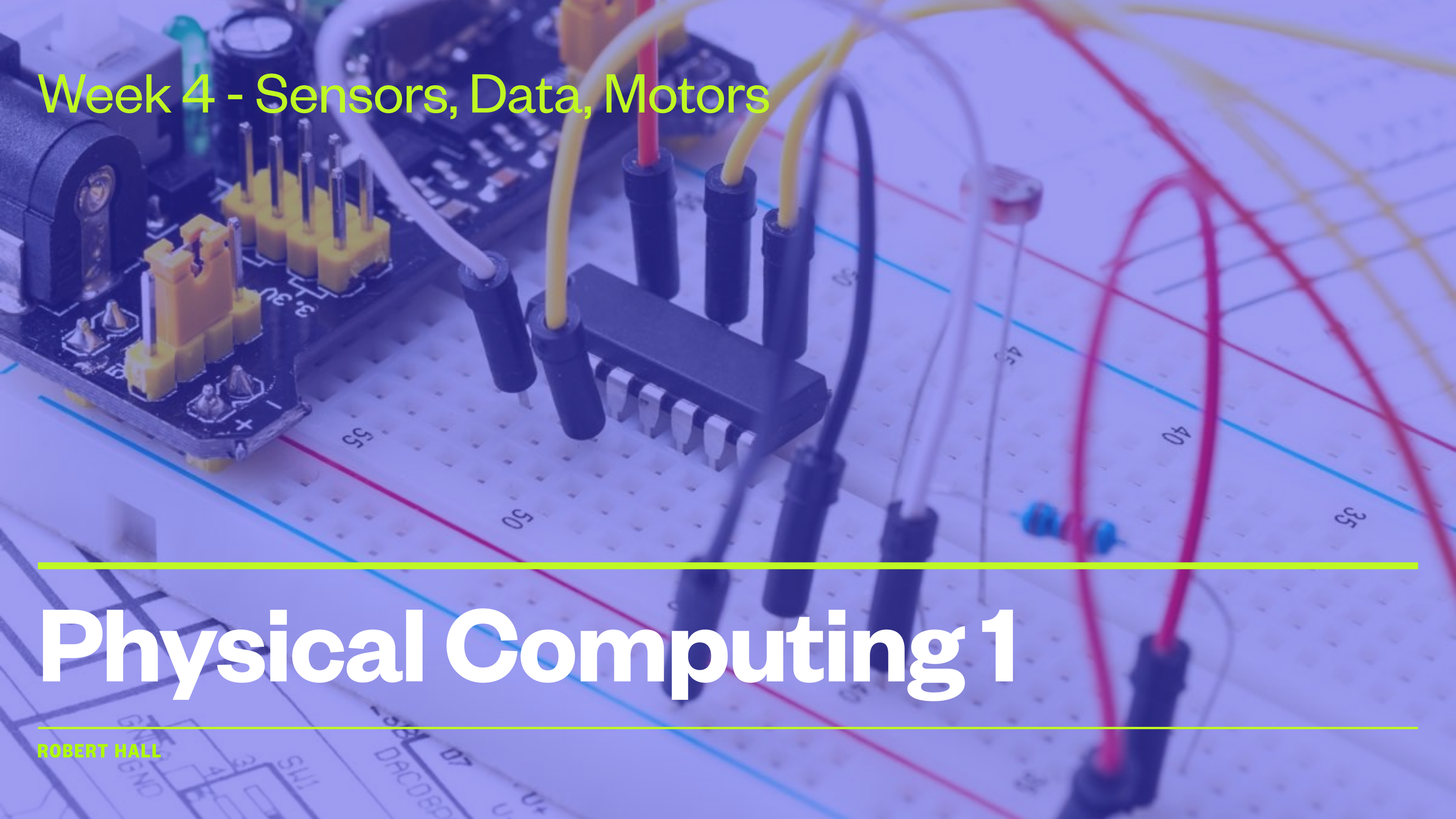


Week 4 - Sensors, Data, Motors

Physical Computing 1

ROBERT HALL

Plan for Today

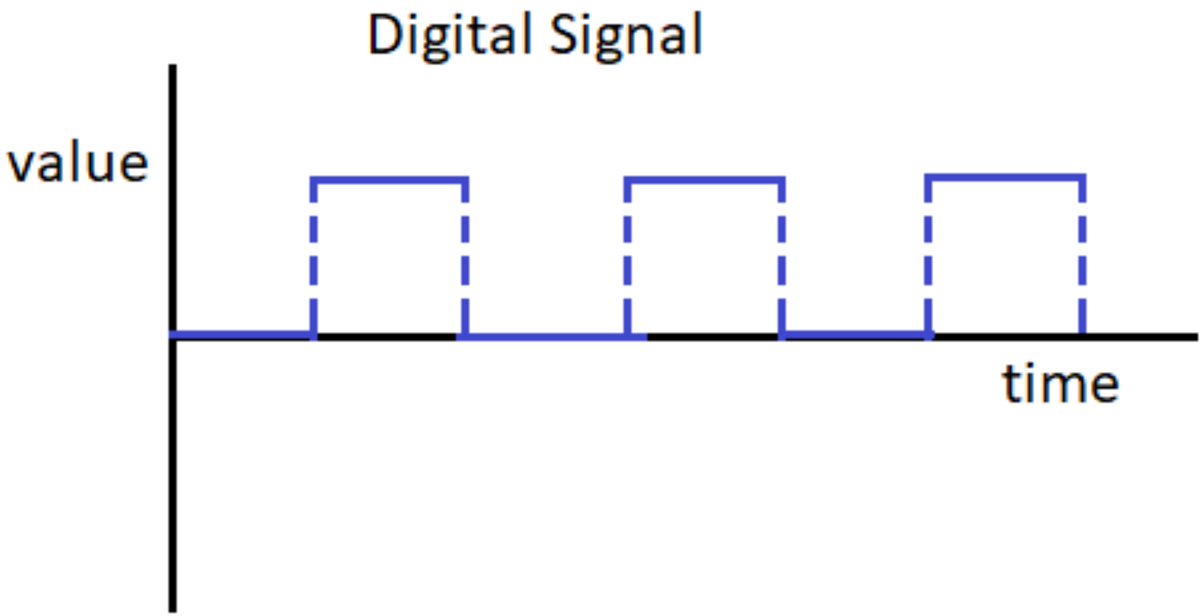
- Homework Review
- Inspiration Time
- Recap of Last Week
- Coming Up in the rest of the Term
- More Sensors
- More Motors
- Timer/Timers/Timing
- Prototyping Advice
- Project Proposal Assignment

Homework Review

Inspiration Time!

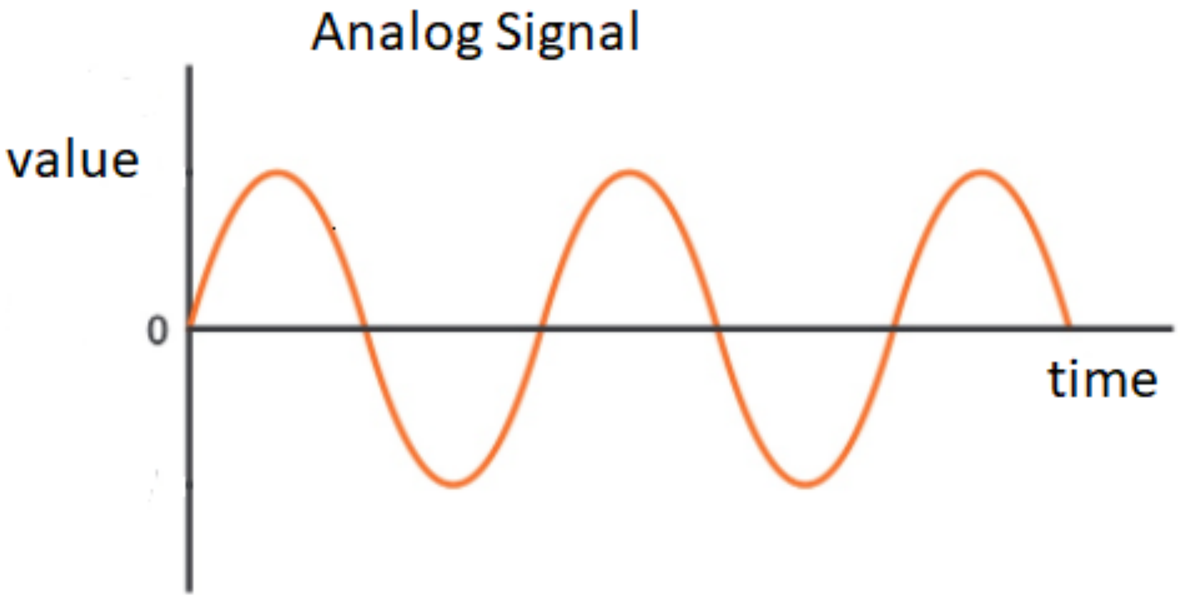
How was this done?

Digital



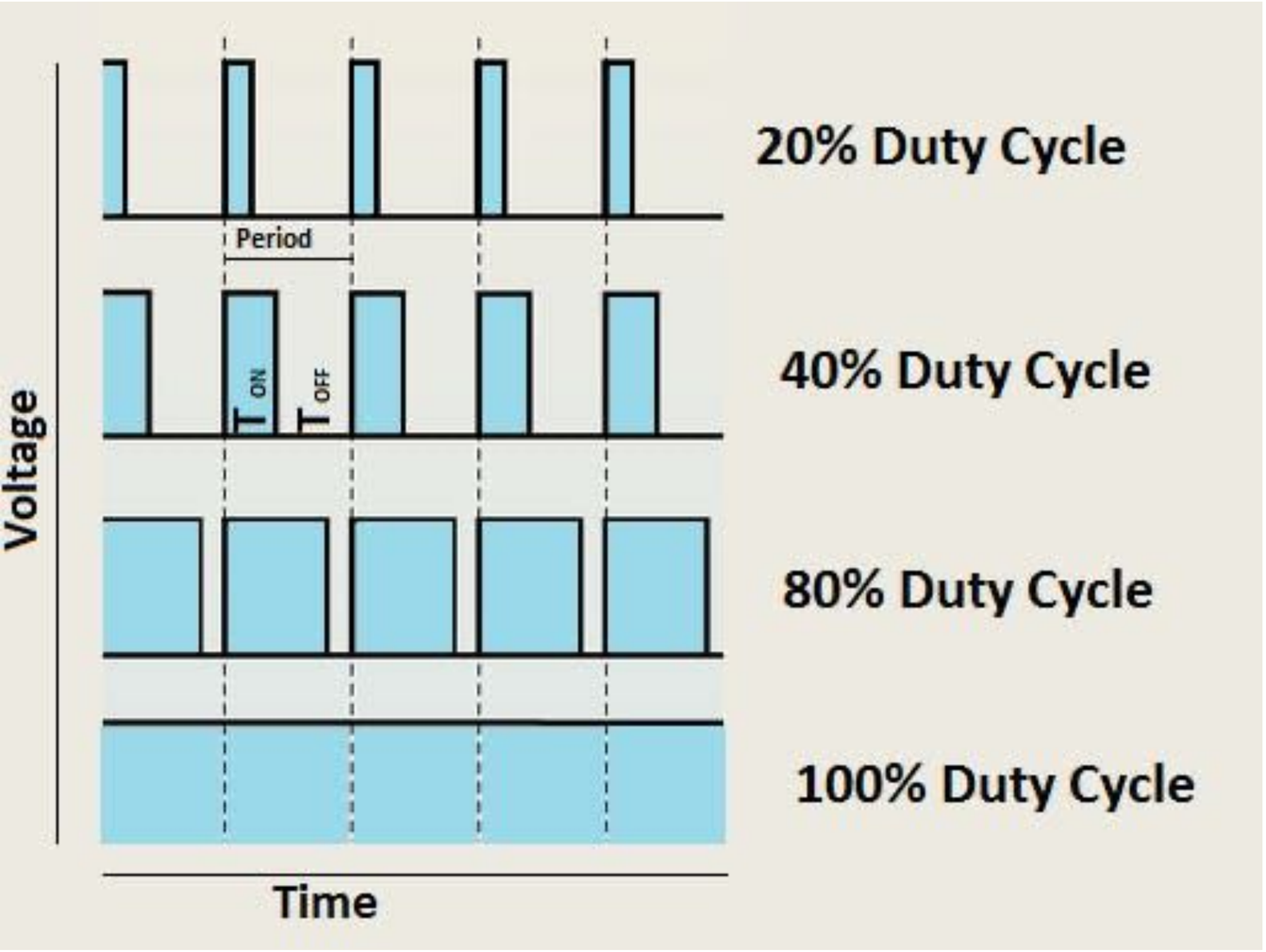
- Digital signals are either ON or OFF
- Digital signals are less susceptible to interference.

Analog

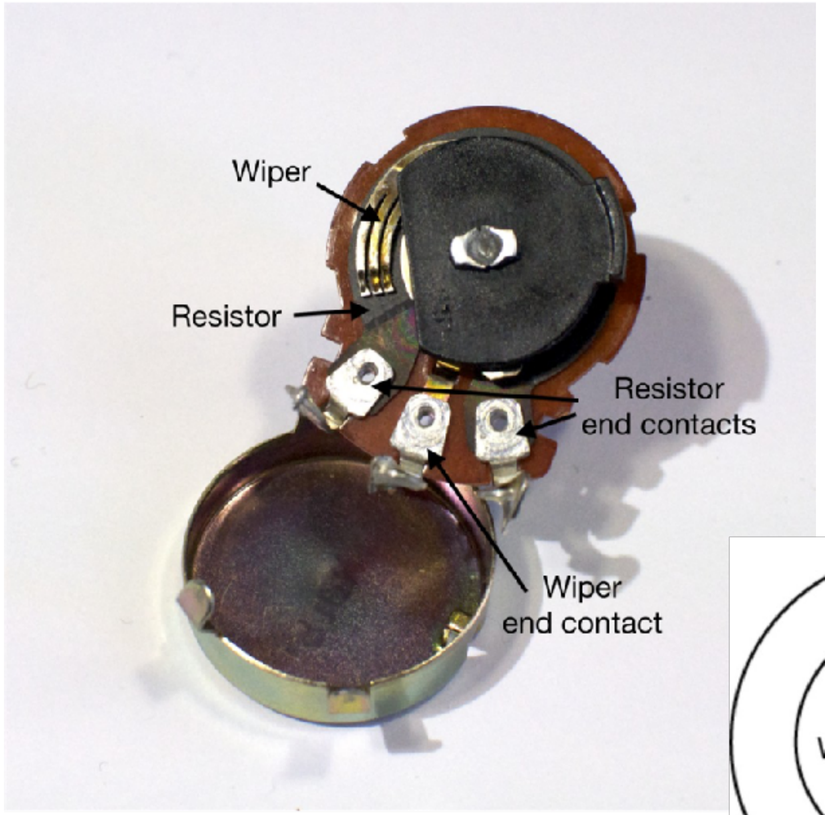


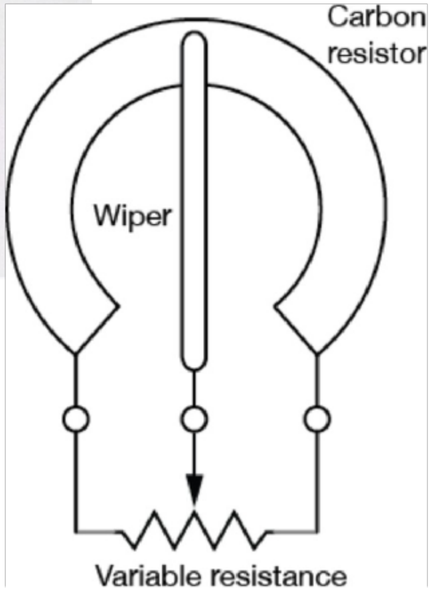
- Analog Signals can be any value, and can move smoothly between values
- Analog Signals are prone to interference as any changes to the signal immediately change the data transmitted

Pulse Width Modulation (PWM)



- PWM is a way of emulating an analog signal by selectively turning on and off a digital signal.
- We can use this signal to dim an LED among other things.
- We call the percentage of time the Digital Signal is ON, the Duty Cycle.



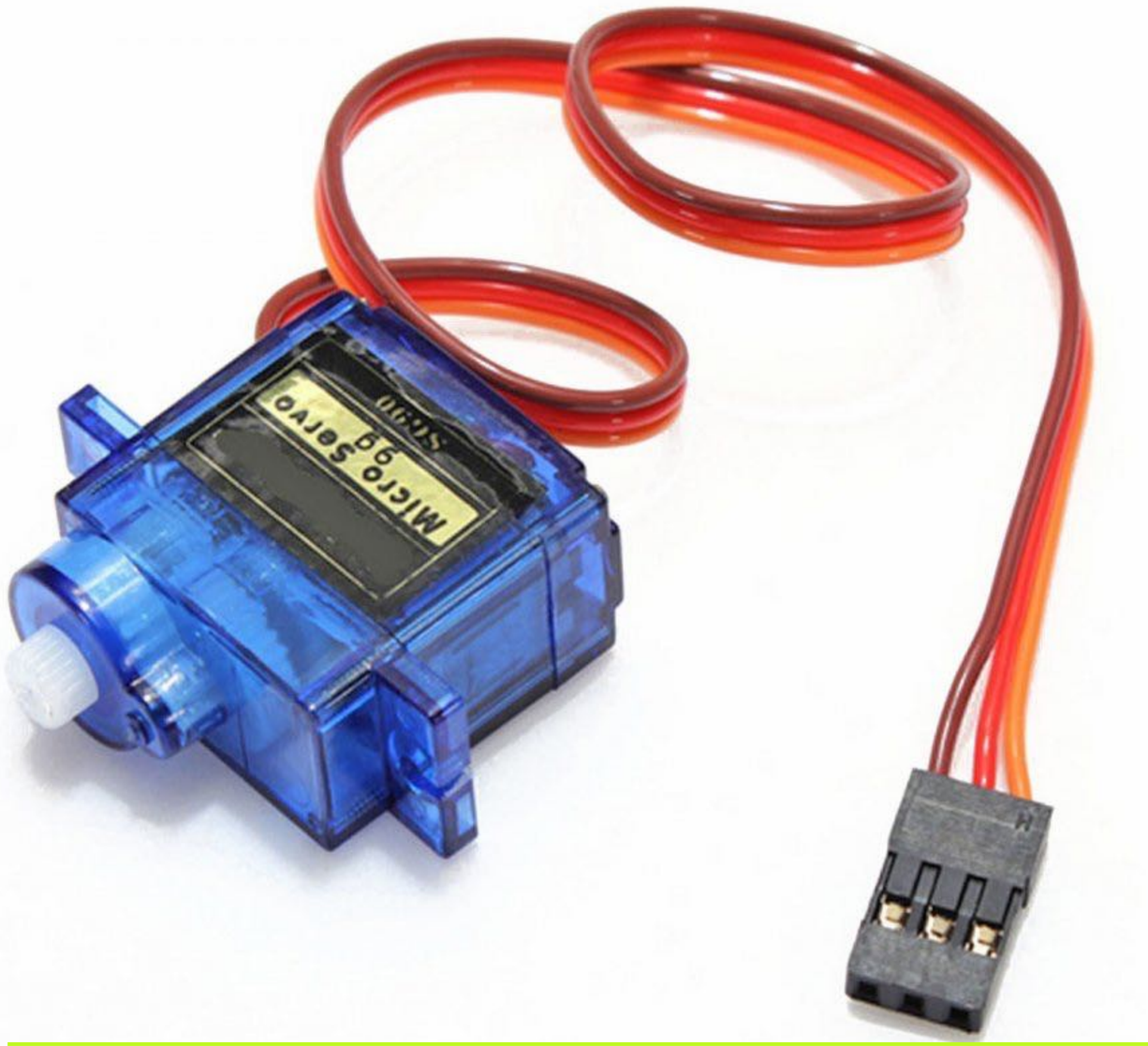


Potentiometer
Variable Resistor

- Potentiometers work by changing how far through a carbon resistor electricity has to travel, the smaller the gap, the less resistance.
- Potentiometers have 3 Pins, GND, 5V and Wiper
- We connect Wiper to the Analog In Pin and the whole device makes a Voltage Divider.

LDR
Light Dependent Resistor

- Changes Resistance when exposed to light or dark.
- Must be used with another resistor (10K) to work.



Servo Motor

- Can move a small weight between 0 and 180 degrees
- Great for pressing buttons and switches or rotating small items
- Once you’re happy using this, there are other compatible motors that are much bigger and stronger but work exactly the same way.

Any Questions so far?

Schedule for the rest of the term

Week 4 (Today) - Sensors, Data, Motors (Project Proposal)

Week 5 - Rest of the Kit, Wearables, Project Proposal Feedback (MVP)

Week 6 - Communication (Serial), MVP Feedback

Week 7 - Capacitive Sensing, Project Work

Week 8 - 3D Printing/Laser Cutting, Project Work

Week 9 - Project Work

Week 10 - Project Demonstrations and Assessments

(Final Project Deadline)

Ideas

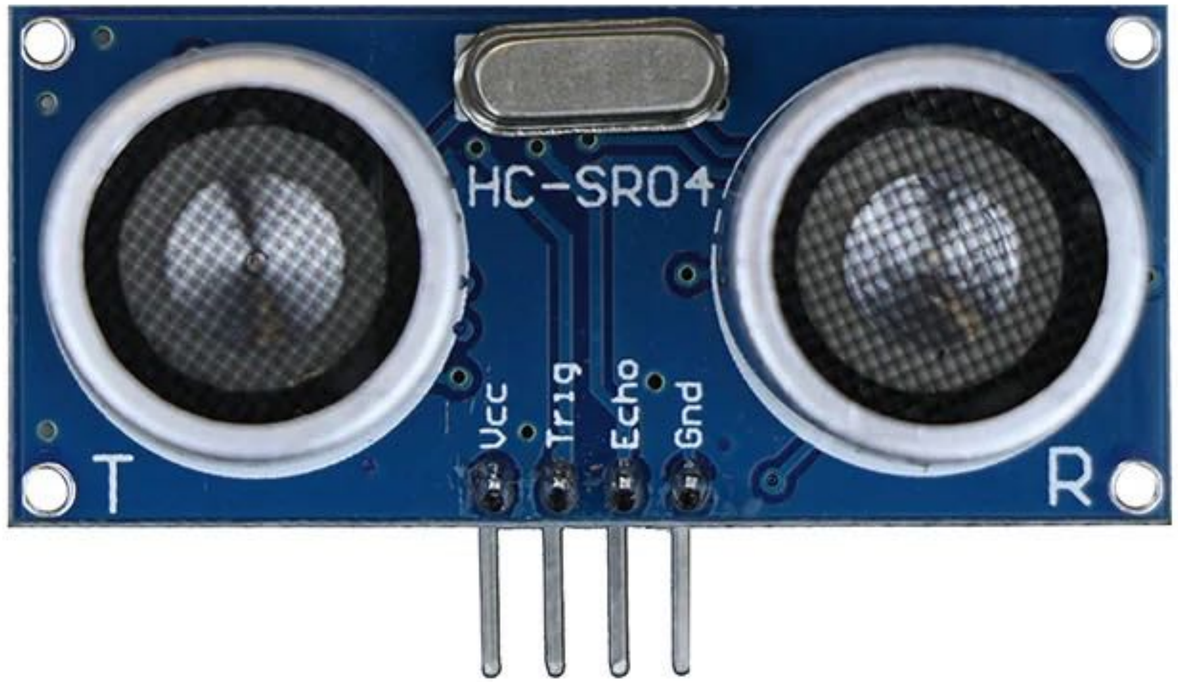
- Research Projects that use Physical Computing
- Find projects you like and think about how they were made
- Start thinking about what you would like to make for your final project - what ideas you have, how you will implement them, how you will start, what equipment do you need, what is the MVP (minimum viable product) you can make.

Ideas before tech!

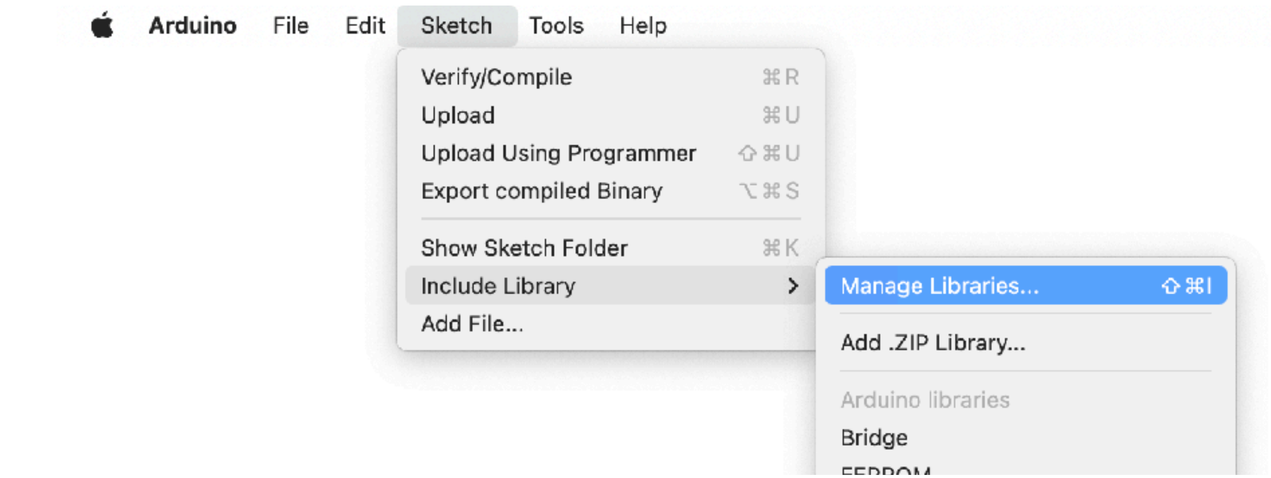
If you make a very technical project, with no idea, it won’t get the best makes

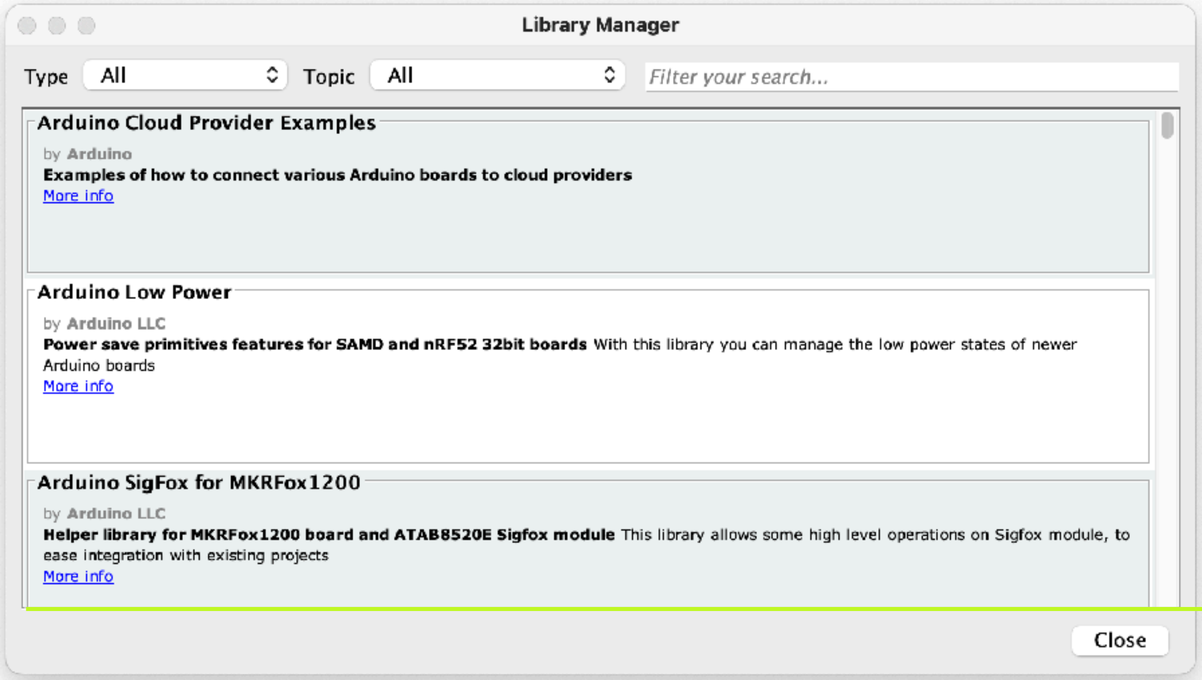
Don’t forget to document as you go!

Ultrasonic Distance Sensor



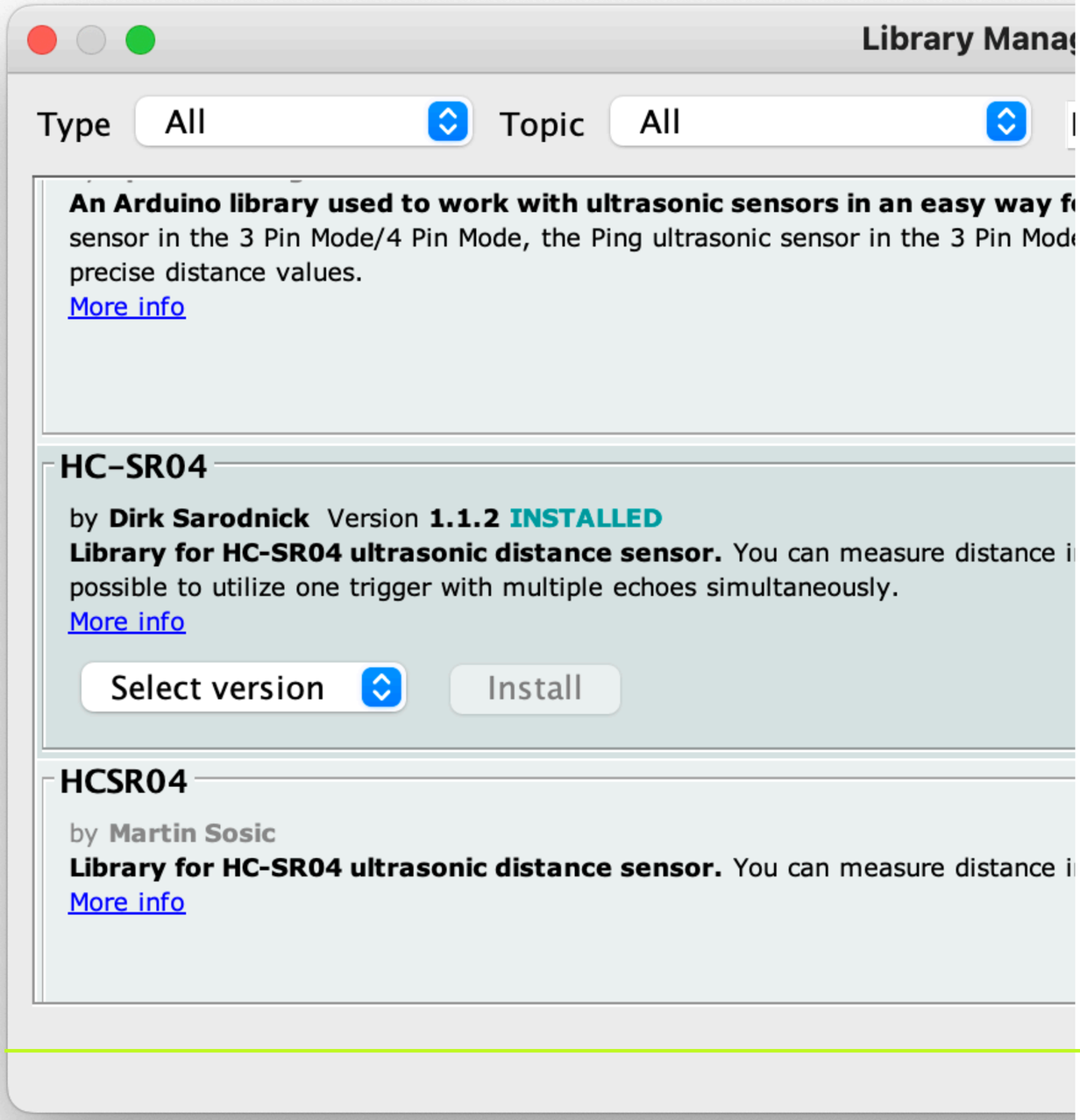
- Uses sound waves to work out how far away it is from something.
- Works great with solid materials like acrylic.
- Doesn’t work well with materials that absorb sound like fabric.
- Many different libraries available.
- This is just what comes in your kit, other distance sensors are available.





Installing Libraries
Using the Library Manager

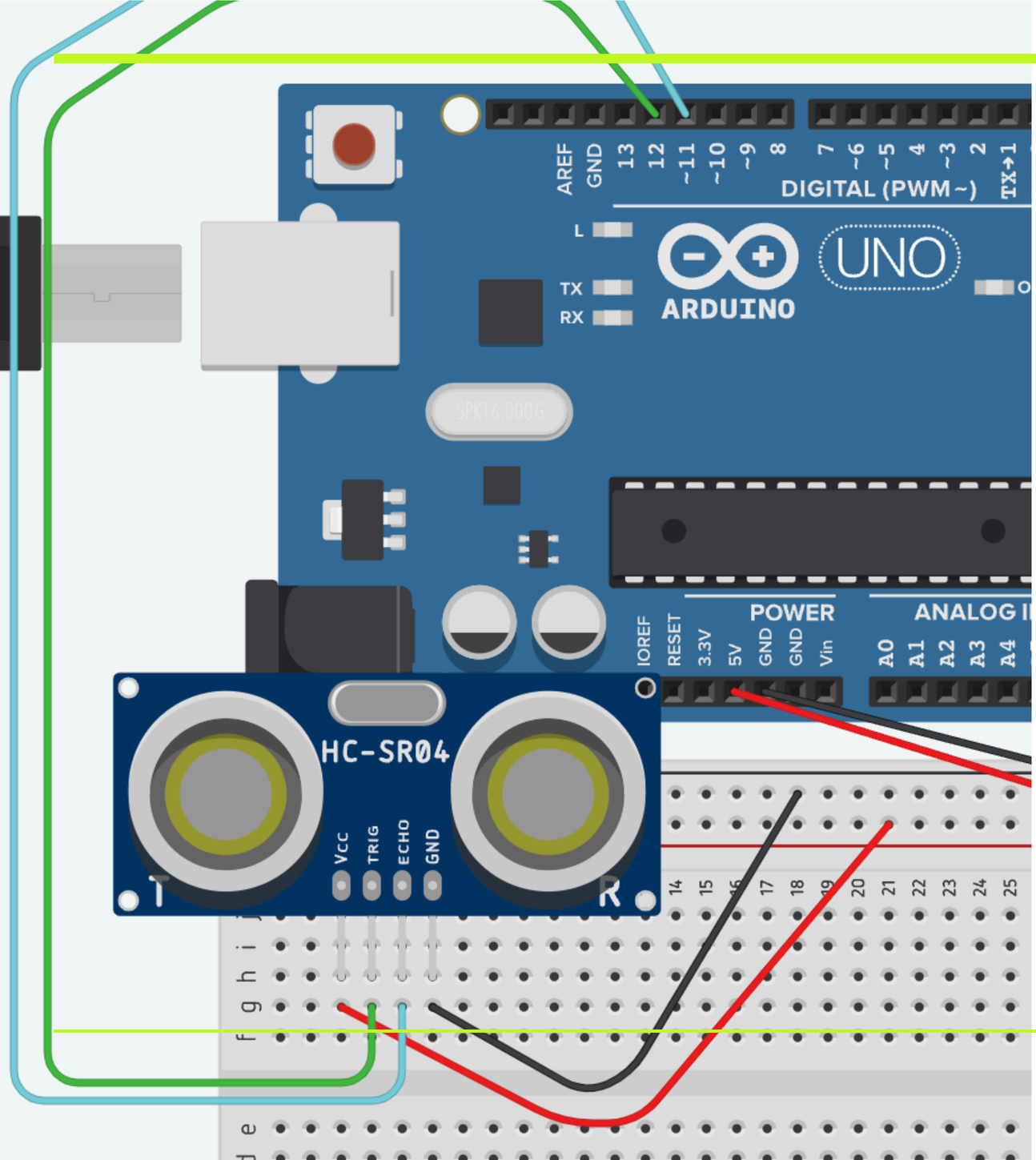
- Sketch>Include Library>Manage Libraries…
- Search for library for a particular sensor/function



Ultrasonic Sensor

Install the HC-SR04 Library

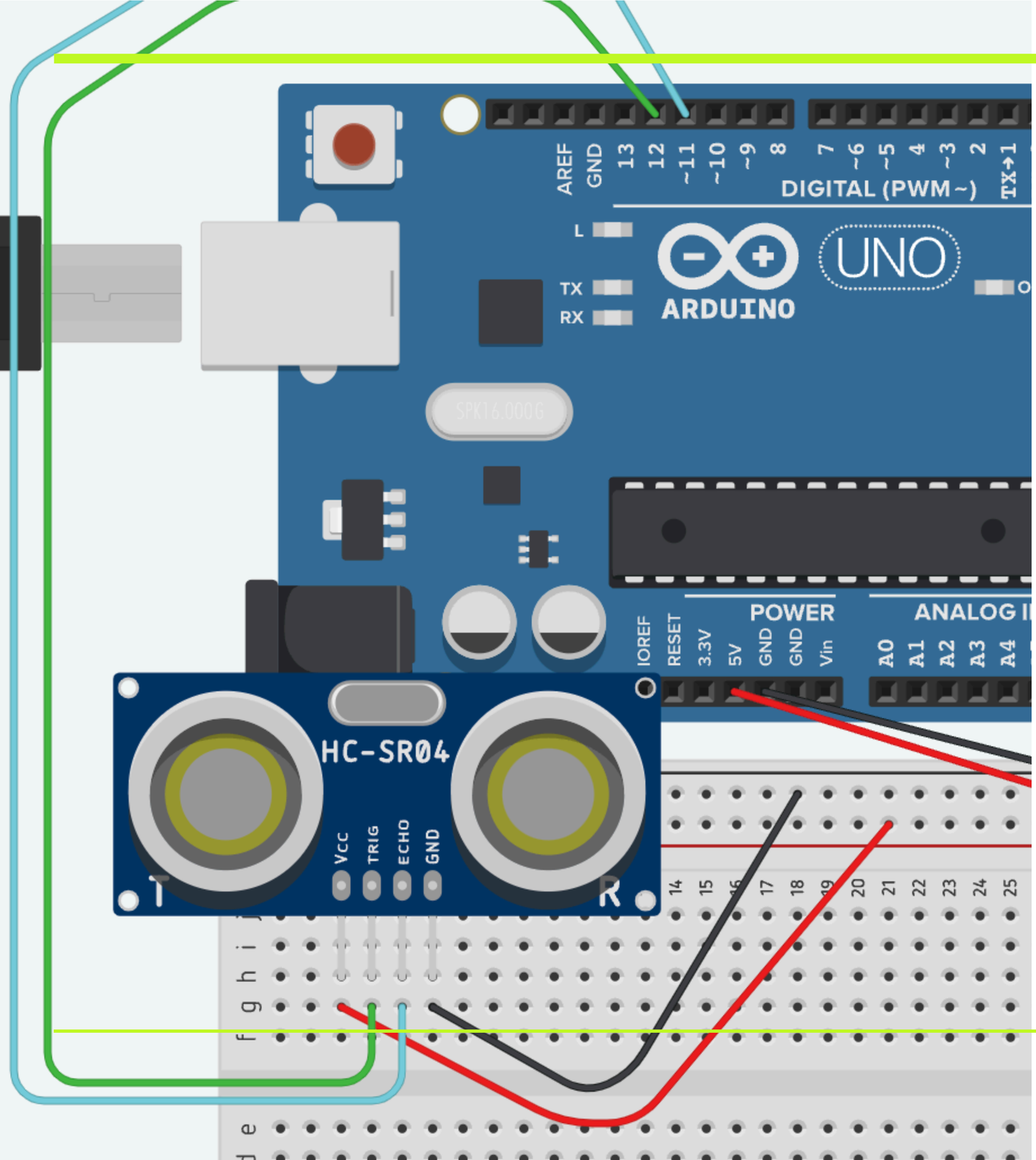
- Search for HC-SR04
- Install the HC-SR04 library by Dirk Sarodnick



Ultrasonic Sensor

Hooking Up the Ultrasonic Sensor

- VCC > 5V
- TRIG>12
- ECHO>11
- GND>GND



Serial Monitor

- Examples>HC-SR04>HC-SR04_SIMPLE
- Serial Monitor shows Distance in CM

Practical

- Ultrasonic Sensor
  - Install Library, set up circuit and run example from library
  - Examples>HC-SR04>HC_SR04_Simple
- Try and use the Distance sensor to control your Servo

millis()

- Counts up the milliseconds
  - 1000 milliseconds every second.
- Can be used as a timer in 2 ways.
  - Using if statements and a variable containing a previous value
  - Using Modulo (%) to make a loop and using map() to turn that to the range required.

Modulo (%)

- Gives the remainder when divided by a value
- 455%100 = 55
- 3540%3000 = 540
- We can use this on a number which increases forever to make it into a number that loops
  - millis()%4000 gives us a number which goes from 0-4000 then jumps back to 0 and starts again and takes 4 seconds to do so.

Using Sensor Data

- You might find the data from you sensor is noisy and moves around more than it should.
- We have some solutions to help us fix this.

- **Calibration - Knowing your data range**
  - Timing using millis()
  - Once in setup()
- **Smoothing - Fixing Erratic Data**
  - Arrays
  - Repeatedly in loop()

Time/Timer

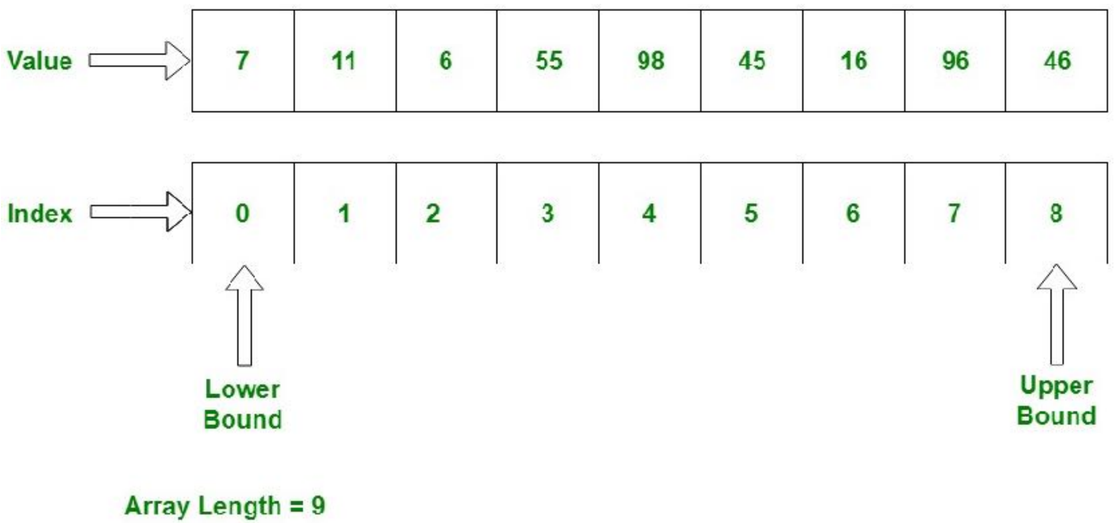
- **Use millis() instead of delay()**
- Returns the number of milliseconds passed since the Arduino board began running the current program. This number will overflow (go back to zero), after approximately 50 days.

```
const int ledPin = 9;          // pin that the LED is attached to

// variables:
int sensorValue = 0;           // the sensor value
int sensorMin = 1023;          // minimum sensor value
int sensorMax = 0;             // maximum sensor value


void setup() {
  // turn on LED to signal the start of the calibration period:
  pinMode(13, OUTPUT);
  digitalWrite(13, HIGH);

  // calibrate during the first five seconds
  while (millis() < 5000) {
    sensorValue = analogRead(sensorPin);

    // record the maximum sensor value
    if (sensorValue > sensorMax) {
      sensorMax = sensorValue;
    }

    // record the minimum sensor value
    if (sensorValue < sensorMin) {
      sensorMin = sensorValue;
    }
  }
```

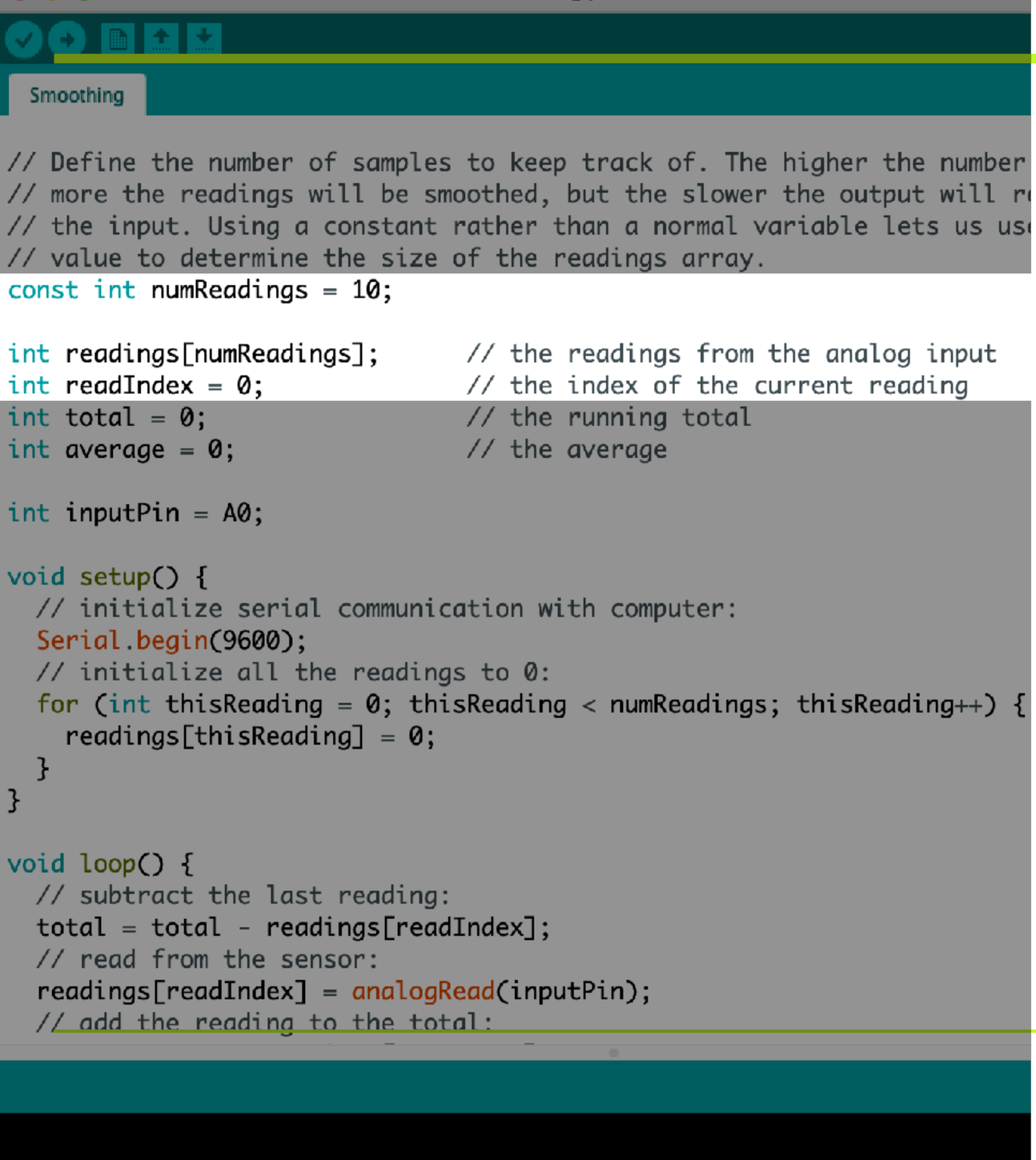
Calibration - in setup()

- Keep reading form the sensor for 5 seconds
- We use a while loop to run some code over and over for a certain length of time.
- Each loop we check if the value we read is higher than the highest we have recorded so far, or lower than the lowest recorded so far.
- If we have a new high or low we save it to the sensorMax and sensorMin variables.
- We can use these later in the code in a map function to get a good range of values from a sensor.

Arrays



- A variable with many different values in it
- A Kind of list
- int arrayName[numberOfValues]
- In arduino we need to say how many values will be in our array when we declare it



Smoothing - in loop()

- First we set the size of the array then we initialise the array with that length

```
  Serial.begin(9600);
  // initialize all the readings to 0:
  for (int thisReading = 0; thisReading < numReadings; thisReading++)
    readings[thisReading] = 0;
  }
}

void loop() {
  // subtract the last reading:
  total = total - readings[readIndex];
  // read from the sensor:
  readings[readIndex] = analogRead(inputPin);
  // add the reading to the total:
  total = total + readings[readIndex];
  // advance to the next position in the array:
  readIndex = readIndex + 1;

  // if we're at the end of the array...
  if (readIndex >= numReadings) {
    // ...wrap around to the beginning:
    readIndex = 0;
  }

  // calculate the average:
  average = total / numReadings;
  // send it to the computer as ASCII digits
  Serial.println(average);
  delay(1);        // delay in between reads for stability
}
```

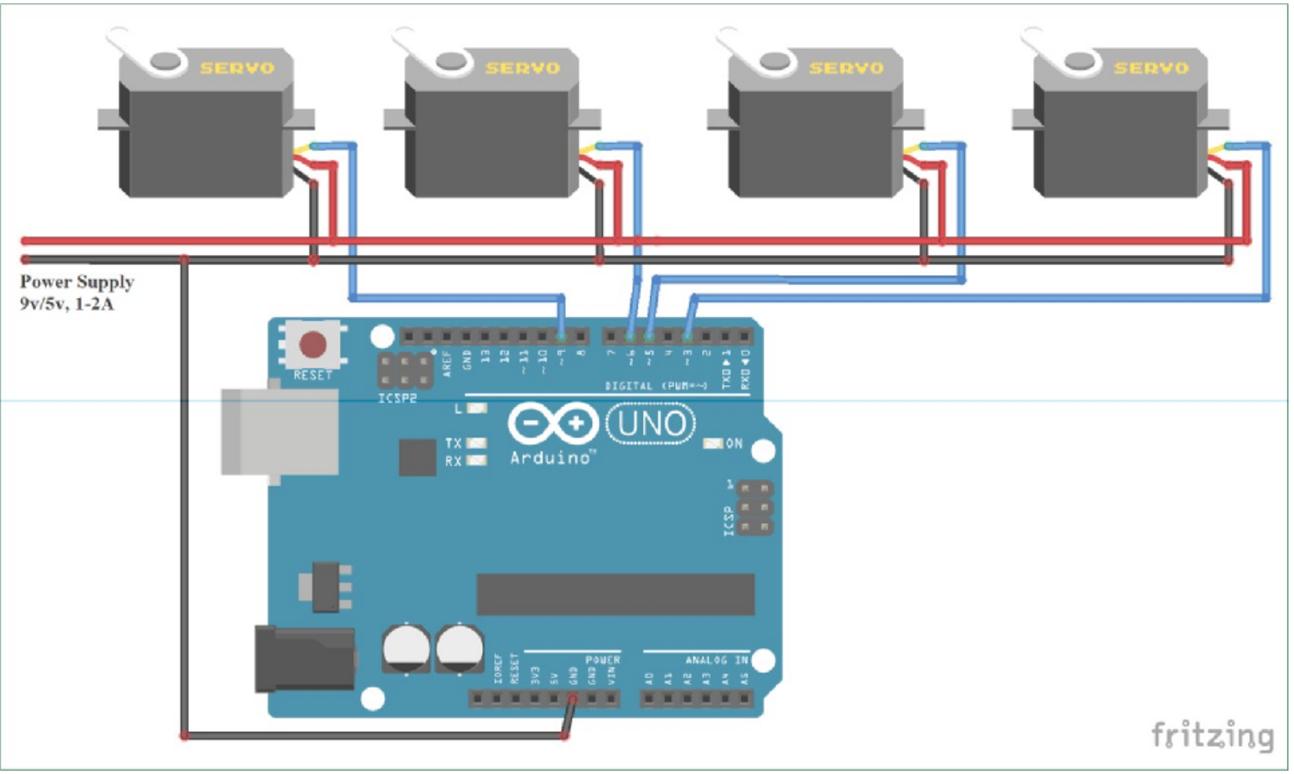
Smoothing - in setup()

- We loop over the array and write a new reading to one position per loop
- Our output is then the average of the last 10 readings

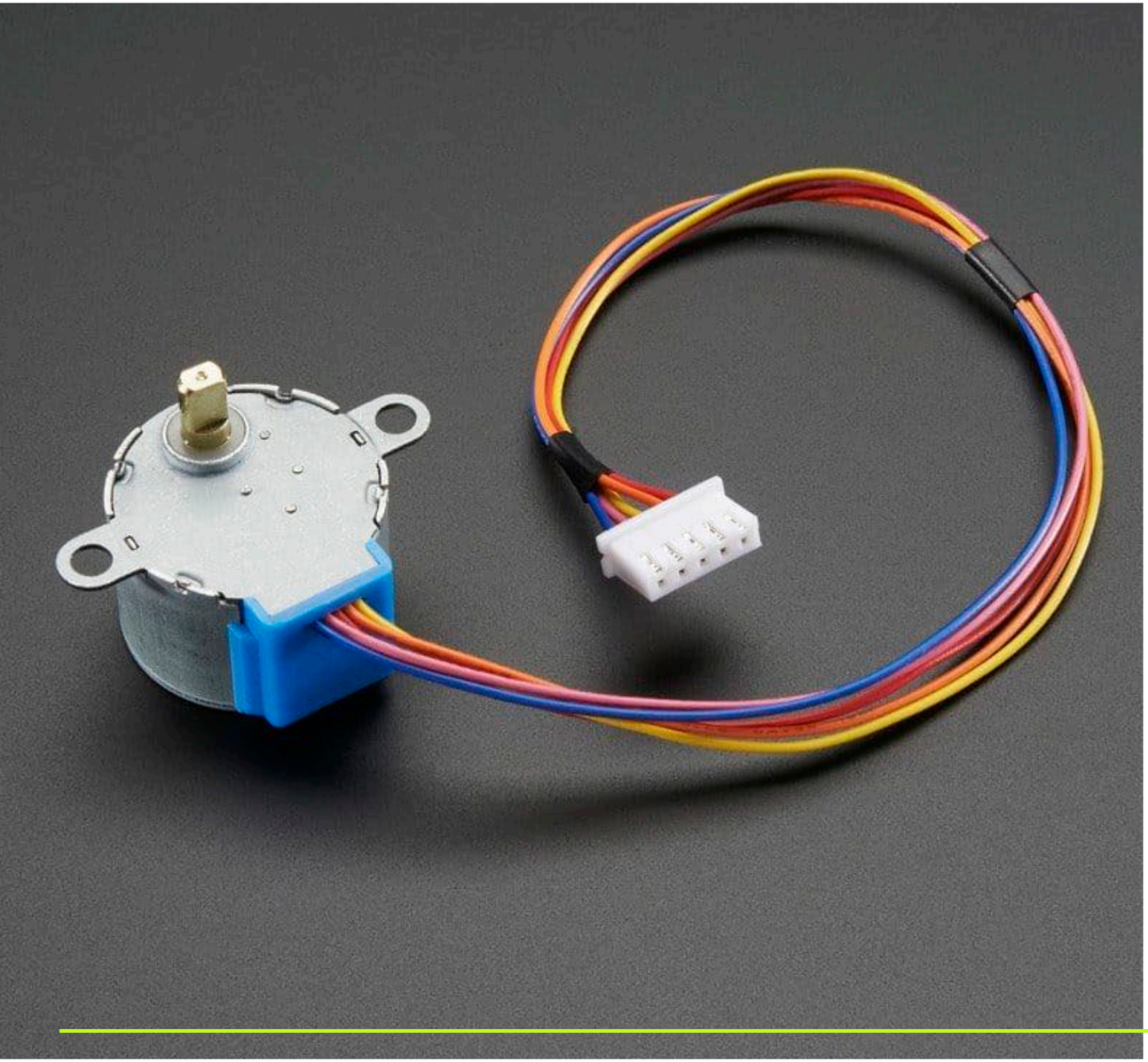
Practical - 2

- Calibrate LDR input Examples>Analog>Calibration
- Smooth LDR input Examples>Analog>Smoothing
- Control the brightness of an LED with the calibrated/smoothed data

Motors & Power



- If you are using more than 1 or 2 motors, or a motor that isn't in your kit you need to use external power.
- The Arduino can only supply 500mA of current, most motors draw more than this and can damage your Arduino (or worse your computer) if you try.
- When you use external power you still need a common ground between the Arduino and the Motor.

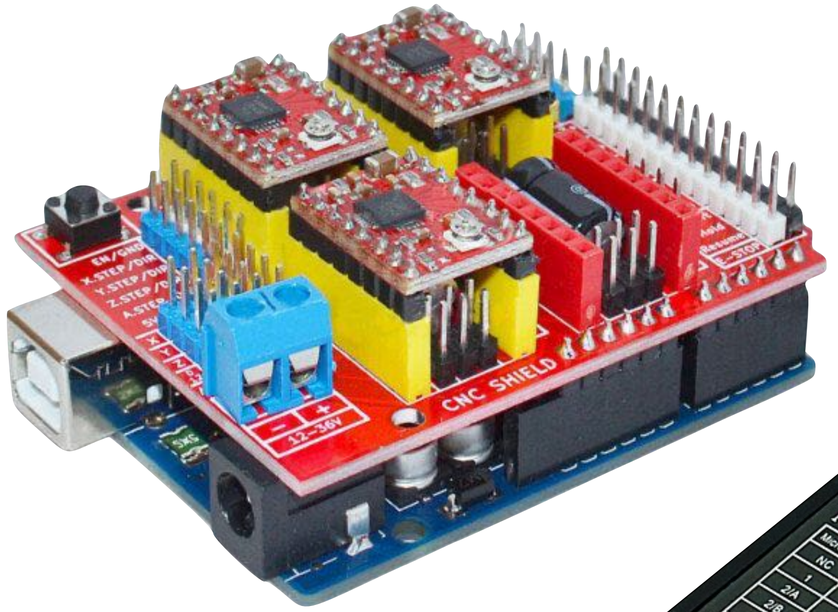


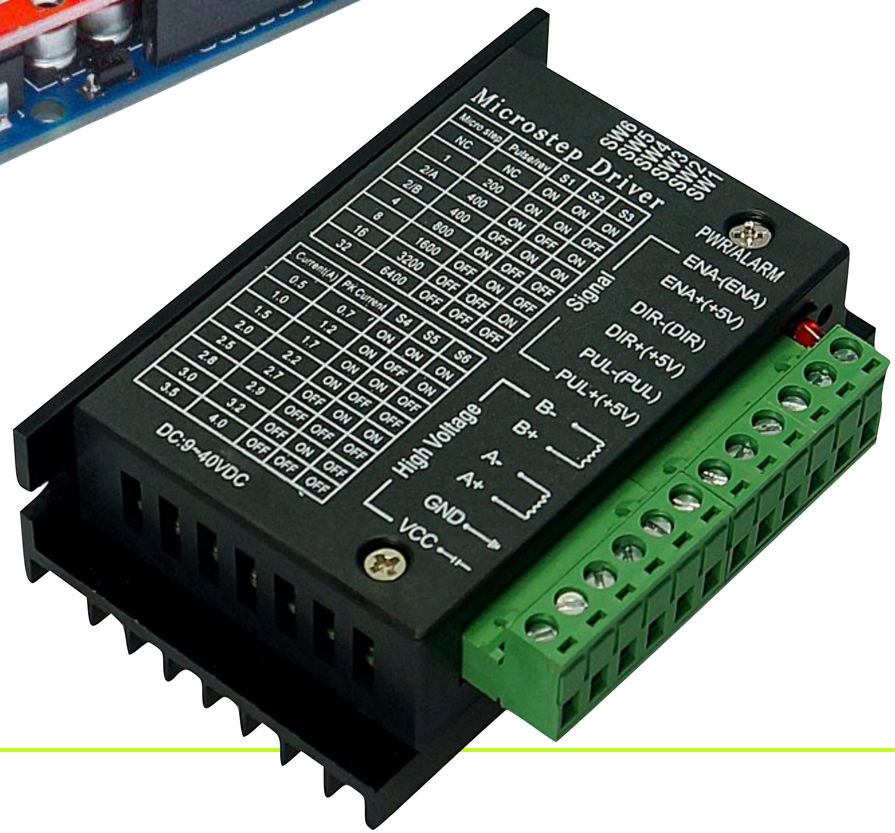
Steppers

- Small Stepper Motor with Driver
- Comes in kit
- Move slowly but can stop at any position

Steppers

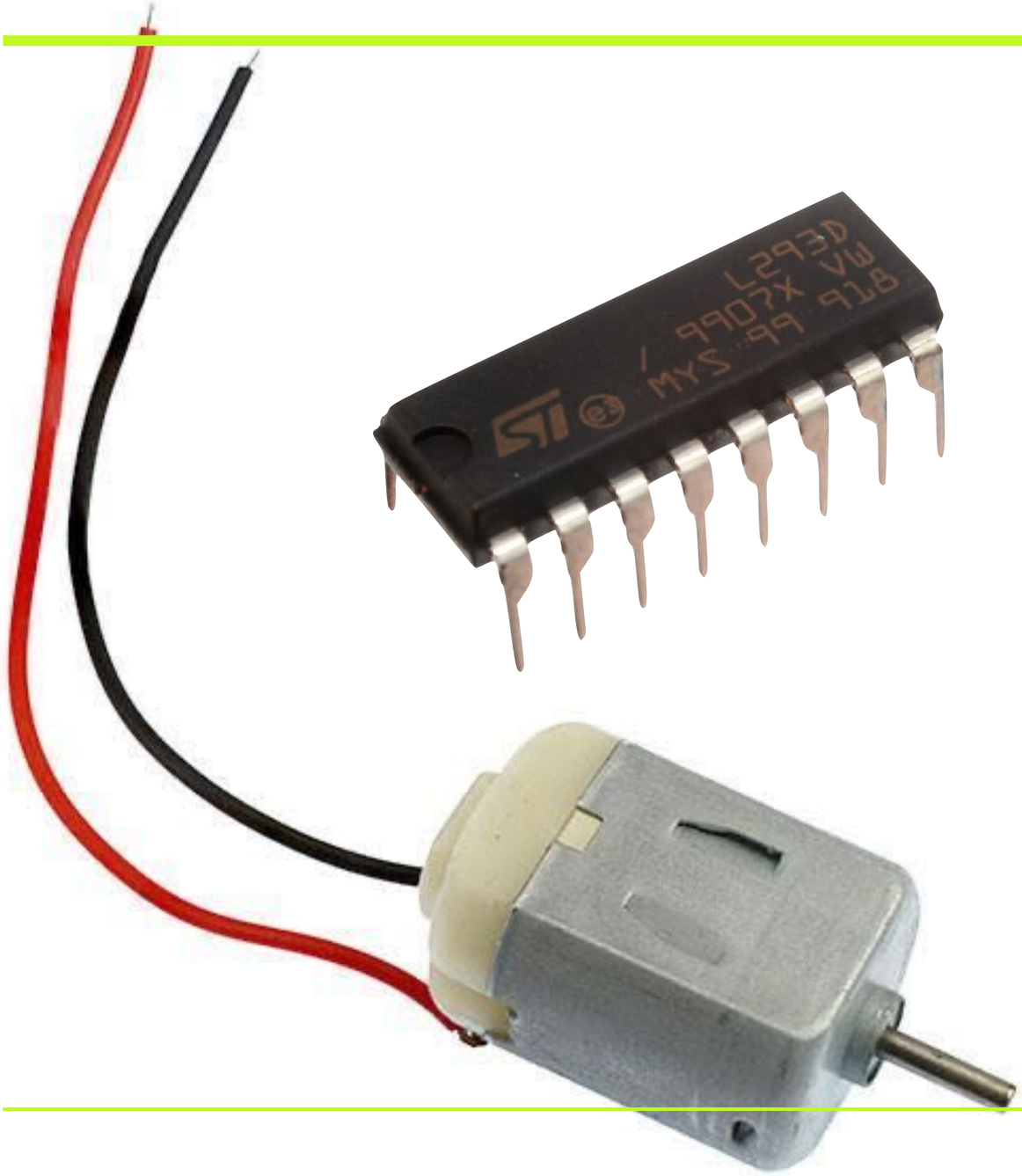
- NEMA 17 stepper motors
- More powerful than the motors in your kit
- Require a separate power supply and Driver





Stepper Drivers

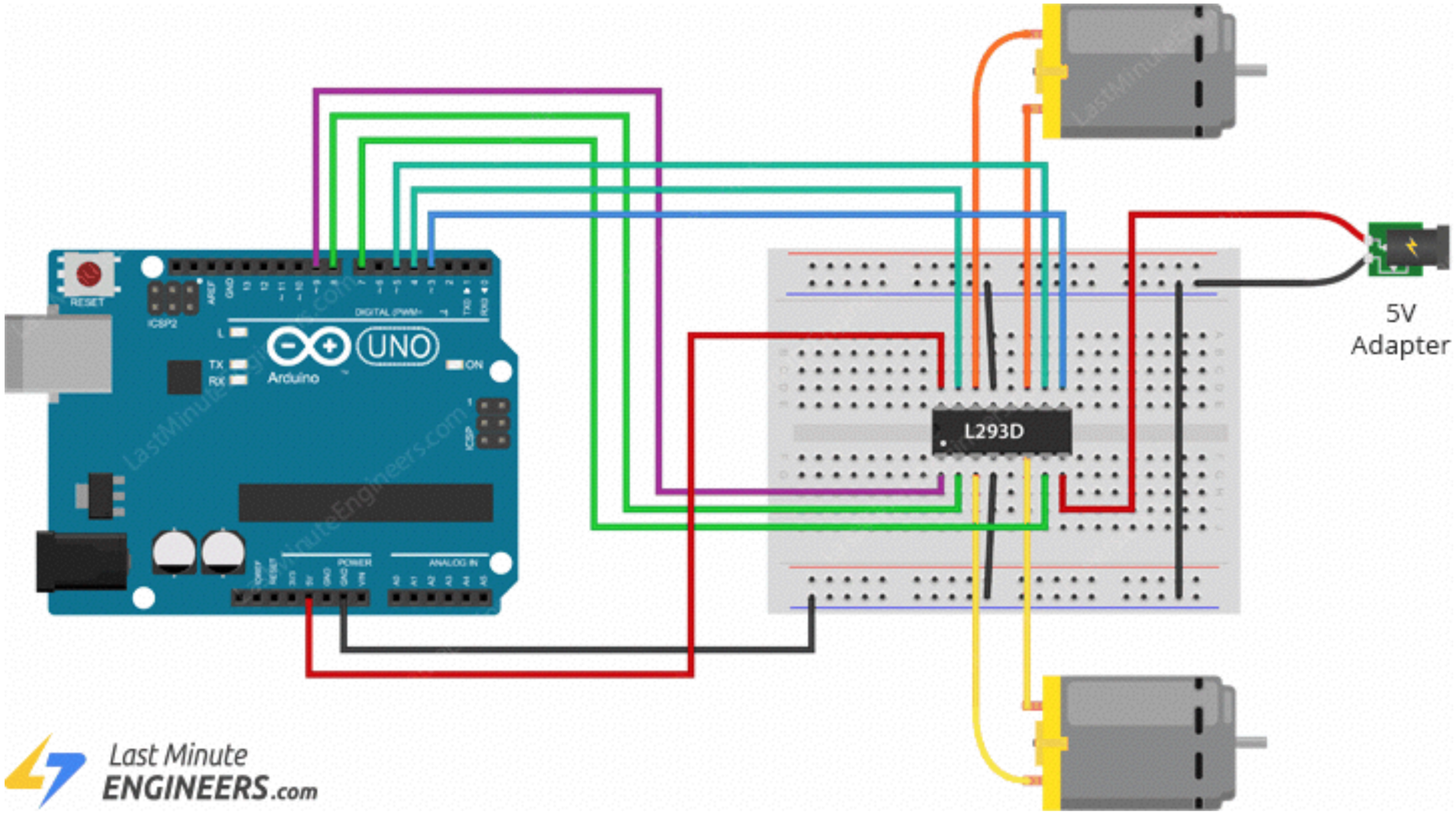
- Stepper drivers come in several types
- A4988 on CNC Shield (Top)
  - Cheap but difficult to use and motors will be loud and can get hot
- TB6600 (Bottom)
  - More Expensive
  - Driver is built with heatsink and terminal blocks which makes it easy to setup and re-use in different projects



DC Motors

- DC Motors spin forever while they are powered
- The driver can change the speed and direction of the motor
- Tiny motors have very little Torque
- This means they only have the force to move pieces of paper

DC Motor with L293D



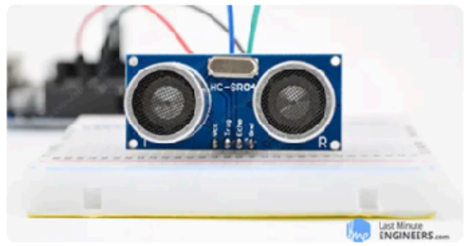
Last Minute Engineers

Arduino Projects

Explore best useful Arduino Projects and tutorials with working principle, pinout, detailed wiring diagram & step-by-step code explanation.

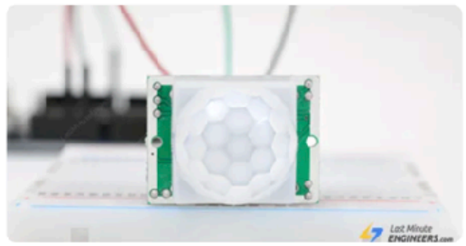
All | Sensors | Modules | Displays | Motors | Wireless & IoT

Sensors



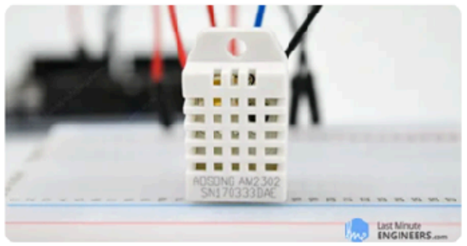
How HC-SR04 Ultrasonic Sensor Works & Interface It With Arduino

Give your next Arduino project bat-powers with the HC-SR04 Ultrasonic Distance Sensor that ca...



How HC-SR501 PIR Sensor Works & Interface It With Arduino

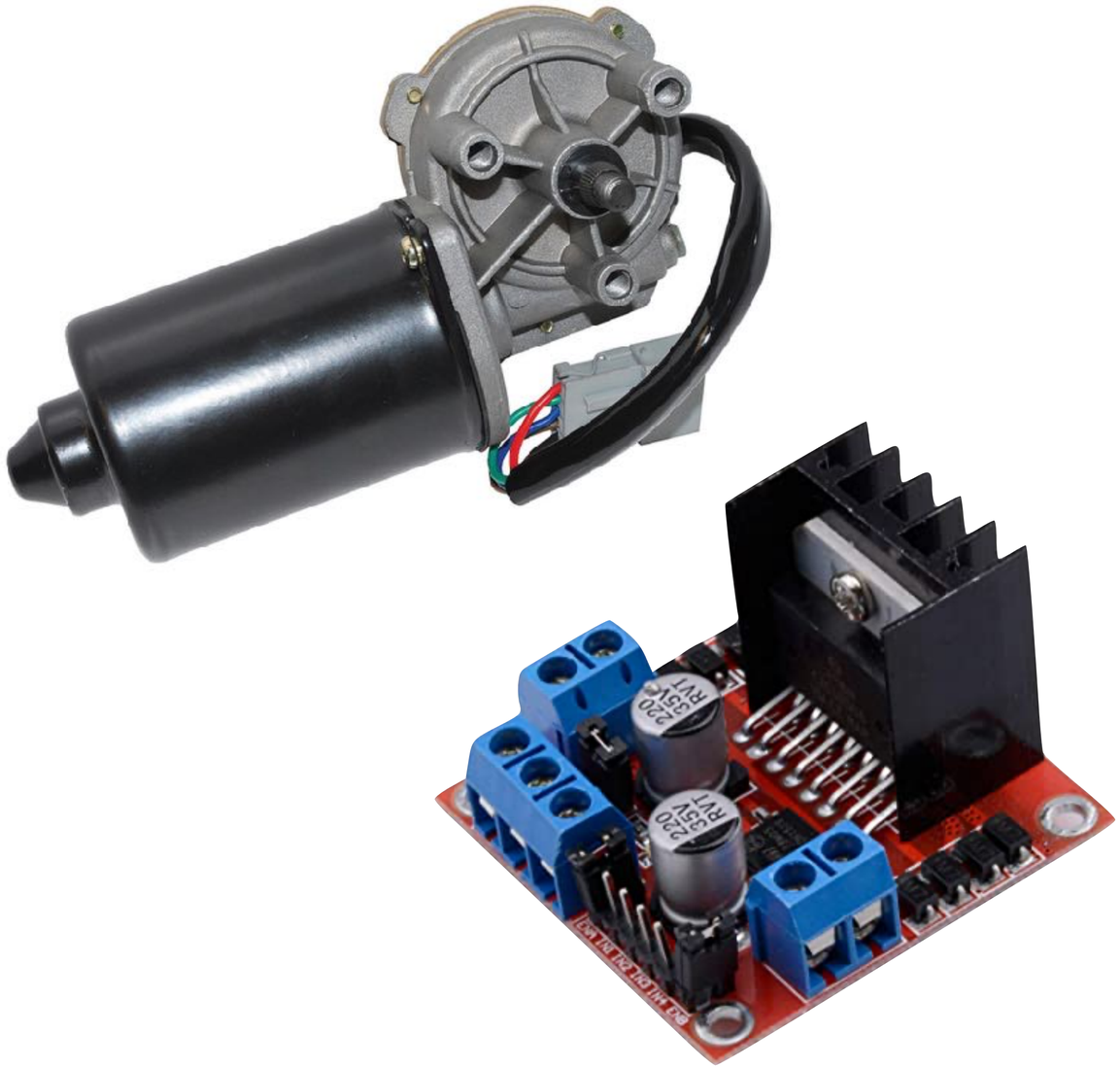
Whether you want to build a home burglar alarm or a trail camera, or perhaps...



How DHT11 DHT22 Sensors Work & Interface With Arduino

Give your next Arduino project the ability to sense the world around it with the...

https://lastminuteengineers.com/electronics/arduino-projects/



DC Motors

- Larger DC Motors use more power but move heavier loads, or spin faster
- They also sometimes include Gears to trade speed for torque
- Speed is measured in Revolutions Per Minute (RPM)
- Bigger motors need a bigger driver like the L298N

Practical - 3

- DC Motor
  - Set up circuit and run the example from the folder on the VLE
- Stepper Motor
  - Run code from the Arduino Examples
  - Examples>Stepper>Stepper_oneRevolution

Practical - 3 - Extension

- Use a potentiometer to control a stepper motor
- Control the direction of a DC motor with a button

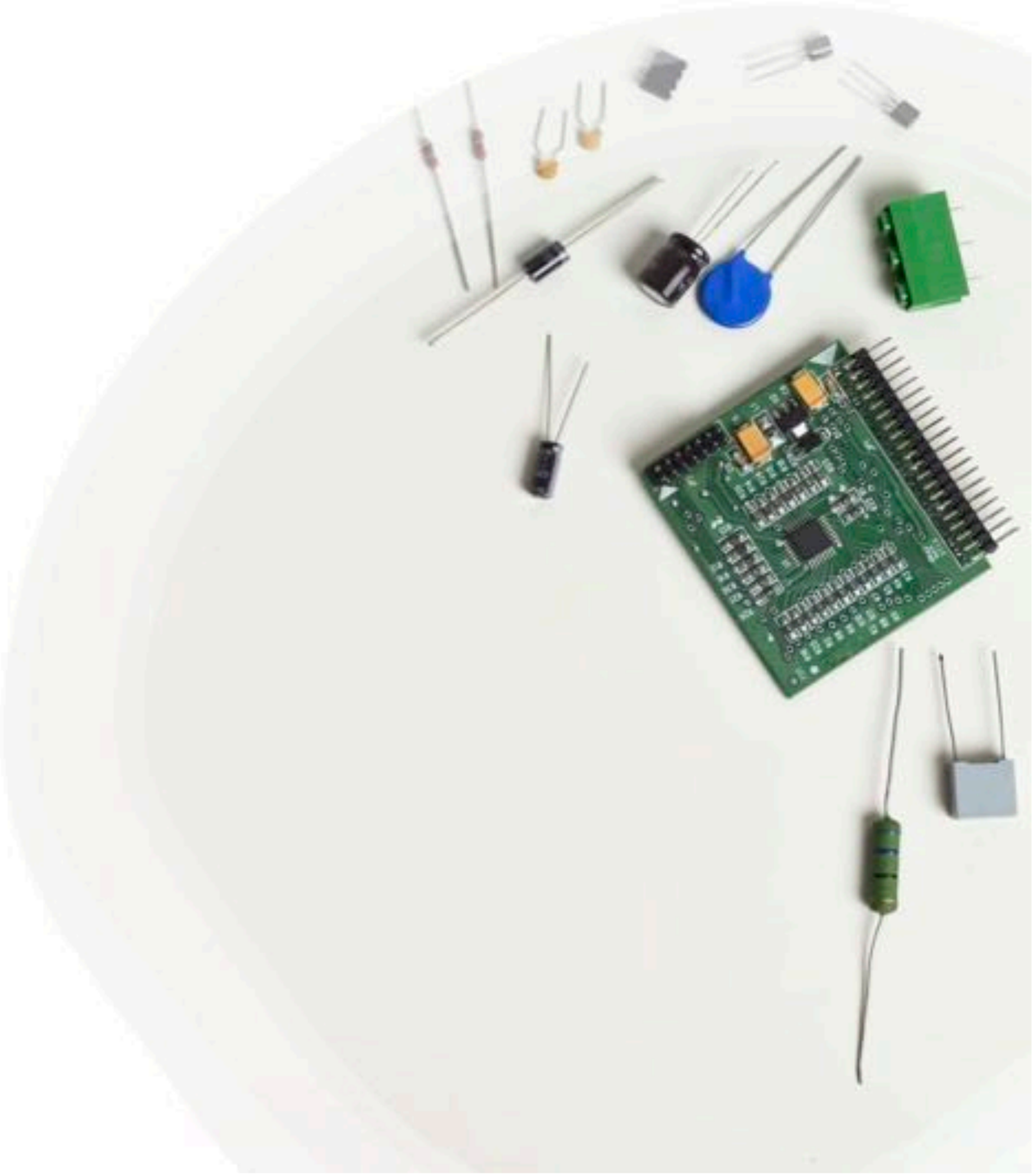
Solenoids

- Can be in one of 2 positions depending on if the power is on or off
- Must be switched on/off with a relay or a MOSFET

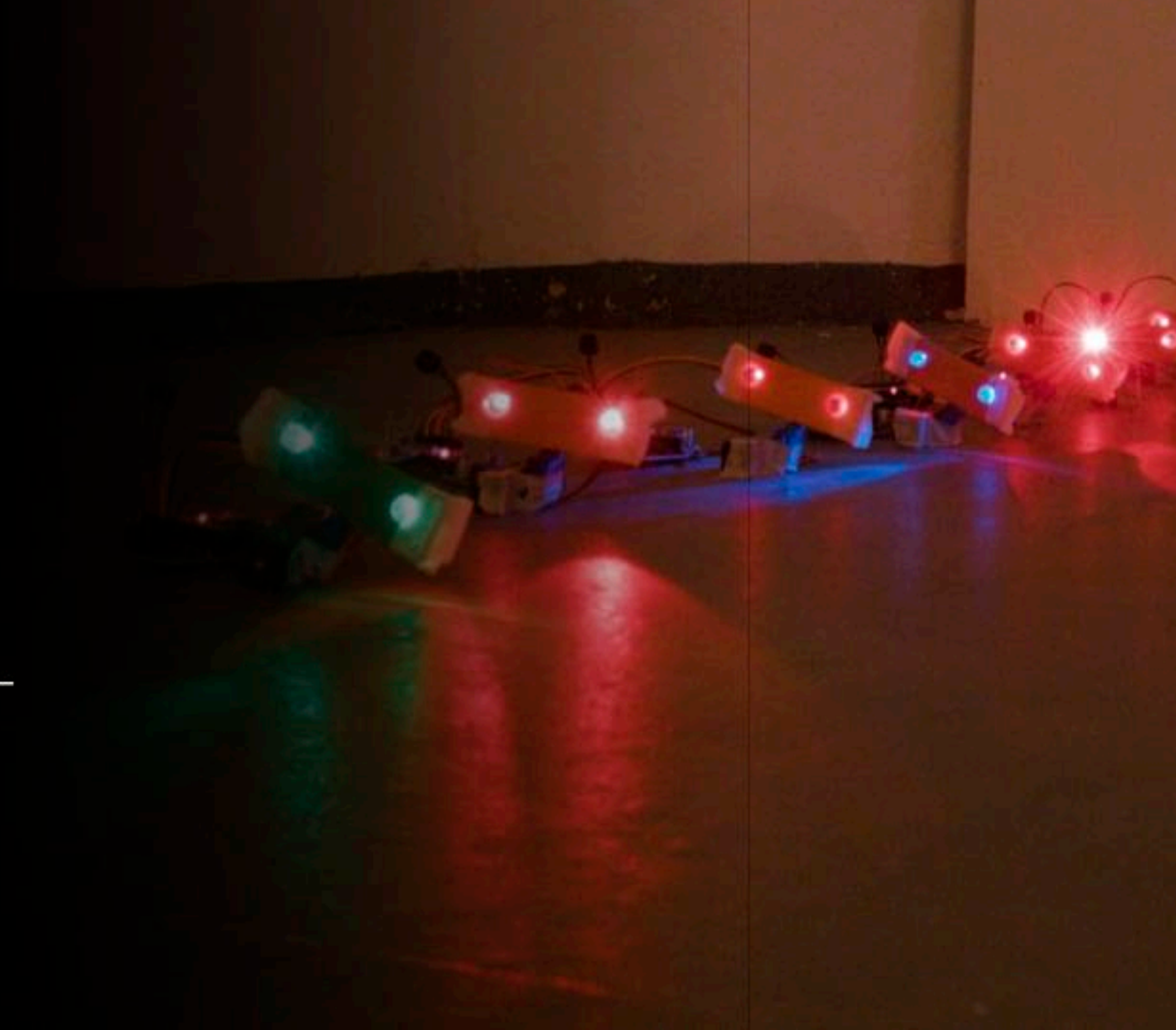
Linear Actuator

- Uses a regular motor and some mechanism to get linear motion
- Moves linearly and can stop at any position along the way.
- Often have sensors inside to stop the motor at fully open and closed positions

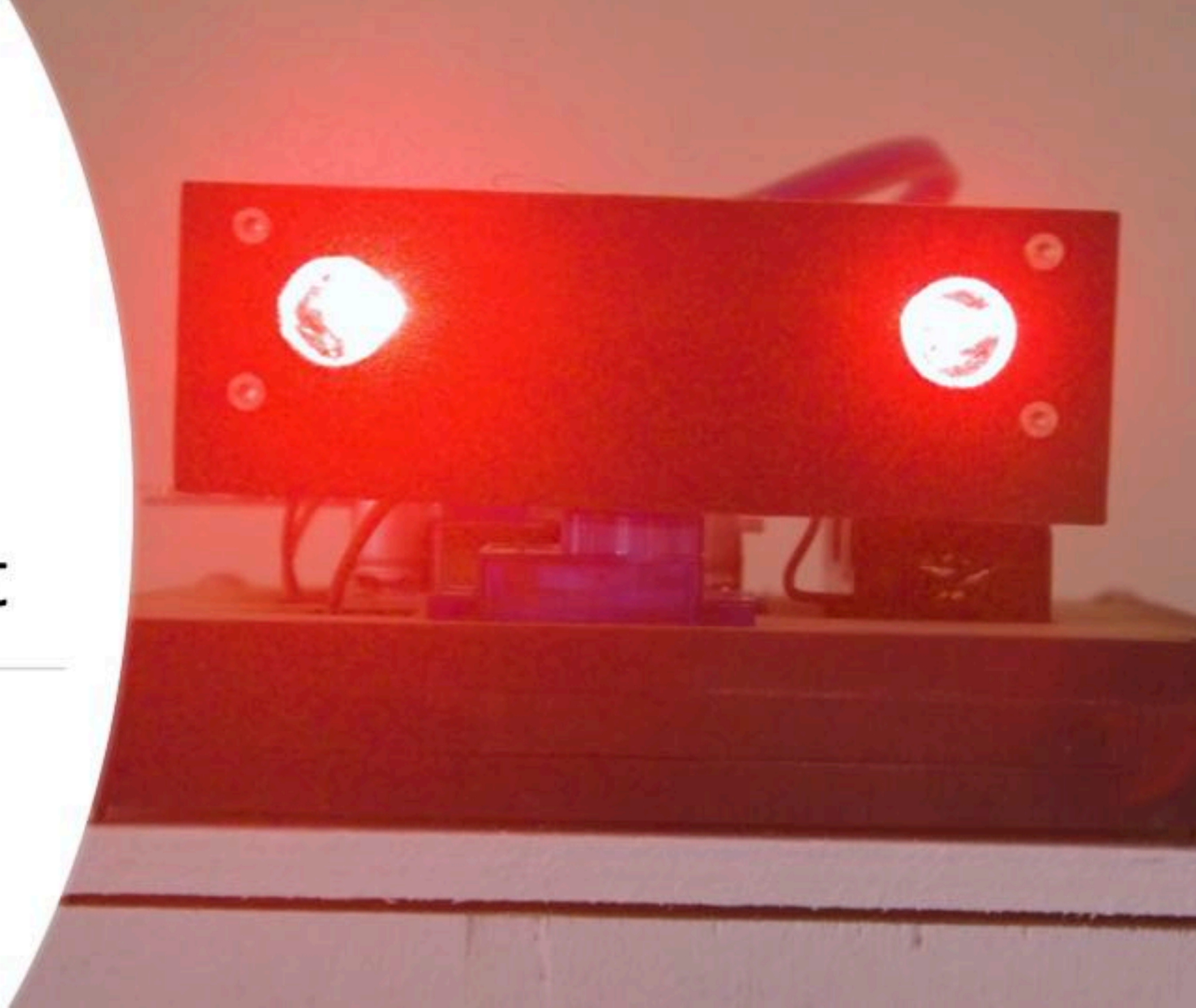
Fabrication in the Lab and at Home



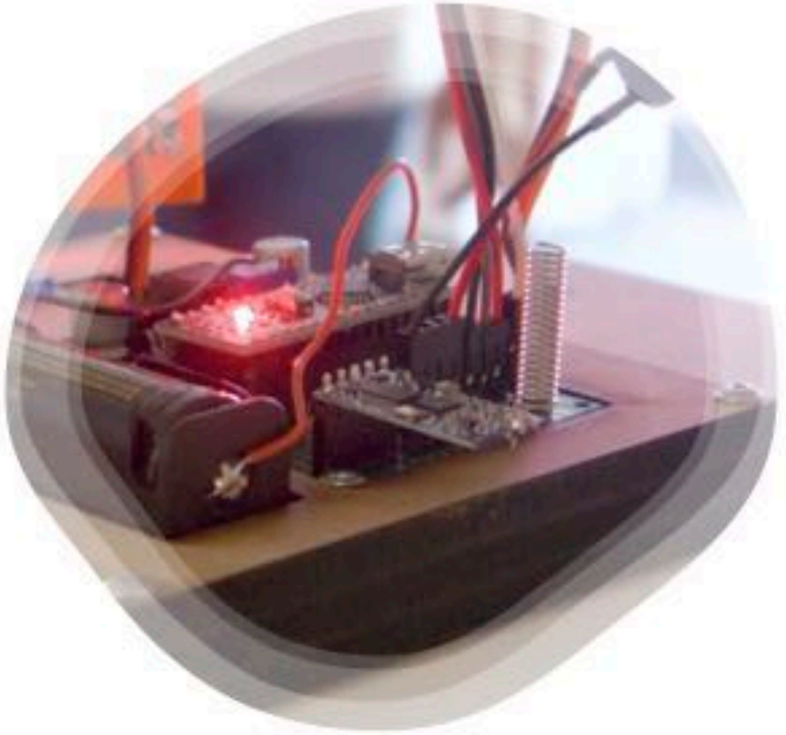
Defining the idea and setting the parameters



Defining a Minimum Viable Product



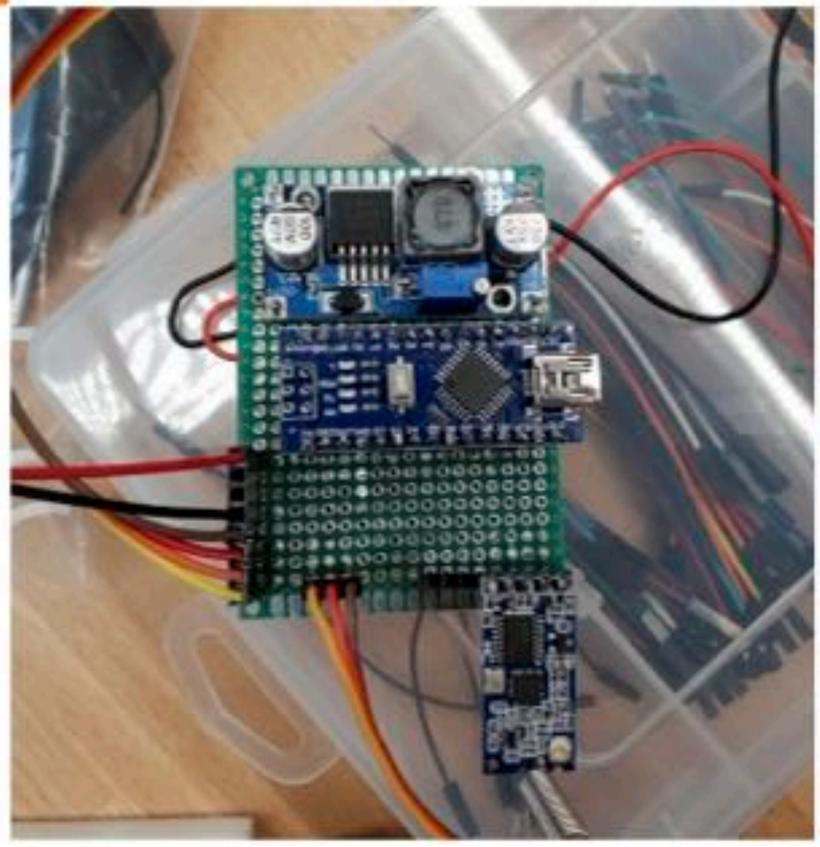
Very Cheap, Too Complicated

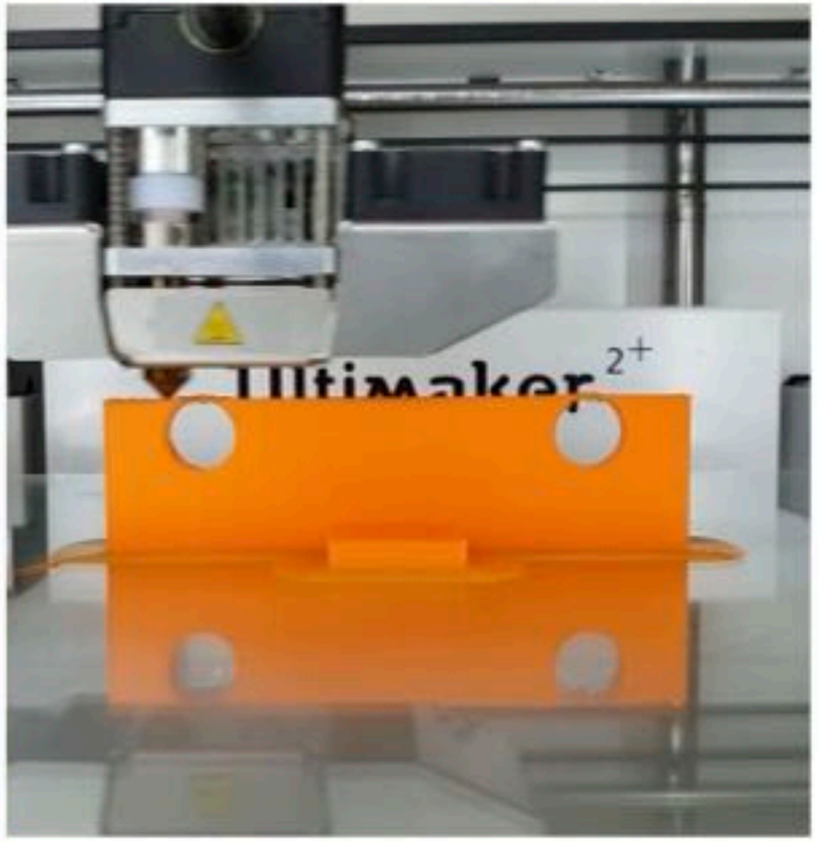


More expensive, Very Easy

More expensive, More Difficult, Most Potential

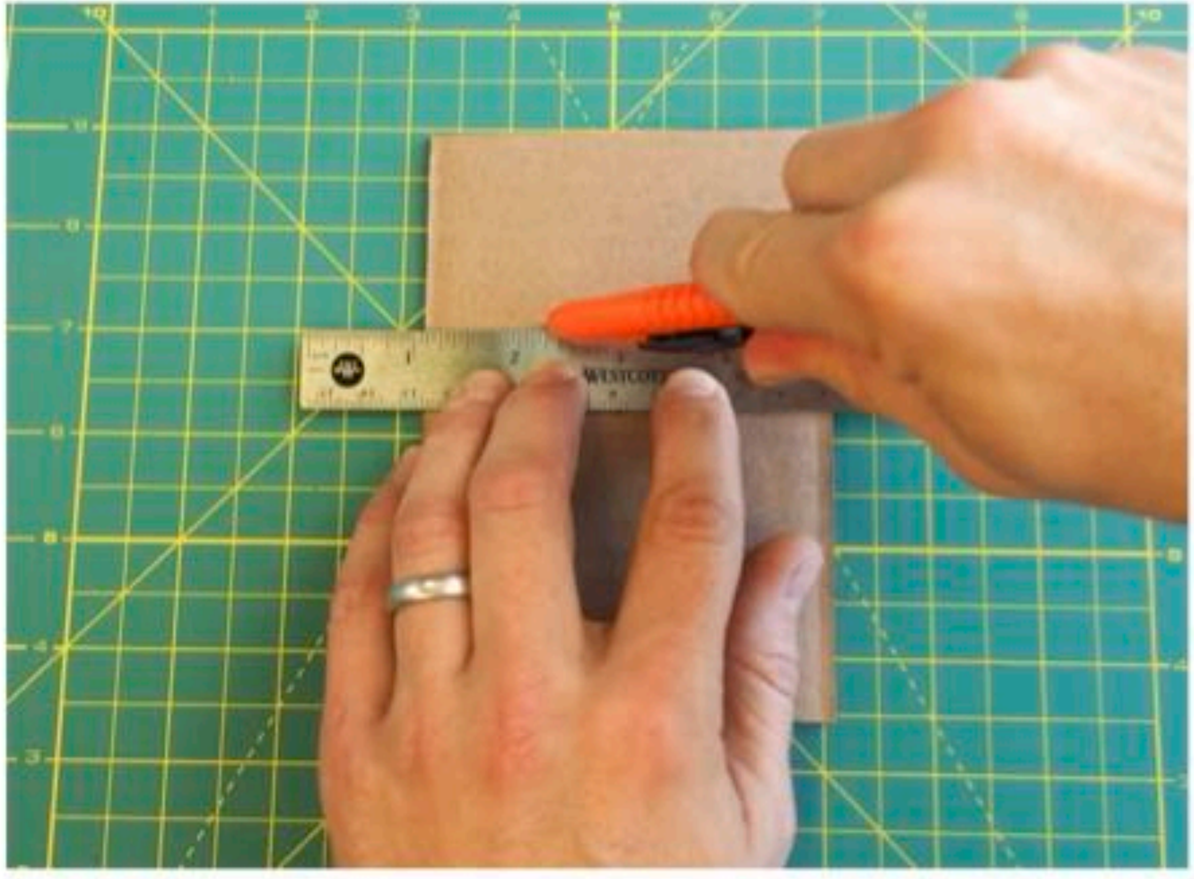
Finding the Right Technology

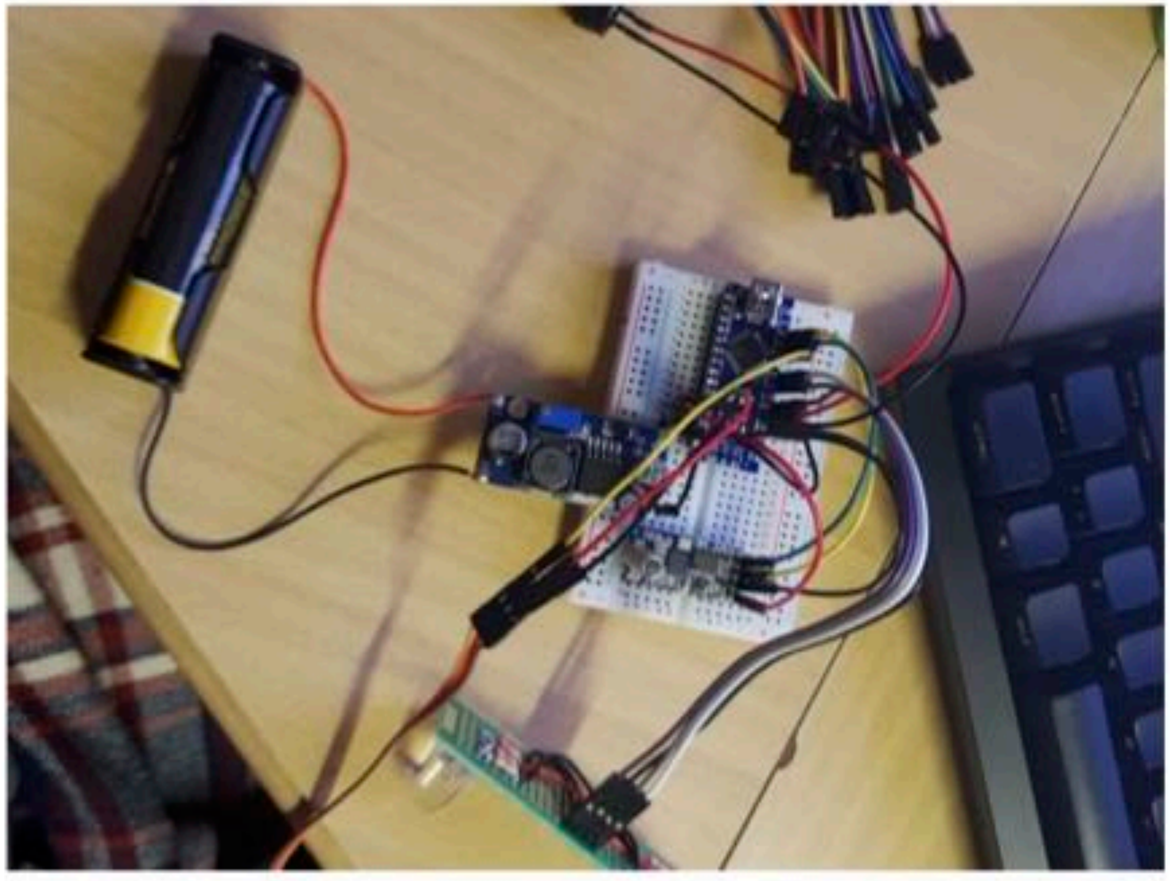




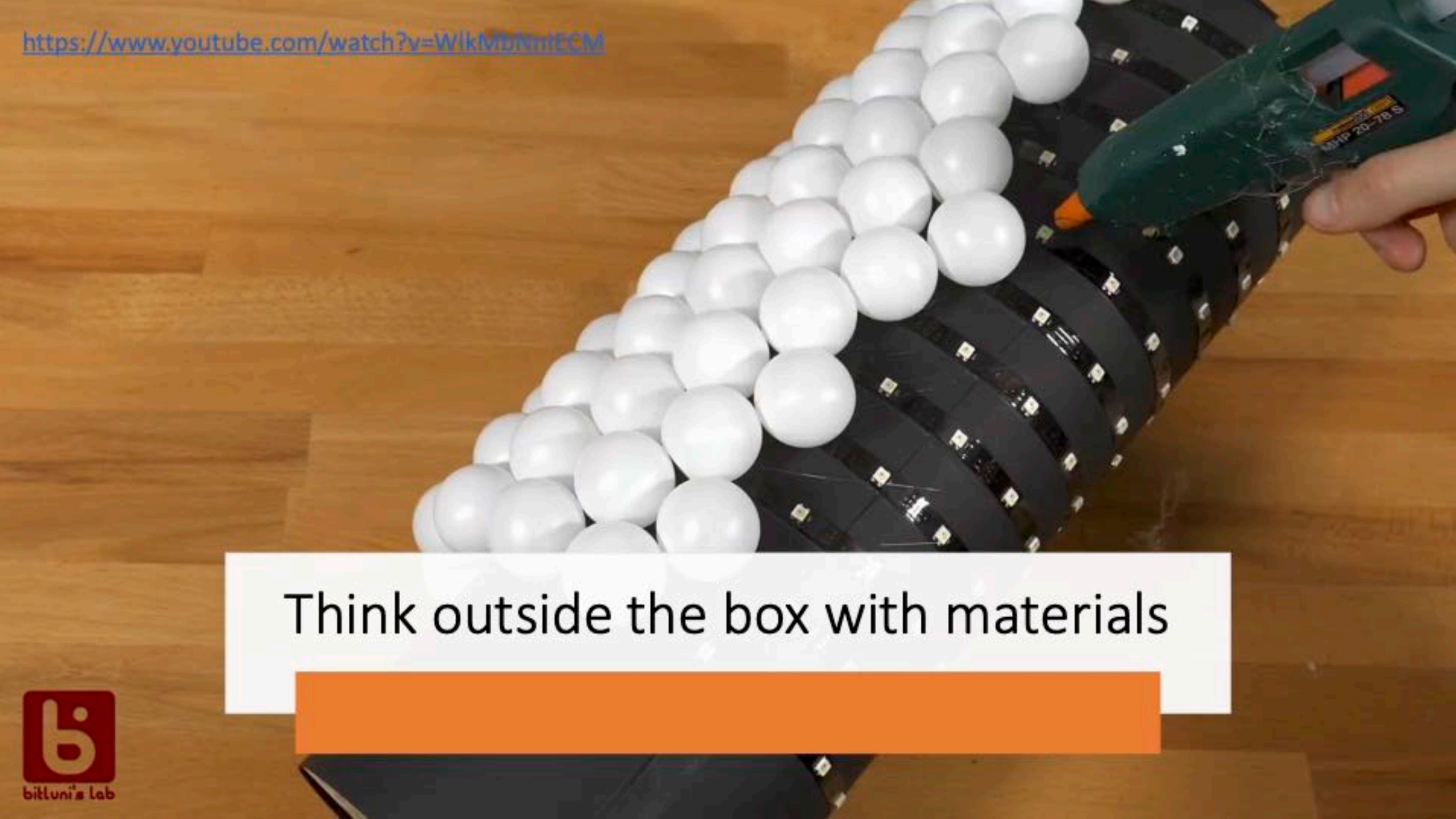
Fabrication in the Lab

Fabrication At Home





https://www.youtube.com/watch?v=WlkMbNmfECM



Think outside the box with materials

bitluni's lab

List of Cheap Useful Tools and Materials

- Soldering Iron
- Hot Glue Gun
- Cutting Matt
- Scalpel or other blade
- Cardboard
- Foamboard
- Screwdriver Set

Don’t Be Afraid to Modify Something

https://youtu.be/PC2-D_Pk1s8

Project Discussion / Ideation

NO TECH TALK

- If anyone in the group uses ANY technical language please stop them and ask the to explain **THE IDEA/CONCEPT!!!**
- **NOT** how they will make it!
- **NOT** what components/software they will use!

Group Project Discussion / Ideation

- Get into groups - 3 People Per Group
- You will have 5-10 minutes each to discuss your ideas in turn
- Imagine you are talking to someone who knows nothing about electronics, computers, physical computing or coding.
- Speaker - Please try to explain
  - What is your current idea?
  - What do you want to make?
  - How will it be used?
  - What will it look like?
  - What makes it interesting, fun, strange, intriguing, or whatever you are trying to communicate

Group Project Discussion / Ideation

- Listeners - Please try to question the speaker about their project
  - Why do you want to make that?
  - Have you thought about … ?
  - I don’t understand this bit … can you explain a bit more?
  - I can see a problem with … ?
  - I wonder if you might … ?
  - I really like … because …
  - How will people know how to … ?

What is this?

Project Proposal

You should submit a proposal in PDF format for the project you'd like to make between now and the end of term.

Describe the project using words, drawings and diagrams.

Tell us what you plan to make for your MVP, and how you will build the project from there.

Talk about the user journey, **how the user will know what to do with your piece.**

Talk about what your piece will convey to the user.

Project Proposal

- Monday Group Deadline October 29th
- Wednseday Group Deadline October 31st

You should try and answer the following questions :

- What's your project about? Is it a game, installation, instrument, performance or something else?
- What does this project do? What is it for?
- Who is it for? What do you hope the experience will be for the participant? What do you hope they think/feel?
- How do you imagine it setup and where?
- How does this project work? What is the set up?
- What is the input to your system? What is the output of your system?
- What technologies are you using? What hardware, what software?
- A diagram, picture, sketch, photograph of the project
- A video mock up or story board of the interaction
- Any problems you envisage? What challenges might you face? How might you solve them?
- What methods might you use for testing the project?
- What will you need to buy or borrow?
- What new skills will you need to acquire?
- Specific help: anything specific you'd like feedback or help with?

You should submit a proposal in PDF format for the project you'd like to make between now and the end of term.
Describe the project using words, drawings and diagrams.
Tell us what you plan to make for your MVP, and how you will build the project from there.
Talk about the user journey, how the user will know what to do with your piece.