



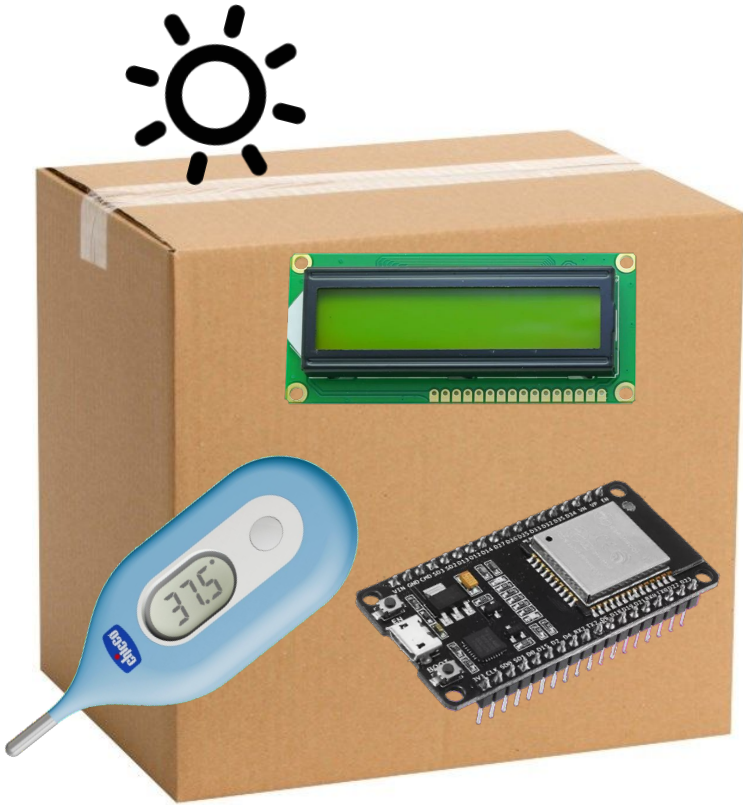
Introduction to Arduino Hardware Hacking

Peter Pfaffeneder

Some googling later...



Conceptual Design





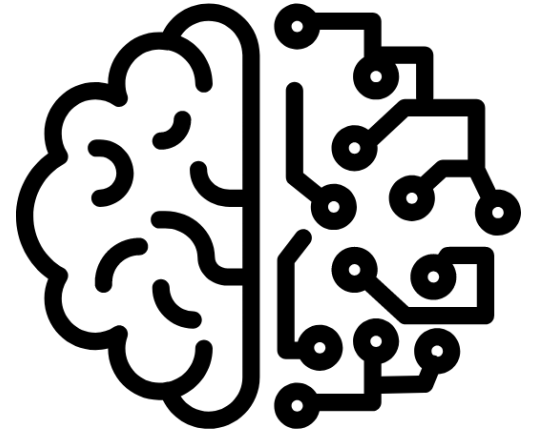
Breaking things down

Approach

1. Idea specification
2. Requirements (Tools/Hardware)
3. Order and wait
4. Do it!
 - a. Prototype individual components
 - b. Put everything together
5. Finalize
 - a. Code cleanup / documentation
 - b. Fix connections (jumper wires -> soldered)
 - c. Casing (3D printed, wood, ...)
6. Next Steps

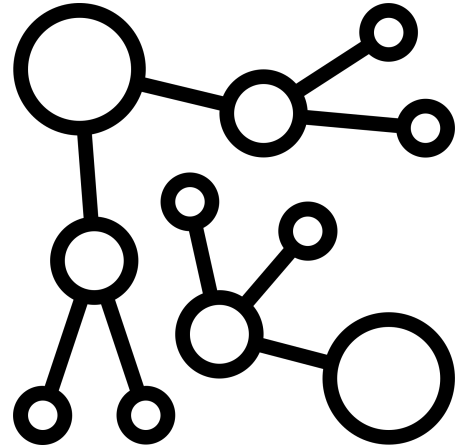
The Brain (aka controller)

- Coordinate interactions
- Compute something
- Notify things (e.g. web service)



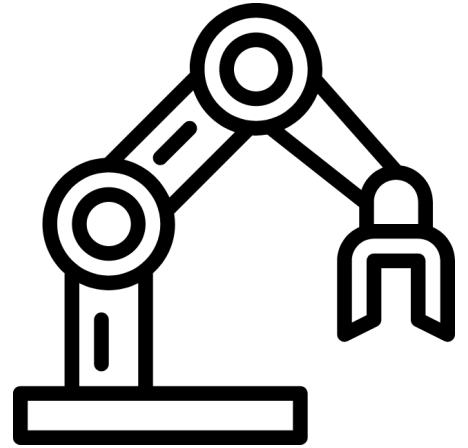
The Nerves (aka sensors)

- Measure things
- Convert to electrical signals



The Limbs (aka actuators)

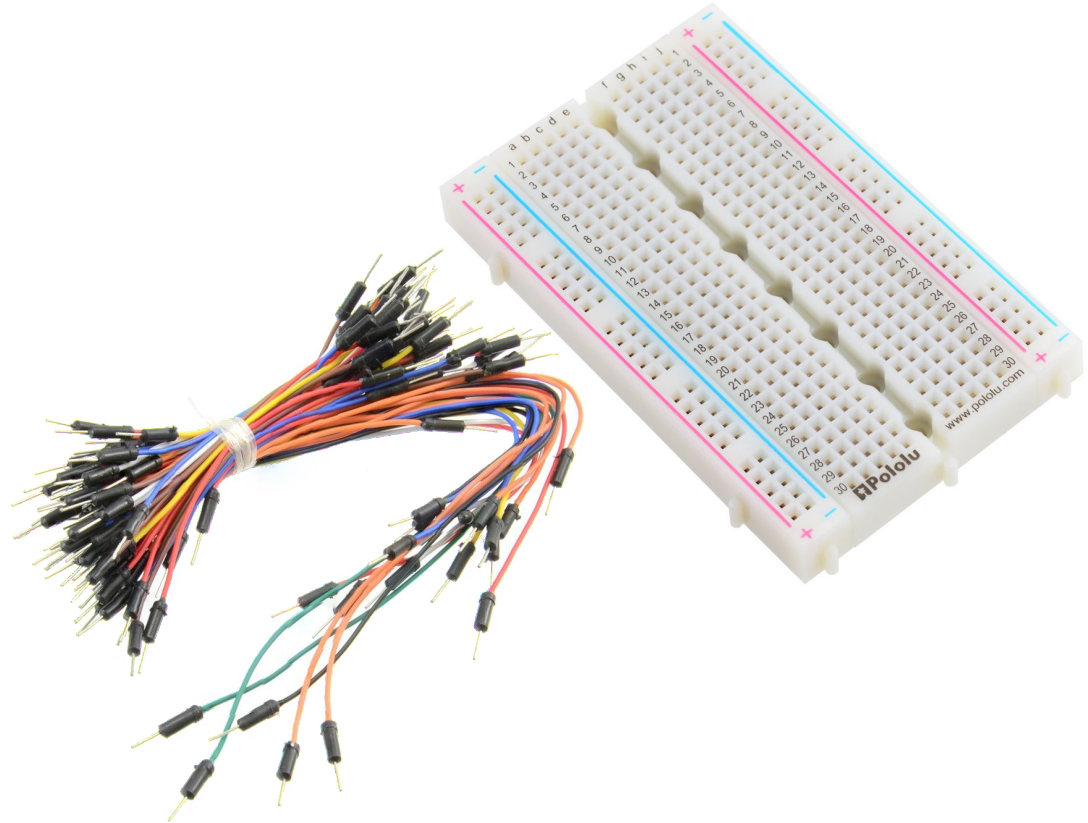
- Receive commands
- Move/display things

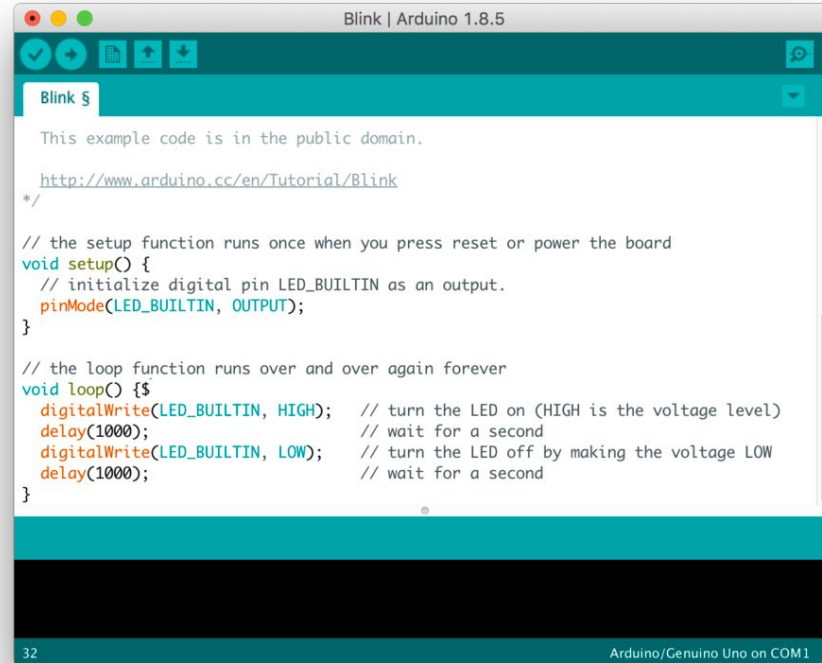


Prerequisites

Prototyping Hardware

- Breadboard
- Jumper wires





The screenshot shows the Arduino IDE window titled "Blink | Arduino 1.8.5". The code editor contains the following text:

```
Blink $
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
}
```

At the bottom left of the IDE window, the number "32" is displayed. At the bottom right, the text "Arduino/Genuino Uno on COM1" is visible.

- Cross-Platform IDE
- Write Arduino Code in C++
- Library Registry
- Built on Atom / VSCode



Library	Purpose
VirtualWire/RadioHead	Interface with various wireless modules
LiquidCrystal	Interface with LCDs
ESP32	ESP32 Library
more can be found in the platformio library registry or google	

20€ 5€

Big €€ is Amazon

- Guaranteed delivery
- Fast

Small €€ is China

- Will it ever arrive?
- High quantity



Hardware Platforms

- Easy to use
- Strong community
- Many boards

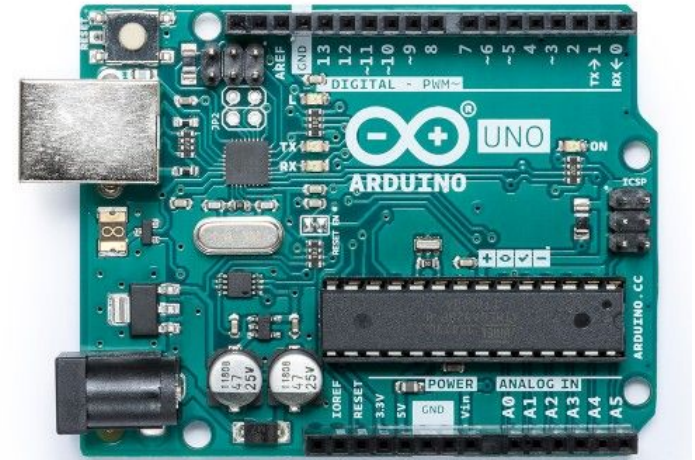


Arduino Uno Rev3

Specs

- 14 Digital I/O Pins
- 6 Analog Input Pins
- A tiny brain w/ 32 KB Flash Memory

20€ 5€

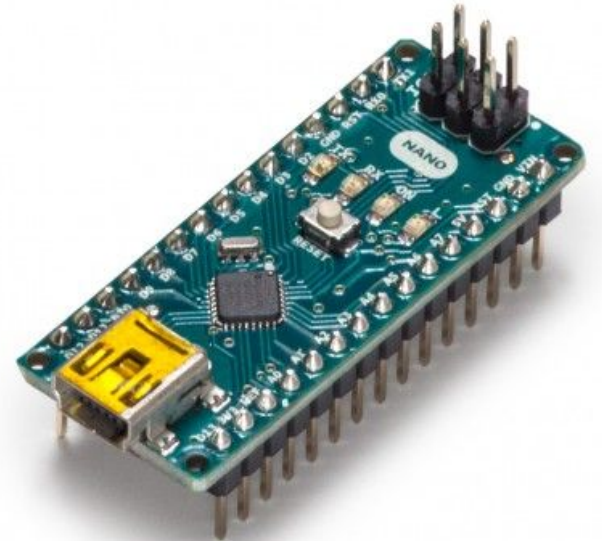


Arduino Nano v3

Specs

- 22 Digital I/O Pins
- 8 Analog Input Pins
- A tiny brain w/ 32 KB Flash Memory

20€ 5€



Features

- Timer Modules
- Deep Sleep Mode
- No wireless connection...

Arduino Code Structure

```
#include <Arduino.h>
```

```
void setup() {  
  // Startup routine  
}
```

```
void loop() {  
  // endless loop  
}
```



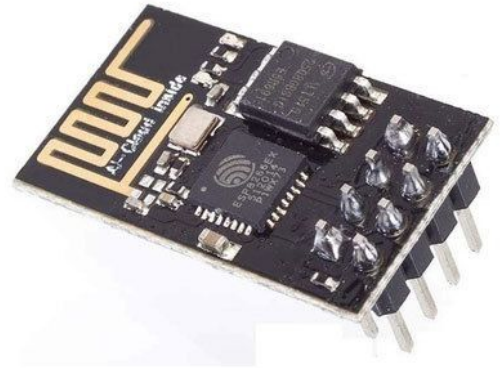
Wireless Communication

ESP-01 WiFi Module (8266 Chip)

Specs

- 802.11b/g/n @ 2.4 GHz
- P2P / softAP
- 3.3 V / 5 V
- needs 3 pins for comm.

3€ 1€



ESP8266 AT Commands

Command	Description
AT+CWMODE<1 2 3>	Set mode (client, server, both)
AT+CWJAP=ssid,pwd	Connect to network
AT+CIPSTART=id,type,url,port	Start a TCP/UDP connection
AT+CIPSEND=id,length	Send data with length

Sending AT Commands

```
#include <SoftwareSerial.h>
SoftwareSerial esp(10, 11); // RX, TX

void setup() {
  esp.begin(9600);
  esp.println("AT+CWJAP=ssid,pswd");
}
```


Sending AT Commands

```
void sendData() {  
    esp.println("AT+CIPSTART=0,TCP,www.server.com,80");  
    esp.println("AT+CIPSEND=0,X"); // X byte long msg  
    esp.println("POST /endpoint HTTP/1.1");  
    esp.println("Host: mydomain.com");  
    esp.println("User-Agent: Mozilla"); // Set more headers...  
    esp.print("Value=");  
    esp.println(myValue);  
    esp.println(); esp.println();  
}
```

<https://www.teachmemicro.com/arduino-wifi-using-esp8266-commands/>



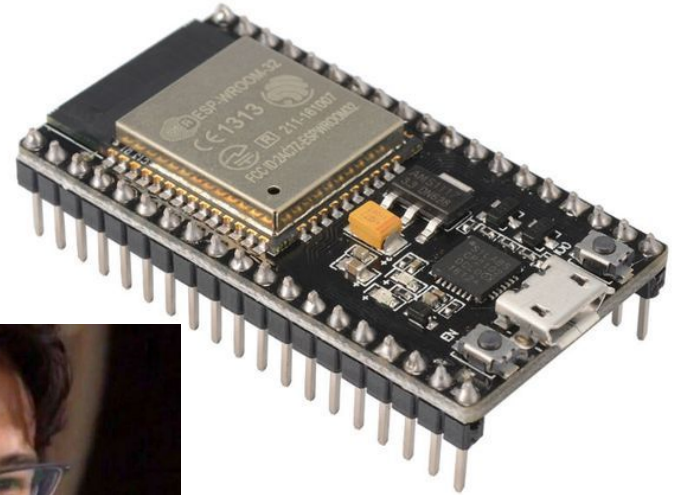
All In One Powerhouse

ESP-32 Dev board

Specs

- 33 GPIO Pins
- 4 MB Flash Memory
- ***Lots of brain***

15€ 5€

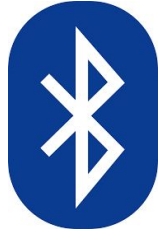


Yeah, this is big brain time.

ESP-32 Dev board

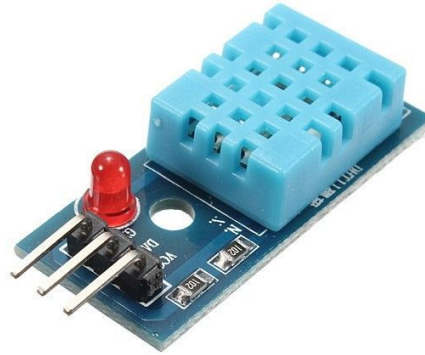
Features

- WiFi
- Bluetooth
- AWS-qualified dev board



Interacting with the world

The Sensor

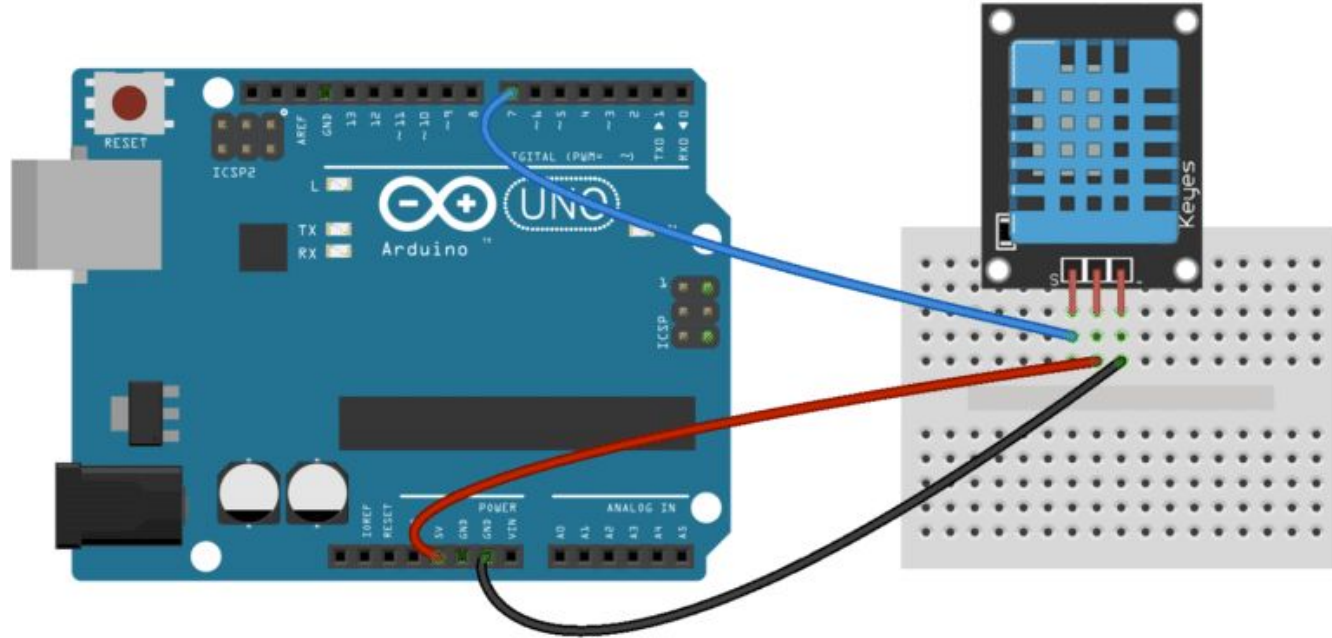


DHT11

(temperature & humidity)

1€

Connecting the DHT11



Reading Sensor Values

```
#include <dht.h>
#define DHT_PIN 7
dht DHT;

void loop() {
  DHT.read11(DHT_PIN);
  double temp = DHT.temperature;
  double hum = DHT.humidity;
}
```


The Display



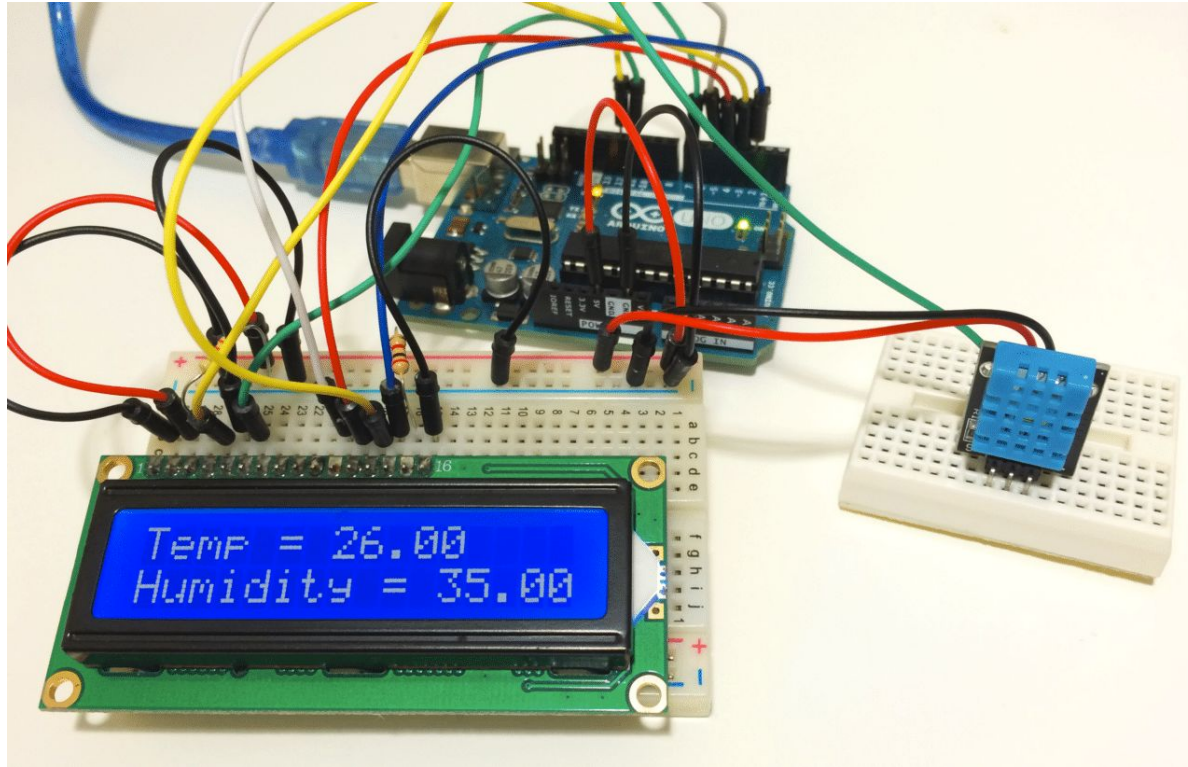
LCD
5€ 2€

Displaying Text

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

void setup () {
  lcd.begin(16, 2); // define dimensions
  lcd.println("Hello World");
}
```

The Result



Growing Cable Salad



Dedicated Tools

- Soldering Iron
- Tin-solder
- Pliers & Wires

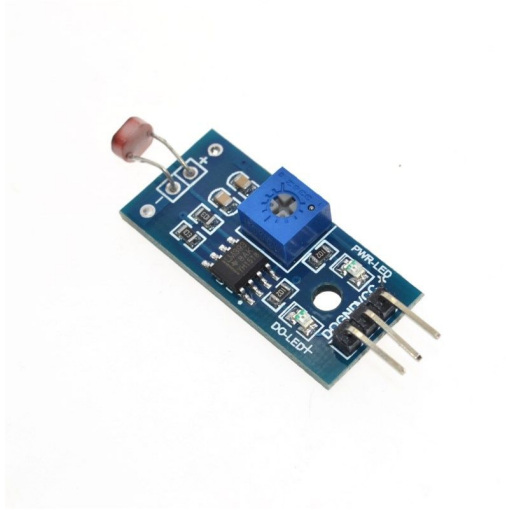
~60€



- Hardware ~15€
 - Arduino
 - LCD
 - Sensors
 - Misc (Resistors)
- Tools ~60€
 - Soldering iron
 - Pliers
 - Tin-solder
 - Jumper cables

Next Steps

Other Sensors



LDR Module
(light-dependent resistor)
0.5€



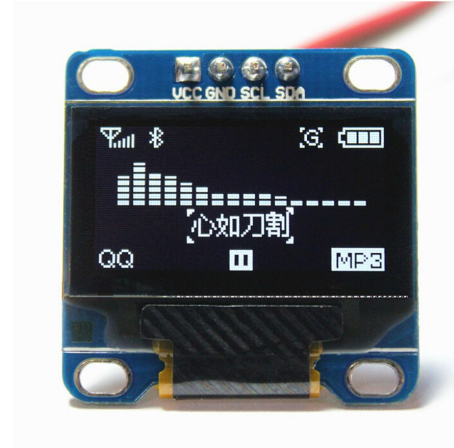
HC-SR04
(ultrasonic sensor)
3€ 1€



Other Displays



E-Ink Display



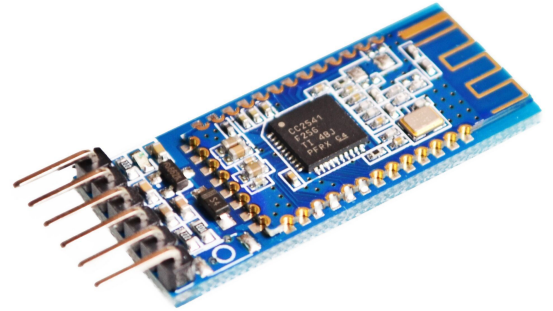
OLED Display

AT-09 Bluetooth Module

Specs

- Bluetooth LE 4.0
- Central / Peripheral Role
- 3.3 V / 5 V

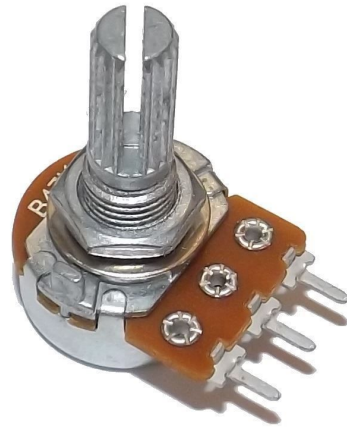
7€ 2€



Buttons/Switches



SMD Switch

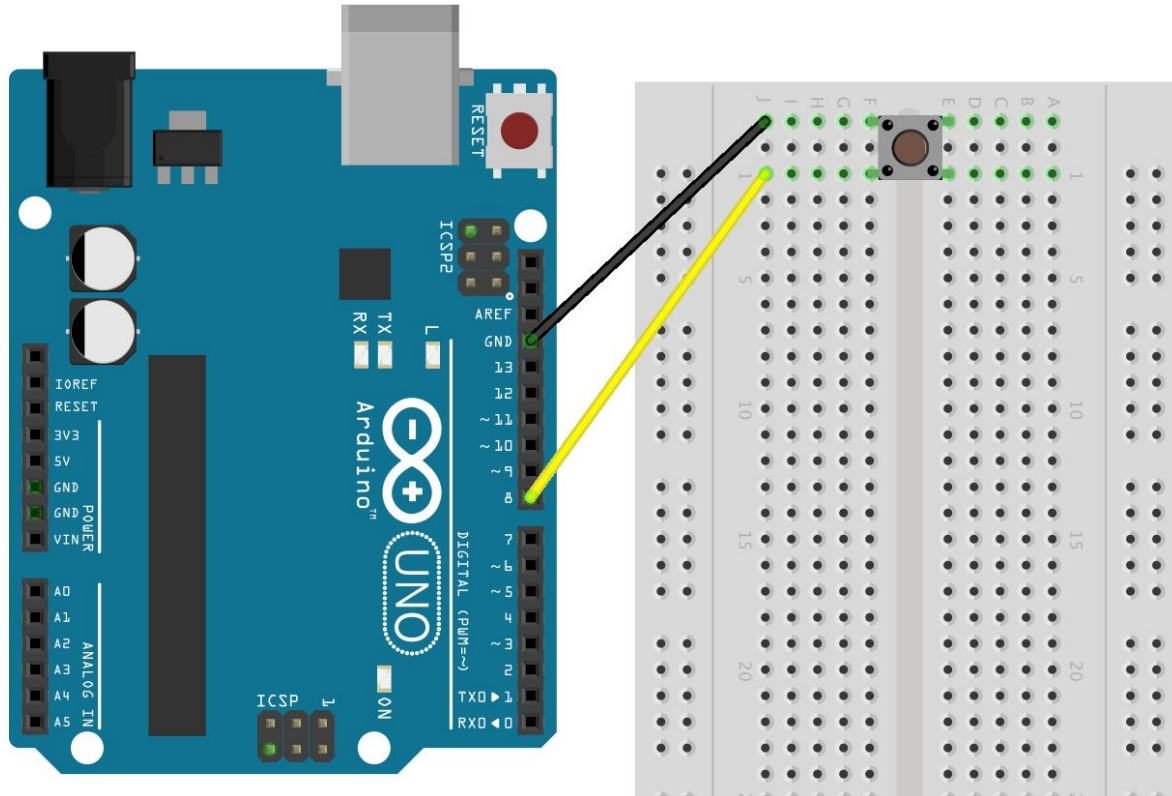


Potentiometer



Cool Switch

Connecting Push Buttons



Reading Button States

```
#include <Arduino.h>
#define BTN_PIN 8

void setup () {
  pinMode(BTN_PIN, INPUT);
}
void loop() {
  int isPressed = digitalRead(BTN_PIN);
}
```

Questions?
