

Take Our Daughters And Sons to Work Day

https://github.com/Mark-MDO47/TODAS_DaughtersAndSons/

June 2024



The Arduino Experience!



TODAS - Electricity, Arduinos, Fun

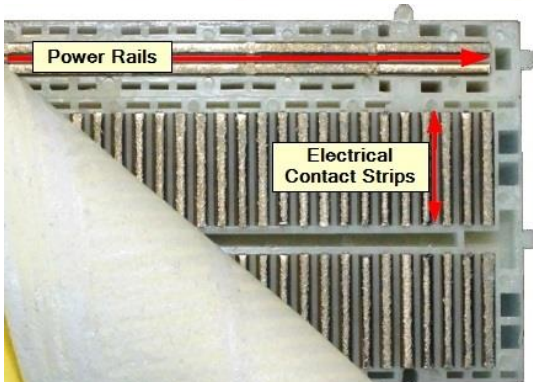
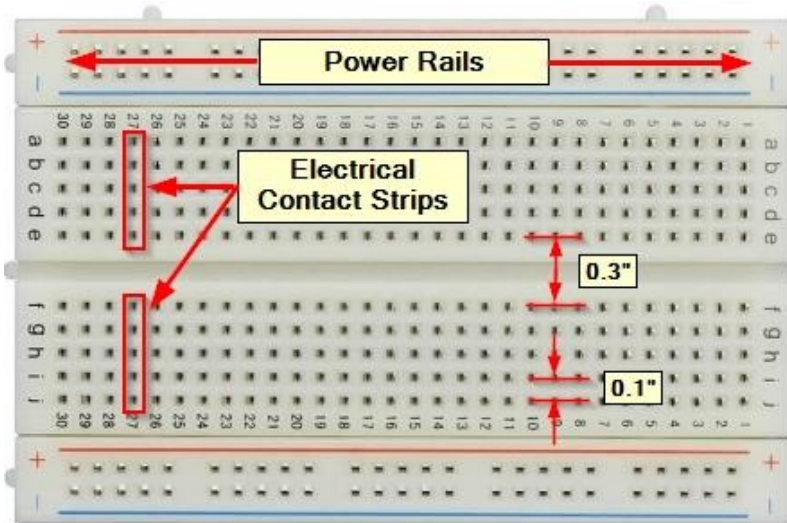
- [Introduction](#)
- [Water Flow - a way to think about Electricity](#)
- [Arduino \(computer on a chip\), buttons, and LEDs](#)
- [Sonar Control and big LED ring](#)
- [Bananas and Sounds](#)
- [Resources](#)



Introduction

- We have one hour – it is just an introduction
 - The idea is to do a quick overview
 - Questions OK but this is not a deep course
 - Lots of resources on the web for further investigation
- 4 projects, 3 using a small computer called Arduino
 - Do some wiring
 - Customize some software
 - Have some fun

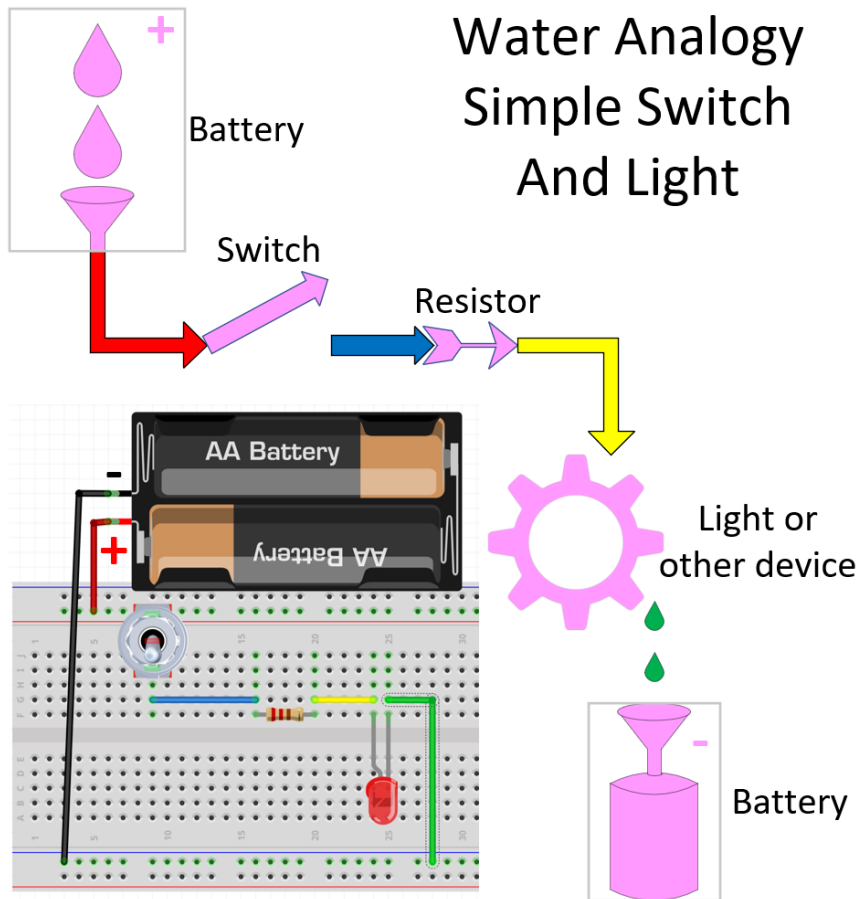
01 - Breadboards - how do they work?



- Sides have power rails - length
- Center has contact strips - width

- Images from protosupplies.com

01 – Water Analogy – Simple Circuit

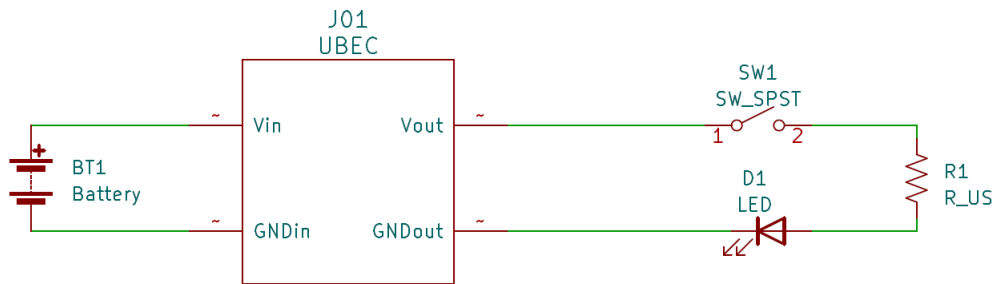


- Electrons in wires actually flow from negative to positive, but many electrical symbols are drawn as if the current flow is from positive to negative so let's get used to it!
- Positive to negative flow was good enough for Benjamin Franklin and for me!
- "Pictorial" circuit is "Fritzing Diagram"
 - <https://fritzing.org/> - 8 Euros

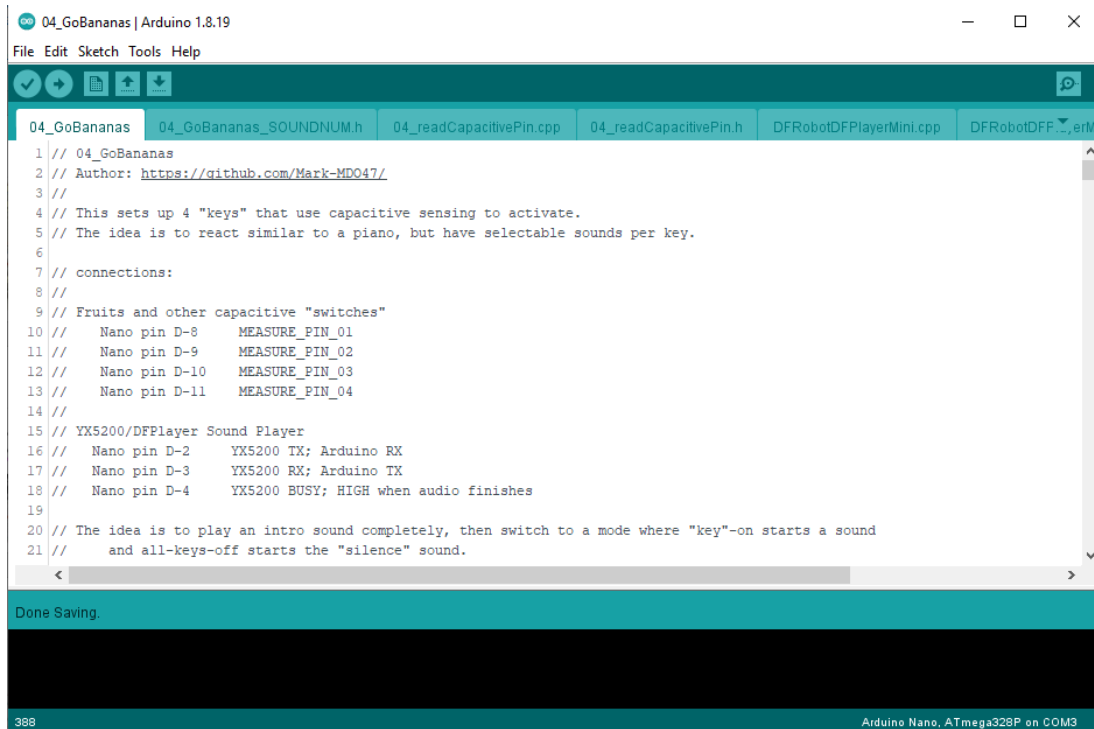
01 Simple Circuit Schematic



- The Universal Battery Eliminator Circuit (photo of type I used) produces 5 volts if the input is from 5.5 Volts to 26 Volts.
- The resistor prevents sending too much current through the LED; that would burn it up.
- Schematic diagram is from KiCad
 - <https://www.kicad.org/> - KiCad is free!



02 – Arduino IDE



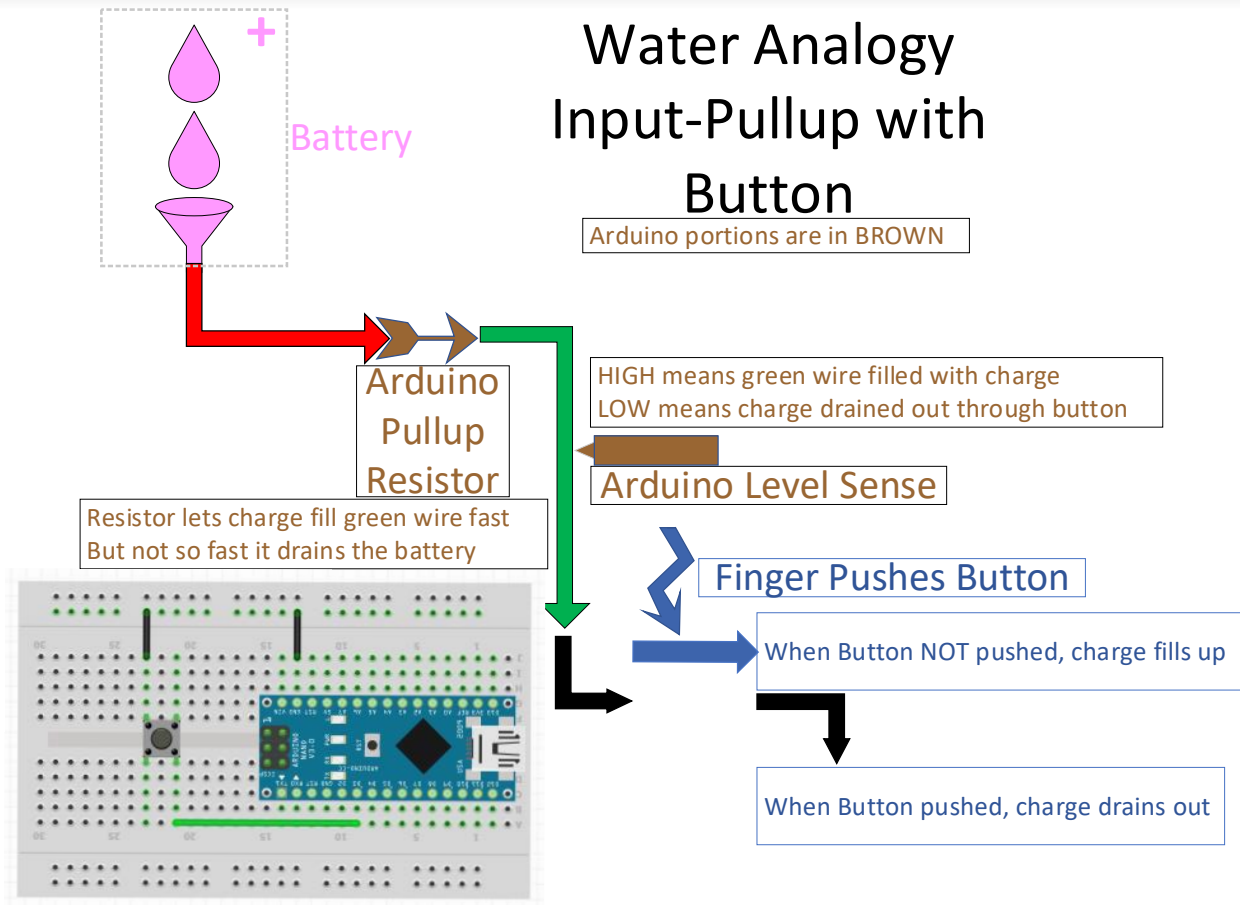
The screenshot shows the Arduino IDE window titled "04_GoBananas | Arduino 1.8.19". The menu bar includes File, Edit, Sketch, Tools, and Help. Below the menu is a toolbar with icons for opening, saving, and running. The main editor area displays a sketch with the following code:

```
1 // 04_GoBananas
2 // Author: https://github.com/Mark-MDO47/
3 //
4 // This sets up 4 "keys" that use capacitive sensing to activate.
5 // The idea is to react similar to a piano, but have selectable sounds per key.
6
7 // connections:
8 //
9 // Fruits and other capacitive "switches"
10 // Nano pin D-8 MEASURE_PIN_01
11 // Nano pin D-9 MEASURE_PIN_02
12 // Nano pin D-10 MEASURE_PIN_03
13 // Nano pin D-11 MEASURE_PIN_04
14 //
15 // YX5200/DFPlayer Sound Player
16 // Nano pin D-2 YX5200 TX; Arduino RX
17 // Nano pin D-3 YX5200 RX; Arduino TX
18 // Nano pin D-4 YX5200 BUSY; HIGH when audio finishes
19
20 // The idea is to play an intro sound completely, then switch to a mode where "key"-on starts a sound
21 // and all-keys-off starts the "silence" sound.
```

At the bottom of the window, a status bar indicates "Done Saving." and "Arduino Nano, ATmega328P on COM3". The line number 388 is visible on the left side of the status bar.

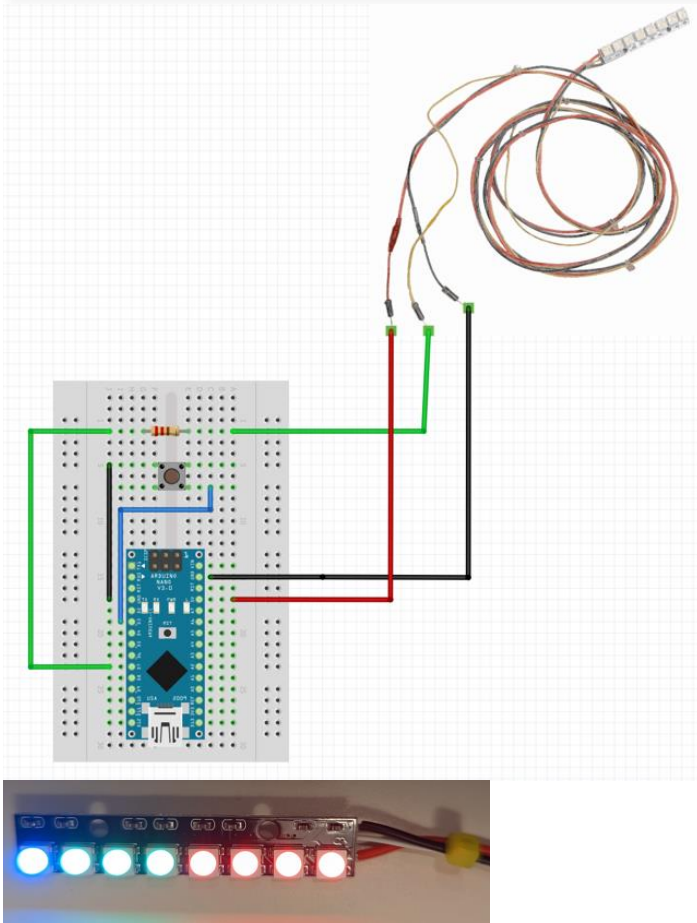
- IDE means Integrated Development Environment
- <https://www.arduino.cc/en/software> - Arduino IDE is free!

02 - Water Analogy Input-Pullup & Button



- Remember: electrons in wires actually flow from negative to positive, but often easier to understand by pretending positive to negative

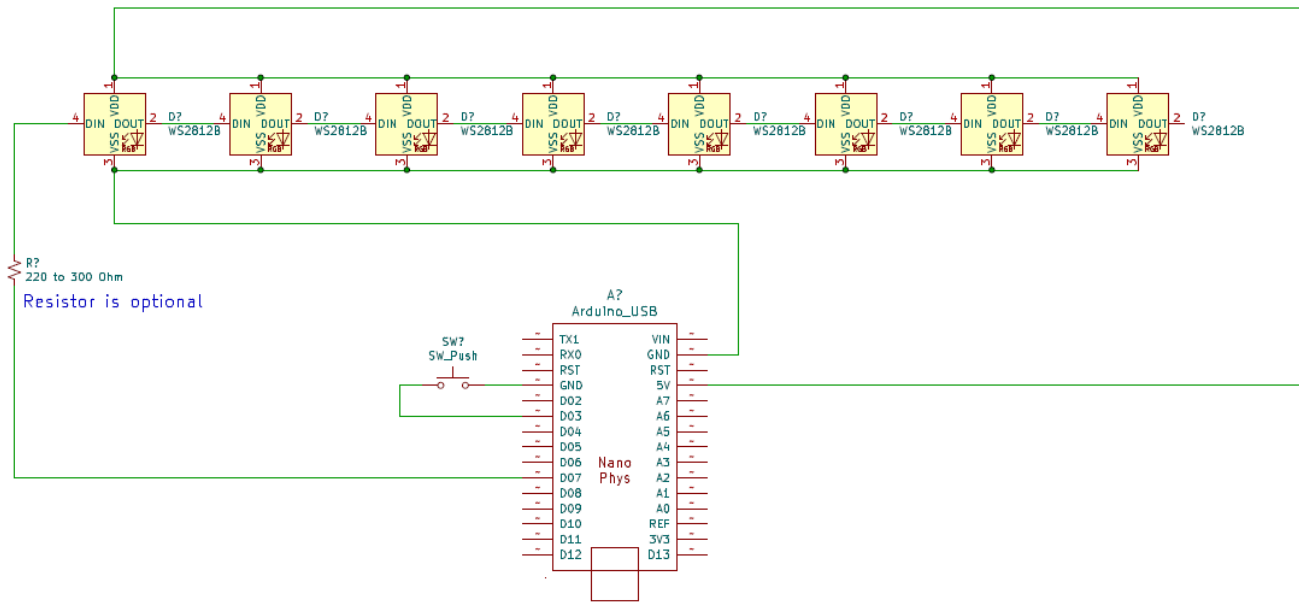
02 - Arduino Moving Color Lights



- “Fritzing diagram” of color lights in motion!
 - LED is Light Emitting Diode
- Configure software for color choices
- Press button to stop, release to continue
- How does it work? SOFTWARE!
 - Pins can be input or output - you tell it which
 - Read the button
 - If not pressed - display next light
 - Short delay
- TLDR - WS2812B individually addressable color LEDs using FastLED library

02 - Arduino Moving Color Lights Schematic

NOTE: connections needed only to leftmost LED; daisy chain is within the LED Stick



- The LED stick has eight small chips that control 3 LEDs each: Red, Green, and Blue.
- 3 LEDs are close together so they look like one color

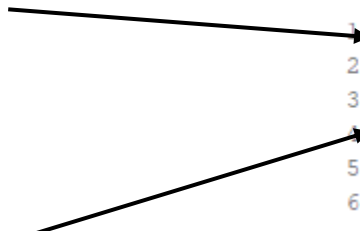
02 – Arduino Inputs

- When button is pushed, Arduino input is LOW
- When button is not pushed, Arduino input is HIGH
- We want to do LED motion when button is NOT pushed
 - Assign name to the pin we use
 - Make the pin an input
 - If the state is HIGH (button not pushed) do the motion

02 - Arduino Code Structure - Empty Sketch

- Empty “sketch” has
 - setup() - called once at start
 - Initialize hardware
 - Initialize software
 - loop() - called repeatedly
 - Process events
 - Generate outputs

```
1 void setup() {  
2   // put your setup code here, to run once:  
3 }  
4 void loop() {  
5   // put your main code here, to run repeatedly:  
6 }
```



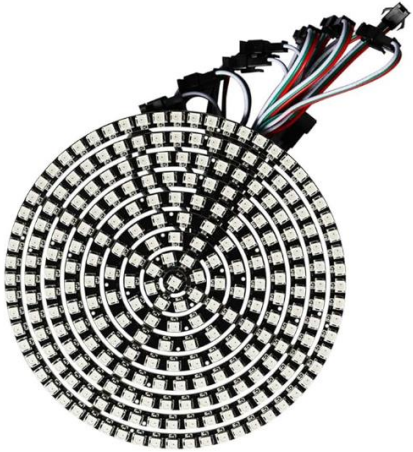
02 - Arduino Button Input Software

- this defines a name for pin D3 for the button
- Inside "setup()" - pinMode sets that pin to be an input with "pullup"; HIGH unless connected to ground by pushing button
- ptrn_phase() is called from code inside "loop()"
 - Because current_phase is "static", it remembers previous value from last time ptrn_phase() was called
 - The "if(HIGH)" block does the motion if button NOT pushed
 - If button WAS pushed we return current_phase of -1 to signify stopping LED motion

```
39 #define BUTTON_PIN_STOP 3 // press to stop action; release to restart
142 pinMode(BUTTON_PIN_STOP, INPUT_PULLUP); // digital INPUT_PULLUP means voltage HIGH unless grounded

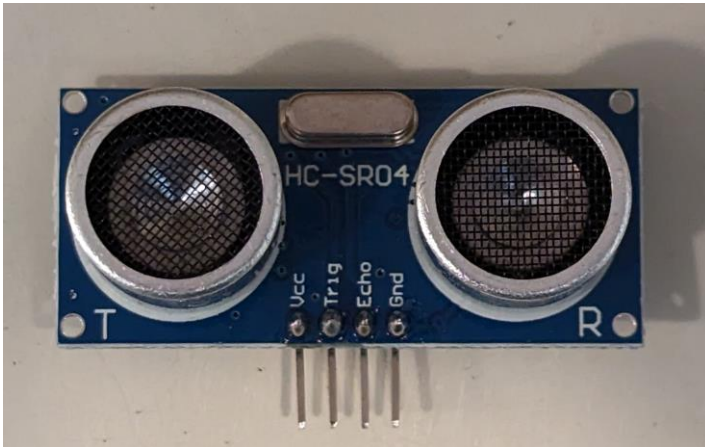
84 //////////////////////////////////////////////////////////////////////////////////////////////////////////////////
85 // ptrn_phase() - determine the state of the phase of pattern generation
86 //   returns: long int with either value >= 0 phase to blink or value < 0 STOP
87 //
88
89 long int ptrn_phase() {
90     static long int current_phase = -1;
91
92     if (HIGH == digitalRead(BUTTON_PIN_STOP)) {
93         current_phase += 1;
94         current_phase %= gPatternsRepeat; // loop through the number of calls before repeat
95         if (0 == current_phase) {
96             step_color_value();
97         }
98     } else {
99         current_phase = -1; // STOP
100     }
101
102     return(current_phase);
103 } // end ptrn_phase()
...
```

03 – Go Big with Ultrasonic Sonar Control

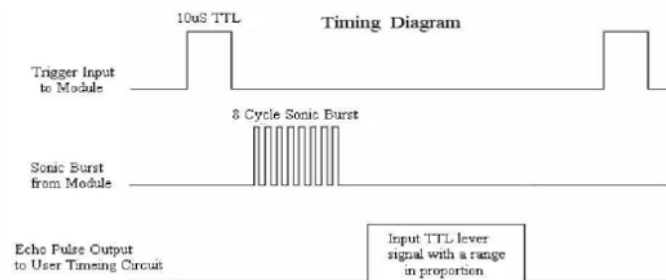


- 8 LEDs is fun – but 241 LEDs is MORE fun!
 - TLDR – WS2812B individually addressable color LEDs using FastLED Library
- Displays moving patterns we choose
- Disk is mostly wired; less soldering needed
- Needs more power than Arduino can give
- Video: <https://youtube.com/shorts/0KehSIJmKcs>
- Pictures from amazon.com
 - TLDR - <https://www.amazon.com/WESIRI-WS2812B-Individually-Addressable-Controller/dp/B083VWVP3J>

03 – Ultrasonic Sonar Control



- Ultrasonic Sonar sensor detects distance
- Bounces ultrasonic sound off objects
- Set "Trig" HIGH then LOW to start sonic burst
- Measure time until "Echo" is HIGH
- Divide time by speed of sound to get distance
- TLDR diagram from the [sparkfun.com HC-SR04 spec](https://www.sparkfun.com/specs/HCSR04.pdf).



03 – Ultrasonic Sonar Detector Software

Include library, define names for pins

"my_ultra" is how I use the HC-SR04

Make a global "gUltraDistance" for debugging

"handle_ultra" returns a pattern number

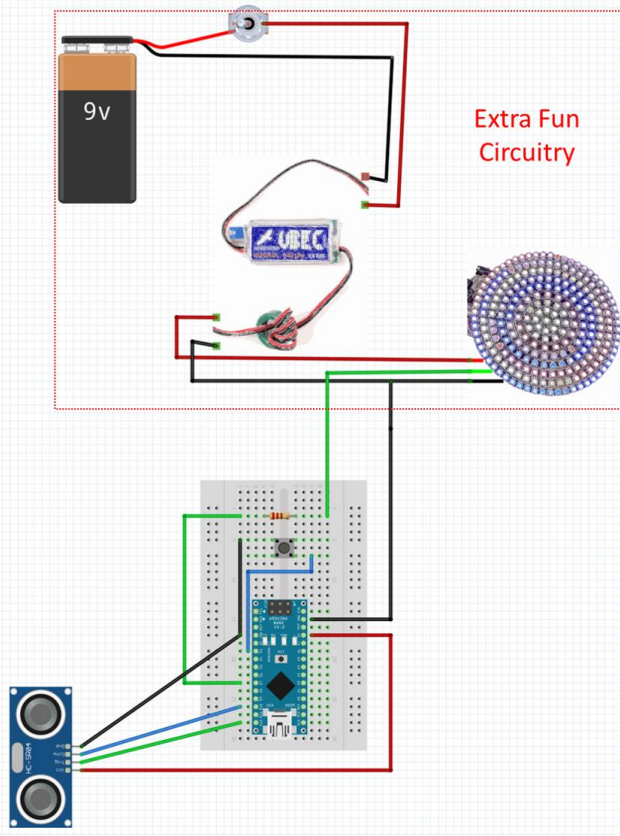
"my_ultra.read(CM)" gives distance in CM
stored in "gUltraDistance"

Use math to turn distance into "pattern"

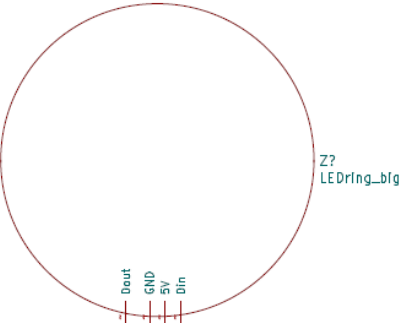
Return "pattern" (number) to caller

```
27 #include <FastLED.h>
28 #include <Ultrasonic.h>
29
30 // Ultrasonic HC-SR04 definitions
31 #define ULTRA_TRIG_PIN 12 // HC-SR04 Trigger digital pin
32 #define ULTRA_ECHO_PIN 10 // HC-SR04 Trigger echo pin
33 #define ULTRA_CM_PER_REGION 9 // HC-SR04 every this many CM is a different pattern
34 #define ULTRA_IGNORE_INITIAL_CM 3 // HC-SR04 ignore the first 3 CM since valid range starts at 2 CM
35
36 // instantiate my HC-SR04 data object
37 Ultrasonic my_ultra = Ultrasonic(ULTRA_TRIG_PIN, ULTRA_ECHO_PIN); // default timeout is 20 milliseconds
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128 int gUltraDistance = 0; // latest measured distance in centimeters
129
130 ///////////////////////////////////////////////////
131 // handle_ultra() - process HC-SR04 data.
132 //   returns: pattern number 0 <= num <= PATTERN_MAX_NUM
133 //
134
135 int handle_ultra() {
136   int pattern; // integer pattern number from 0 thru 5 inclusive
137   // get the range reading from the Ultrasonic sensor in centimeters
138   int ultra_dist;
139
140   gUltraDistance = (my_ultra.read(CM));
141   ultra_dist = gUltraDistance - ULTRA_IGNORE_INITIAL_CM;
142   if (ultra_dist < 0) ultra_dist = 0;
143   pattern = ultra_dist / ULTRA_CM_PER_REGION;
144   if (pattern > 5) pattern = 5;
145
146   return(pattern);
147 } // end handle_ultra()
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```

03 – Fritzing Diagram



- Replace 8-LED stick with 241-LED Disk
 - Separate power for 241-LED Disk
- Add new HC-SR04 Ultrasonic Sensor
- Button unused – can leave it
- We add the battery and UBEC because the 241 LEDs take a lot of power!



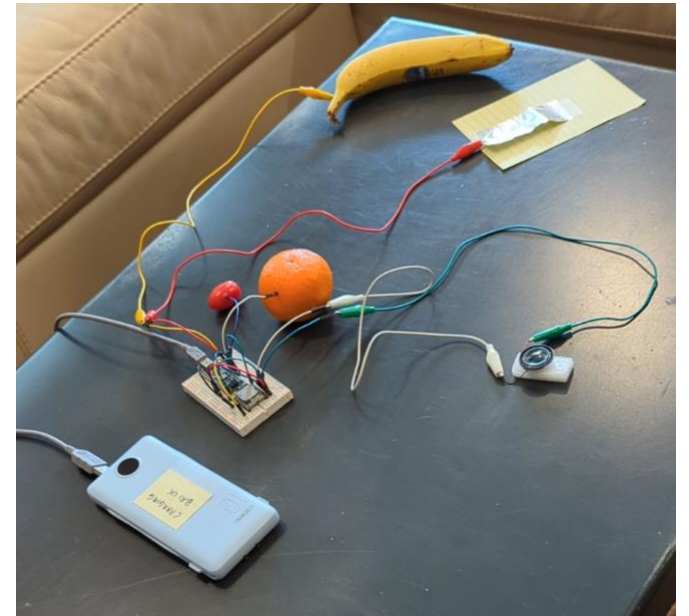
We leave it on the breadboard; no need to remove it.

That allows both LED and HC-SR04 to recognize the voltages from the Arduino

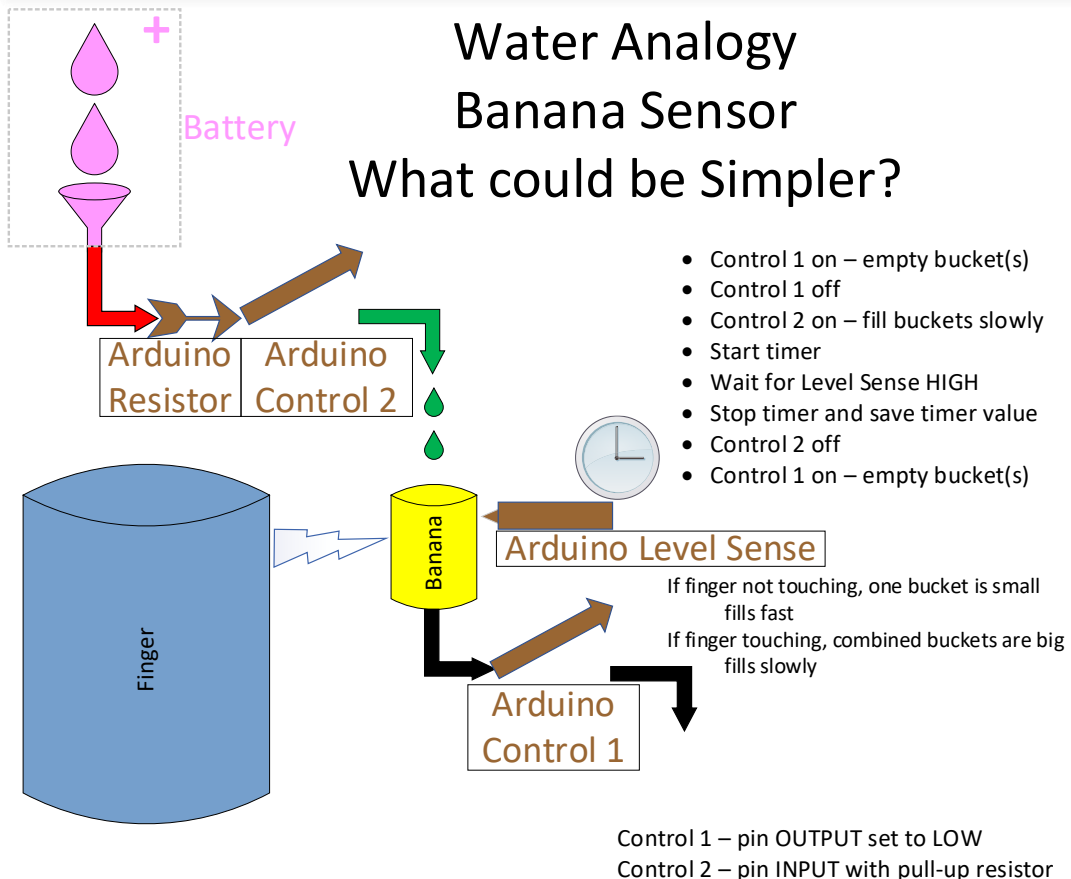
04 – Go Bananas!



- A Banana Piano! Several “key” fruit types...
 - Uses “capacitive sensing” – depends on how fast Arduino can charge it up
 - Touching banana makes it take longer to charge
- Digitized sounds are played when the “key” is pressed
- Only one sound at a time is played
- Sounds are “sampled” – digital storage format
- Video: <https://youtu.be/EC1qHbE89JI>
- TLDR – Image to the left by krakenimages.com on Freepik



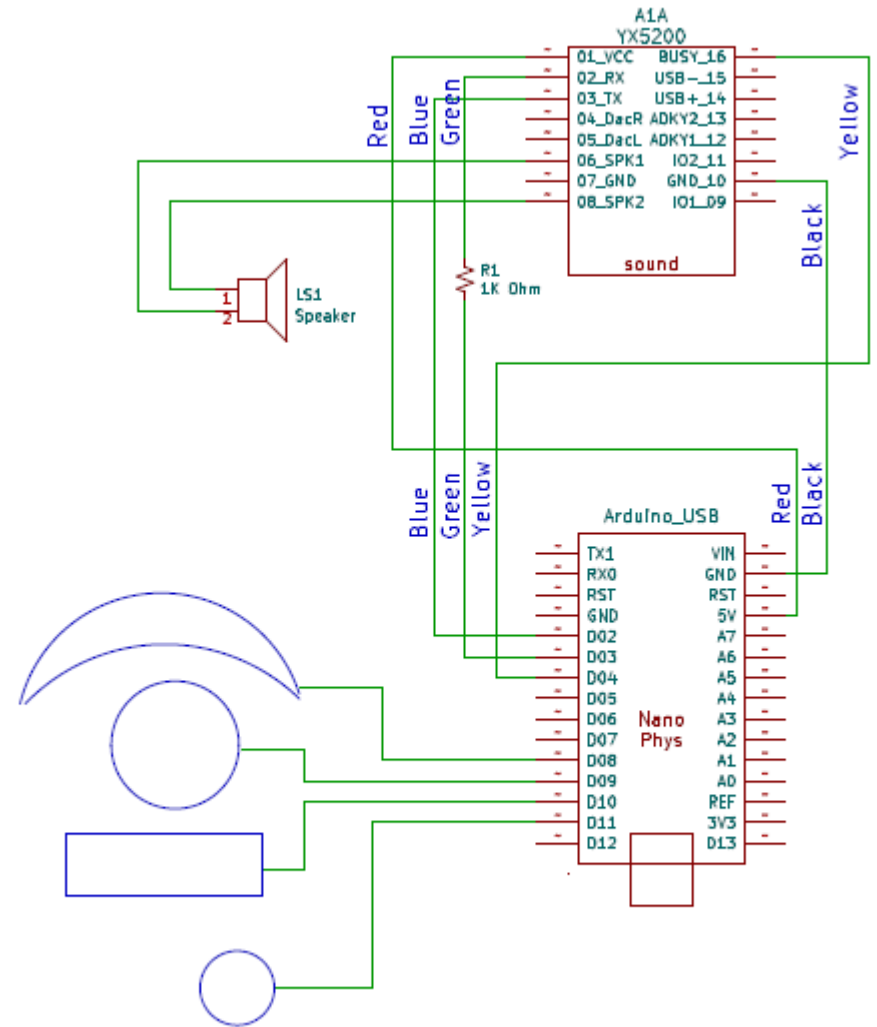
04 – Water Analogy - Banana Input



- Note that this is an analog of how it works
- The diagram shows the flow of the code
- The code uses tricks to be fast – makes code harder to understand
 - But that is all hidden in 04_readCapacitivePin.*

04 Bananas Schematic

- Bottom half has Arduino and fruits
 - Capacitive sensing of fruits
- Top half has sound module and speaker
 - UART serial interface
 - Universal Asynchronous Receiver / Transmitter



```
// "pin index" state:  
//   -1 means nothing selected  
//   0-3 (3 = NUM_MEASURE_PINS-1) represent pins MEASURE_PIN_01 to MEASURE_PIN_03,  
//   any other value is invalid  
  
int8_t gCurrentPinIndex = -1; // Index number of which PinIndex is current - nothing selected  
int8_t gPrevPinIndex = -1; // previous PinIndex - nothing selected  
  
// "pin index" to sound mapping  
//   pin index goes from -1 to 3 (3 = NUM_MEASURE_PINS-1)  
//   we add one to that number to go from 0 to 4  
//       0 = Silence sound  
//       1 through 4 = MEASURE_PIN_01 through MEASURE_PIN_04  
  
uint16_t gPinIndex2SoundNum[1+NUM_MEASURE_PINS] = { SOUNDNUM_silence, SOUNDNUM_electric_piano_C, SOUNDNUM_organ_D, SOUN
```

- Place sound numbers into array gPinIndex2SoundNum[]
- Calls to pin2soundnum() will convert PinIndex to sound number
- Most of routine is error checking (this is normal)

Only one line is needed to actually do translation

could just use `gPinIndex2SoundNum[pinIndex+1]` if wanted to skip error checking

```

////////////////////////////////////////
// pin2soundnum(pinIndex) - convert pin index to sound number
//
// pinIndex to sound mapping
//     pinIndex goes from -1 to 3 (3 = NUM_MEASURE_PINS-1)
//     we add one to that number to go from 0 to 4
//         0 = Silence sound
//         1 through 4 = MEASURE_PIN_01 through MEASURE_PIN_04

uint16_t pin2soundnum(int8_t pinIndex) {
    uint16_t soundNum = SOUNDNUM_INVALID;
    if ((pinIndex >= -1) and (pinIndex < NUM_MEASURE_PINS)) {
        soundNum = gPinIndex2SoundNum[pinIndex+1];
    } else {
        Serial.print("ERROR pin2soundnum() - pinIndex="); Serial.println(pinIndex);
        soundNum = SOUNDNUM_INVALID; // not really needed
    }
    return(soundNum);
} // end pin2soundnum()

```

04 Bananas Software - loop() - repeats

- Executes block every 50 milliseconds
- Gets active PinIndex
- If this is change in PinIndex: start sound
 - Could be "silence" sound
- Not a change, still holding: repeat sound
- No key pressed: repeat silence
- **Extra credit:** can you simplify the last if/else/endif ?
- **Extra credit:** can you write simple code to replace EVERY_N_MILLISECONDS(50) ? Do we even need this?

```
////////////////////////////////////  
// loop()  
void loop() {  
  EVERY_N_MILLISECONDS( 50 ) {  
    gCurrentPinIndex = handle_capacitive();  
    if (gPrevPinIndex != gCurrentPinIndex) {  
      // "key" (PinIndex) is different than before so start a new sound  
      // -1 will start the silent sound, otherwise the chosen key sound will start  
      gPrevPinIndex = gCurrentPinIndex;  
      DFstartSound(pin2soundnum(gCurrentPinIndex), SOUND_DEFAULT_VOL);  
    } else if (DFcheckSoundDone()) {  
      if (gCurrentPinIndex >= 0) {  
        // PinIndex is not -1 so we are still holding a key down - restart sound  
        gPrevPinIndex = gCurrentPinIndex;  
        DFstartSound(pin2soundnum(gCurrentPinIndex), SOUND_DEFAULT_VOL);  
      } else {  
        // PinIndex is -1 so no key is held down - start silence sound  
        gPrevPinIndex = -1;  
        DFstartSound(pin2soundnum(gCurrentPinIndex), SOUND_DEFAULT_VOL);  
      } // end if  
    } // end EVERY_N_MILLISECONDS  
  } // end loop()  
}
```

- Initialize serial debug interface.
- Do capacitive sensing setup
- Initialize sound card interface
- Initialization complete
- Play intro sound then start

```

// setup()
void setup() {
  Serial.begin(115200);          // this serial communication is for general debug; set the USB serial port
  while (!Serial) {
    ; // wait for serial port to connect. Needed for native USB port only
  }
  Serial.println(""); // print a blank line in case there is some junk from power-on

  CapacitiveSetup();

  pinMode(DPIN_AUDIO_BUSY, INPUT_PULLUP); // HIGH when audio stops
  mySoftwareSerial.begin(9600); // this is control to DFPlayer audio player
  // initialize the YX5200 DFPlayer audio player
  DFsetup();

  Serial.println("TODAS init complete...");

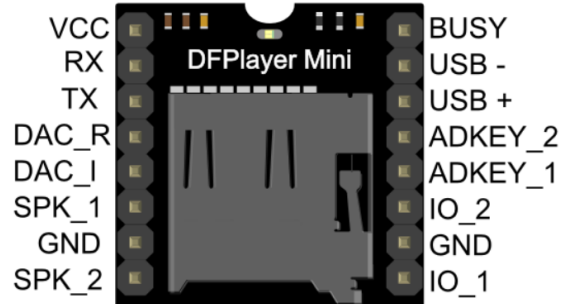
  // play the INTRO sound to completion, then allow normal loop() processing
  DFstartSound(SOUNDNUM_introduction, SOUND_DEFAULT_VOL);
  while (!DFcheckSoundDone()) {
    delay(10); // wait for the INTRO sound to finish
  } // end while
  Serial.println("Intro Sound Complete");
  gCurrentPinIndex = gPrevPinIndex = -1;
  DFstartSound(SOUNDNUM_silence, SOUND_DEFAULT_VOL);

} // end setup()

```

04 – Digitized Sound Output

- DFPlayer (YX5200) accepts SD card with digitized audio

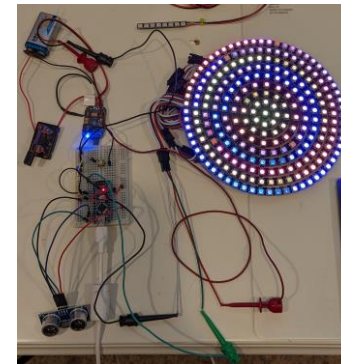
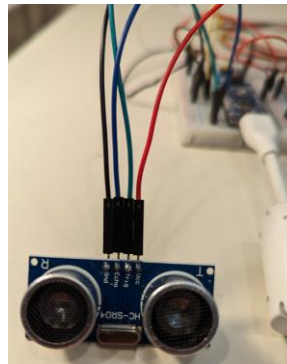
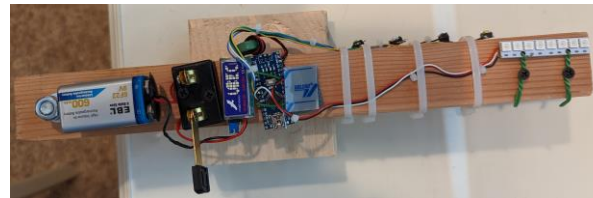
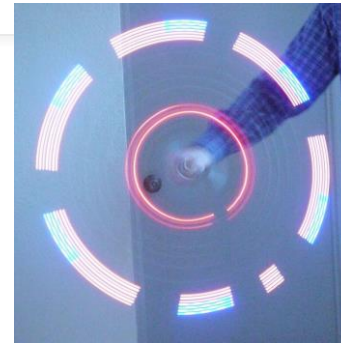
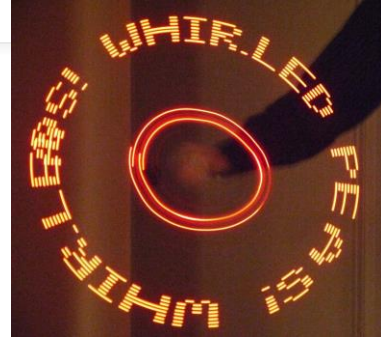
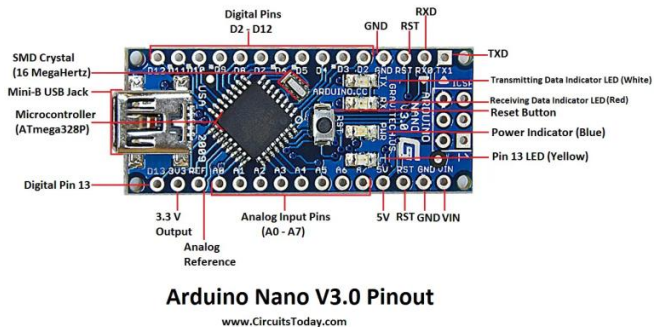


- Plays SD card audio files by number
 - UART interface to Arduino
 - Direct mono speaker output
 - Line-out stereo output, usable for BlueTooth
-
- Many tricks to using YX5200
<https://github.com/Mark-MDO47/AudioPlayer-YX5200>
 - Espeak for robotic voice
<https://github.com/Mark-MDO47/RubberBandGun/tree/master/sounds>
 - Audacity for sound processing
<https://www.audacityteam.org/>

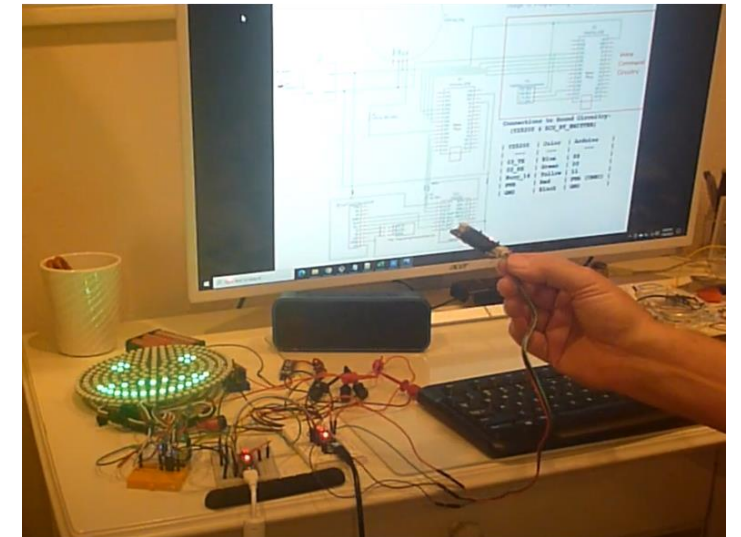
Resources – Arduino



<https://github.com/Mark-MDO47/ArduinoClass>



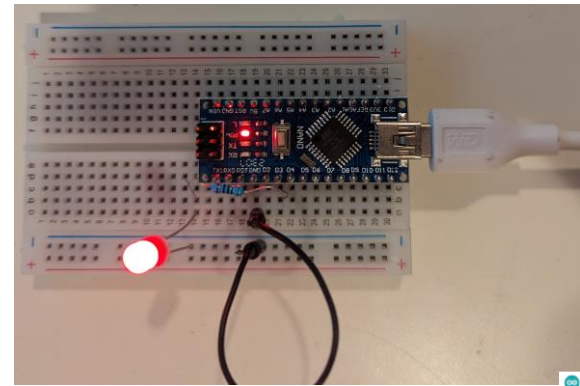
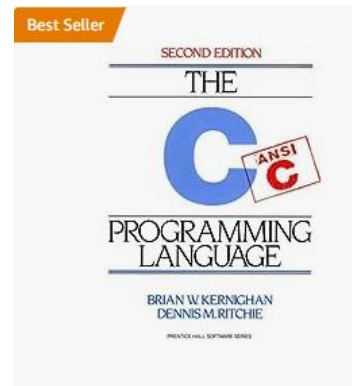
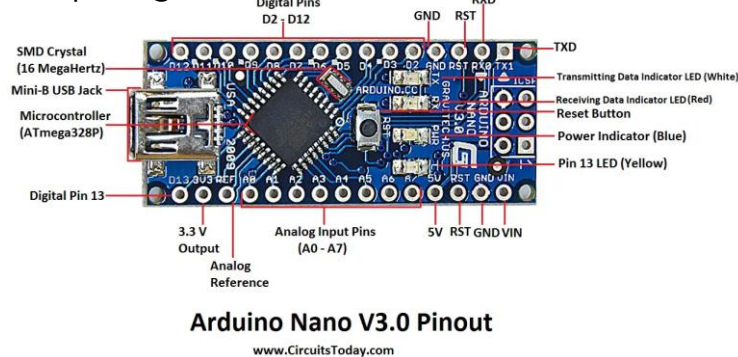
If you know a bit of programming...



Resources – C for Arduino



<https://github.com/Mark-MDO47/CforArduinoClass>



If you can use a programming refresher...

