



Sensor Plotting with Mu and CircuitPython

Created by Kattni Rembor



<https://learn.adafruit.com/sensor-plotting-with-mu-and-circuitpython>

Last updated on 2022-12-01 03:11:45 PM EST

Table of Contents

Light	3
Temperature	4
Buttons and Switch	6
Motion	7
Sound	9
Capacitive Touch	11
Potentiometer	13
Color	15
Heartbeat Pulse	17
Soil Moisture	21

Light

We're going to use CircuitPython, Mu, and the light sensor on Circuit Playground Express to plot light levels. We have a simple nine-line piece of code below. We'll run this code on our Circuit Playground Express and use Mu to plot the sensor data that CircuitPython prints out.

Visit our [Welcome to CircuitPython page](#) to learn how to install the Mu editor & plotter

Save the following as `code.py` on your Circuit Playground Express board, using the Mu editor:

```
# SPDX-FileCopyrightText: 2018 Phillip Torrone for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import time

import analogio
import board

light = analogio.AnalogIn(board.LIGHT)

while True:
    print((light.value,))
    time.sleep(0.1)
```

On the first few lines we import `analogio`, `board` and `time`, and setup our light sensor. Inside our `while` loop, we are `print()`-ing the light level. The `time.sleep()` is to keep from spamming the results - if they're too fast, they get difficult to read!

Note that the Mu plotter looks for tuple values to print. Tuples in Python come in parentheses () with comma separators. If you have two values, a tuple would look like `(1.0, 3.14)` Since we have only one value, we need to have it print out like `(1.0,)` note the parentheses around the number, and the comma after the number. Thus the extra parentheses and comma in `print((light.value,))`.

Once you have everything setup and running, try placing your hand over the Circuit Playground Express, and watch the plotter immediately react! When you block the light from reaching the CPX, the graphing plotter line goes down. If you shine a flashlight on it to add more light, the plotter goes up!

It's a really easy way to test out your sensors and get a feeling for analog reads in CircuitPython!



Note you can have the text REPL on the left and resize the plotter to be big and on the right like above. That way you see the numbers and the graph at the same time. The plotter will automatically re-scale depending on light levels.

Temperature

We're going to use CircuitPython, Mu and the temperature sensor built into the Circuit Playground Express to plot temperature change. We'll run this code on our Circuit Playground Express and use Mu to plot the sensor data that CircuitPython prints out.

Visit our [Welcome to CircuitPython](#) page to learn how to install the Mu editor & plotter

Save the following as code.py on your Circuit Playground Express board, using the Mu editor:

```
# SPDX-FileCopyrightText: 2018 Kattni Rembor for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import time

import adafruit_thermistor
import board

thermistor = adafruit_thermistor.Thermistor(
    board.TEMPERATURE, 10000, 10000, 25, 3950)

while True:
    print((thermistor.temperature,))
```

```
# print(((thermistor.temperature * 9 / 5 + 32),)) # Fahrenheit
time.sleep(0.25)
```

Our code is quite simple. We import `adafruit_thermistor`, `board` and `time`. Then we setup our temperature sensor. Inside our `while` loop, we `print` the temperature in Celsius.

If you'd like to see Fahrenheit instead, place a `#` (`# + space`) before the line `print((thermistor.temperature,))` and remove the `#` before the line `print(((thermistor.temperature * 9 / 5 + 32),))`. The temperature is in Celsius by default, so we include a little math (the `* 9 / 5 + 32`) to convert it to Fahrenheit.

Note that the Mu plotter looks for tuple values to print. Tuples in Python come in parentheses () with comma separators. If you have two values, a tuple would look like `(1.0, 3.14)`. Since we have only one value, we need to have it print out like `(1.0,)` note the parentheses around the number, and the comma after the number. Thus the extra parentheses and comma in `print((thermistor.temperature,))`.

Once you have everything loaded and running, you can place your finger over the temperature sensor to see the plotter immediately respond! Try breathing on your CPX temperature sensor to increase the temperature and watch the plotter go up! Try setting it on a cool surface to watch the plotter go down!

This is a great way to tell the temperature and plot temperature changes in Celsius (or Fahrenheit).



Buttons and Switch

We're going to use CircuitPython, Mu, and the two buttons and one switch on Circuit Playground Express to plot button presses and the switch location. We'll run this code on our Circuit Playground Express and use Mu to plot the data that CircuitPython prints out.

Visit our [Welcome to CircuitPython page](#) to learn how to install the Mu editor & plotter

Save the following as `code.py` on your Circuit Playground Express board, using the Mu editor:

```
# SPDX-FileCopyrightText: 2018 Kattni Rembor for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import time

import board
import digitalio

button_a = digitalio.DigitalInOut(board.BUTTON_A)
button_a.direction = digitalio.Direction.INPUT
button_a.pull = digitalio.Pull.DOWN

button_b = digitalio.DigitalInOut(board.BUTTON_B)
button_b.direction = digitalio.Direction.INPUT
button_b.pull = digitalio.Pull.DOWN

switch = digitalio.DigitalInOut(board.SLIDE_SWITCH)
switch.direction = digitalio.Direction.INPUT
switch.pull = digitalio.Pull.UP

while True:
    if button_a.value:
        print((1,))
    elif button_b.value:
        print((2,))
    elif switch.value:
        print((-1,))
    else:
        print((0,))
    time.sleep(0.1)
```

Our code is very simple. First we import `digitalio`, `board` and `time`. Then, we create the `button_a`, `button_b` and `switch` objects.

Our main loop consists of `if`, `elif`, and `else` statements. An `elif` statement says "otherwise, if" something happens, do a thing. An `else` statement says "otherwise do" a thing regardless of what is happening. So, our main loop reads: if

Save the following as code.py on your Circuit Playground Express board, using the Mu editor:

```
# SPDX-FileCopyrightText: 2018 Kattni Rembor for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import time
import board
import adafruit_lis3dh
import busio

i2c = busio.I2C(board.ACCELEROMETER_SCL, board.ACCELEROMETER_SDA)
lis3dh = adafruit_lis3dh.LIS3DH_I2C(i2c, address=0x19)
lis3dh.range = adafruit_lis3dh.RANGE_8_G

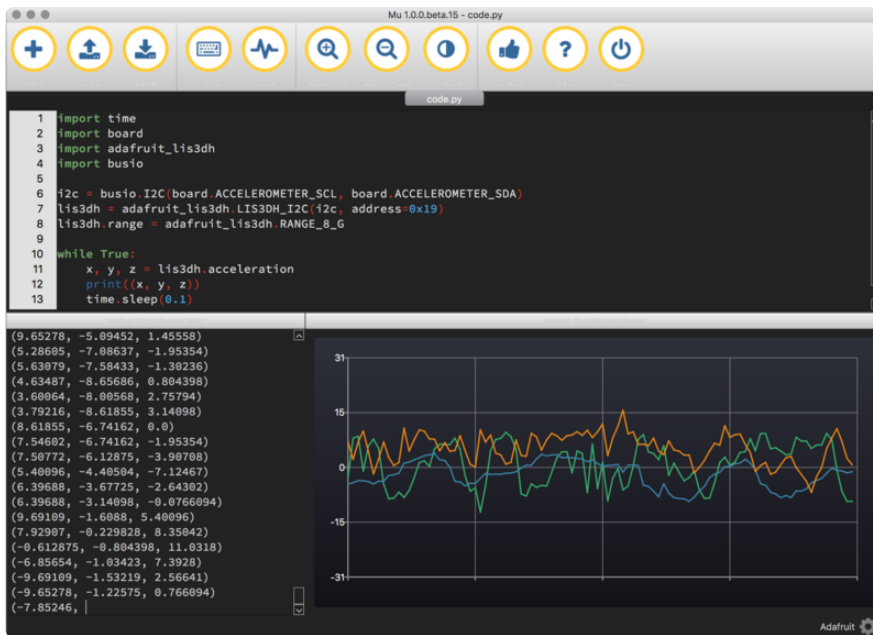
while True:
    x, y, z = lis3dh.acceleration
    print((x, y, z))
    time.sleep(0.1)
```

Our code is really simple. We import `time`, `board`, `adafruit_lis3dh`, and `busio`. Then we setup the accelerometer. Inside our while loop, we assign `x, y, z` to be the motion values. Then we `print` our motion values. The `time.sleep(0.1)` slows down the readings a little - without it they're too fast to read!

Note that the Mu plotter looks for tuple values to print. Tuples in Python come in parentheses () with comma separators. If you have two values, a tuple would look like `(1.0, 3.14)`. We have three values, `(x, y, z)`, and note that the tuple itself has its own parentheses. Thus the extra parentheses in `print((x, y, z))`.

Once you have everything up and running, try moving the board around to see the plotter respond immediately! The accelerometer is in the center of the board, and depending on which axis you move the board around, the x, y or z values will change. Try moving it only one direction to watch a single value change! Try shaking it all around to see all the values change significantly!

This is a great way to see the motion values and plot the motion as you move the board!



Sound

We're going to use CircuitPython, Mu and the sound sensor built into the Circuit Playground Express to plot sound levels. We'll run this code on our Circuit Playground Express and use Mu to plot the sensor data that CircuitPython prints out.

Visit our [Welcome to CircuitPython](#) page to learn how to install the Mu editor & plotter

Save the following as code.py on your Circuit Playground Express board, using the Mu editor:

```

# SPDX-FileCopyrightText: 2018 Kattni Rembor for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import array
import math
import time

import audiobusio
import board

def mean(values):
    return sum(values) / len(values)

def normalized_rms(values):
    minbuf = int(mean(values))
    sum_of_samples = sum(
        float(sample - minbuf) * (sample - minbuf)
        for sample in values)

```

```

    )

    return math.sqrt(sum_of_samples / len(values))

mic = audiobusio.PDMIn(
    board.MICROPHONE_CLOCK,
    board.MICROPHONE_DATA,
    sample_rate=16000,
    bit_depth=16
)
samples = array.array('H', [0] * 160)
mic.record(samples, len(samples))

while True:
    mic.record(samples, len(samples))
    magnitude = normalized_rms(samples)
    print((magnitude,))
    time.sleep(0.1)

```

Let's look at the code!

First we import `audiobusio`, `time`, `board`, `array` and `math`. Then we have two helper functions. The first one uses `math` to return a mean, or average. It is used in the second helper. The second one uses `math` to return a [normalised rms average \(\)](#). We use these functions to take multiple sound samples really quickly and average them to get a more accurate reading.

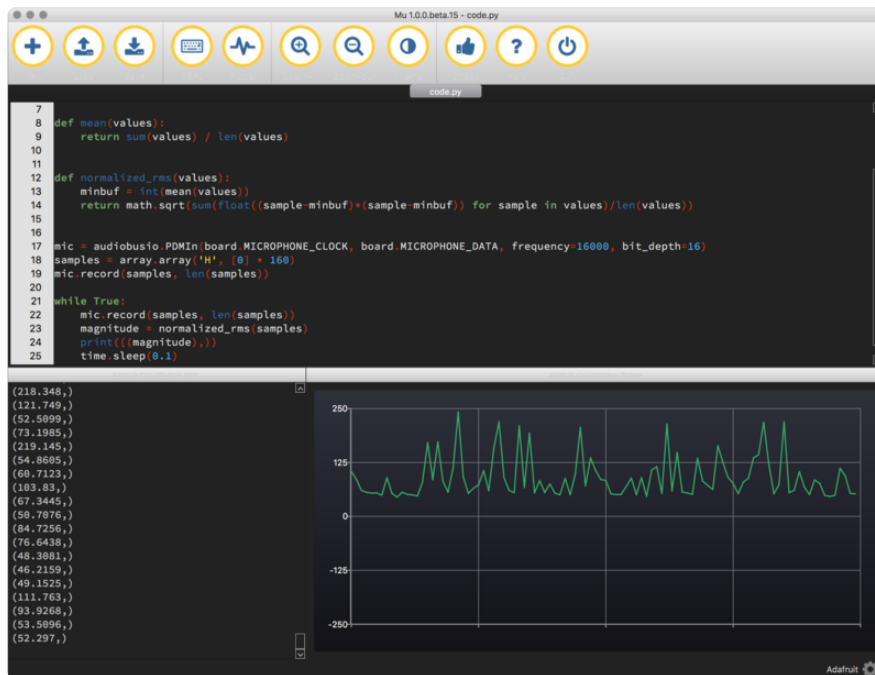
Next we set up the microphone object and our samples variable. Then we initialise the mic object so it's ready when we are.

Then we use the mic object to start taking sound samples. We use our normalised rms to find the average of a given set of samples, and we call that the `magnitude`. Last, we `print` the `magnitude` to the serial console.

Note that the Mu plotter looks for tuple values to print. Tuples in Python come in parentheses () with comma separators. If you have two values, a tuple would look like `(1.0, 3.14)` Since we have only one value, we need to have it print out like `(1.0,)` note the parentheses around the number, and the comma after the number. Thus the extra parentheses and comma in `print((magnitude,))`.

Once you have everything setup and running, try speaking towards the Circuit Playground Express, and watch the plotter immediately react! Move further away from the board to cause smaller changes in the plotter line. Move closer to the board to see bigger spikes!

It's a really easy way to test your microphone and see how it reads sound changes on the Circuit Playground Express!



Capacitive Touch

We're going to use CircuitPython, Mu and the capacitive touch pads built into the Circuit Playground Express to plot the raw capacitive touch values. We'll run this code on our Circuit Playground Express and use Mu to plot the capacitive touch data that CircuitPython prints out.

Visit our [Welcome to CircuitPython](#) page to learn how to install the Mu editor & plotter

Save the following as code.py on your Circuit Playground Express board, using the Mu editor:

```
# SPDX-FileCopyrightText: 2018 Kattni Rembor for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import time

import board
import touchio

touch_A1 = touchio.TouchIn(board.A1)
touch_A2 = touchio.TouchIn(board.A2)
touch_A5 = touchio.TouchIn(board.A5)
touch_A6 = touchio.TouchIn(board.A6)

while True:
    value_A1 = touch_A1.raw_value
    value_A2 = touch_A2.raw_value
    value_A5 = touch_A5.raw_value
```

```

value_A6 = touch_A6.raw_value
print((value_A1, value_A2, value_A5, value_A6))
time.sleep(0.1)

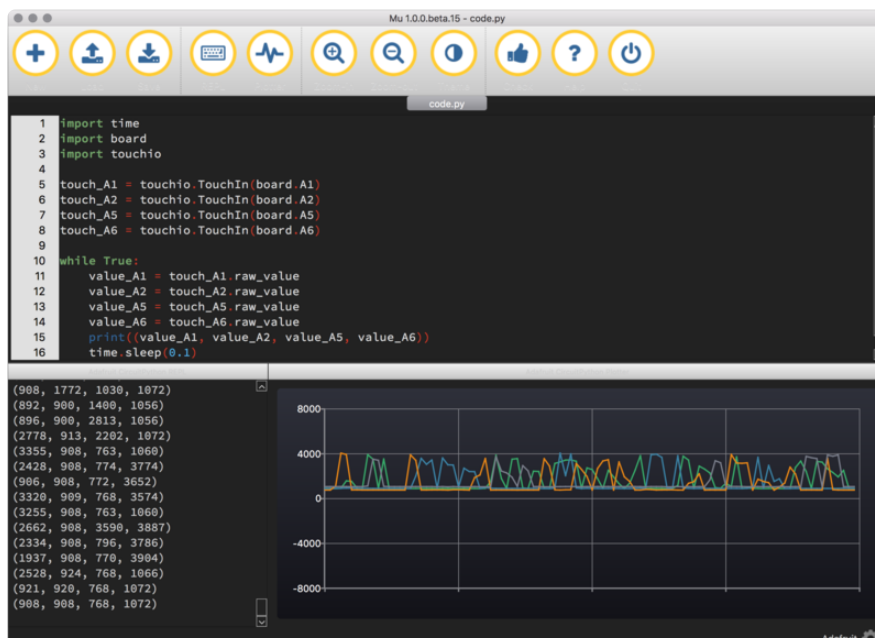
```

Our code is fairly simple. First we import `time`, `touchio` and `board`. Next, we setup four touch pads, A1, A2, A5 and A6. Inside our `while` loop, we assign `value_PadName` to the `raw_value` for each pad, e.g. `value_A1 = touch_A1.raw_value`, etc. Then we `print` those values in a tuple. And last, we have a `time.sleep(0.1)` to slow down the reading of the values - if it's too fast, it's really hard to read!

Note that the Mu plotter looks for tuple values to print. Tuples in Python come in parentheses () with comma separators. If you have two values, a tuple would look like `(1.0, 3.14)`. We have four values, `(value_A1, value_A2, value_A5, value_A6)`, and note that the tuple itself has its own parentheses. Thus the extra parentheses in `print((value_A1, value_A2, value_A5, value_A6))`.

Once you have everything up and running, try touching any of the four pads, A1, A2, A5 or A6 to see the plotter respond immediately! Try touching only one pad to see if the four lines in the plotter go up. Try touching more than one pad at once to see multiple lines move. The harder you touch the pad, the higher the plotter line will go!

This is a great way to test your capacitive touch pads and plot the changes as you touch different pads!

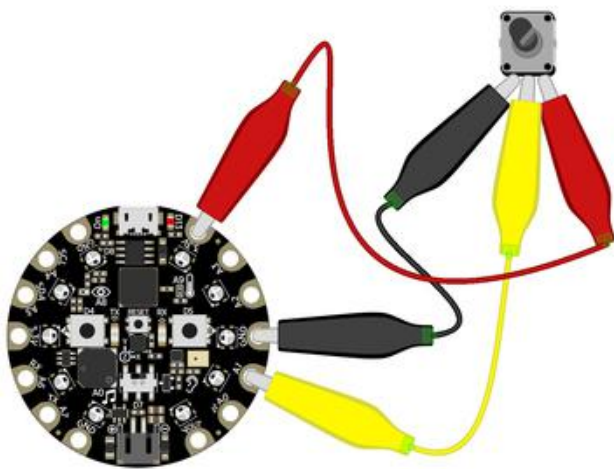


Potentiometer

We're going to use CircuitPython, Mu, and a potentiometer with Circuit Playground Express to plot voltage levels. We'll run this code on our Circuit Playground Express and use Mu to plot the voltage data that CircuitPython prints out.

Visit our [Welcome to CircuitPython](#) page to learn how to install the Mu editor & plotter

First, let's get the potentiometer attached to your Circuit Playground Express!



To connect the potentiometer to the Circuit Playground Express:

Connect the left pin on the potentiometer to GND on the Circuit Playground Express. Connect the middle pin on the potentiometer to A1 on the Circuit Playground Express.

Connect the right pin on the potentiometer to 3.3V on the Circuit Playground Express.

Save the following as code.py on your Circuit Playground Express board, using the Mu editor:

```
# SPDX-FileCopyrightText: 2018 Kattni Rembor for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import time

import analogio
import board

potentiometer = analogio.AnalogIn(board.A1)

def get_voltage(pin):
    return (pin.value * 3.3) / 65536

while True:
    print((get_voltage(potentiometer),))
    time.sleep(0.1)
```

Let's take a look at the code!

First we import `time`, `analogio` and `board`. Next we create the `potentiometer` object and assign it to pin `A1`.

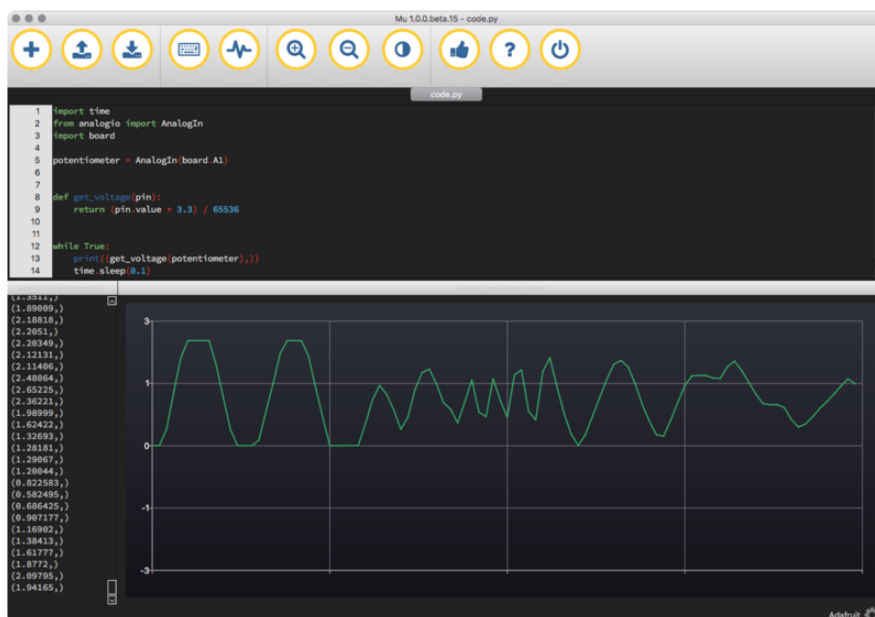
Then we have the `get_voltage()` helper function. By default, analog readings will range from 0 (minimum) to 65535 (maximum). This helper will convert the 0-65535 reading from `pin.value` and convert it to a 0-3.3V voltage reading.

Our main loop is super simple. Inside our `print` statement, we call the `get_voltage()` helper and provide it with the `potentiometer` object. Then we have a `time.sleep(0.1)` to slow down the printed results - otherwise they'd be too fast to read!

Note that the Mu plotter looks for tuple values to print. Tuples in Python come in parentheses `()` with comma separators. If you have two values, a tuple would look like `(1.0, 3.14)`. Since we have only one value, we need to have it print out like `(1.0,)` note the parentheses around the number, and the comma after the number. Thus the extra parentheses and comma in `print((get_voltage(potentiometer),))`.

Once you have everything setup and running, try rotating the potentiometer knob attached to the Circuit Playground Express, and watch the plotter immediately react! Rotate to the left to watch the plotter go down. Rotate to the right to watch it go up!

This is a great way to see the voltage changes resulting from using a potentiometer, and plot the changes as you move the knob!



Color

We're going to use CircuitPython, Mu, and the light sensor on Circuit Playground Express to plot color levels. We'll run this code on our Circuit Playground Express and use Mu to plot the color data that CircuitPython prints out.

Visit our [Welcome to CircuitPython](#) page to learn how to install the Mu editor & plotter

Save the following as code.py on your Circuit Playground Express board, using the Mu editor:

```
# SPDX-FileCopyrightText: 2018 Kattni Rembor for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import analogio
import board
import neopixel

pixels = neopixel.NeoPixel(board.NEOPIXEL, 10, brightness=1.0)
light = analogio.AnalogIn(board.LIGHT)

while True:
    pixels.fill((0, 0, 0))
    pixels[1] = (255, 0, 0)
    raw_red = light.value

    red = int(raw_red * (255 / 65535))
    pixels[1] = (0, 255, 0)
    raw_green = light.value

    green = int(raw_green * (255 / 65535))
    pixels[1] = (0, 0, 255)
    raw_blue = light.value

    blue = int(raw_blue * (255 / 65535))
    pixels.fill((0, 0, 0))

    # Printed to match the color lines on the Mu plotter!
    # The orange line represents red.
    print((green, blue, red))
```

Let's take a look at the code!

First we import `neopixel`, `analogio`, `time` and `board`. Next, we create the `pixels` object for the NeoPixels and the `light` object for the light sensor.

LED colors are set using a combination of red, green, and blue, in the form of an (R, G, B) tuple. Each member of the tuple is set to a number between 0 and 255 that determines the amount of each color present. Red, green and blue in different

combinations can create all the colors in the rainbow! So, for example, to set the LED to red, the tuple would be (255, 0, 0), which has the maximum level of red, and no green or blue. Green would be (0, 255, 0), etc. For the colors between, you set a combination, such as cyan which is (0, 255, 255), with equal amounts of green and blue.

The light sensor works as a color sensor by using the NeoPixel next to it (pixel 1) to flash red, green and blue, and then record the reflected light levels of each color to determine the color of the object being held against it. So, inside our main loop, we need to flash red, green and blue, record the reflected light levels, and then use math to determine the level of each color.

The first thing we do in our main loop is make sure the NeoPixels are off with `pixels.fill((0, 0, 0))`. Next, we begin with red. We flash `pixel[1]` red by assigning it `(255, 0, 0)`, for `0.5` seconds. Then we grab the light sensor value and assign it to `raw_red`.

The light sensor returns a value between 0 and 65535. Since color values are 0-255, we need to use math to scale the raw light sensor value down to a viable color value. So, to get our red value, we use `red = int(raw_red * (255/65535))`. This takes whatever value the light sensor provides, and returns an equivalent value between 0 and 255. Now we have our red level!

We repeat the exact same steps for green, and then for blue.

The last thing we do, is `print` our `red`, `green` and `blue` values in the form of a tuple, so we can see them on the plotter! We've changed the order a bit to `print((green, blue, red))` so the color of the lines on the plotter match the colors they represent: green for green, blue for blue and orange for red.

Once you have everything setup and running, try holding a colored item up to the light sensor on the Circuit Playground Express, and watch the plotter immediately react! Hold up a green item to watch the green line go higher than the blue or red. Hold up a red item and watch the orange line go higher than the green or the blue!

This is a great way to see color levels sense using the light sensor, and plot the changes as you hold up different colors!



Heartbeat Pulse

We're going to use CircuitPython, Mu, and the light sensor on Circuit Playground Express to plot pulse sensing. We'll run this code on our Circuit Playground Express and use Mu to plot the pulse data that CircuitPython prints out.

Visit our [Welcome to CircuitPython](#) page to learn how to install the Mu editor & plotter

Save the following as code.py on your Circuit Playground Express board, using the Mu editor:

```

# SPDX-FileCopyrightText: 2018 Kattni Rembor for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import time

import analogio
import board
import neopixel

pixels = neopixel.NeoPixel(board.NEOPIXEL, 10, brightness=1.0)
light = analogio.AnalogIn(board.LIGHT)

# Turn only pixel #1 green
pixels[1] = (0, 255, 0)

# How many light readings per sample
NUM_OVERSAMPLE = 10
# How many samples we take to calculate 'average'
NUM_SAMPLES = 20
samples = [0] * NUM_SAMPLES

while True:
    for i in range(NUM_SAMPLES):

```

```

# Take NUM_OVERSAMPLE number of readings really fast
oversample = 0
for s in range(NUM_OVERSAMPLE):
    oversample += float(light.value)
# and save the average from the oversamples
samples[i] = oversample / NUM_OVERSAMPLE # Find the average

mean = sum(samples) / float(len(samples)) # take the average
print((samples[i] - mean,)) # 'center' the reading
time.sleep(0.025) # change to go faster/slower

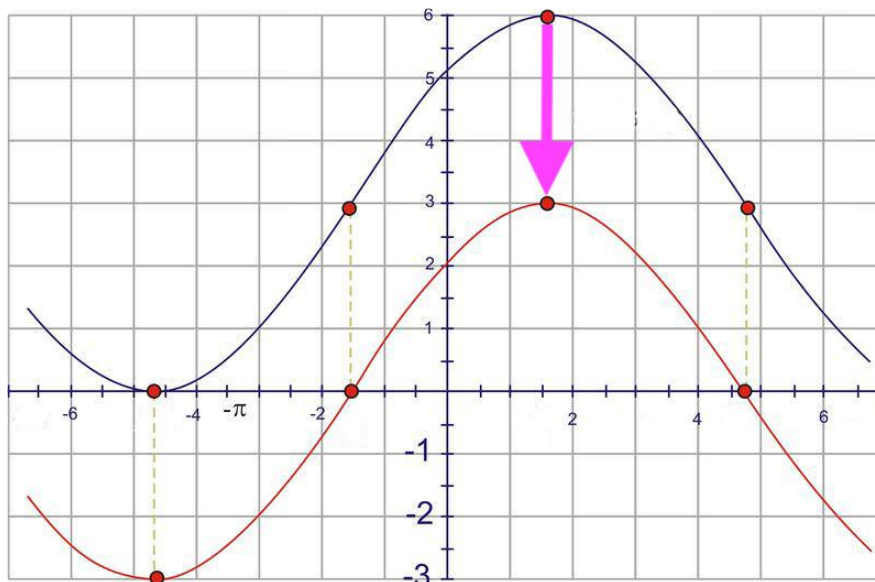
```

For a detailed explanation of how LED pulse sensing works, [check out this article \(\)](#).

There are two things we have to do.

First, the values that result from pulse sensing are often noisy or jittery: some are too high, and some are too low, so we smooth them out by taking an average. We take 10 readings as fast as possible (faster than we need to), find the average, and that smooth out the noise. This is called oversampling.

Second, we want to center the readings around zero. The original samples are all the values are positive (greater than or equal to zero). To center the values around zero, we find the average and shift all the values down. So instead of the value always being greater than zero, it will vary above and below zero, with the average being zero. This is called "removing the DC bias" on the signal. To learn more about DC bias, [check out this article \(\)](#).



Since the signal keeps changing, the average is also going to keep changing. So we keep the last 20 samples and compute their average. When the next sample comes along, we drop the oldest sample, and recompute the average again of the 20 most recent values. This is called a "moving average". Picture a moving window that is

20 samples wide, moving along the stream of sample data that we are taking. For more detailed information about moving averages, [check out this article \(\)](#).

We begin our code by importing the modules we need: `neopixel`, `analogio`, `time` and `board`. Next, we create the `pixels` object for the NeoPixels and the `light` object for the light sensor.

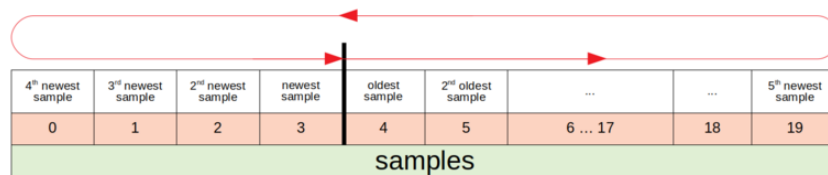
Then, we turn the pixel next to the light sensor green. Note that we turned pixel number "1" green, but it's actually the second pixel on the board. This is because Python starts counting with 0, so the first pixel is pixel number "0".

Next, we assign `NUM_OVERSAMPLE = 10` to specify how many light readings we'll take per sample, and `NUM_SAMPLES = 20` to specify how many samples we're going to take to calculate the average we need to remove the DC bias. Then we create a place to store the samples for the moving average, in `samples = [0] * NUM_SAMPLES`.

Now we start reading samples. The outer loop `for i in range(NUM_SAMPLES):` tells the code to cycle through a range of 20 values, so `i` keeps running between 0 and 19 continuously.

As we mentioned above, we are also going to take 10 samples as fast as possible and average them to smooth out the noise. The inner loop `for s in range(NUM_OVERSAMPLE):` reads 10 values from the light sensor. We sum up all those oversampling values using `oversample += float(light.value)`, until we've added up `NUM_SAMPLES` number of values. Then we divide by 10 to find the average of the oversampling values, and store the value with `samples[i] = oversample / NUM_OVERSAMPLE`.

After we've computed the oversampling average, we compute the moving average with `mean = sum(samples) / float(len(samples))`. The window wraps around the `samples` array. For instance, if `i` is 3, the most recent sample is in `samples[3]`, and the previous samples are in `samples[2]`, `samples[1]`, `samples[0]`, and then wraps around back to `samples[19]`, `samples[18]`, etc. all the way back to `samples[4]`, the oldest value. This image provides a visual explanation.



We subtract the average from the sampled value, with `samples[i] - mean,` to center the reading around zero, or remove the DC bias.

Remember, we initialised the moving average samples array with `samples = [0] * NUMSAMPLES`. You'll notice the plotter doesn't respond correctly at the very beginning. This is because the the moving average that we're taking while the first 20 samples are still in our moving window includes the zeros that we started with before our main loop. So, until we've moved past the first 20 samples, our average will be skewed.

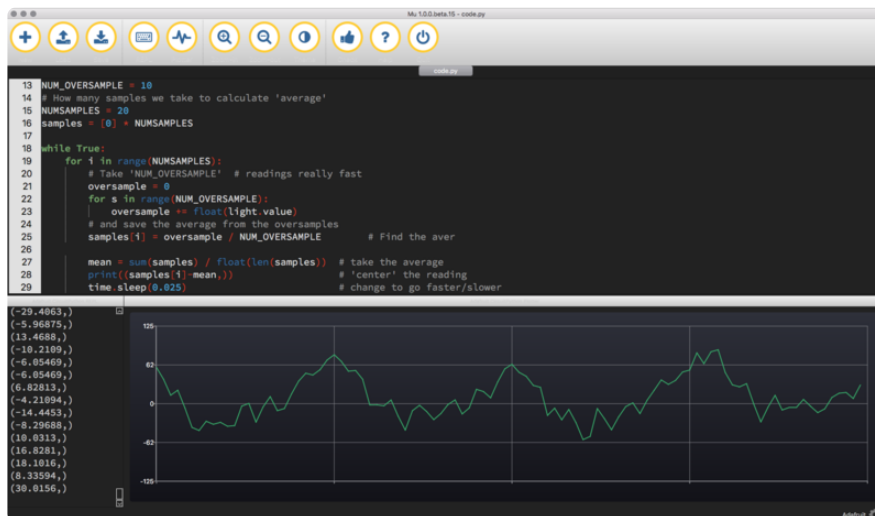
Then, we `print` it as a tuple `print((samples[i] - mean,))`.

Note that the Mu plotter looks for tuple values to print. Tuples in Python come in parentheses () with comma separators. If you have two values, a tuple would look like `(1.0, 3.14)`. Since we have only one value, we need to have it print out like `(1.0,)` note the parentheses around the number, and the comma after the number. Thus the extra parentheses and comma in `print((samples[i] - mean,))`.

Finally we include `time.sleep(0.025)` to give a slight delay to the readings.

Once you have everything setup and running, try pressing your finger over the green LED and the light sensor on the Circuit Playground Express, and watch the plotter react! If you press too hard, sometimes it won't respond. But if you press lightly, you'll see a wave form on the plot that matches your pulse!

This is a great way to sense your pulse using the light sensor, and watch plot the changes as you press your finger against it!



Soil Moisture

We're going to use CircuitPython, Mu, and the capacitive touch pads on Circuit Playground Express to plot soil moisture sensing. We'll run this code on our Circuit Playground Express and use Mu to plot the soil moisture data that CircuitPython prints out.

Visit our [Welcome to CircuitPython page](#) to learn how to install the Mu editor & plotter

The hardware you'll need for this project is the Circuit Playground Express, an alligator clip and a nail. You'll also need at least two soil samples, one wet and one dry, for calibrating the code.

Assembly is as simple as connecting one end of your alligator clip to pad A1 on the Circuit Playground Express, and the other end of your alligator clip to the top of your nail.

Save the following as code.py on your Circuit Playground Express board, using the Mu editor:

```
# SPDX-FileCopyrightText: 2018 Kattni Rembor for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import time
from adafruit_circuitplayground.express import cpx
import touchio
import simpleio
import board

cpx.pixels.brightness = 0.2
touch = touchio.TouchIn(board.A1)

DRY_VALUE = 1500 # calibrate this by hand!
WET_VALUE = 2100 # calibrate this by hand!

while True:
    value_A1 = touch.raw_value
    print((value_A1,))

    # fill the pixels from red to green based on soil moisture
    percent_wet = int(simpleio.map_range(value_A1, DRY_VALUE, WET_VALUE, 0, 100))
    cpx.pixels.fill((100-percent_wet, percent_wet, 0))
    time.sleep(0.5)
```

First we import the libraries we need. The first library is `time`. Next, you'll see we import a specific part of the second library by saying `from`

`adafruit_circuitplayground.express import cpx`. This way we can call this library by typing `cpx` instead of the longer library name. Then we import `touchio`, `simplio`, and `board`.

We set the pixel brightness. Pixel brightness is set by a number between 0 and 1, representing 0-100%, i.e. 0.3 would be 30%. So we set our brightness to 20% with `cpx.pixels.brightness = 0.2`. Then we create the `touch` object so we can use it as our moisture sensor. We are going to use pin A1 in this project, so we provide `board.A1`.

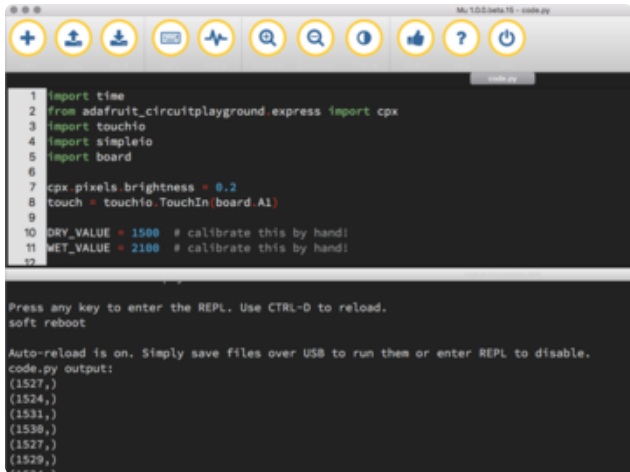
To sense whether the soil is dry or wet, we're going to use the raw capacitive touch values from the capacitive touch pad on the Circuit Playground Express. We create two variables, `DRY_VALUE` and `WET_VALUE` and assign them to the raw capacitive touch values associated with dry and wet soil.

We find these values in the main loop. We assign `value_A1 = touch.raw_value`, and then `print` the results of `value_A1`. This allows us to view the results of the raw capacitive touch values in the serial output. Wet soil has a higher raw capacitive touch value than dry soil, and we can use this to track whether the soil is wet or dry. The code comes with default values for both of these variables, however, the your actual results may be different. Therefore, you should calibrate these values first.

Note that the Mu plotter looks for tuple values to print. Tuples in Python come in parentheses () with comma separators. If you have two values, a tuple would look like `(1.0, 3.14)`. Since we have only one value, we need to have it print out like `(1.0,)` note the parentheses around the number, and the comma after the number. Thus the extra parentheses and comma in `print((value_A1,))`.

`DRY_VALUE` and `WET_VALUE` both need to be calibrated by hand. To calibrate them, place the nail into your soil sample, and open the serial console (REPL) in Mu. Then you can see what the returned value is and you can change your variables to reflect it.

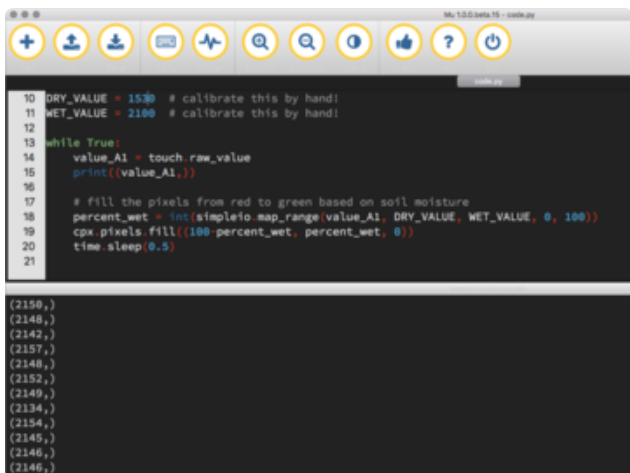
First place your nail into your dry soil sample.



```
1 import time
2 from adafruit_circuitplayground_express import cpx
3 import touchio
4 import simpleio
5 import board
6
7 cpx.pixels.brightness = 0.2
8 touch = touchio.TouchIn(board.A1)
9
10 DRY_VALUE = 1500 # calibrate this by hand!
11 WET_VALUE = 2100 # calibrate this by hand!
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
```

As you can see, the dry value we are getting back is a little bit different than the default number. So let's change `DRY_VALUE` to reflect our results.

Now we'll do the same to get our wet value.



```
10 DRY_VALUE = 1530 # calibrate this by hand!
11 WET_VALUE = 2100 # calibrate this by hand!
12
13 while True:
14     value_A1 = touch.raw_value
15     print((value_A1,))
16
17 # Fill the pixels from red to green based on soil moisture
18 percent_wet = int(simpleio.map_range(value_A1, DRY_VALUE, WET_VALUE, 0, 100))
19 cpx.pixels.fill((100-percent_wet, percent_wet, 0))
20 time.sleep(0.5)
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
```

Place the nail into your wet soil sample.

Now look at the values in the serial output. Our wet value is a little bit different, so let's change `WET_VALUE` as well

We've determined our wet and dry values. Now we'll use these values to make the LEDs green when the soil is 100% wet, and red when the soil is dry, or 0% wet. This is how you'll know your plant needs to be watered!

LED colors are set using a combination of red, green, and blue, in the form of an (R, G, B) tuple. Each member of the tuple is set to a number between 0 and 255 that determines the amount of each color present. Red, green and blue in different combinations can create all the colors in the rainbow! So, for example, to set the LED to red, the tuple would be (255, 0, 0), which has the maximum level of red, and no green or blue. Green would be (0, 255, 0), etc.

So, we're going to need to map the raw capacitive touch values to fit within the values needed for an RGB tuple. To do this, we're going to use `simpleio.map_range`. This works by providing the value we're going to use (`value_A1`), the minimum value we expect `value_A1` to be (which is `DRY_VALUE`), the maximum value we expect `value_A1` to be (`WET_VALUE`), and then the minimum and maximum numbers we'd like to

match it to, which is `0` and `100`. By assigning `percent_wet = int(simpleio.map_range(value_A1, DRY_VALUE, WET_VALUE, 0, 100))`, we are taking the raw capacitive touch values and mapping them to a whole number (`int`) between 0 and 100 to get a percentage.

We use this percentage to set the LEDs to be red when dry, green when wet, and a yellowish color in between as the soil is slowly drying out. We light up all the pixels with `cpx.pixels.fill((100-percent_wet, percent_wet, 0))`, which uses the `percent_wet` we get from the previous line.

When the soil is 100% wet, the first member of the tuple is `0` (`100-percent_wet` if `percent_wet`=100 is 0), and the second member is `100` (because `percent_wet`=100). So the tuple when the soil is wet is (0, 100, 0) which means the LEDs will be green. This is how you know you don't need to water your soil!

When the soil is 0% wet, the first member of the tuple is `100` (`100-percent_wet` if `percent_wet`=0 is 100), and the second member is `0` (because `percent_wet`=0). So the tuple when the soil is wet is (100, 0, 0) which means the LEDs will be red. This is how you know it's time to water your soil!

But what about when your soil is sort of wet and sort of dry? When the soil is 50% wet, the first member of the tuple is `50` (`100-percent_wet` if `percent_wet`=50 is 50), and the second member is `50` (because `percent_wet`=50). So the tuple when the soil is half dry is (50, 50, 0) which means the LEDs will be yellow. The yellow color will range from a greenish-yellow to a reddish-yellow as your soil goes from moist to slowly drying out. This is how you'll know it'll be time to water your soil soon!

Finally, we include a `time.sleep(0.5)` to slow down the speed of reading the data. Soil dries out slowly so there's no need for reading the data super quickly.

Once you have everything setup and running, try placing your nail into wet soil, and watch the plotter immediately react! Place your nail into dry soil to watch the plotter go down. Place it into soil that's only sort of wet to watch it go up a little Place it back into wet soil and watch it go up higher!

This is a great way to see soil moisture levels using the capacitive touch pad, and plot the changes as the soil slowly dries out!

