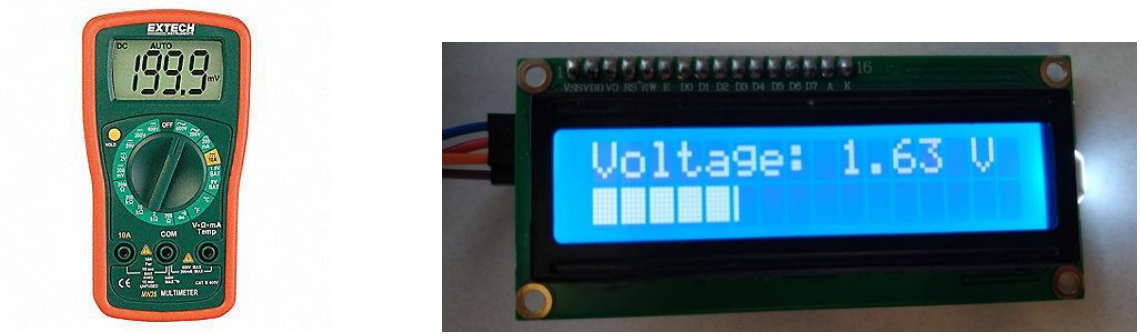
Arduino Voltmeter Lab

Before class, you should have completed the prepare activity (link). If you get to class without having done the prepare activity, please come anyway, and complete the lab along with the class. Then go back and do the prepare activity after.

Introduction

A device that measures voltage is called a *voltmeter*; a device that measures current is called an *ammeter*; and a device that measured resistance is called an *ohmmeter*. A device that can measure all of these is called a *multimeter*. See an example in Figure 1(a). You may watch this video to learn more.



(a) (b)

Figure 1

For this lab, you will use your Arduino as a voltmeter. Your Arduino will send the value it measures to your LCD display to show the measured voltage, as in the image above in Figure 1(b). You will measure voltage using Analog Pin 0 (A0), which the Arduino will compare to its *ground* signal, which we will call zero volts. In other words, we will measure how much voltage A0 has above ground.

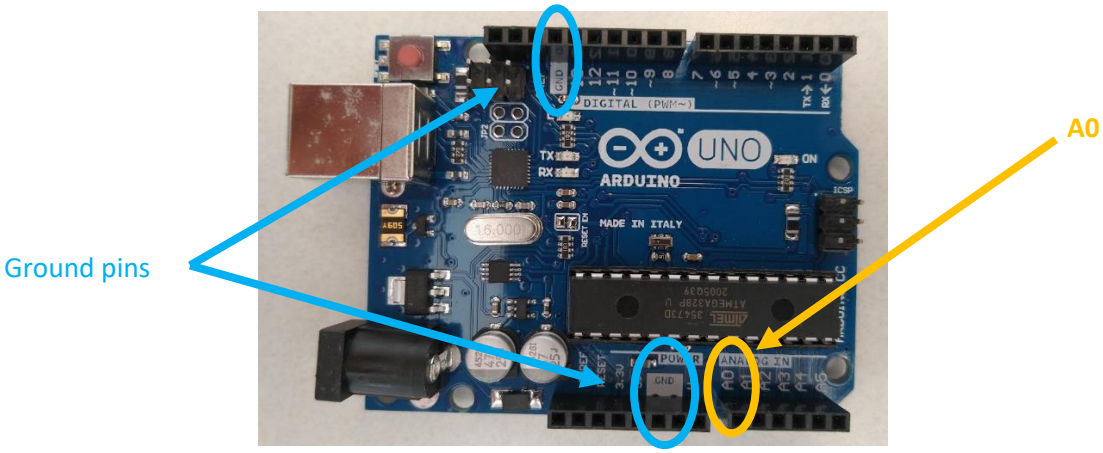


Figure 2

Part 1: Wiring Up your Breadboard

1. Find your breadboard in your kit.

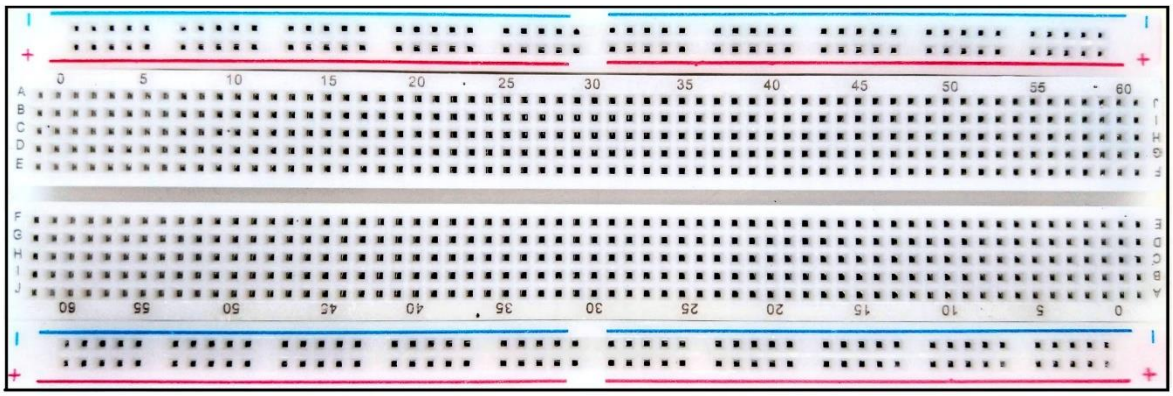


Figure 3

On the breadboard, all the holes next to a blue line are connected underneath to all other holes next to that same blue line. That is called a Ground Bus. Similarly, all the holes next to a red line are connected underneath to all other holes next to that same red line. That is called a High Voltage Bus (or the Vcc Bus). There are busses on the top and the bottom. On many of the breadboards, there is a break in the middle between the busses on the left and the busses on the right. If that's the case, your breadboard has four Ground Busses and four High Voltage Busses.

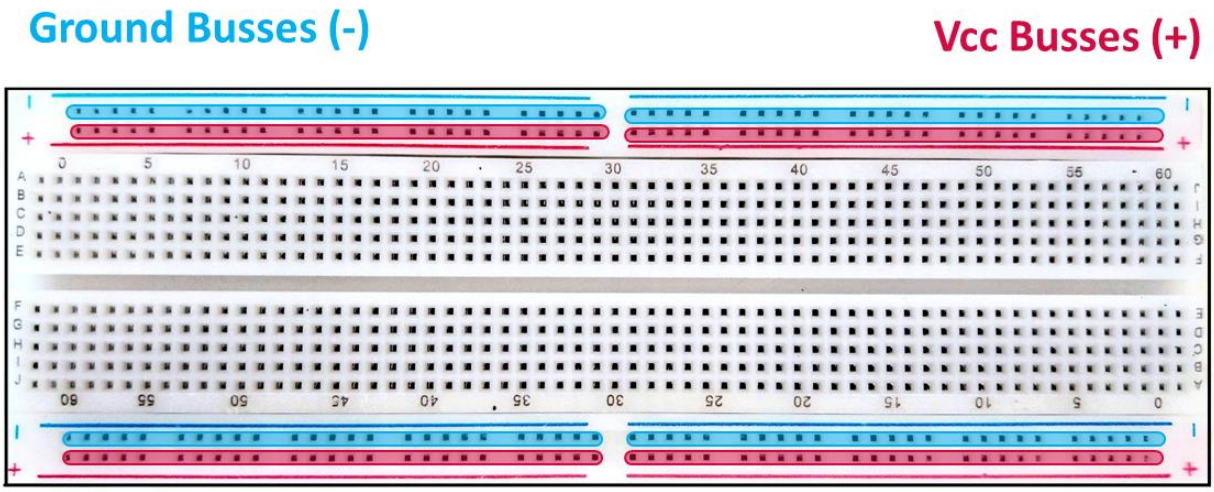


Figure 4

Follow these steps to connect power to your Busses (see Figure 5):

2. Connect GND on your Arduino to a hole on a Ground Bus on your breadboard.
3. Connect that Ground Bus to the other Ground Busses on your breadboard.
4. Connect 5V on your Arduino to a hole on a High Voltage Bus on your breadboard.
5. Connect that High Voltage Bus to the other High Voltage Busses on your breadboard.

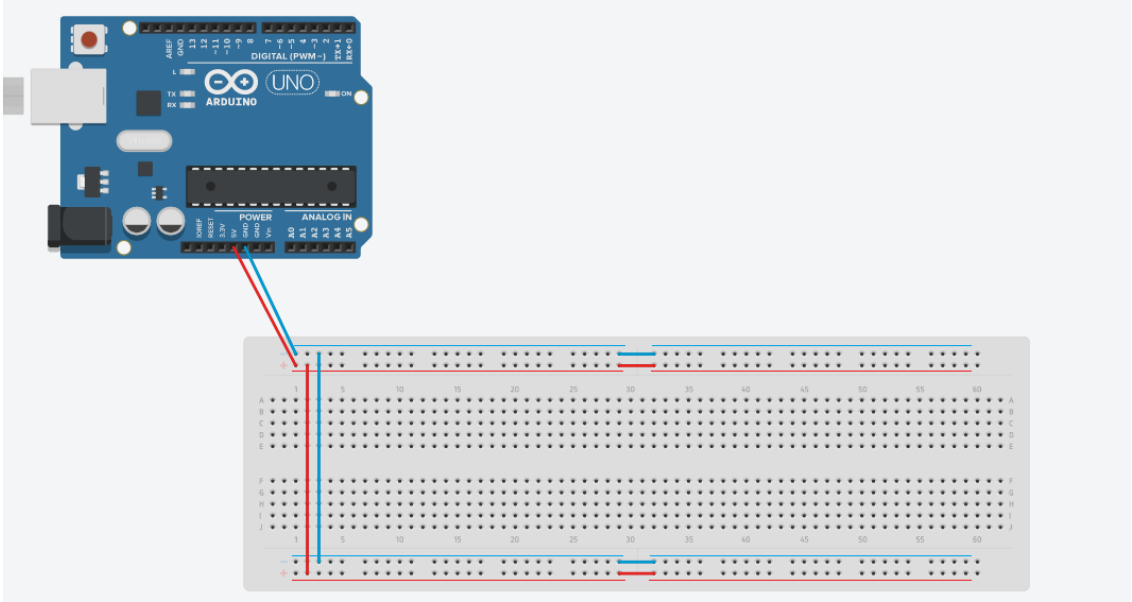


Figure 5

Note: In future labs, whenever you use the breadboard, you will set it up this way. Pay attention to these details:

- Your breadboard should be oriented so that the blue line is on top and the red line is on bottom.
- The GND pin on the Arduino goes into the (-) row on the breadboard.
- The 5V pin on the Arduino goes into the (+) row on the breadboard.
- The wires you added above connect the top busses to the bottom busses and the left busses to the right busses. Now all four High Voltage Busses are connected to 5V and all four Ground Busses are connected to ground.

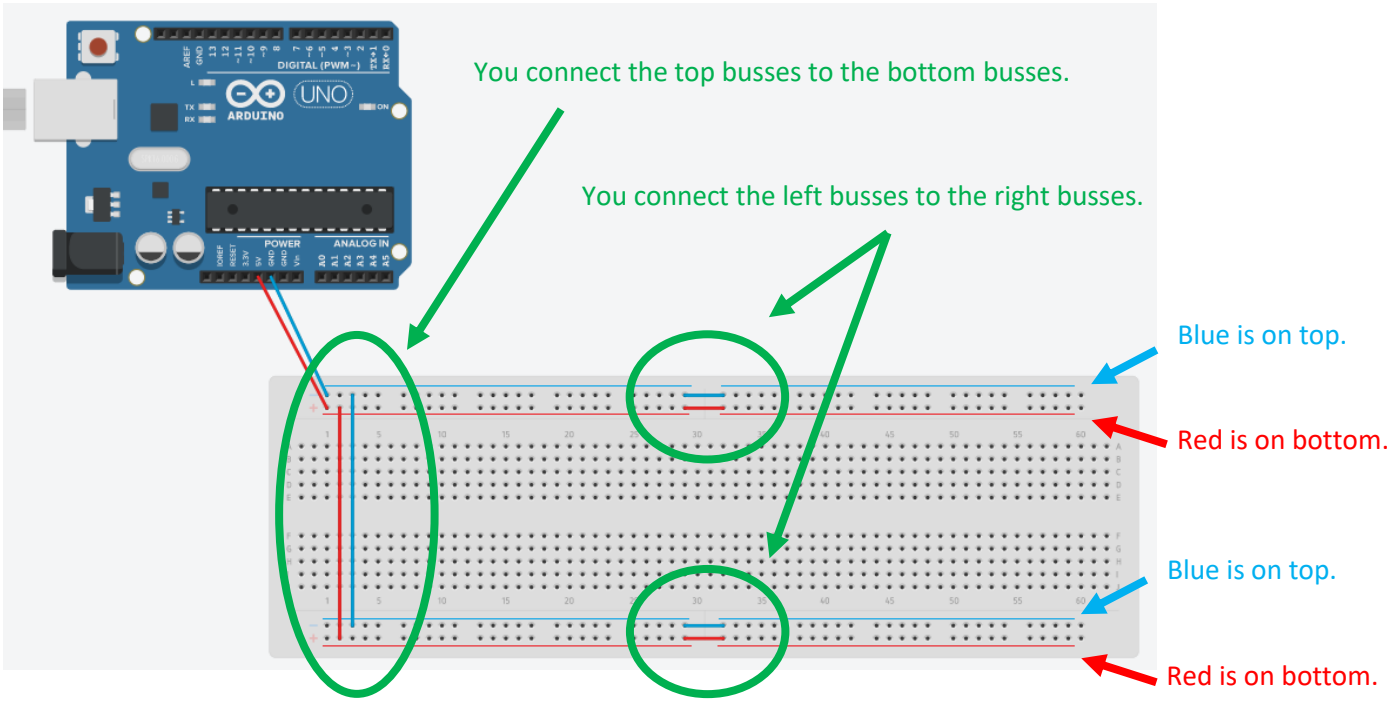


Figure 6

Part 2: Wiring Up your LCD

You will follow the same steps as the previous lab for connecting your LCD to your Arduino. However, you are already using the 5V pin on the Arduino. Luckily, on the breadboard, all the pins on a High Voltage Bus are also now at 5V. Follow these steps:

1. Connect the GND pin on your LCD to a hole on a Ground Bus on your breadboard.
2. Connect the VCC pin on your LCD to a hole on a High Voltage Bus on your breadboard.
3. Connect the SDA pin on your LCD to pin A4 on the Arduino.
4. Connect the SCL pin on your LCD to pin A5 on the Arduino.

Your circuit should now look like Figure 7:

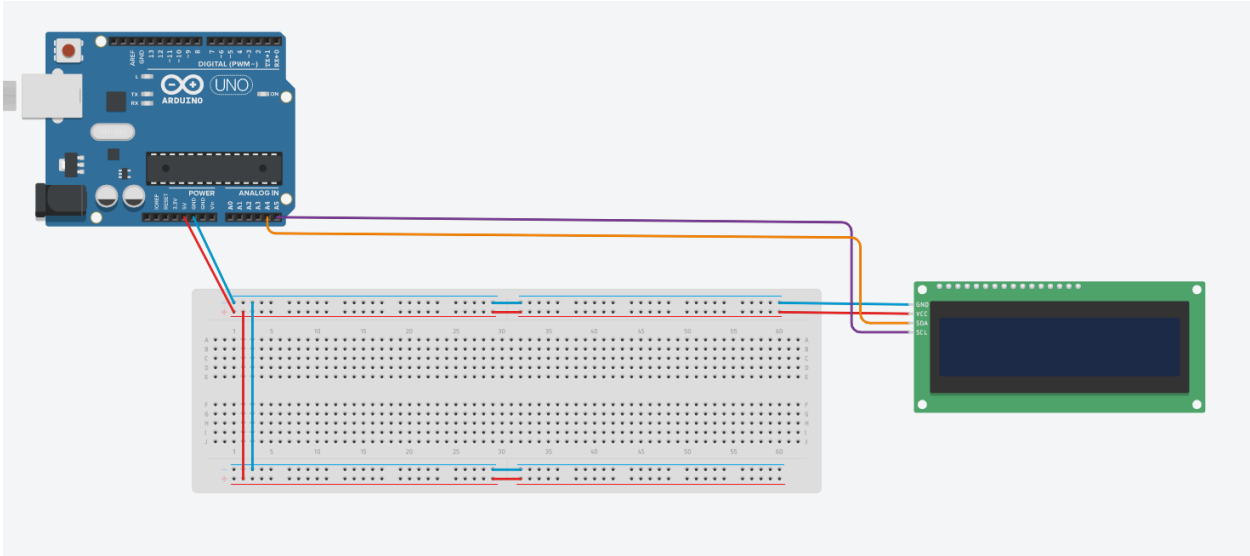


Figure 7

Part 3: Run the Voltmeter Code

1. Download the ArduinoVoltmeterLCD.ino file.
2. Open Arduino IDE.
3. From within Arduino IDE, open the ArduinoVoltmeterLCD.ino file that you just downloaded. (It may be in your Downloads folder.)
4. If it asks you to put it in a different folder, say OK.
5. Plug your Arduino into your laptop.
6. From the dropdown menu in the Arduino IDE, select the correct port and board.
7. Press the upload arrow.

You should now see your LCD display "`Voltage: X.XX V`" where "`X.XX`" is the value in volts that it is reading. (See Figure 8.) If your screen displays garbage, reset your Arduino by pressing the red button. If the screen is too dim or too dark, adjust the contrast knob on the back with a screwdriver.

Important Note: It is reading the voltage on Pin A0. For now, since you don't have Pin A0 attached to anything, you may see erratic, rapidly changing numbers. *That is normal.*

Figure 8

Part 4: Measure Ground

The A0 pin is what is measuring voltage.

1. With a male-to-male jumper wire, connect A0 on the Arduino to a GND bus (any hole along a blue line) on your breadboard.

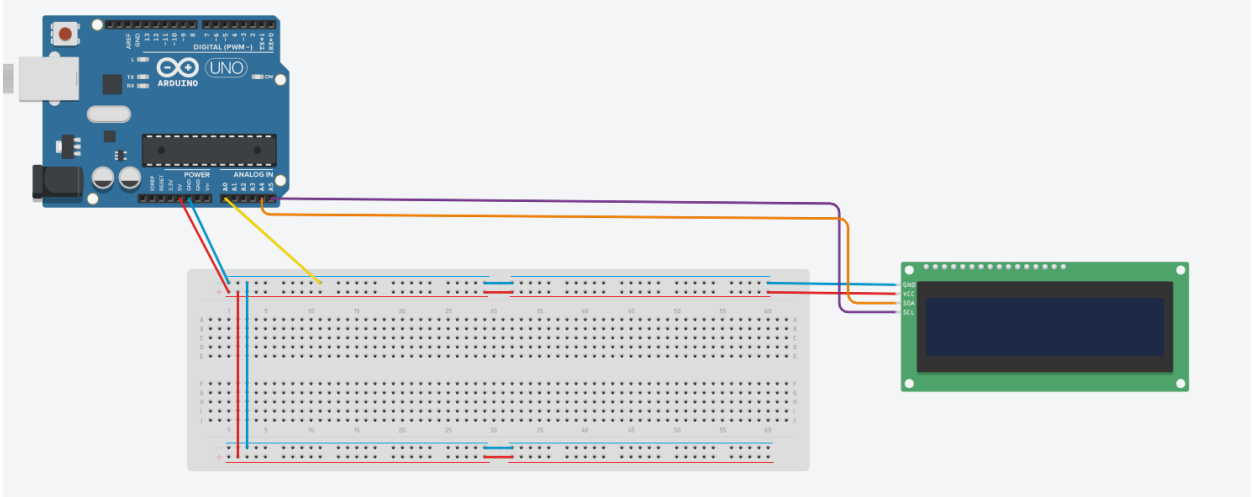


Figure 9

Your screen should now measure approximately 0.00 Volts. (It doesn't need to be exact.)

2. **Take a photo** of your measurement of Ground (GND, zero volts) for I-Learn. The photo should include your breadboard and LCD.

Part 5: Measure 5 Volts

Note: From now on, these instructions will refer to the wire connected to A0 as "the probe." One end will stay connected to A0. The other end will connect to the pin or wire you are measuring voltage on.

1. Connect the probe to the High Voltage Bus.

Your screen should now measure approximately 5.00 Volts. (It doesn't need to be exact.)

2. **Take a photo** of your measurement of 5 Volts for I-Learn.

Part 6: Measure 3.3 Volts

1. Connect the probe to the 3.3V pin on the Arduino. (Remember, the probe is the wire connected to A0, so this means to connect the A0 pin to the 3.3V pin.)

   Your screen should now measure approximately 3.30 Volts. (It doesn't need to be exact.)

2. **Take a photo** of your measurement of 3.3 Volts for I-Learn.

Part 7: Build a Two-Resistor Series Circuit

When current flows through two resistors in a row, those resistors are in "series." You will need two resistors that you will connect in series. Find your resistors that are 1000 Ohms (1kΩ). They have the following color band order: **BROWN**, **BLACK**, **BLACK**, **BROWN**, **BROWN**.

Figure 10

Note: The direction of a resistor doesn't matter. So, the order could be reversed.

1. Find a 1kΩ resistor.
2. Plug one end of the resistor into a High Voltage Bus.
3. Plug the other end into one of the middle columns of the breadboard (see image below).
4. Find another 1kΩ resistor.
5. Plug one end into the same column as the first resistor. (Note: the columns do not connect across the middle gap, so both must be in the same column on the same side of the gap.)
6. Plug the other end of the second resistor to a GND bus.

Your circuit should look like the image below.

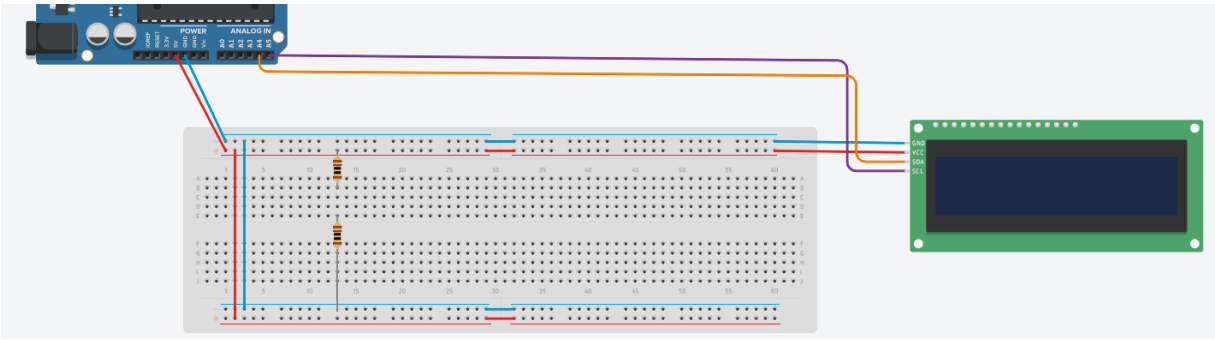


Figure 11

Verify that the resistors are connected correctly to the busses by measuring with the probe:

7. Touch the tip of the probe to the top pin of the top resistor (the metal part connected to the High Voltage Bus). It should measure 5V.
8. Then, touch the tip of the probe to the bottom of the bottom resistor (the metal part connected to the Low Voltage Bus). It should measure 0V.

Don't measure the middle yet (where the two resistors meet). Wait until Part 10 to measure in between.

Part 8: Calculate the Current

By having the current run through both resistors on its way from 5V to GND, the total resistance is the sum of both resistors: 1kΩ + 1kΩ = 2kΩ, or 2,000Ω.

1. Using Ohm's Law, calculate the current with 5V and 2,000 Ω.

That is how many Amps are flowing through the resistors.

2. Enter that number in I-Learn, **correct to 4 decimal places**.

Part 9: Calculate the Voltage Between the Resistors

Now, if each resistor has that amount of current running through it, then you can calculate the voltage difference between the top and bottom of each resistor.

1. For a single 1kΩ resistor, calculate the voltage difference between the top and the bottom by using Ohm's Law. (In other words, multiply 1000 by the current you calculated above in Part 8.)

That is the voltage difference between the top and bottom of each individual resistor.

2. Enter the number in I-Learn, **correct to 1 decimal place**:

Part 10: Measure the Voltage Difference

Now, use the probe to measure the difference from the top to the bottom of each resistor.

We already know the very top is at 5V, and the very bottom is at 0V. Measure in the middle:

1. Touch the probe to the middle, where the two resistors connect, by plugging it into the same column as the connected resistors (see image below).

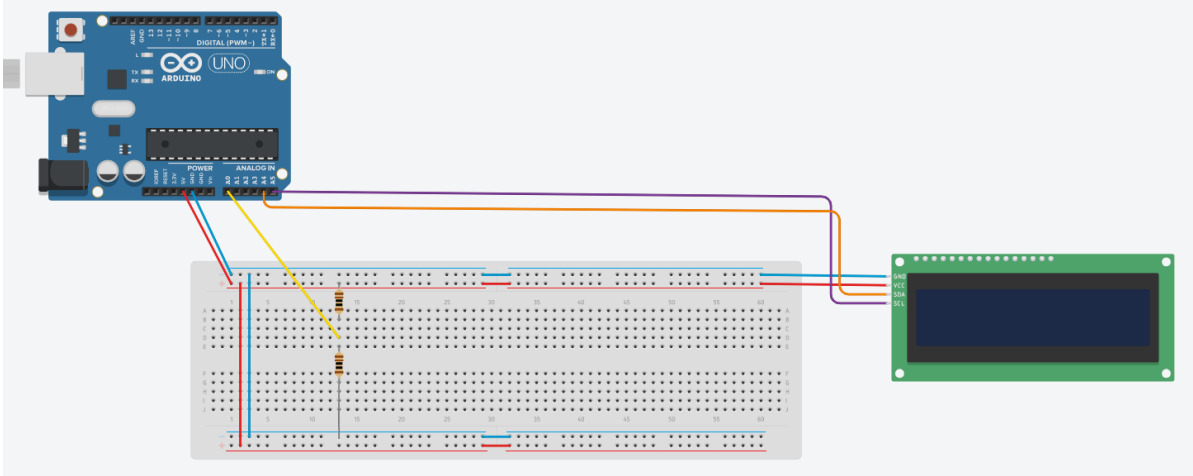


Figure 12

Your measurement on your LCD screen should match your calculation above. If your calculation and measurement do not match, ask the instructor or T.A. for help.

2. **Take a photo** for I-Learn of your measurement of the wire between the two resistors.

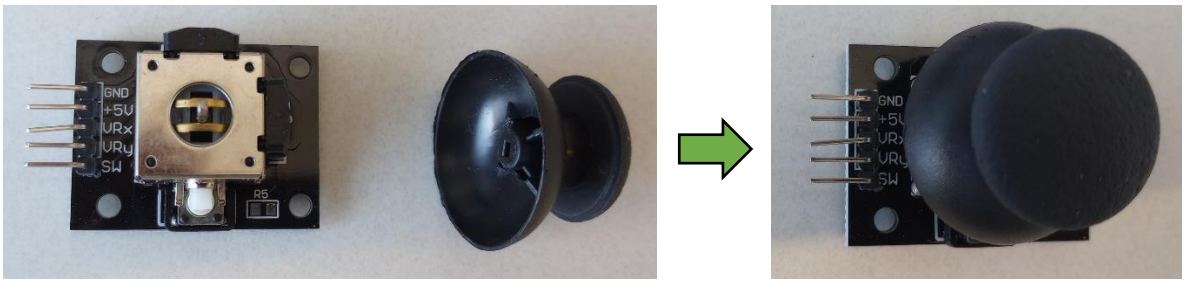
Just for Fun: Use the X-axis of a Joystick

(This part is optional.)

If you would like to precisely control the voltage, you can use a variable resistor (potentiometer) inside the joystick from your kit. The joystick knob and the joystick base might be separated–if so, just put them together (see Figure 13 below).

1. Connect GND on the joystick to one of the GND busses.
2. Connect +5V on the joystick to one of the High Voltage busses.
3. Connect VRx on the joystick to the probe (A0).

You should now be able to move the joystick left to right and control the voltage from 0.0V to 5.0V.



Putting together the joystick
Figure 13

Just for Fun: Use both the X-axis *and* the Y-axis of a Joystick

(This part is also optional.)

If you would like to use both the X-axis (left and right) and the Y-axis (up and down) of the joystick, you will need to measure two analog input signals. To do this, you will use two pins as probes: A0 for the X direction and A1 for the Y direction. You'll need a different program for measuring both at the same time:

1. Download the ArduinoVoltmeterLCD_TwoChannel.ino sketch file.
2. Upen the file from within the Arduino IDE.
3. Upload this new program to your Arduino using the upload arrow.

In addition to the connections above, you will need to connect the Y-axis:

4. Connect VRy on the joystick to the second probe (A1).

You should now be able to move the joystick left to right and control the bottom scale and up and down to control the top scale.

Submit to I-Learn

Find the lab report assignment for this lab in I-Learn. Upload your images and enter your calculations there.

Congratulations! You are finished with the lab.