HiBall Balloon Payload Workshop

Sensors Part 2

Partner

Part 1 – Arduino Test Drive Sensors

A. LED Visual Display
B. Analog vs. Digital
C. Balloon Shield Build
D. Thermometer

Part 2 – Arduino Road Trip Sensors

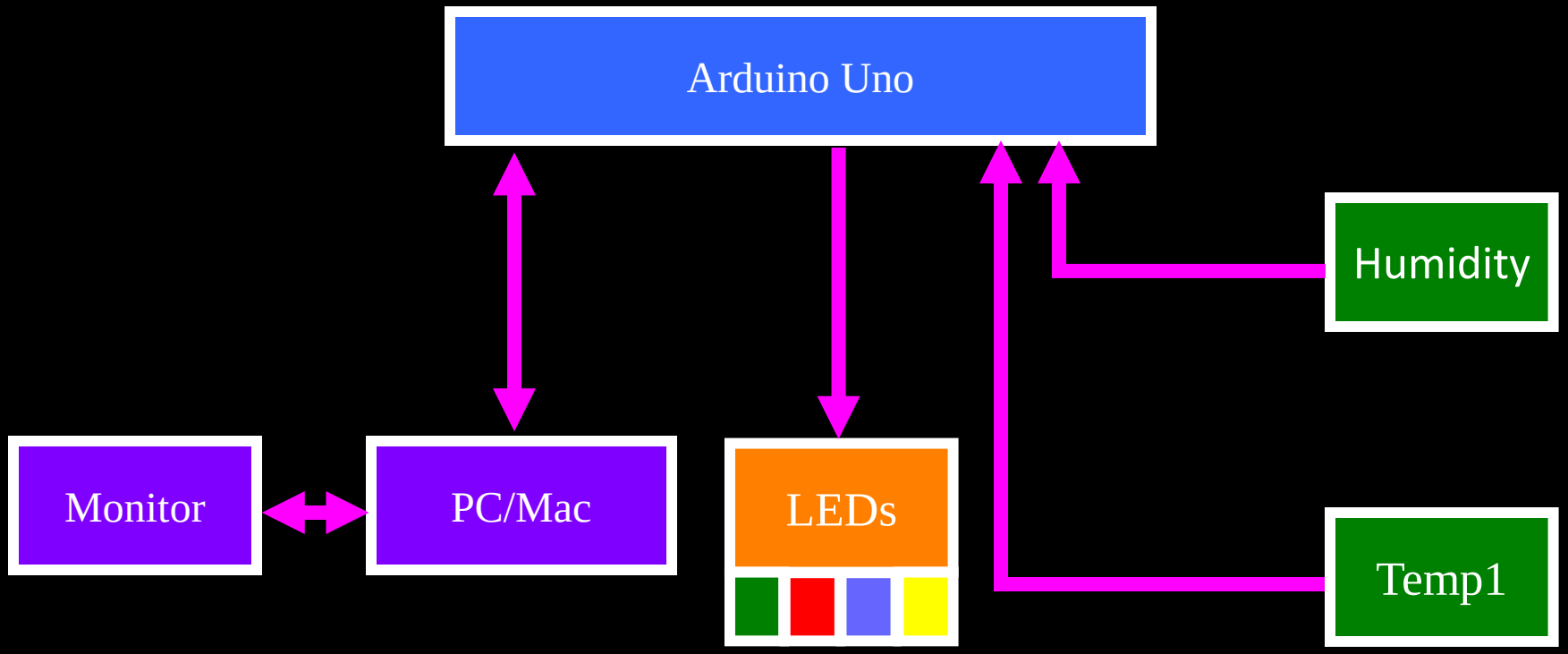
A. Humidity Sensor
B. Pressure Sensor
C. Accelerometers
D. External Temp Sensor

Part 2 – Arduino Road Trip Sensors

A. Humidity Sensor
B. Pressure Sensor
C. Accelerometers
D. External Temp Sensor

Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**



Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

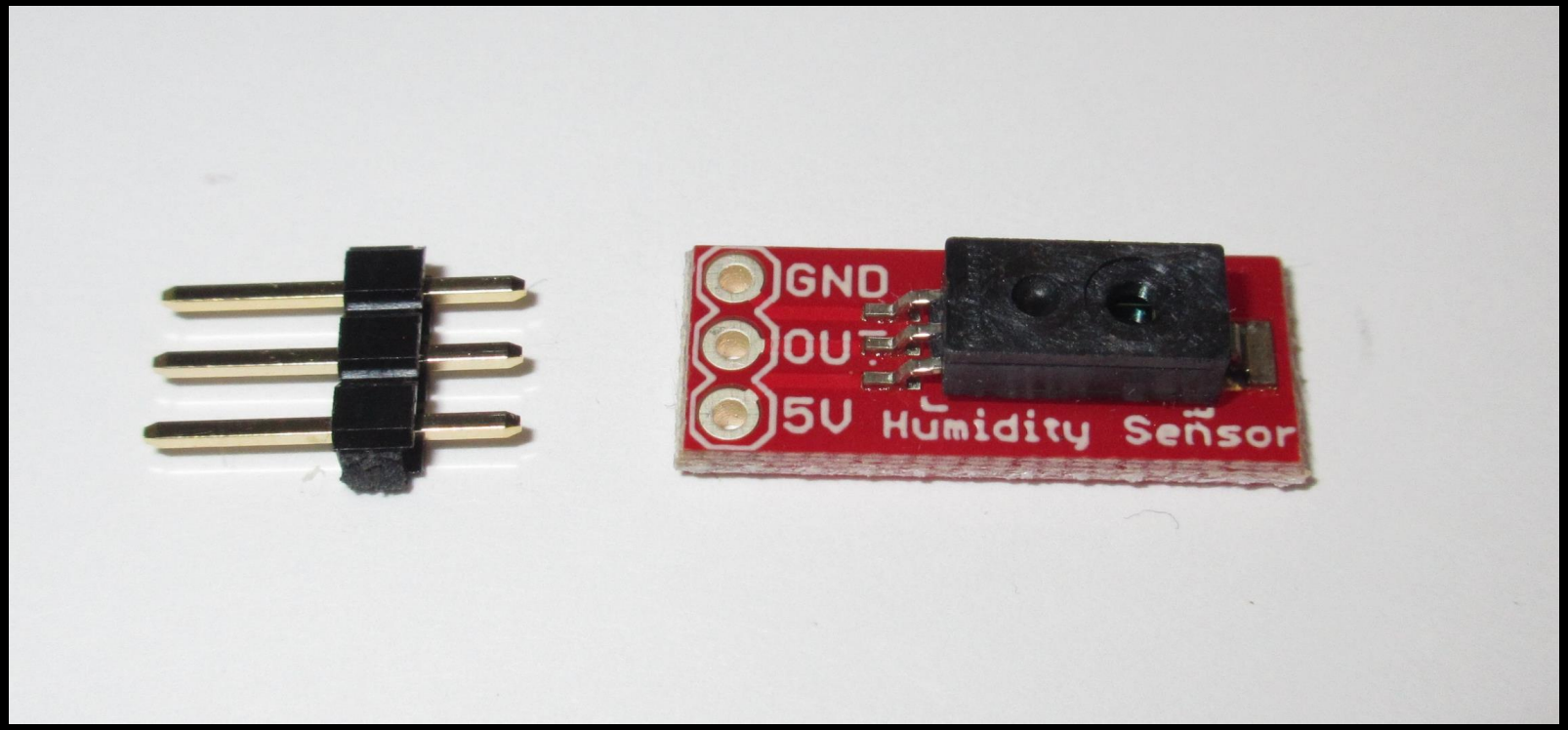
- Humidity sensor (or the Darth Vader Sensor)

- It measures moisture in the air, which is great for balloon flights (condensation failures)

Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

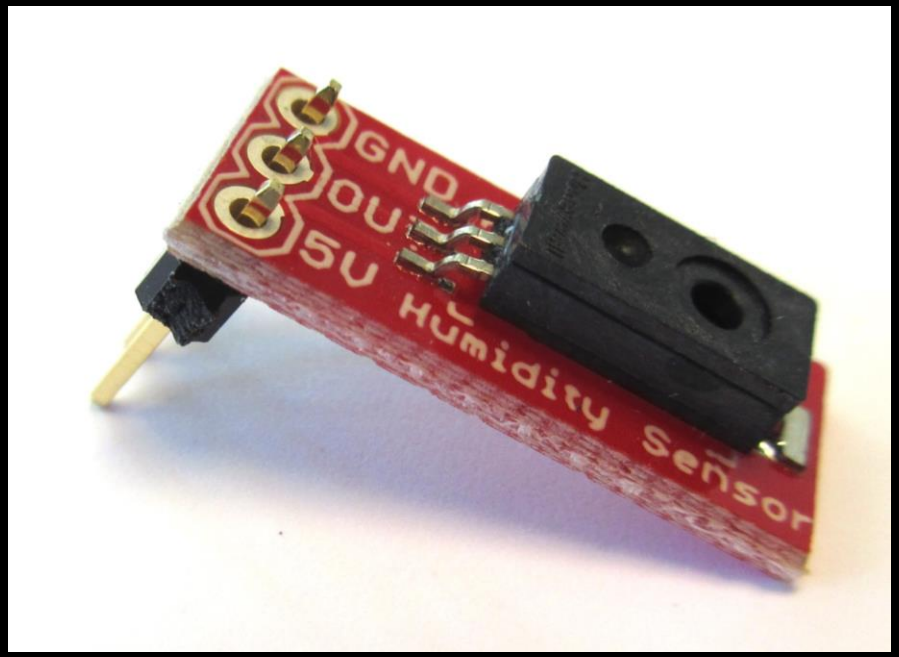
- First need to solder header to sensor

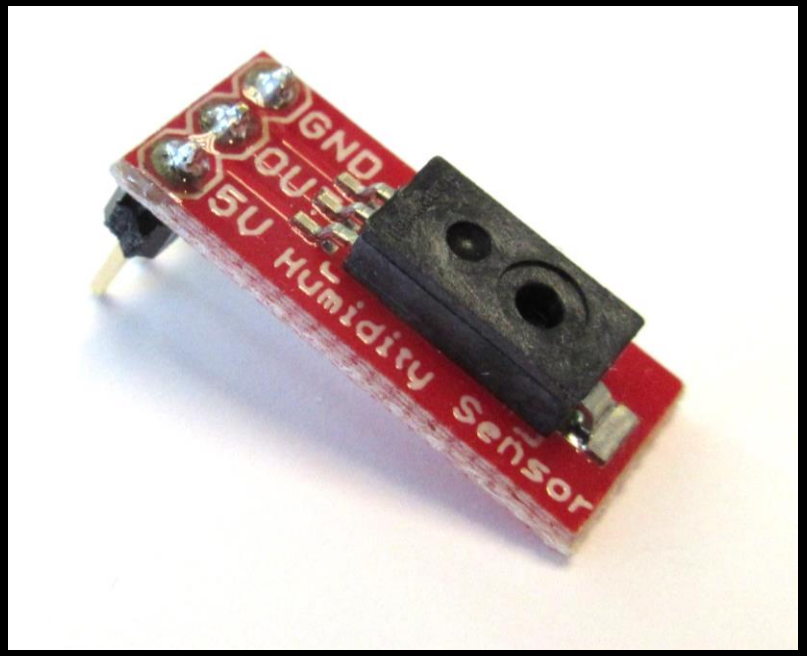


Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Install header like shown and solder from top of board
- Short side through the bottom of the board
- Keep header perpendicular to board





Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

Leave your Balloon Shield attached to Arduino

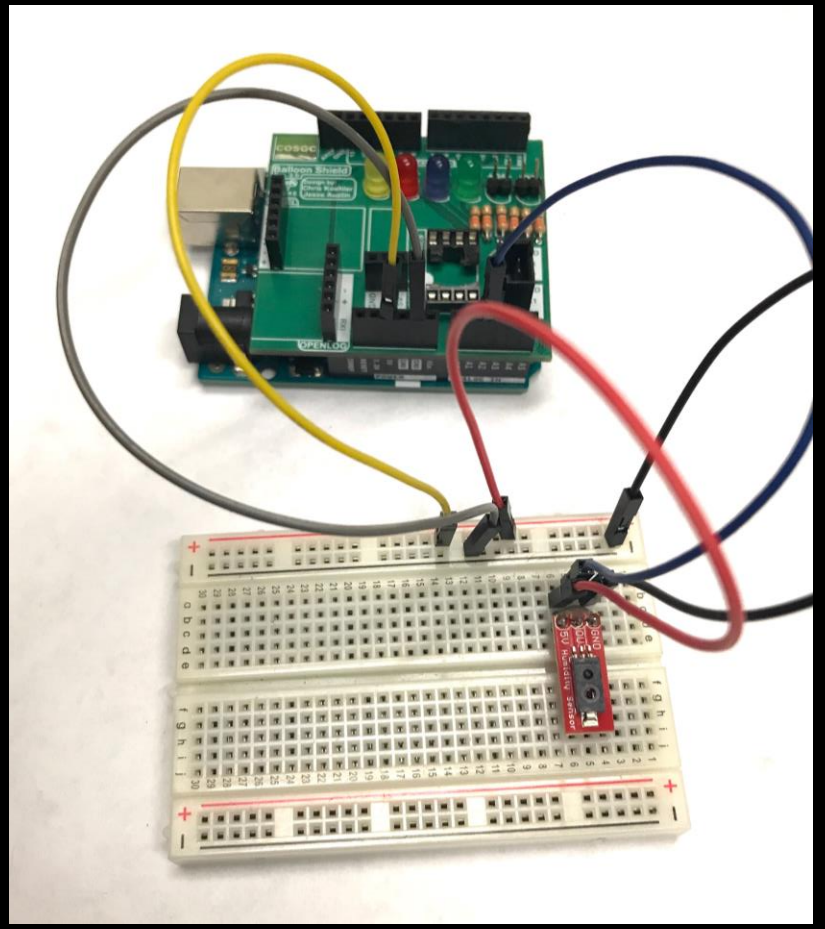
- Wire **Arduino 5V** to Breadboard **(BB) 5V PWR Rail**

- Wire **Arduino GND** to **BB GND Rail**

- Wire **Sensor 5V** to **BB 5V Rail**

- Wire **Sensor GND** to **BB GND Rail**

- Wire **Sensor OUT** to **Arduino A2**



Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

Leave your Balloon
Shield attached to Arduino

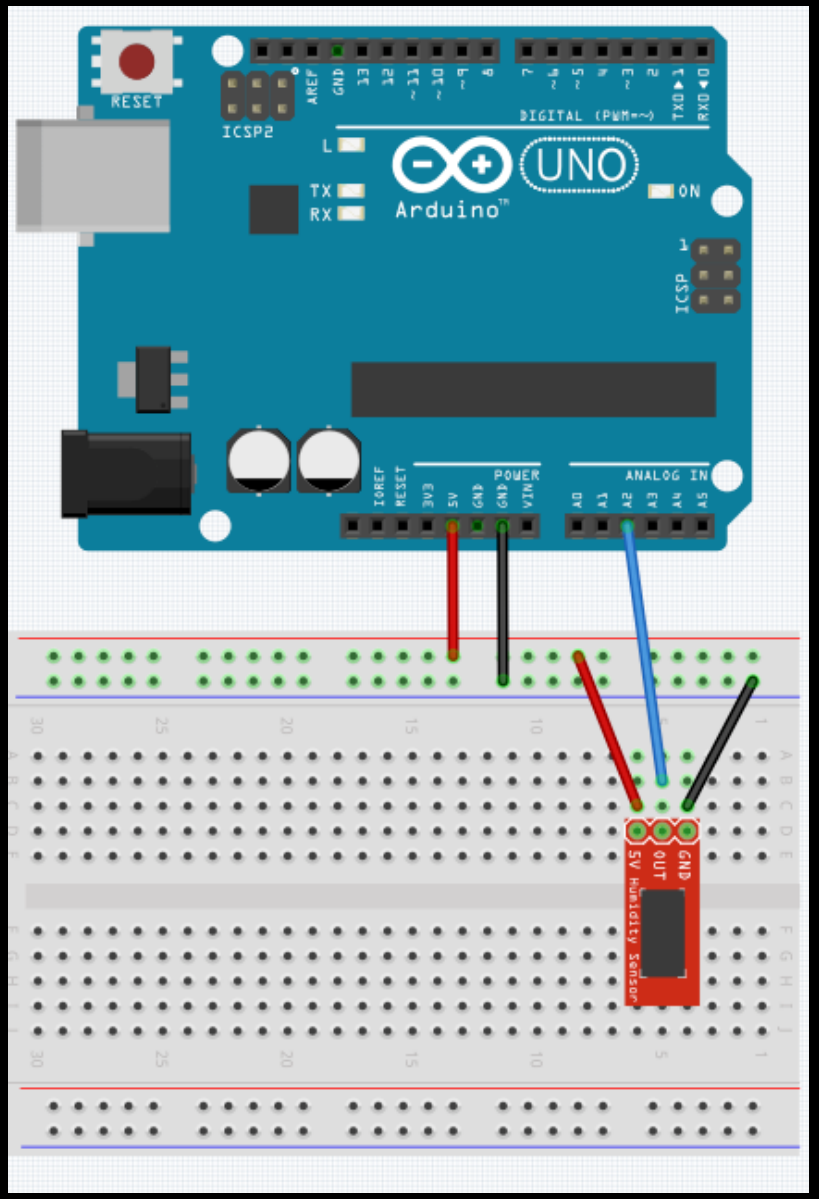
- Wire **Arduino 5V** to Breadboard **(BB) 5V PWR Rail**

- Wire **Arduino GND** to **BB GND Rail**

- Wire **Sensor 5V** to **BB 5V Rail**

- Wire **Sensor GND** to **BB GND Rail**

- Wire **Sensor OUT** to **Arduino A2**



Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

Leave your Balloon
Shield attached to Arduino

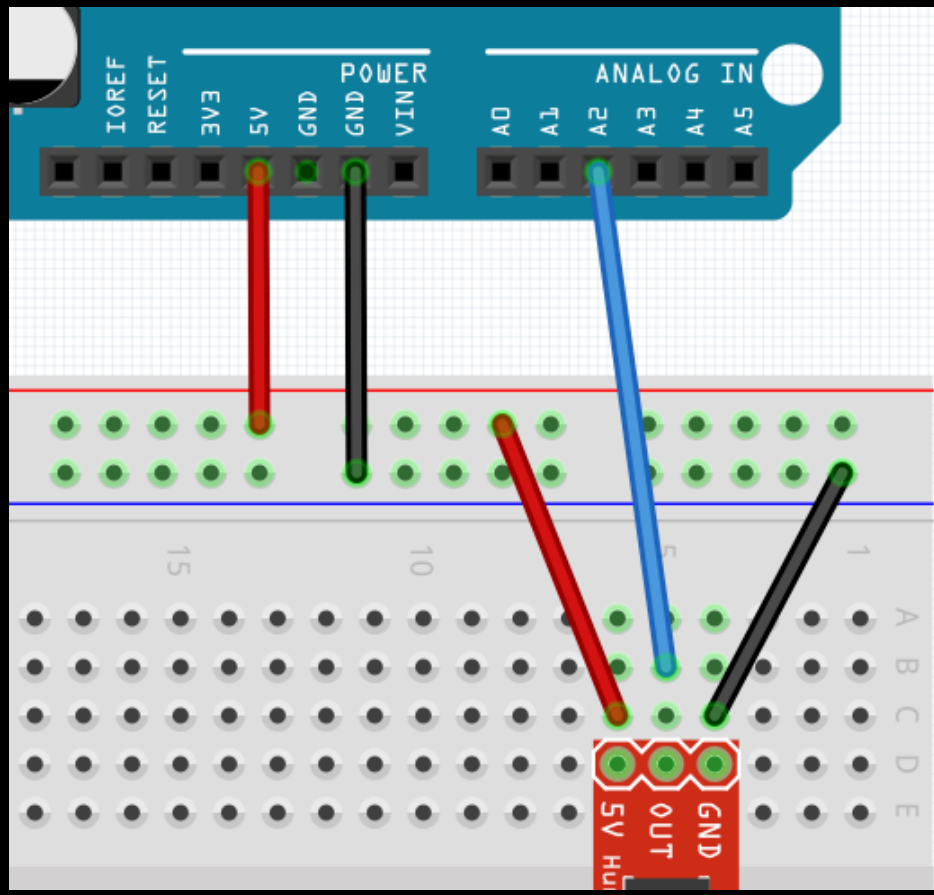
- Wire **Arduino 5V** to Breadboard **(BB) 5V PWR Rail**

- Wire **Arduino GND** to **BB GND Rail**

- Wire **Sensor 5V** to **BB 5V Rail**

- Wire **Sensor GND** to **BB GND Rail**

- Wire **Sensor OUT** to **Arduino A2**



Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- Modify sketch to read new sensor on A2

```
// Definitions
      int sensor;
      float sensorVolt;
```

```
void loop() {
//    put your main code here, to run

      sensor = analogRead(A2);
      sensorVolt = sensor*(5.0/1023);
      Serial.print(sensor);
      Serial.print("\t voltage ");
      Serial.println(sensorVolt);

//    Turn script running leds OFF at begir
      digitalWrite(5, LOW);  //Green LED
```

```
if(sensorVolt > 1.25) {
digitalWrite(5, HIGH);
}
if(sensorVolt > 1.75) {
digitalWrite(6, HIGH);
}
if(sensorVolt > 2.25) {
digitalWrite(7, HIGH);
}
if(sensorVolt > 2.75) {
digitalWrite(9, HIGH);
}
delay(100);
```

EXTRA

Humidity Sensor:

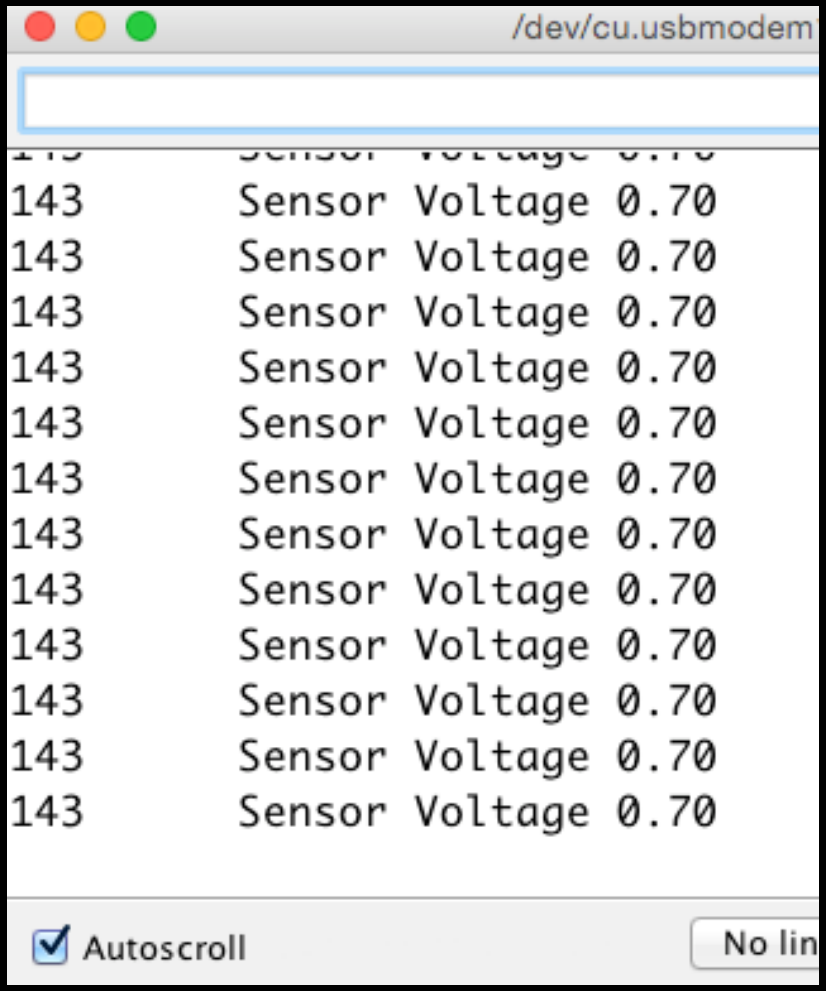
Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Compile and Upload**

- **Start Serial Monitor**

- **Breathe on humidity sensor like Darth Vader**

- **Watch LEDs on Shield**



- Next, let's convert volts to % humidity

Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Look at the data sheet to understand output of the sensor**

- **We know Vout and Vsupply so using algebra**

Honeywell

HIH-4030/31 Series

Humidity Sensors

DESCRIPTION

Honeywell has expanded our HIH Series to include an SMD (Surface Mount Device) product line: the new HIH 4030/4031. The HIH 4030/4031 complements our existing line of non-SMD humidity sensors. SMD packaging on tape and reel allows for use in high volume, automated pick and place manufacturing, eliminating lead misalignment to printed circuit board through-hole.

The HIH-4030/4031 Series Humidity Sensors are designed specifically for high volume OEM (Original Equipment Manufacturer) users.

Direct input to a controller or other device is made possible by this sensor's near linear voltage output. With a typical current draw of only 200 µA, the HIH-4030/4031 Series is often ideally suited for low drain, battery operated systems.

Tight sensor interchangeability reduces or eliminates OEM production calibration costs. Individual sensor calibration is available.

The HIH-4030/4031 Series delivers instrumentation-quality RH (Relative Humidity) sensing performance in a competitively priced, solderable SMD.

The HIH-4030 is a covered integrated circuit humidity sensor. The HIH-4031 is a covered, condensation-resistant, integrated circuit humidity sensor that is factory-fitted with a hydrophobic filter allowing it to be used in condensing environments including industrial, medical and commercial applications.

The RH sensor uses a laser trimmed, thermoset polymer capacitive sensing element with on-chip integrated signal conditioning.

The sensing element's multilayer construction provides excellent resistance to most application hazards such as condensation, dust, dirt, oil, and common workplace chemicals.

FEATURES

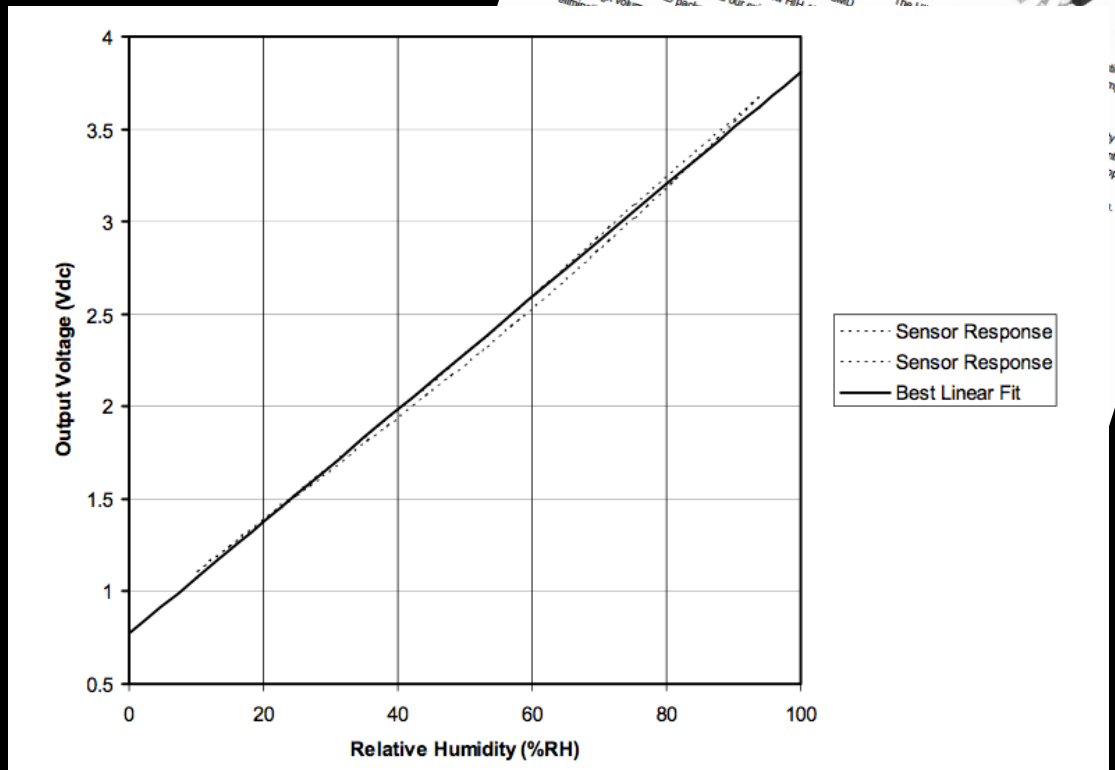
Voltage output (1st order curve fit)	$V_{OUT}=(V_{SUPPLY})(0.0062(\text{sensor RH})+0.16)$, typical at 25 °C
Temperature compensation	True RH = (Sensor RH)/(1.0546 – 0.00216T), T in °C

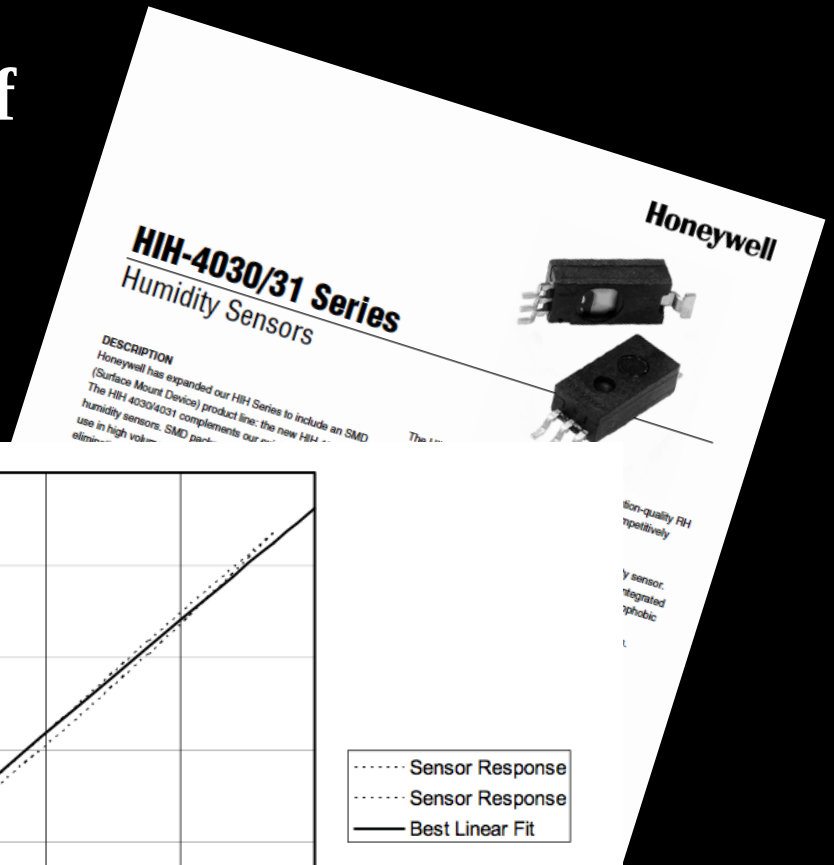
Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- % RH is a linear function of voltage

- 100% RH looks like ~3.7 V





Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- **Here's the algebra and the equation to code**

$$V_{OUT} = \left(V_{SUPPLY}\right)\left(0.0062\left(sensorRH\right) + 0.16\right)$$

$$\frac{\left(\frac{V_{OUT}}{\left(V_{SUPPLY}\right)} - 0.16\right)}{0.0062} = sensorRH$$

$$sensorRH = \frac{\left(\frac{V_{OUT}}{\left(5.0\ V\right)} - 0.16\right)}{0.0062}$$

Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

```
// Definitions
      int sensor;
      float sensorVolt;
      float sensorUnits;
```

```
void loop() {
//    put your main code here, to run repeatedly:

      sensor = analogRead(A2);
      sensorVolt = sensor*(5.0/1023);
      sensorUnits = (((sensorVolt/5.0)-0.16)/0.0062);
      Serial.print(sensor);
      Serial.print("\t voltage ");
      Serial.print(sensorVolt);
      Serial.print("\t units ");
      Serial.println(sensorUnits);
```

```
if(sensorUnits > 10) {
digitalWrite(5, HIGH);
}
if(sensorUnits > 20) {
digitalWrite(6, HIGH);
}
if(sensorUnits > 30) {
digitalWrite(7, HIGH);
}
if(sensorUnits > 40) {
digitalWrite(9, HIGH);
}
delay(100);
```

Humidity Sensor:

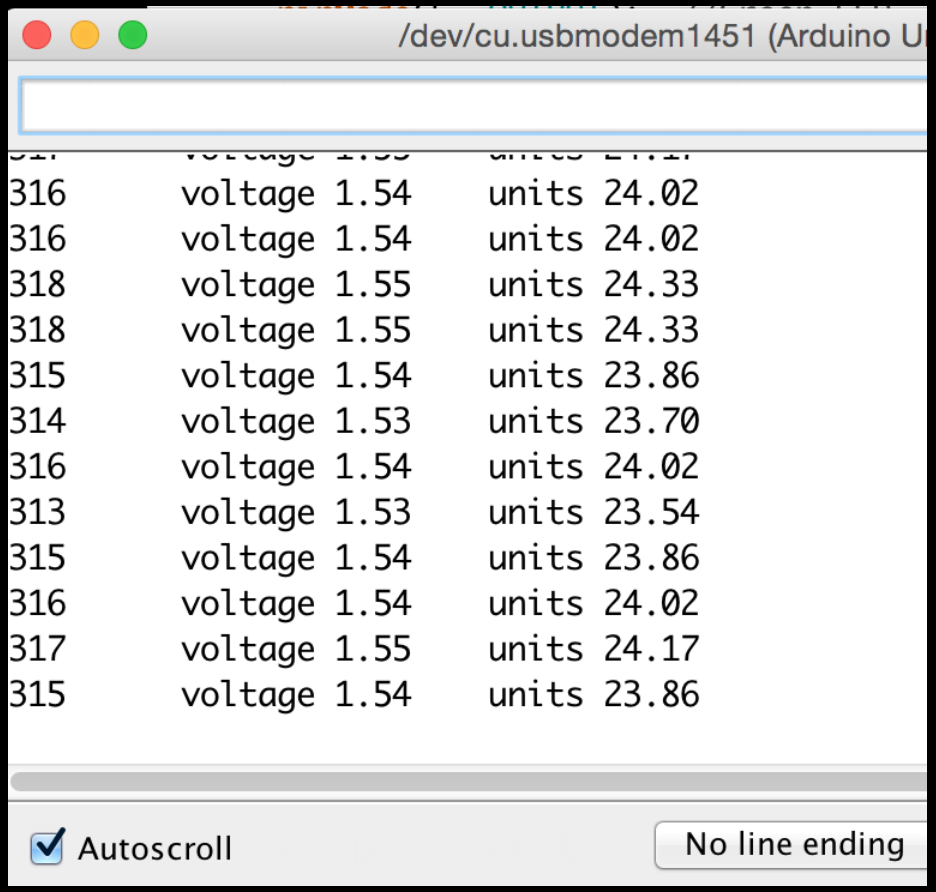
Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Verify and upload your code

- Launch serial monitor

- Breathe on humidity sensor like Darth Vader

- Watch LEDs on Shield



Humidity Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Play with your new sensor some to make sure you understand how it works!

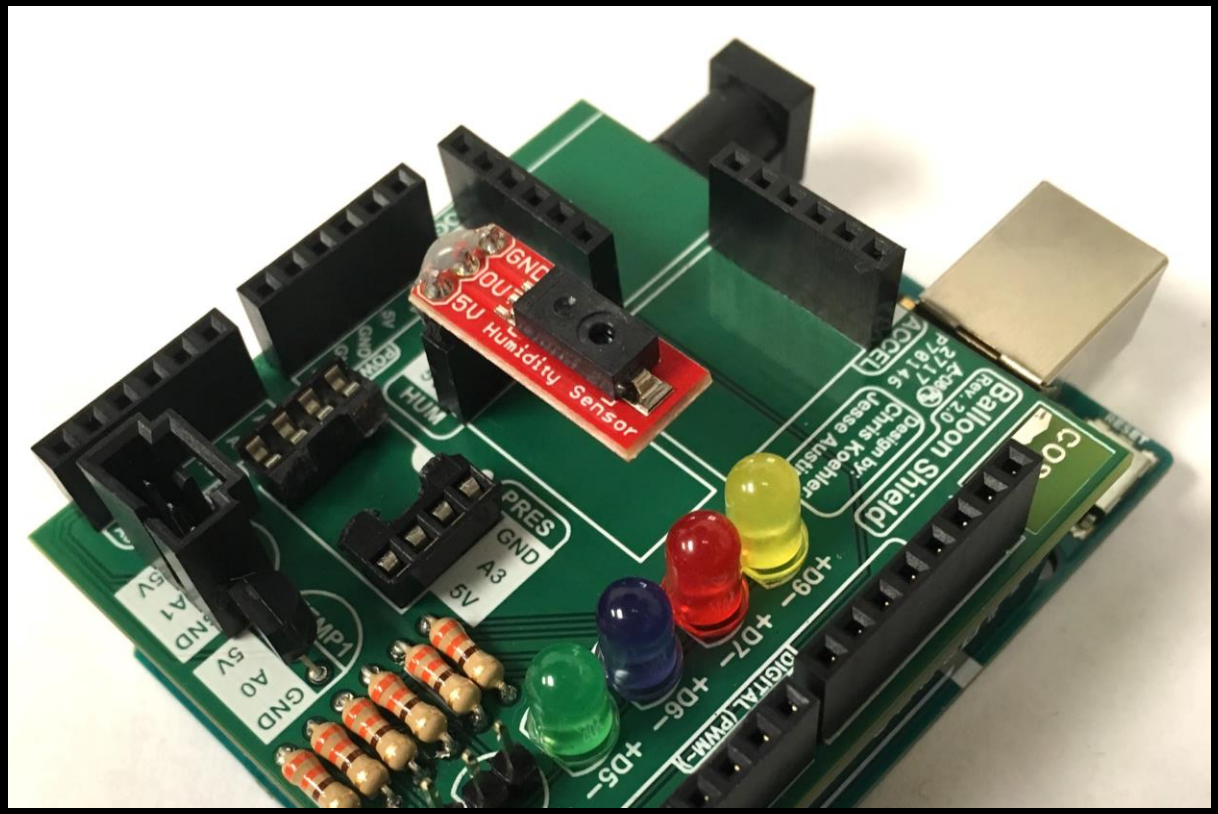
- Also, look at the data sheet and determine the voltage at maximum humidity

PLEASE SAVE YOUR SKETCH FILE

Balloon Shield Build Part 3:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Disconnect you Balloon Shield and add the Humidity Sensor



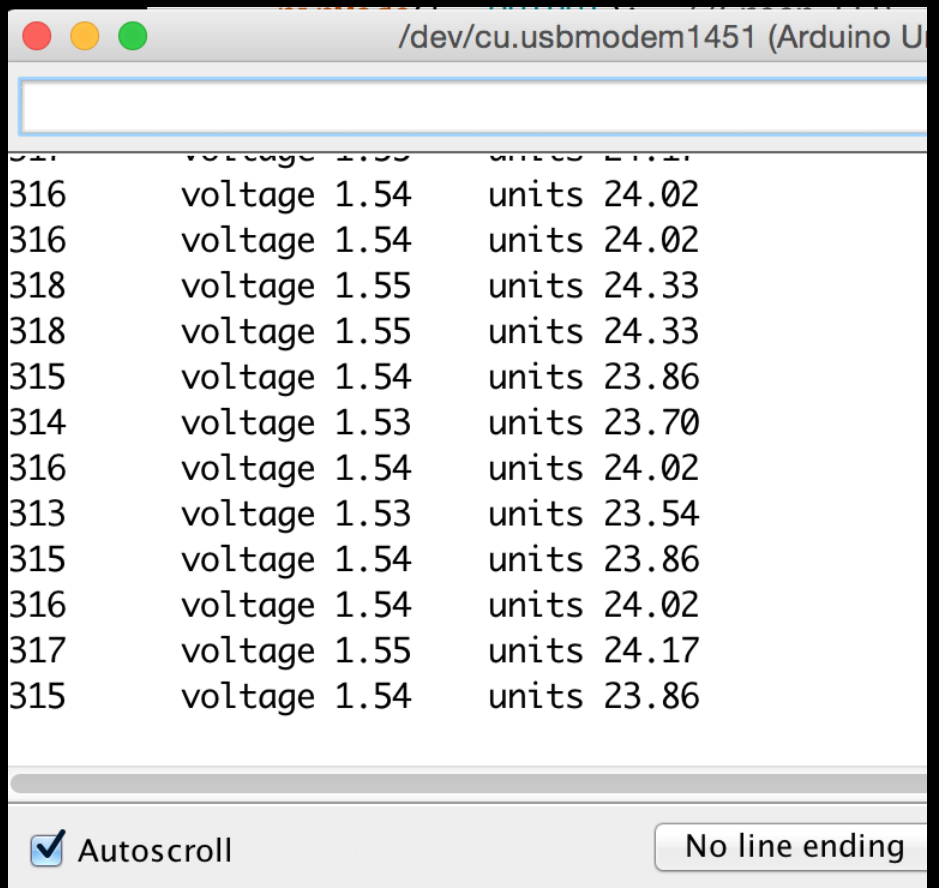
Balloon Shield Build Part 2:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- Reconnect your Balloon Shield to the Arduino

- Connect USB and reload code

- Verify same results

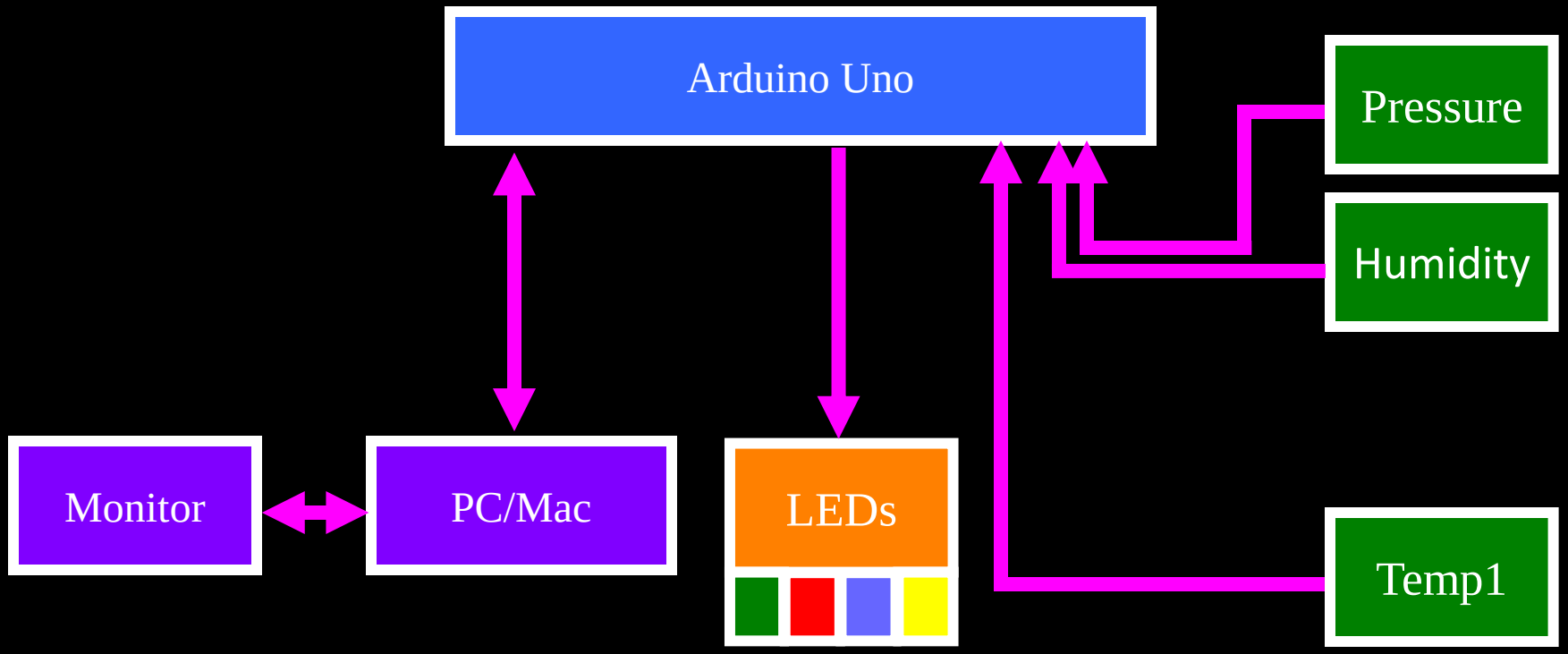


Part 2 – Arduino Road Trip Sensors

A. Humidity Sensor
B. Pressure Sensor
C. Accelerometers
D. External Temp Sensor

Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**



Pressure Sensor:

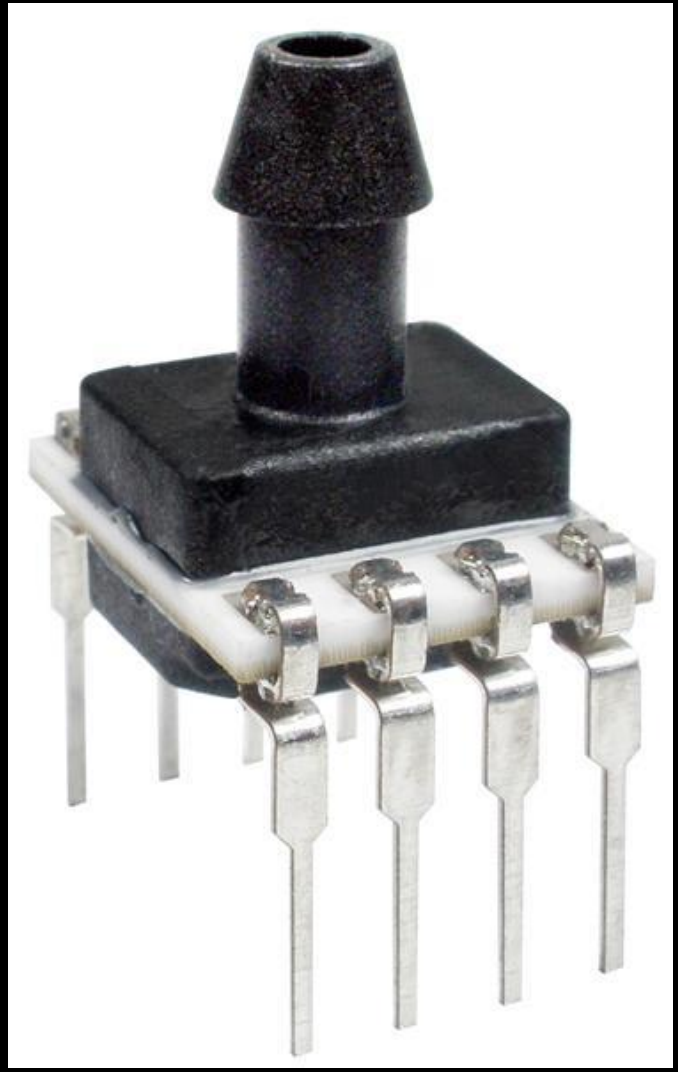
Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Pressure Sensors is fragile and $$$**

- **A bit tricky to see the markings to install correctly**

- **Can use it to determine pressure/altitude of payload**

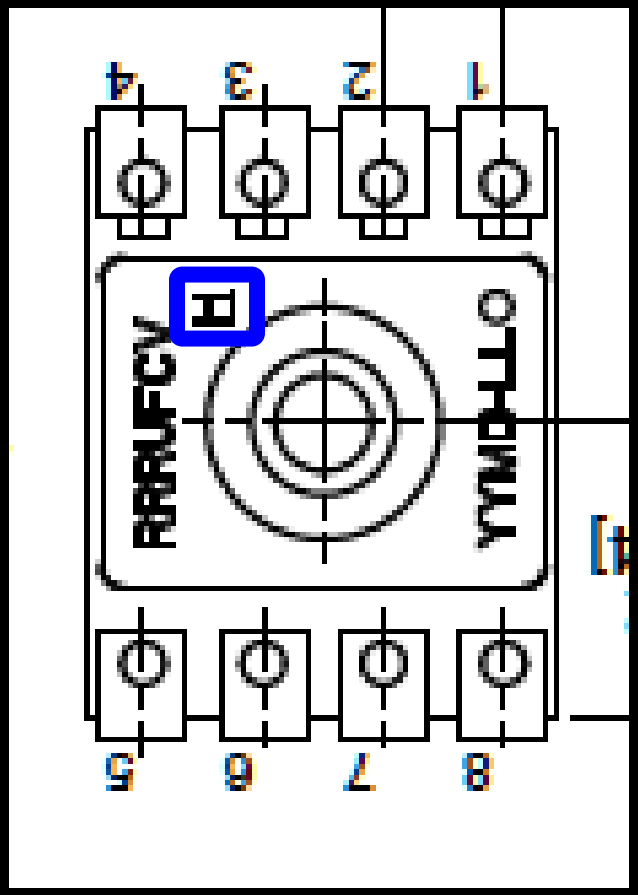
- **To be safe, please disconnect power from your Arduino**

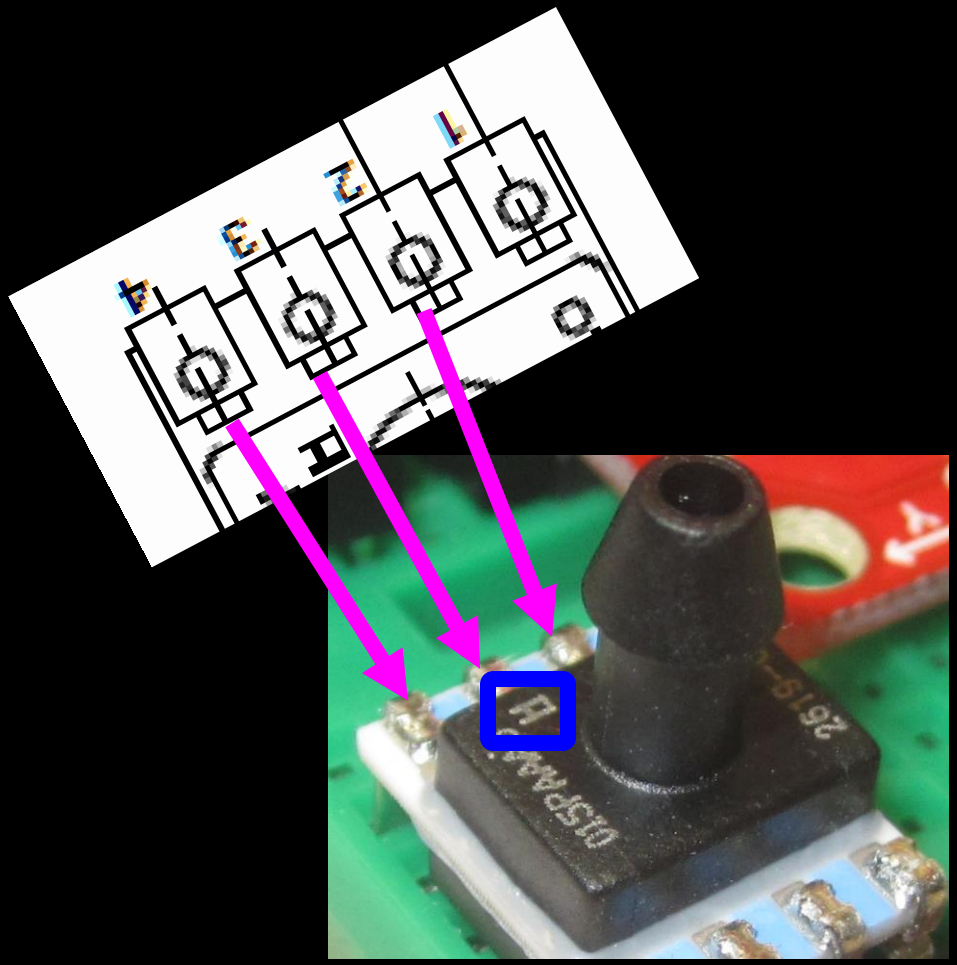


Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- Pressure sensor orientation

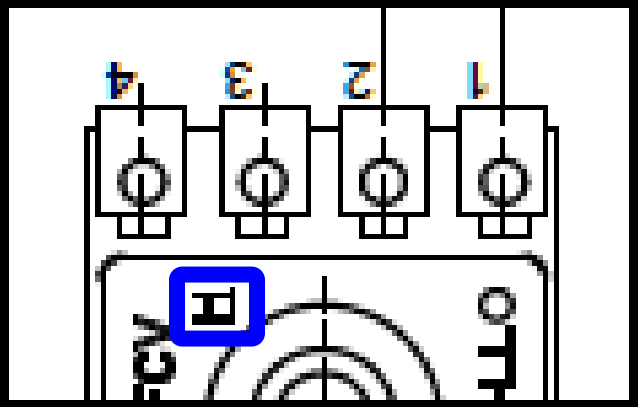


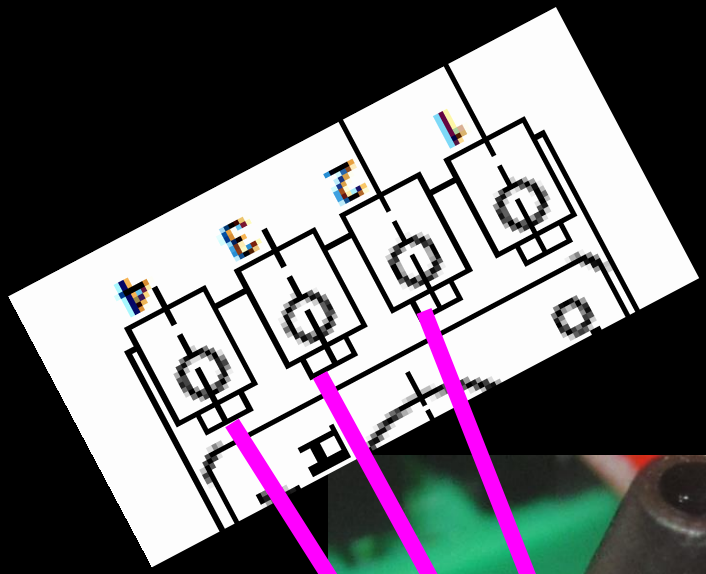


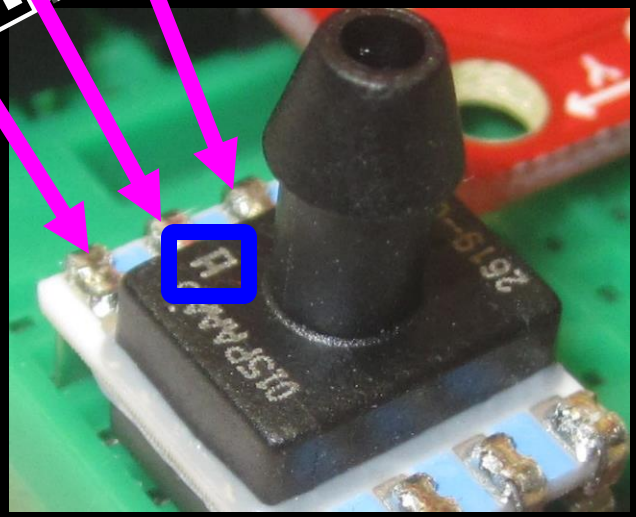
Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- Pressure sensor orientation







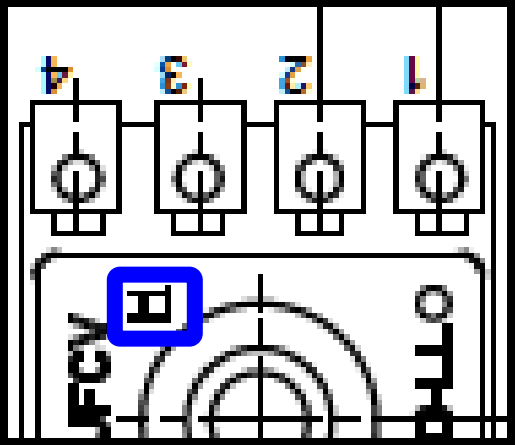
Pin 1	Pin 2	Pin 3	Pin 4
NC	V_{supply}	OUTPUT+	GND

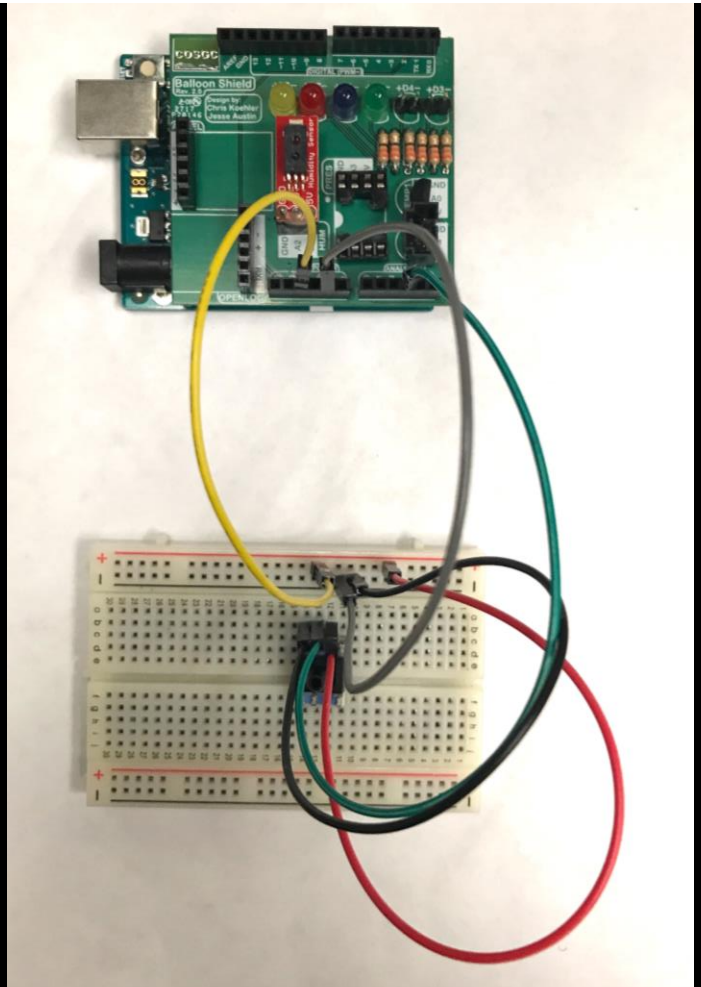
Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Connect GND to Pin 4, 5V to Pin 2, and Pin 3 to A3 on the Arduino

Pin 1	Pin 2	Pin 3	Pin 4
NC	V_{supply}	OUTPUT+	GND

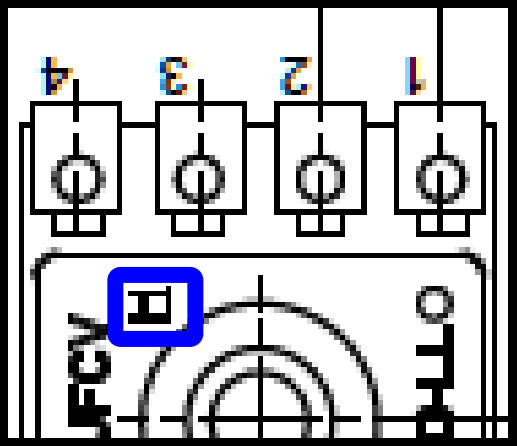




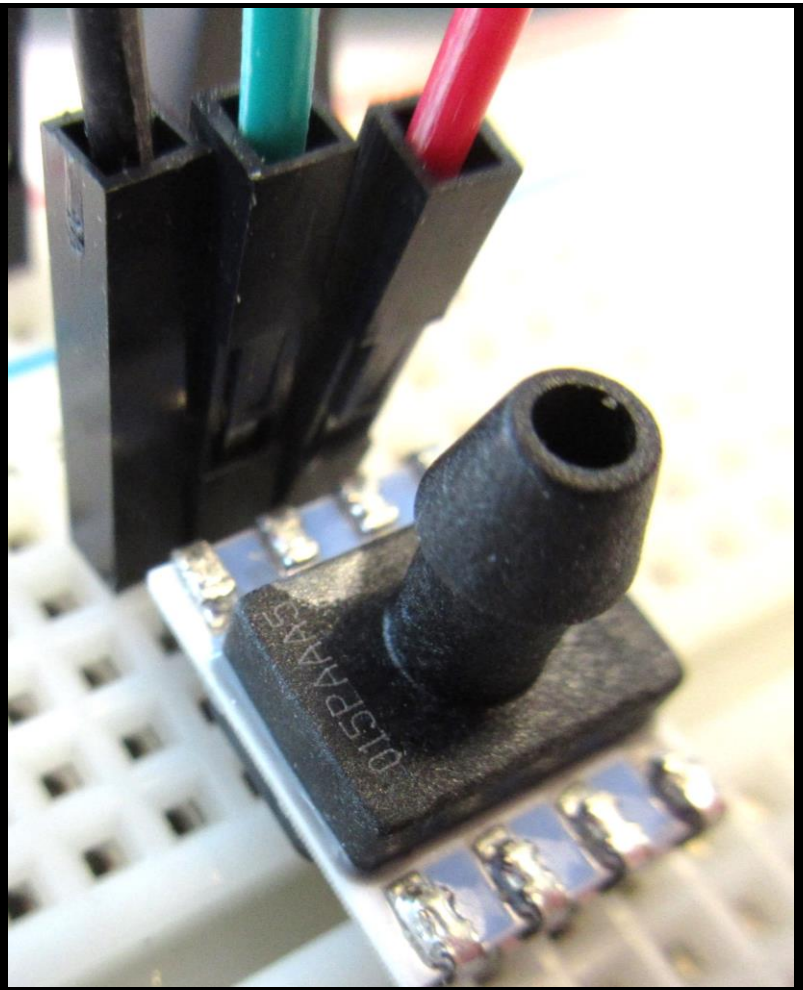
Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Connect GND to Pin 4, 5V to Pin 2, and Pin 3 to A3 on the Arduino



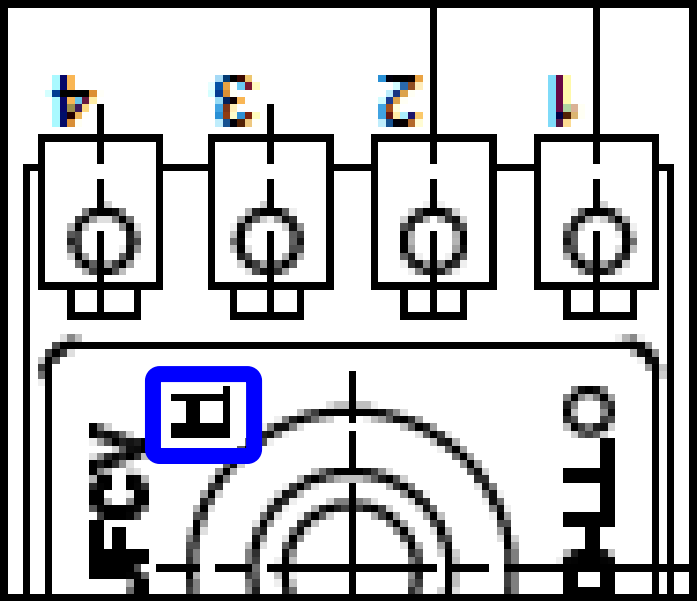
Pin 1	Pin 2	Pin 3	Pin 4
NC	V_{supply}	OUTPUT+	GND



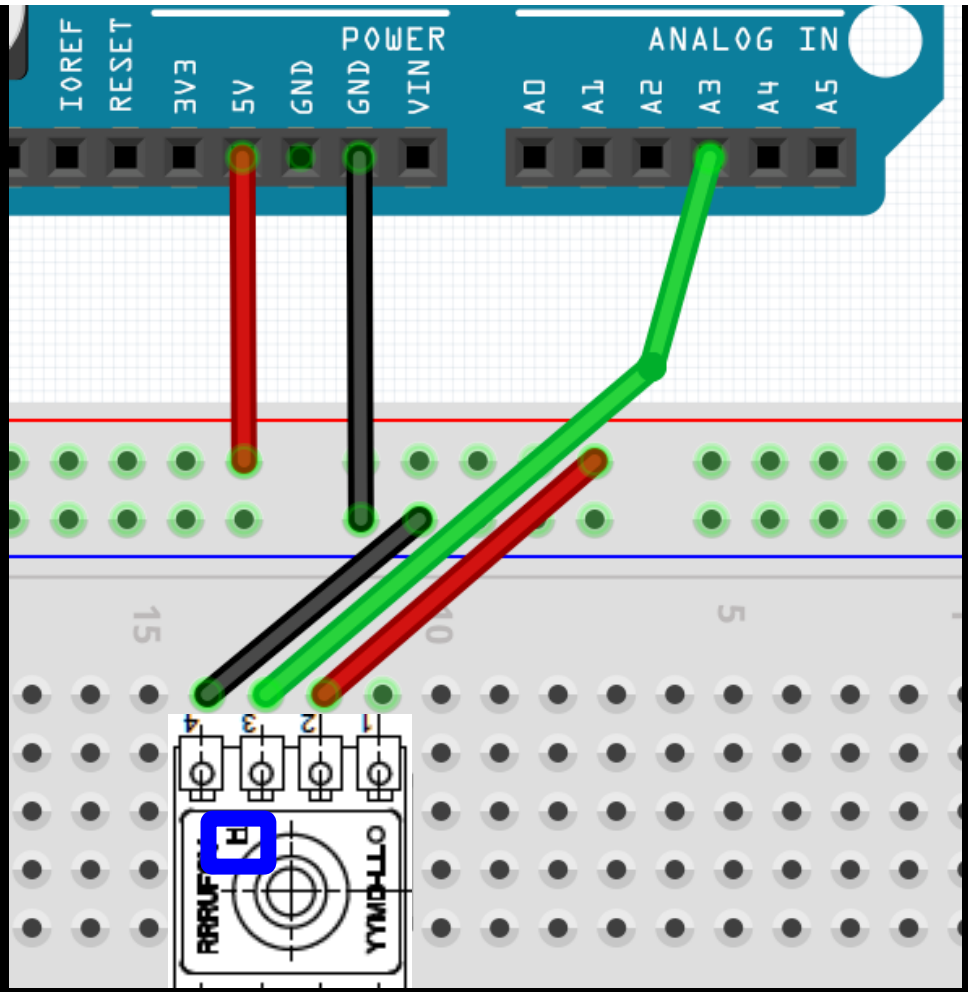
Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Connect GND to Pin 4, 5V to Pin 2, and Pin 3 to A3 on the Arduino**



Pin 1	Pin 2	Pin 3	Pin 4
NC	V_{supply}	OUTPUT+	GND



Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- Look at the data sheet to understand output of the sensor

- Known:
  Vsupply = 5.0 V
  Pmax = 15.0 psi
  Pmin = 0.0 psi
  Output(V) = measured
  Pressure applied = solve

TruStability® Silicon Pressure Sensors: SSC Series–Standard Accuracy

Honeywell

±2% Total Error Band, Amplified Compensated Analog Output, 1 psi to 150 psi (60 mbar to 10 bar)

DESCRIPTION

The TruStability® Standard Accuracy Silicon Ceramic (SSC) Series is a piezoresistive silicon pressure sensor offering a ratiometric analog output for reading pressures over the specified full scale pressure span and temperature range.

The SSC Series is fully calibrated and temperature compensated for sensor offset, sensitivity, temperature effects, and non-linearity using an on-board Application Specific Integrated Circuit (ASIC). Calibrated output values for pressure are updated at approximately 1 kHz.

The SSC Series is calibrated over the temperature range of -20 °C to 85 °C [-4 °F to 185 °F]. The sensor is characterized for operation from a single power supply of either 3.3 Vdc or 5.0 Vdc.

These sensors measure absolute, differential, and gage pressures. The absolute versions have an internal vacuum reference and an output value proportional to absolute pressure. Differential versions allow application of pressure to either side of the sensing diaphragm. Gage versions are referenced to atmospheric pressure and provide an output proportional to pressure variations from atmosphere.

The TruStability® pressure sensors are intended for use with non-corrosive, non-ionic gases, such as air and other dry gases. An available option extends the performance of these sensors to non-corrosive, non-ionic liquids.

All products are designed and manufactured according to ISO 9001 standards.

FEATURES

- Industry-leading long-term stability
- Extremely tight accuracy of ±0.25% FSS BFSL (Full Scale Span Best Fit Straight Line)
- Total error band of ±2% full scale span maximum
- Modular and flexible design offers customers a variety of package styles and options, all with the same industry-leading performance specifications
- Miniature 10 mm x 10 mm [0.39 in x 0.39 in] package
- Low operating voltage
- Extremely low power consumption
- Ratiometric analog output
- High resolution (min. 0.03 %FSS)
- Precision ASIC conditioning and temperature compensated over -20 °C to 85 °C [-4 °F to 185 °F] temperature range
- RoHS compliant
- Virtually insensitive to mounting orientation
- Internal diagnostic functions increase system reliability
- Also available with I²C or SPI digital output
- Absolute, differential and gage types
- Pressure ranges from 1 psi to 150 psi (60 mbar to 10 bar)
- Custom calibration available
- Various pressure port options
- Liquid media option

$$\text{Output (V)} = \frac{0.8 \times V_{supply}}{P_{max.} - P_{min.}} \times (\text{Pressure}_{applied} - P_{min.}) + 0.10 \times V_{supply}$$

Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- **Here's the algebra and the equation to code**

$$Output(V) = \frac{(0.8 * V_{SUPPLY})}{(P_{max} - P_{min})} * (pressure_{applied} - P_{min}) + 0.10 * V_{supply}$$

$$Output(V) = \frac{(0.8 * 5.0)}{(15.0 - 0.0)} * (pressure_{applied} - 0.0) + 0.10 * 5.0$$

$$Output(V) = \frac{(4.0)}{(15.0)} * (pressure_{applied}) + 0.5$$

$$\frac{15.0}{4.0} * (-0.5 + Output(V)) = pressure_{applied}$$

Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

```
// Definitions
      int sensor;
      float sensorVolt;
      float sensorUnits;
//      float sensorUnitsC;
```

```
void loop() {
//   put your main code here, to run repeatedly:

      sensor = analogRead(A3);
      sensorVolt = sensor*(5.0/1023);
      sensorUnits = (sensorVolt-0.5)*(15.0/4.0);
      Serial.print(sensor);
      Serial.print("\t voltage ");
      Serial.print(sensorVolt);
      Serial.print("\t units ");
      Serial.println(sensorUnits);
```

```
if(sensorUnits < 12.20) {
digitalWrite(5, HIGH);
}
if(sensorUnits < 10.10) {
digitalWrite(6, HIGH);
}
if(sensorUnits < 8.10) {
digitalWrite(7, HIGH);
}
if(sensorUnits < 3.10) {
digitalWrite(9, HIGH);
}
delay(100);
```

> to <

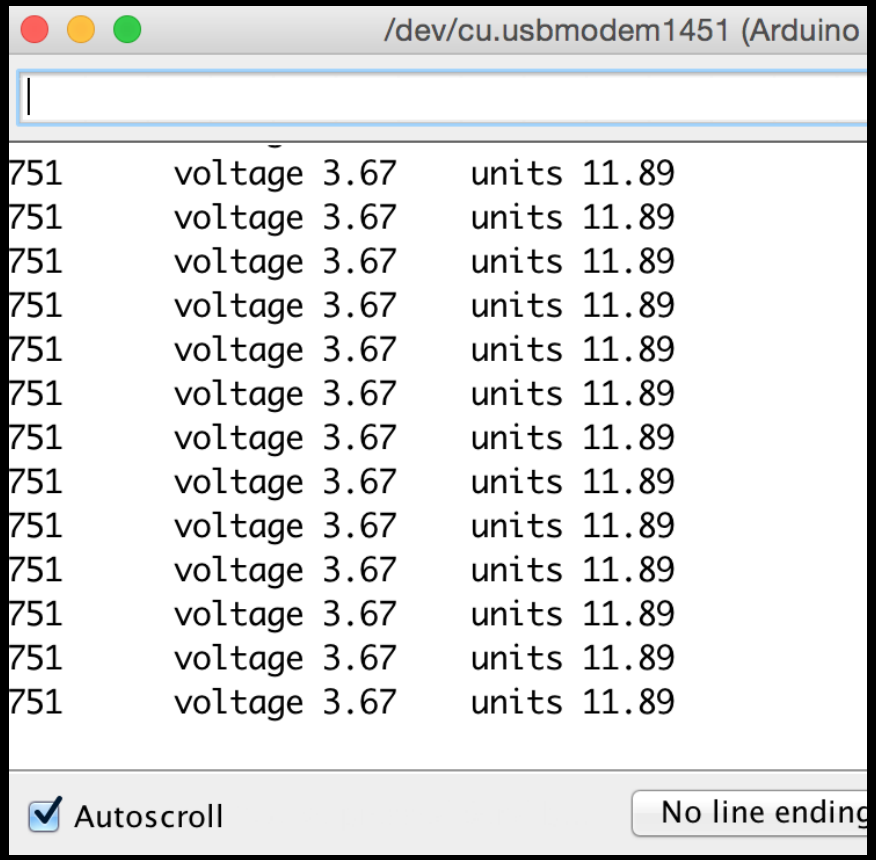
Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Build and Upload**

- **DO NOT BLOW or DO NOT APPLY PRESSURE; it will break the sensor**

- **Use solder sucker**



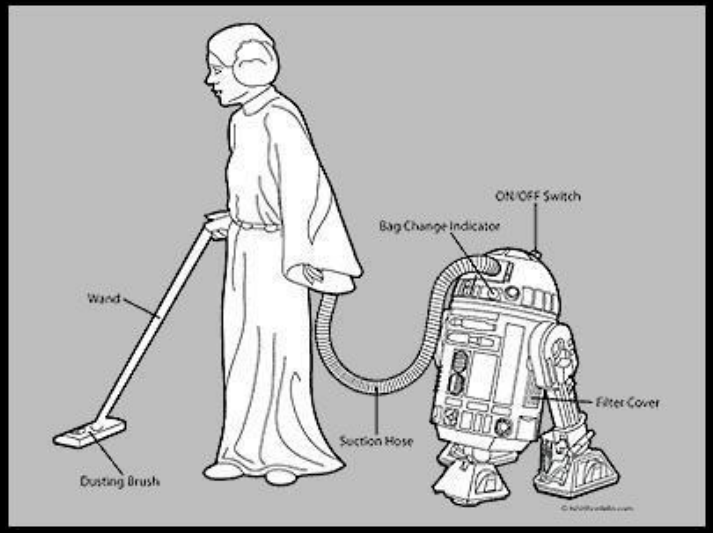
PLEASE SAVE YOUR SKETCH FILE

Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Play with your new sensor to get a feel for how it works

- Try to get your sensor to zero

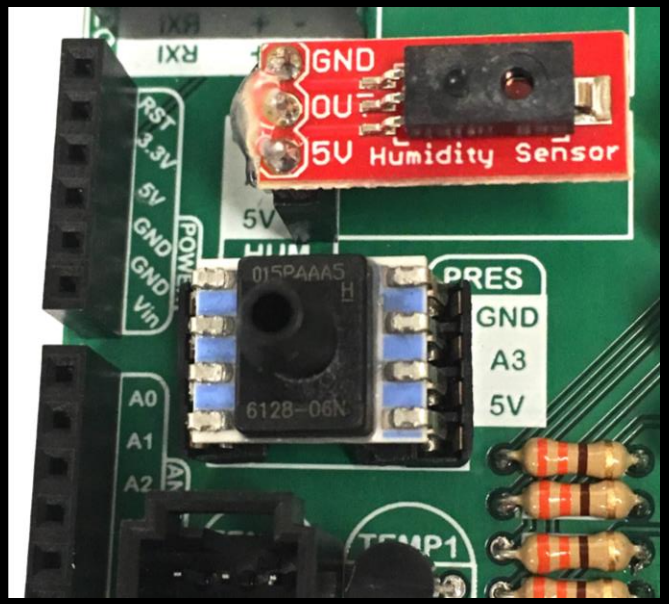


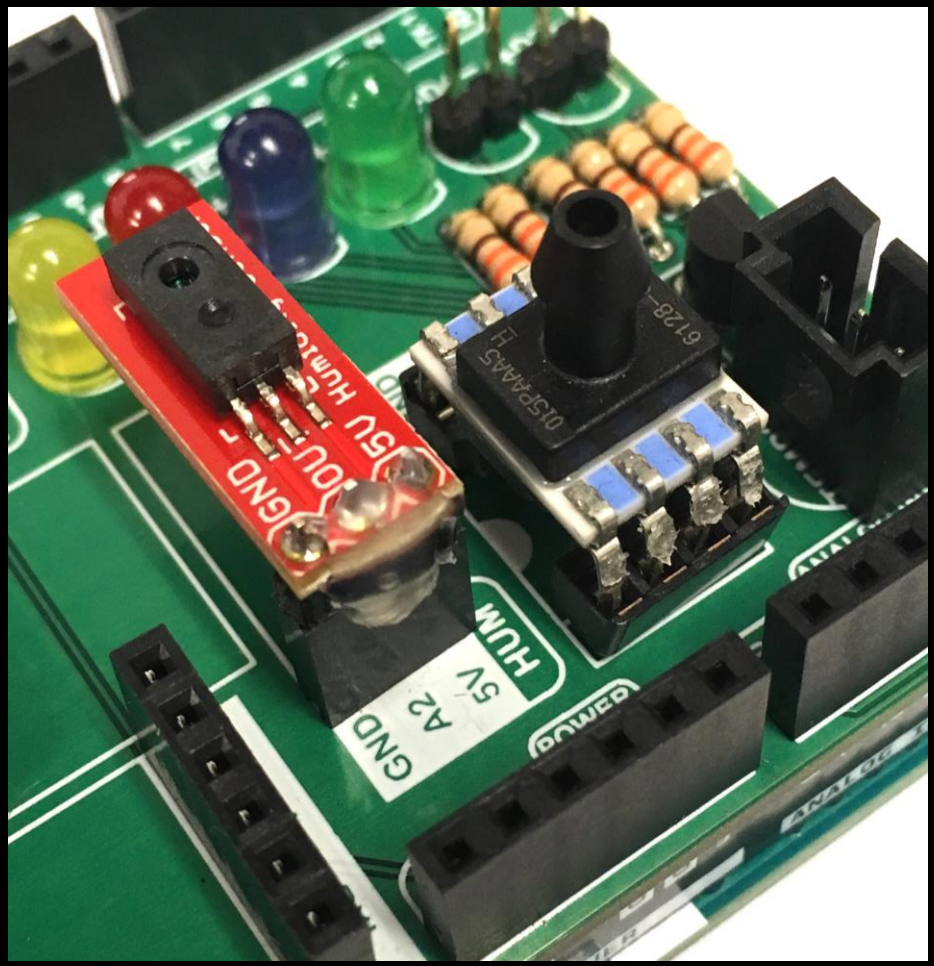
PLEASE SAVE YOUR SKETCH FILE

Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Install Pressure Sensor into headers**





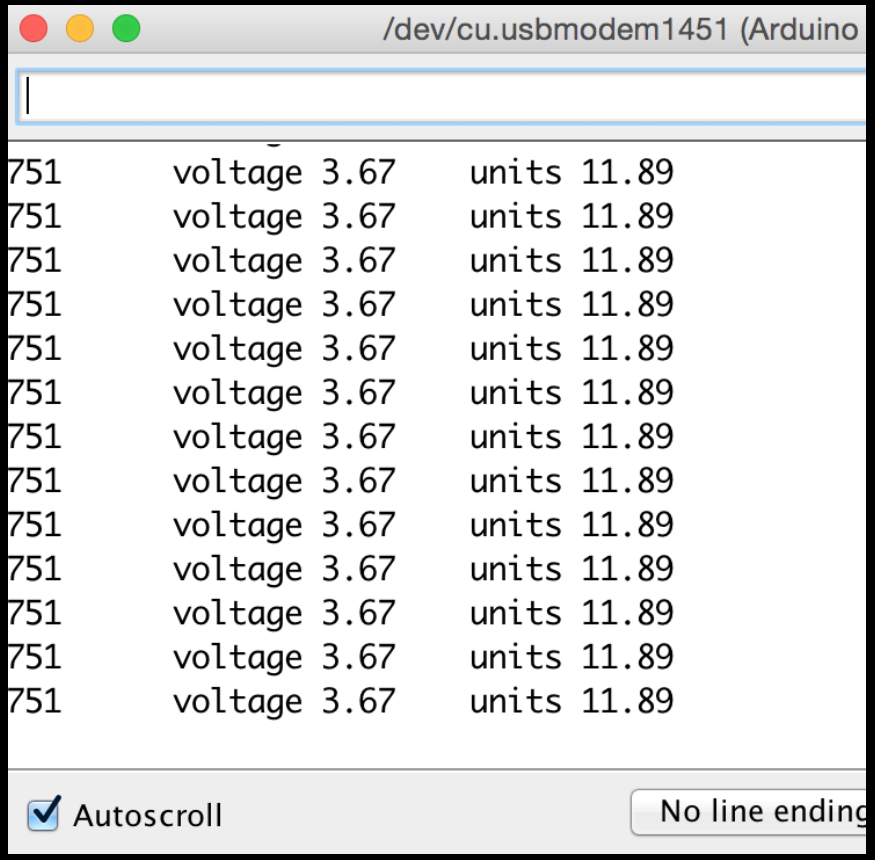
Pressure Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Reconnect your Balloon Shield to the Arduino**

- **Connect USB and reload code**

- **Verify same results**

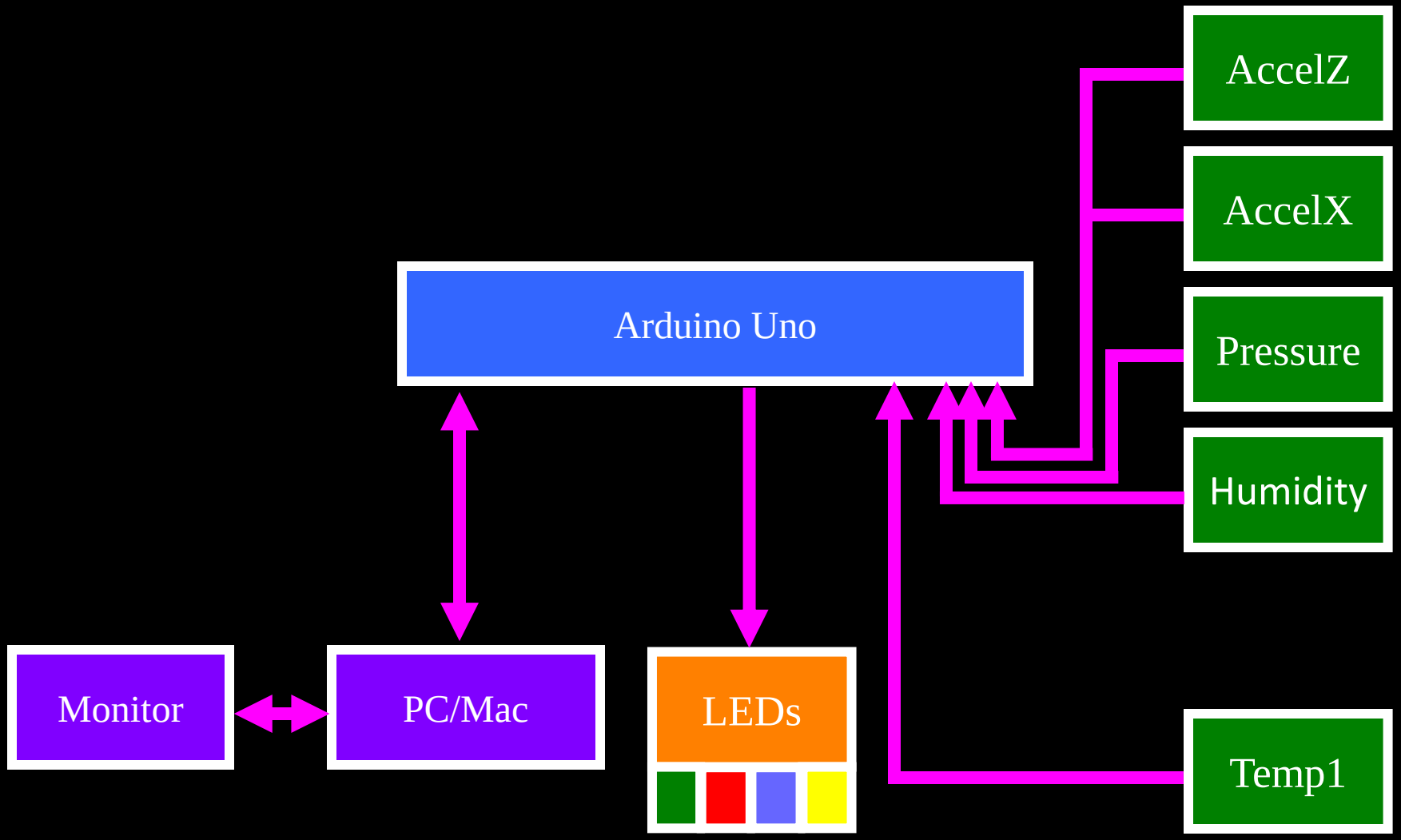


Part 2 – Arduino Road Trip Sensors

A. Humidity Sensor
B. Pressure Sensor
C. Accelerometers
D. External Temp Sensor

Accelerometer:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**



Accelerometer:

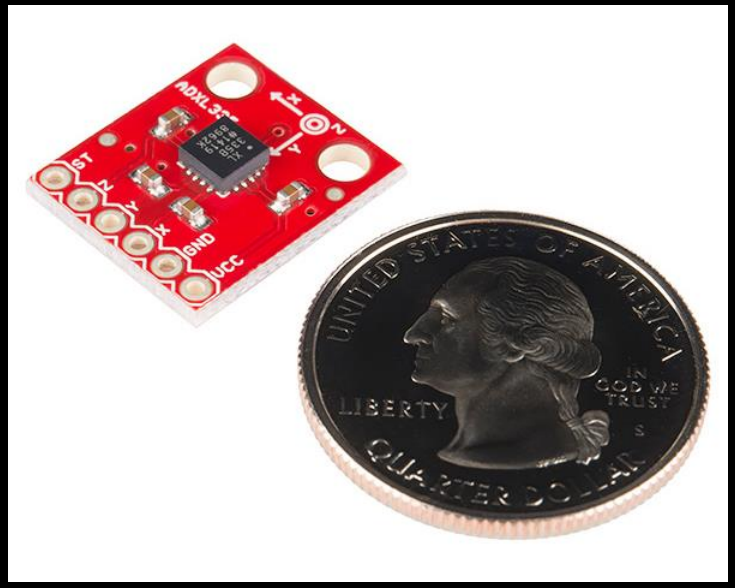
Space Minor
UNIVERSITY OF COLORADO **BOULDER**

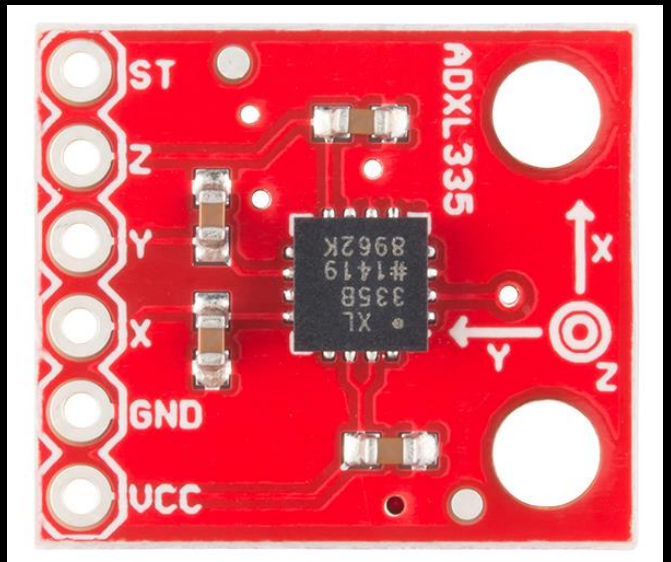
- Accelerometers are used to detect forces acting on a payload

- This is a 3 axis accelerometer

- Measures g forces in X, Y, and Z directions

- **Only have two analog** channels left so X and Z

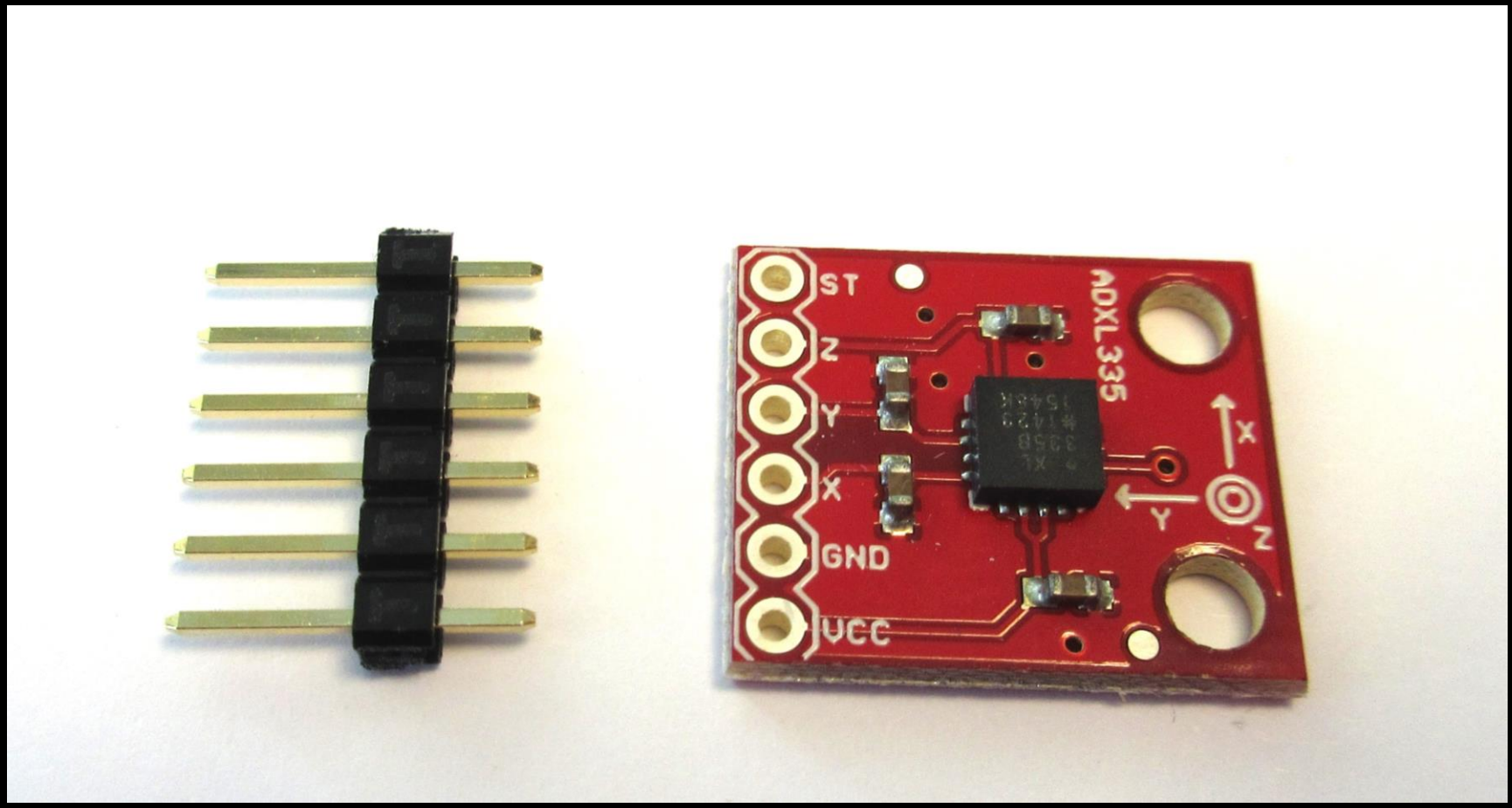




Accelerometer:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

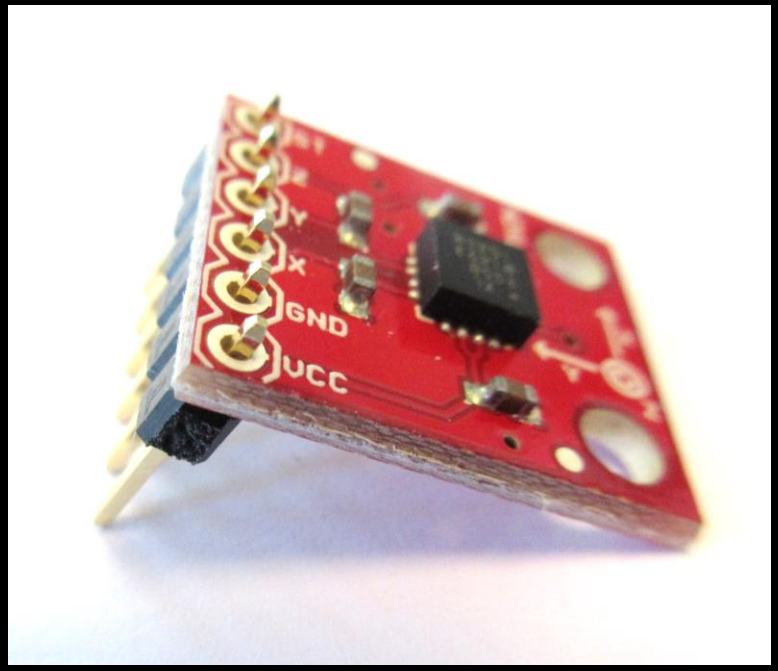
- Solder 6 pin header to board

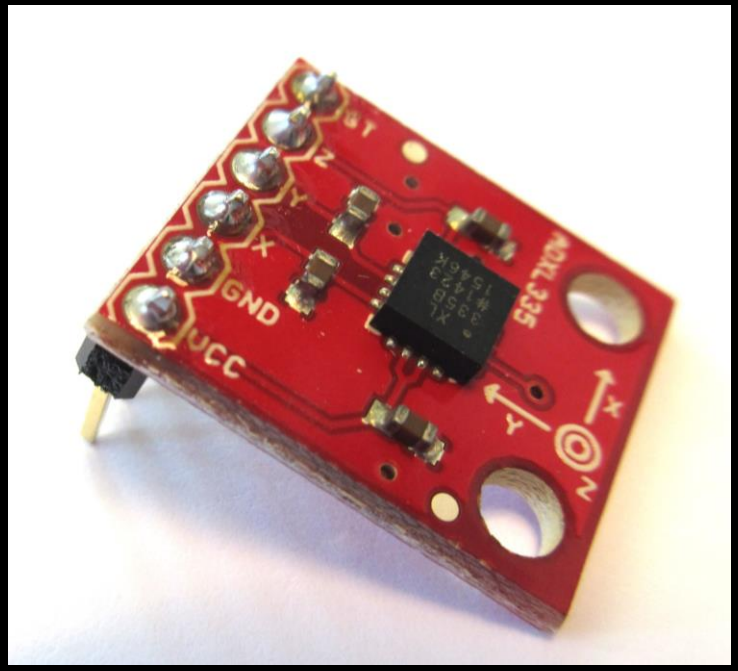


Accelerometer:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Solder 6 pin header to board
- Short side through the bottom of the board
- Keep header perpendicular to board



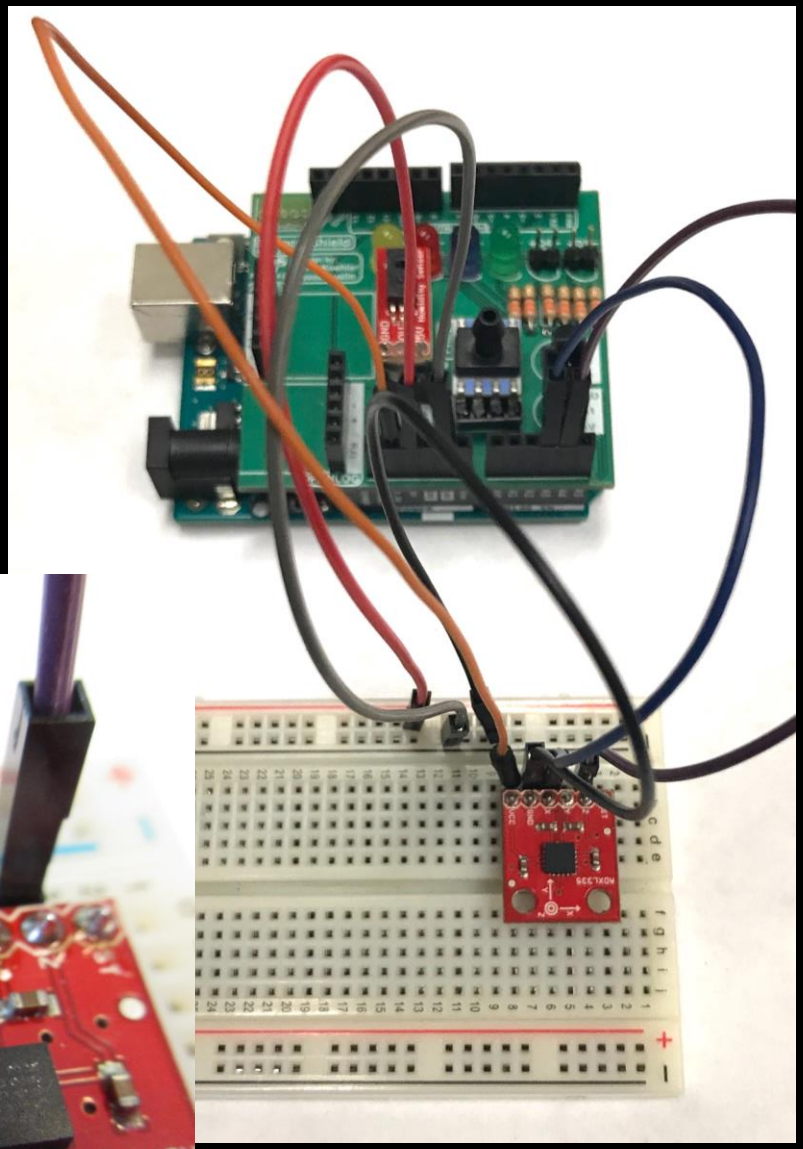


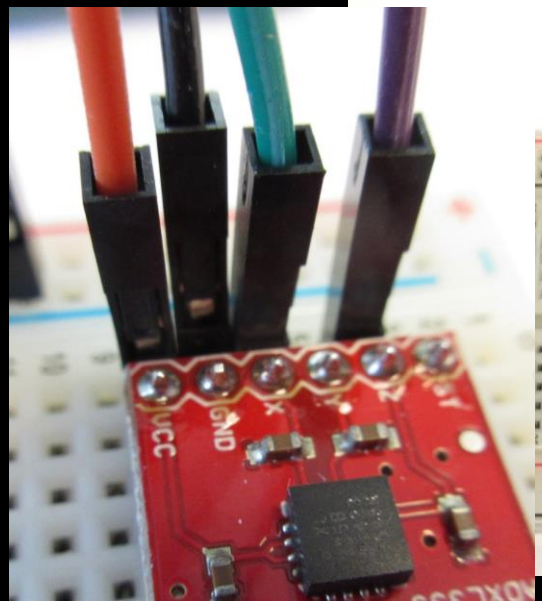
Accelerometer:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Wire accelerometer as shown**

  Vcc is to 3.3V
  GND is to GND
  X is to A4
  Z is to A5



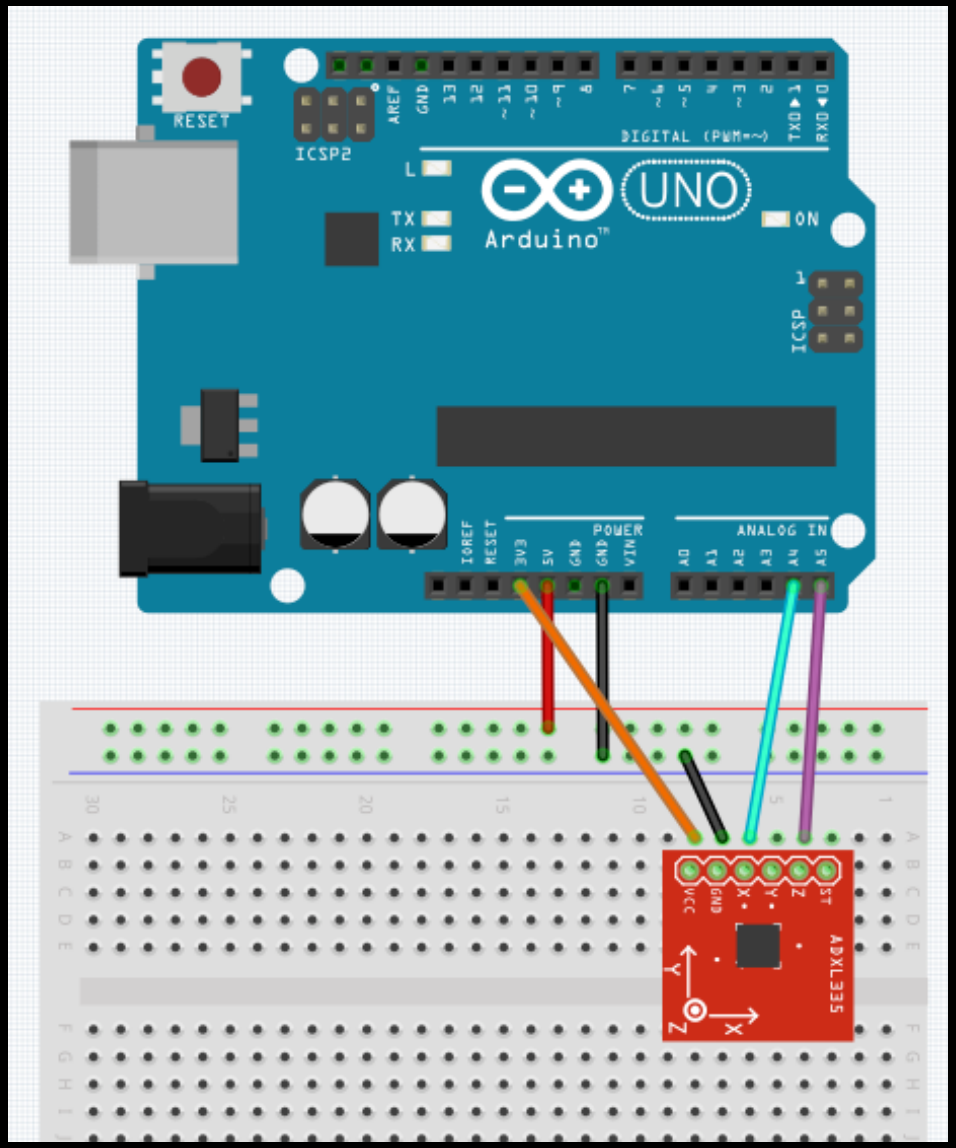


Accelerometer:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Wire accelerometer as shown

Vcc is to **3.3V**
GND is to GND
X is to A4
Z is to A5

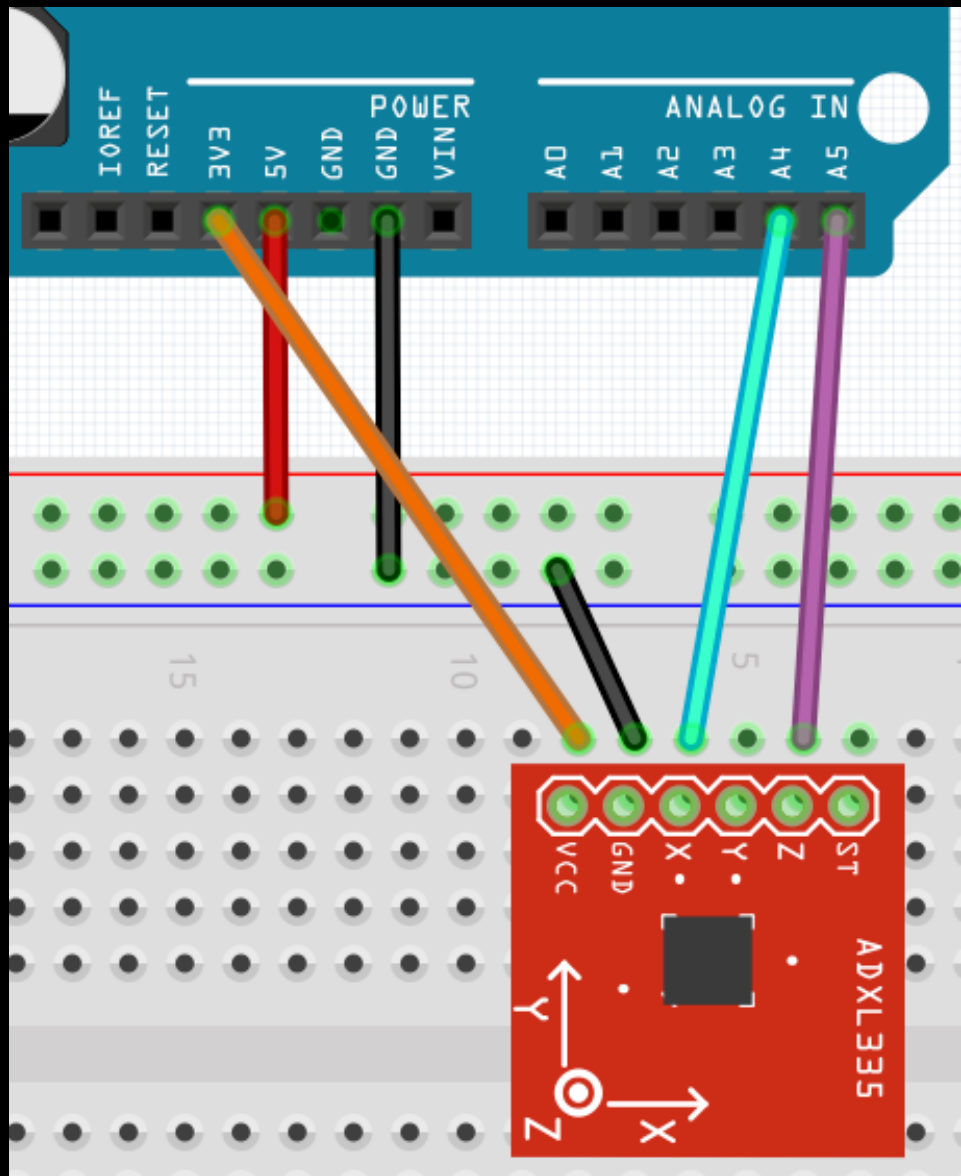


Accelerometer:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Wire accelerometer as shown

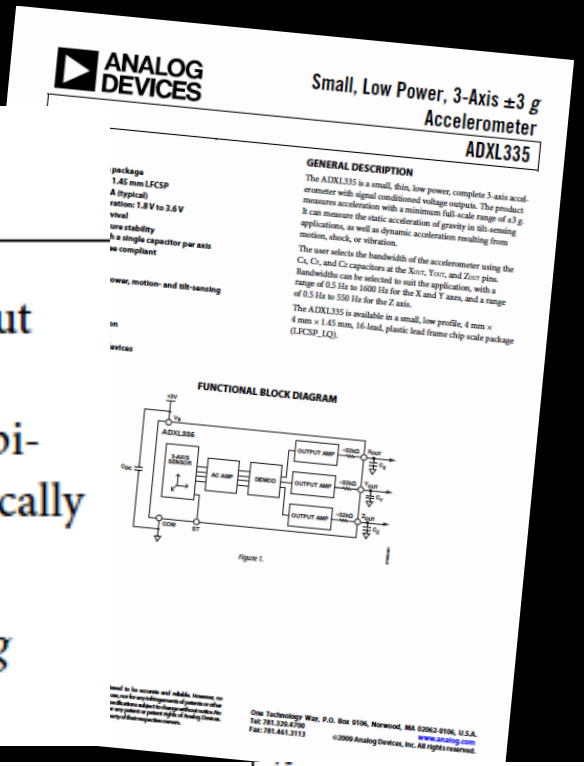
Vcc is to 3.3V
GND is to GND
X is to A4
Z is to A5



Accelerometer:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Looking at the data sheet…


ANALOG DEVICES

Small, Low Power, 3-Axis ±3 *g* Accelerometer

ADXL335

GENERAL DESCRIPTION

FUNCTIONAL BLOCK DIAGRAM

ADXL335

The ADXL335 output is ratiometric, therefore, the output sensitivity (or scale factor) varies proportionally to the supply voltage. At V_S = 3.6 V, the output sensitivity is typically 360 mV/*g*. At V_S = 2 V, the output sensitivity is typically 195 mV/*g*.

The zero *g* bias output is also ratiometric, thus the zero *g* output is nominally equal to V_S/2 at all supply voltages.

SENSITIVITY (RATIOMETRIC)[2]	Each axis				
Sensitivity at X_{OUT}, Y_{OUT}, Z_{OUT}	V_S = 3 V	270	300	330	mV/*g*
Sensitivity Change Due to Temperature[3]	V_S = 3 V		±0.01		%/°C
ZERO *g* BIAS LEVEL (RATIOMETRIC)					
0 *g* Voltage at X_{OUT}, Y_{OUT}	V_S = 3 V	1.35	1.5	1.65	V
0 *g* Voltage at Z_{OUT}	V_S = 3 V	1.2	1.5	1.8	V
0 *g* Offset vs. Temperature			±1		mg/°C
NOISE PERFORMANCE					

Accelerometer:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- 3.3V/2 is what it should read at “zero G” orientation or 1.65V

- Then 330 mV for every G so…

Gs = (Accelvoltage – 1.65 V) / (0.330 V)

ADXL335

The ADXL335 output is ratiometric, therefore, the output sensitivity (or scale factor) varies proportionally to the supply voltage. At V_S = 3.6 V, the output sensitivity is typically 360 mV/*g*. At V_S = 2 V, the output sensitivity is typically 195 mV/*g*.

The zero *g* bias output is also ratiometric, thus the zero *g* output is nominally equal to $V_S/2$ at all supply voltages.

Accelerometer:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- **A4, A5,**
  comment out LED ifs

```
// Definitions
int sensorX;
int sensorZ;
float sensorVoltX;
float sensorVoltZ;
float sensorUnitsX;
float sensorUnitsZ;
```

```
void loop() {
//   put your main code here, to run

     sensorX = analogRead(A4);
     sensorZ = analogRead(A5);
     sensorVoltX = sensorX*(5.0/1023);
     sensorVoltZ = sensorZ*(5.0/1023);
     sensorUnitsX = (sensorVoltX-(3.3/2))/(0.330);
     sensorUnitsZ = (sensorVoltZ-(3.3/2))/(0.330);
     Serial.print("X ");
     Serial.print(sensorUnitsX);
     Serial.print("\t Z ");
     Serial.println(sensorUnitsZ);
```

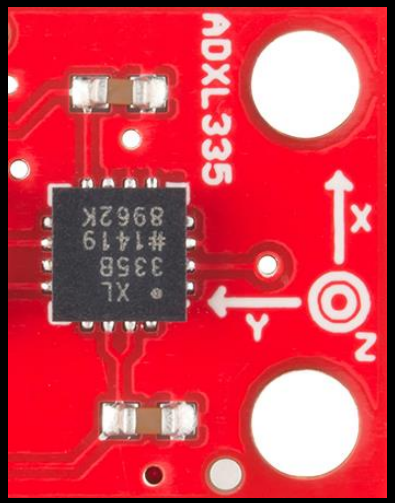
Accelerometer:

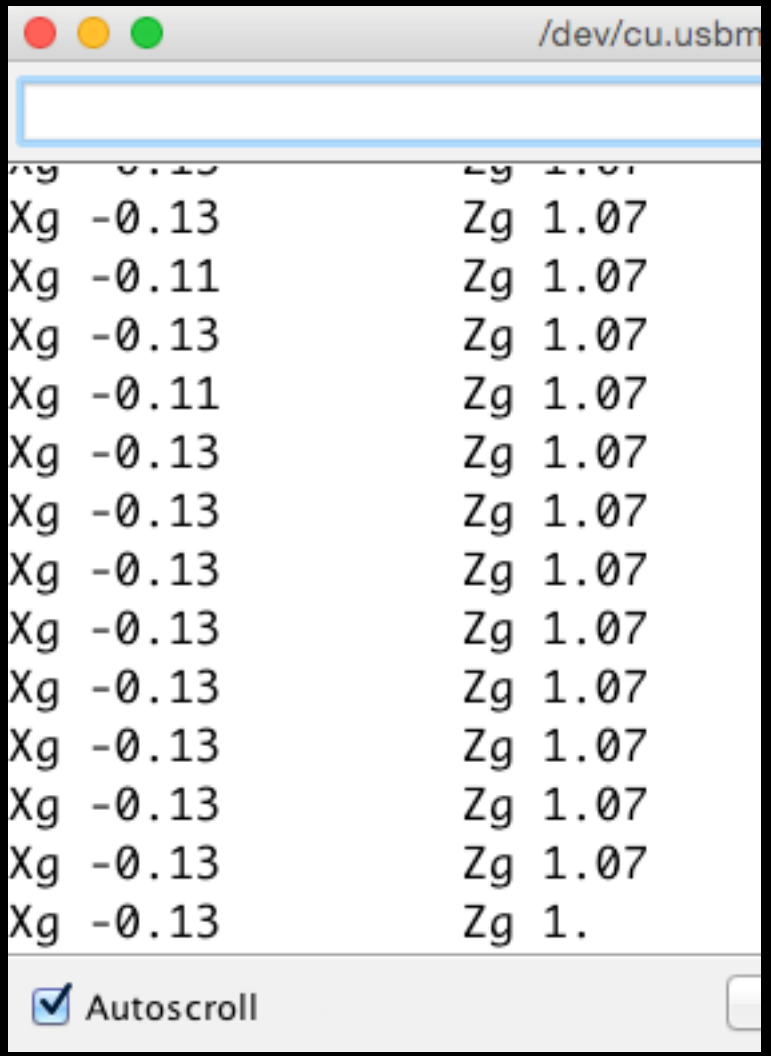
Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Upload you code and launch your serial monitor (no LEDs this time)

- Rotate your breadboard and look for changes in both X and Z

- X up and X down
- Z up and Z down



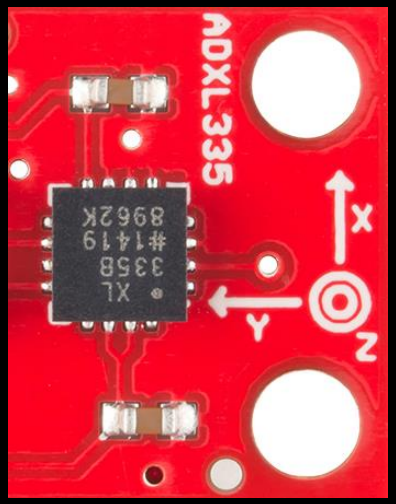


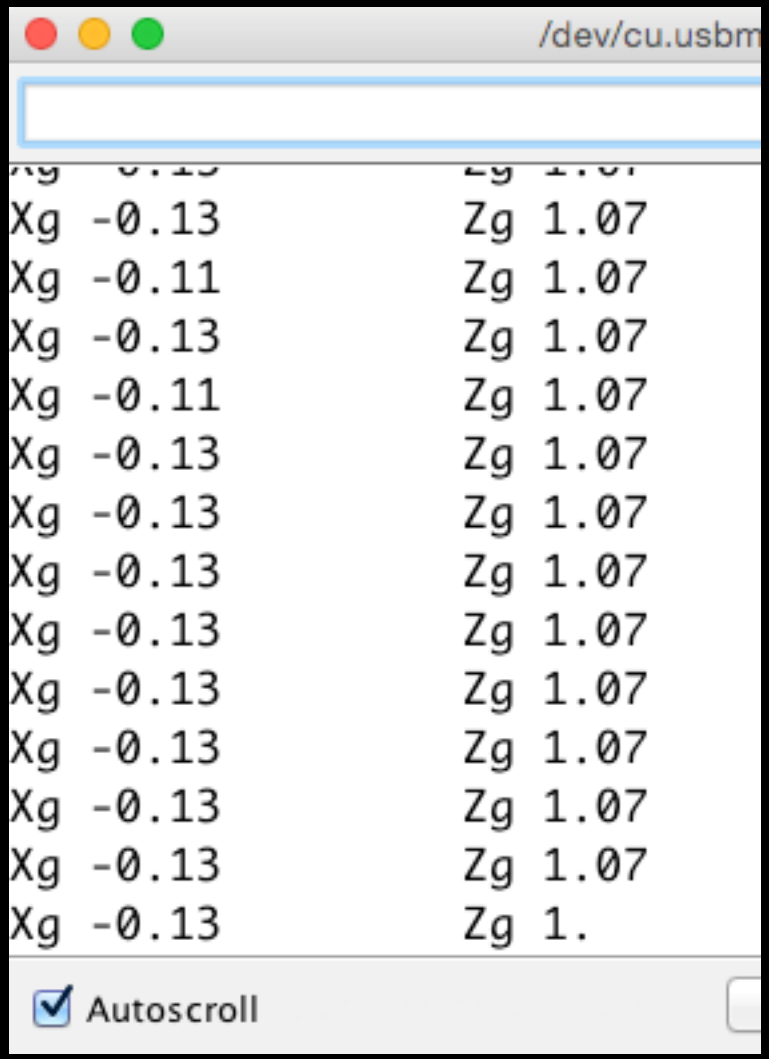
Accelerometer:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- Upload you code and launch your serial monitor

- When Z up ~ 1.0G
- When Z down ~ -1.0G
- When X up ~ 1.0G
- When X down ~ -1.0G

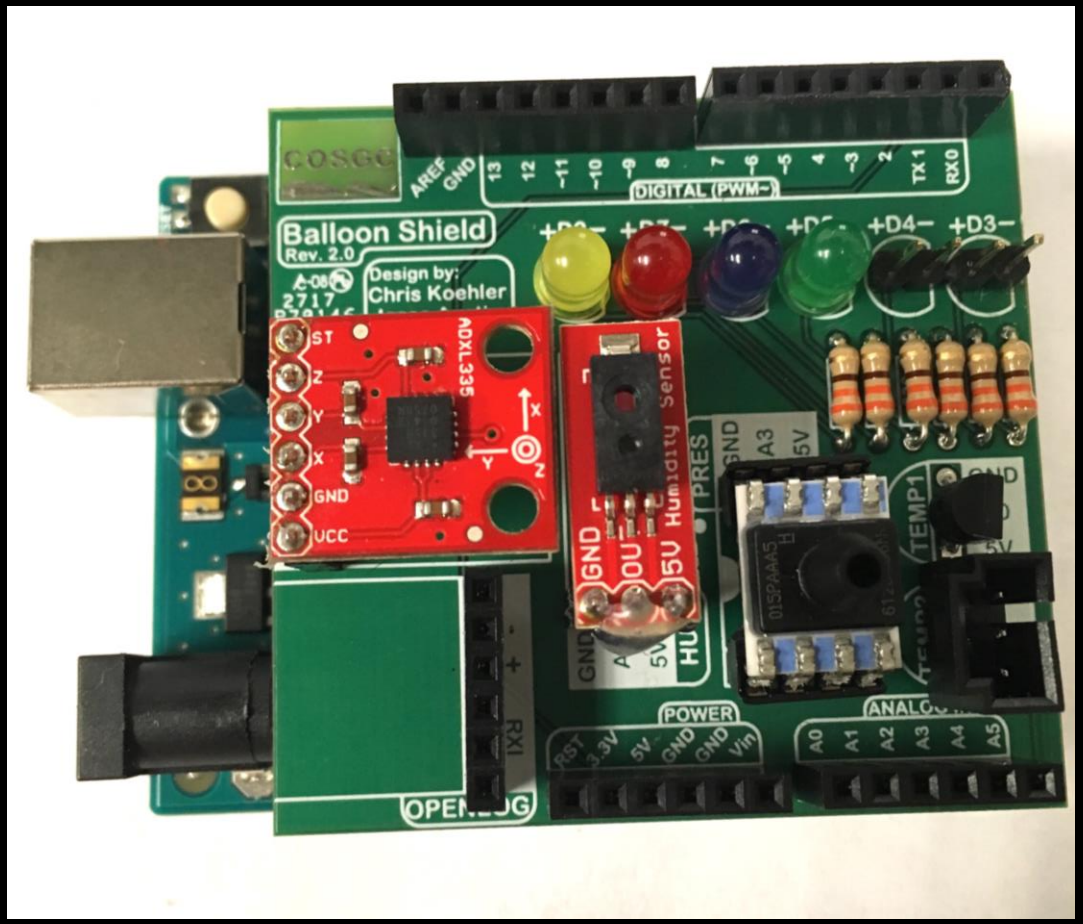




Accelerometer:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Disconnect your Balloon Shield and add the Accelerometer**



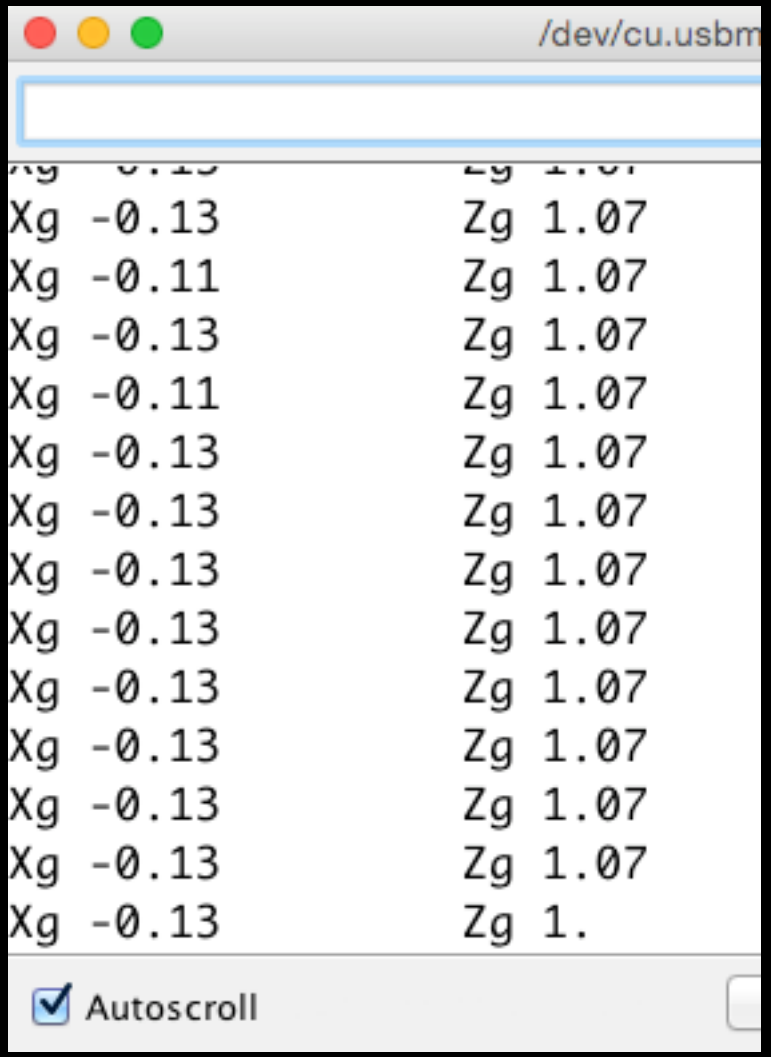
Accelerometer:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Reconnect your Balloon Shield to the Arduino**

- **Connect USB and reload code**

- **Verify same results**

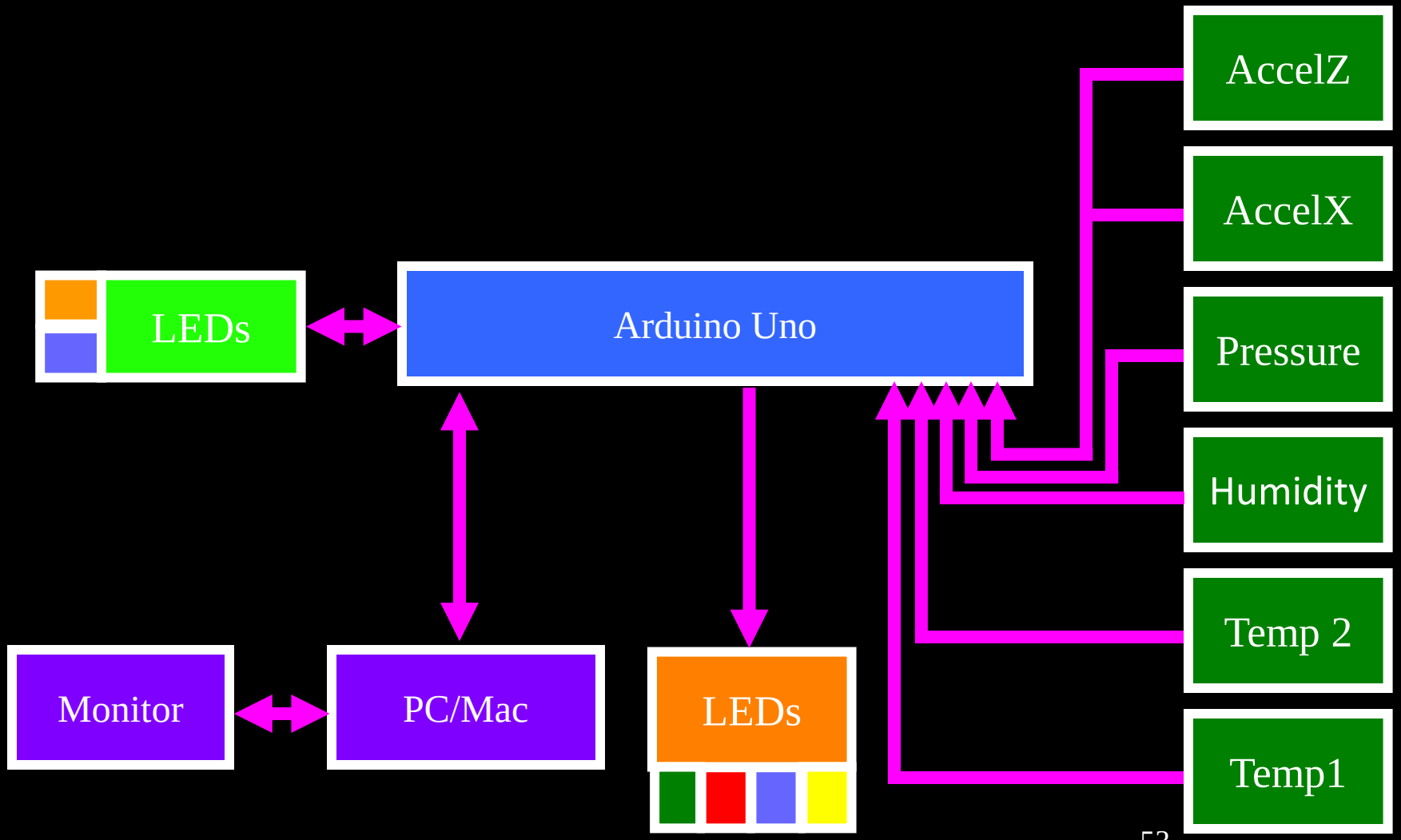


Part 2 – Arduino Road Trip Sensors

A. Humidity Sensor
B. Pressure Sensor
C. Accelerometers
D. External Temp Sensor

External Temperature Sensor:

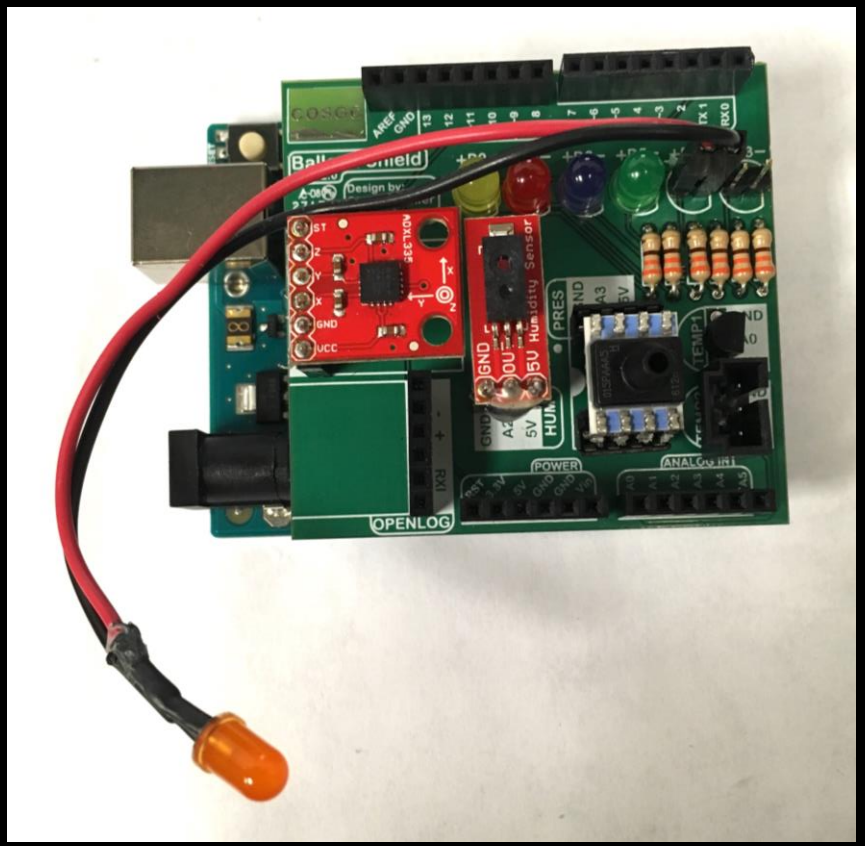
Space Minor
UNIVERSITY OF COLORADO BOULDER

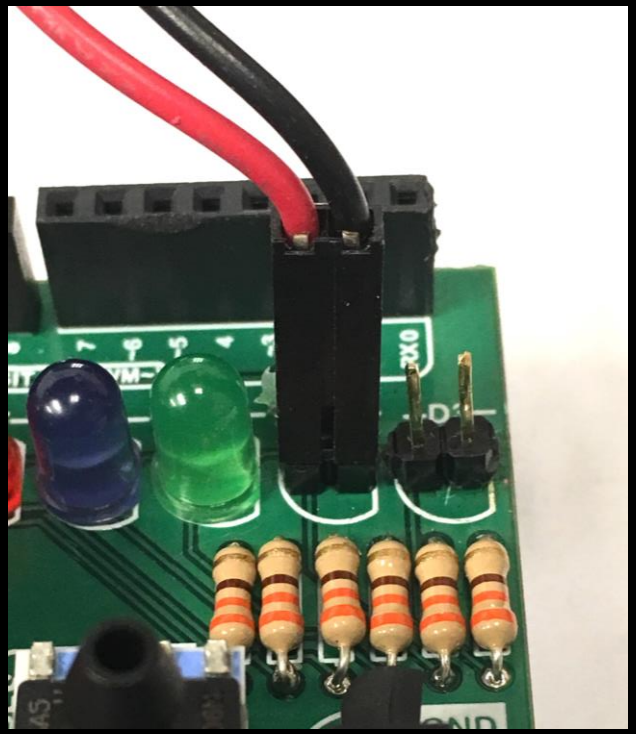


External Temperature Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Add Orange LED to D4
- Red wire to + and Black wire to -

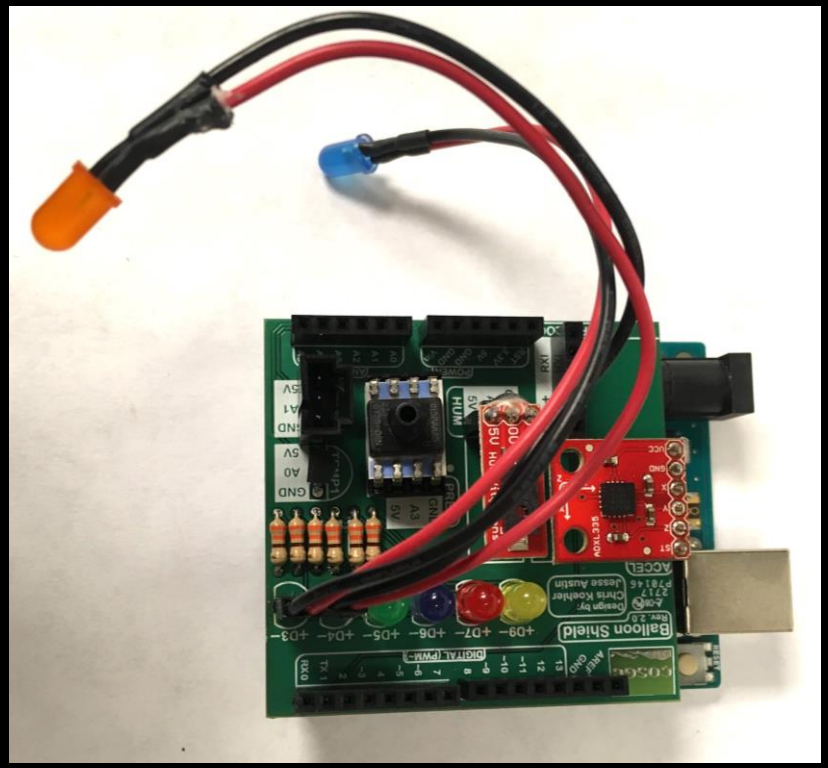


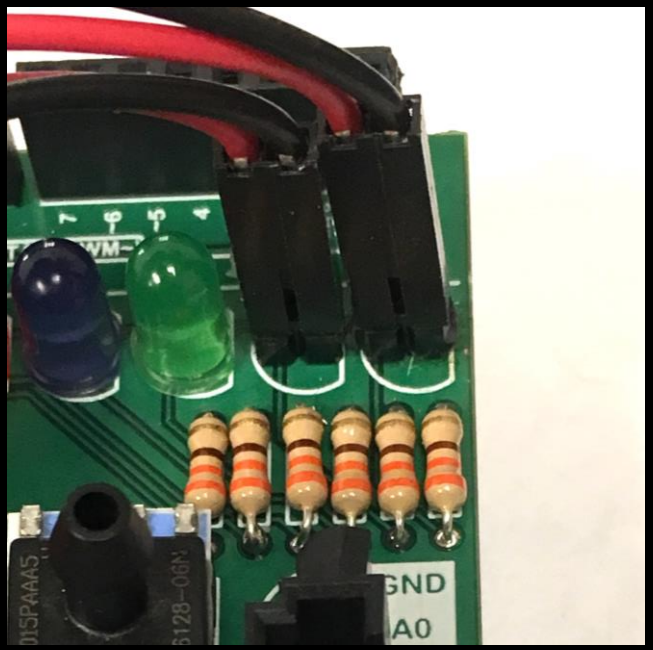


External Temperature Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Add Blue LED to D3**
- **Red wire to + and Black wire to -**

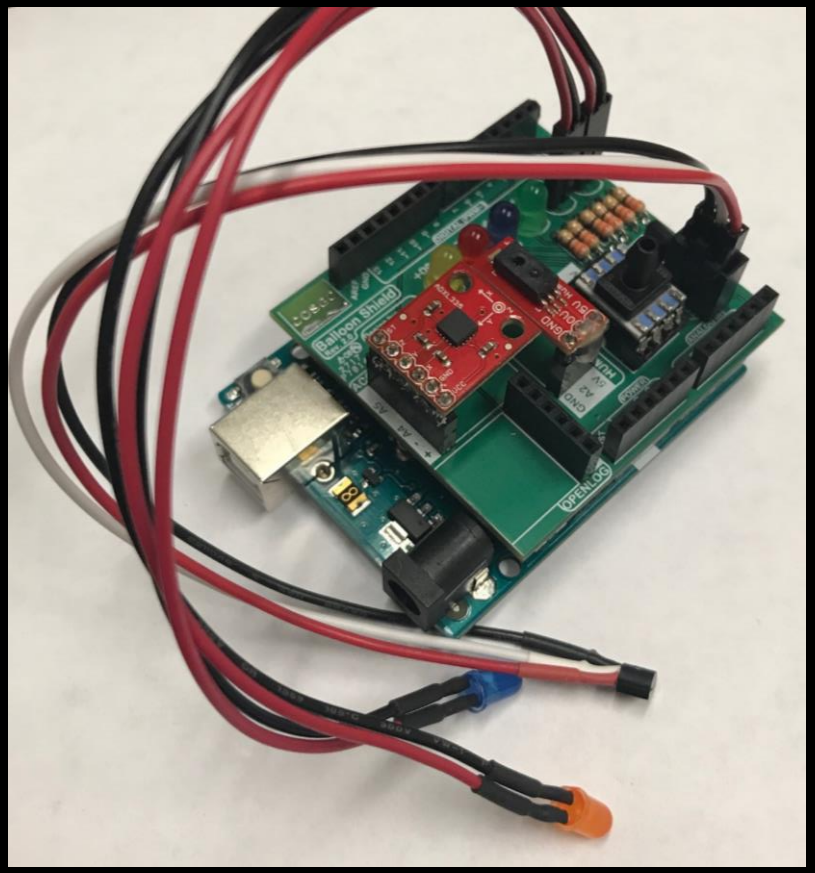


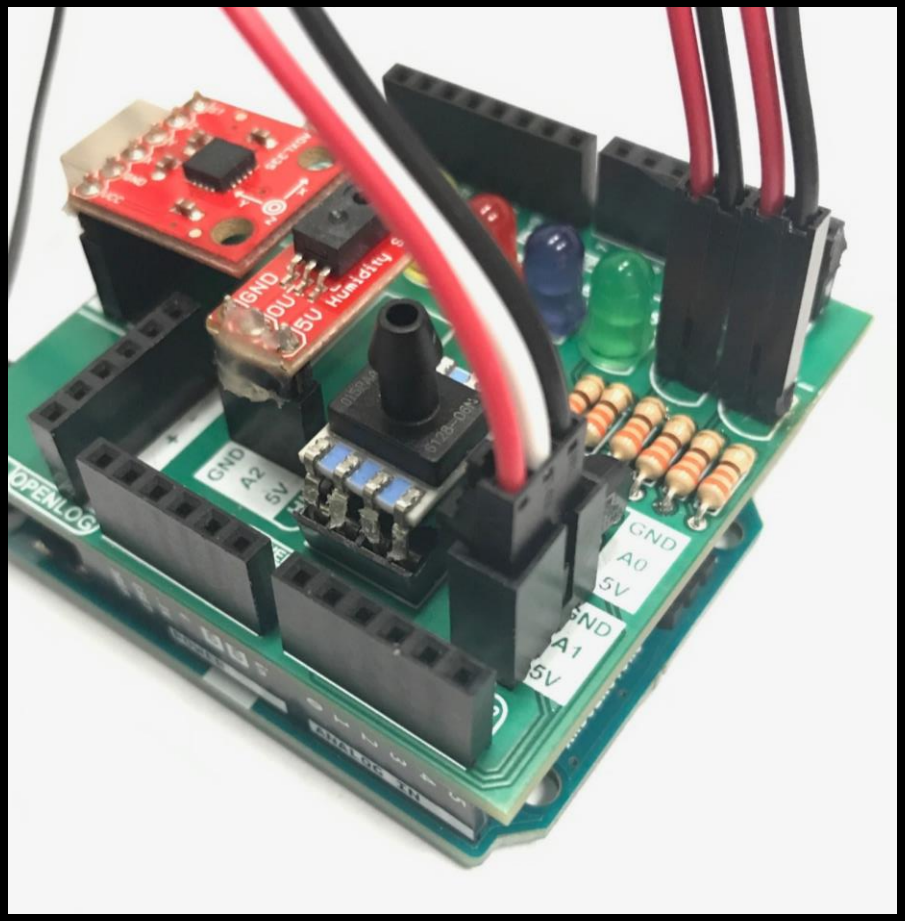


External Temperature Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Add Temp2 to Temp2
- Note wire colors





External Temperature Sensor:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- Open Temp1 Sketch; save as Temp2

```
// Definitions
      int sensor;
      float sensorVolt;
      float sensorUnits;
      float sensorUnitsC;
```

```
void setup() {
// put your setup code here, to run once:

      Serial.begin(9600);

// setup the LED Visual Display
      pinMode(3, OUTPUT);  //Blue LED
      pinMode(4, OUTPUT);  //Orange LED
      pinMode(5, OUTPUT);  //Green LED
      pinMode(6, OUTPUT);  //Purple LED
      pinMode(7, OUTPUT);  //Red LED
      pinMode(9, OUTPUT);  //Yellow LED
}
```

Balloon Shield Build Part 6:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

```
void loop() {
//   put your main code here, to run repeatedly:

     sensor = analogRead(A1);
     sensorVolt = sensor*(5.0/1023);
     sensorUnitsC = (sensorVolt - 0.5)/(0.01);
     sensorUnits = (sensorUnitsC*(9.0/5.0) + 32);
     Serial.print(sensor);
     Serial.print("\t voltage ");
     Serial.print(sensorVolt);
     Serial.print("\t units ");
     Serial.println(sensorUnits);

//   Turn script running leds OFF at begining of l
     digitalWrite(3, LOW);  //Blue LED
     digitalWrite(4, LOW);  //Orange LED
     digitalWrite(5, LOW);  //Green LED
     digitalWrite(6, LOW);  //Purple LED
     digitalWrite(7, LOW);  //Red LED
     digitalWrite(9, LOW);  //Yellow LED
```

```
if(sensorUnits > 78.0) {
digitalWrite(5, HIGH);
}
if(sensorUnits > 79.0) {
digitalWrite(6, HIGH);
}
if(sensorUnits > 80.0) {
digitalWrite(7, HIGH);
}
if(sensorUnits > 81.0) {
digitalWrite(9, HIGH);
}
digitalWrite(3, HIGH);
digitalWrite(4, HIGH);
delay(100);
```

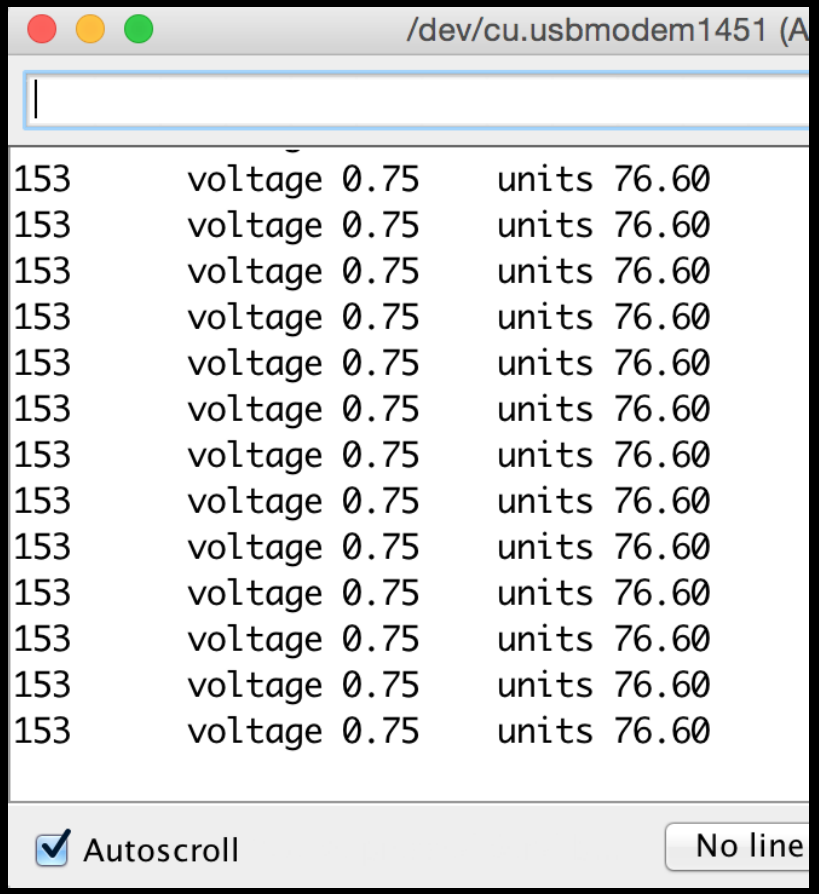
External Temperature Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Build and upload your sketch**

- **Temp2 will stick outside your BalloonSat**

- **LED 3 and 4, will also stick outside your BalloonSat**



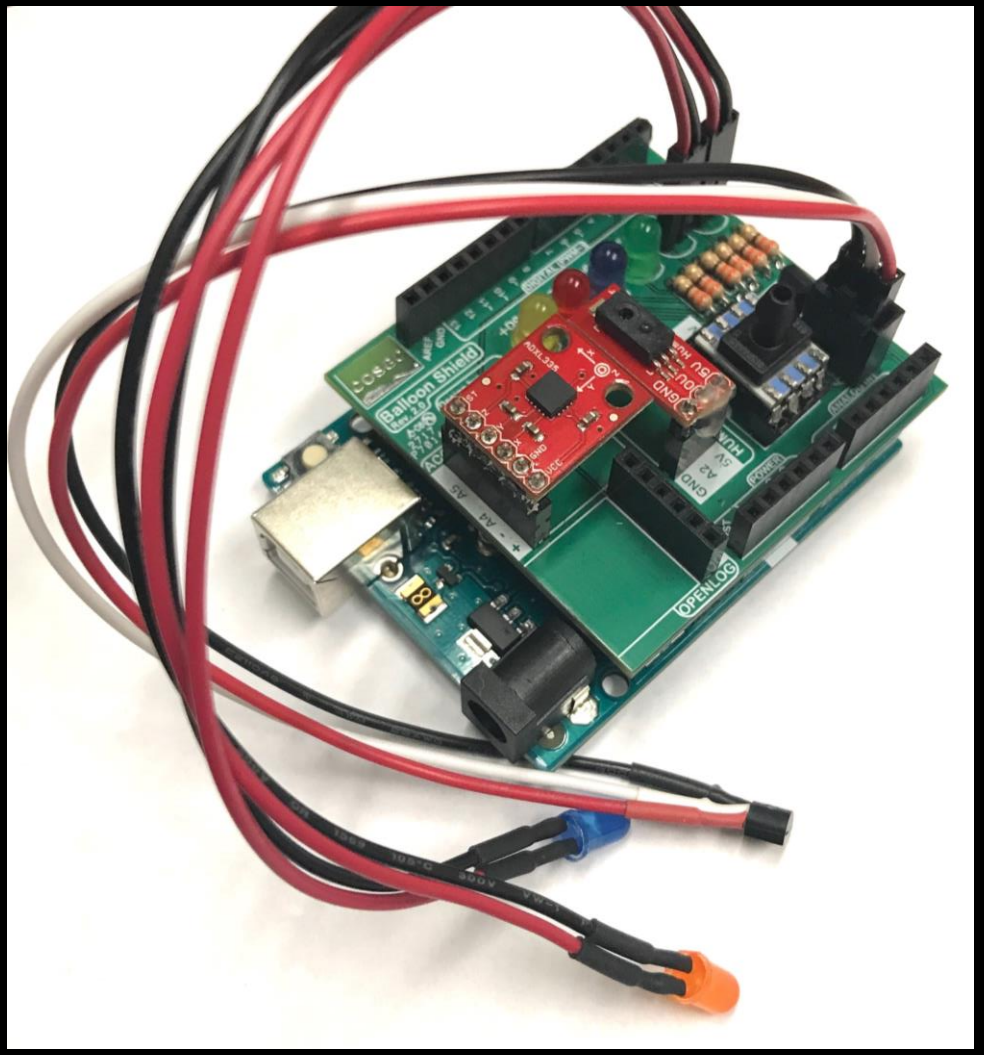
External Temperature Sensor:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Build and upload your sketch**

- **Temp2 will stick outside your BalloonSat**

- **LED 3 and 4, will also stick outside your BalloonSat**

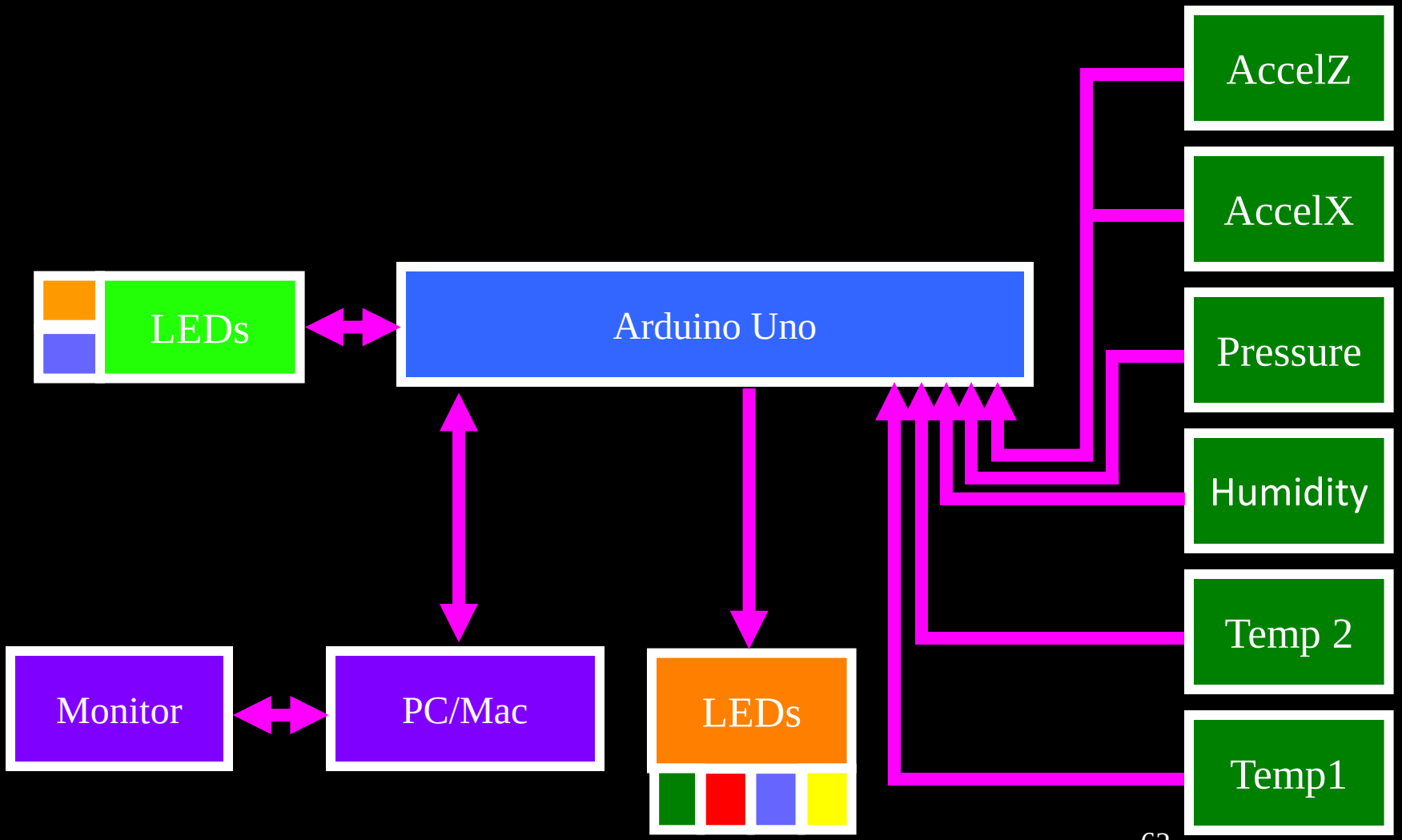


Part 2 – Arduino Road Trip Sensors

A. Humidity Sensor
B. Pressure Sensor
C. Accelerometers
D. External Temp Sensor

External Temperature Sensor:

Space Minor
UNIVERSITY OF COLORADO BOULDER



Part 2 – Arduino Road Trip Sensors

A. Humidity Sensor
B. Pressure Sensor
C. Accelerometers
D. External Temp Sensor

Full Sensor Code Testing:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- **Now let's integrate all the code and sensors together and test**

- **We will review code but you will use a pre-coded sketch**

- **Everything should look familiar**

- **Download code from spacegrant.colorado.edu**
    - **Statewide Programs**
    - **DemoSat Program**

Full Sensor Code Testing:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

```
// Definitions
// Temperature Sensor #1
    int temp1;
    float temp1Volt;
    float temp1C;
    float temp1F;

// Temperature Sensor #2
    int temp2;
    float temp2Volt;
    float temp2C;
    float temp2F;

// Humidity Sensor
    int humidity;
    float humidityVolt;
    float RH;
```

```
// Presure Sensor
    int pressure;
    float pressureVolt;
    float psi;

// Accelerometer X
    int accelX;
    float accelXVolt;
    float accelXG;

// Accelerometer Z
    int accelZ;
    float accelZVolt;
    float accelZG;
```

Full Sensor Code Testing:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

```
// Time keeper
// The time stamp used when recording data points
    uint32_t timeStamp = 0;
```

Full Sensor Code Testing:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

```
void setup() {
// put your setup code here, to run once:

      Serial.begin(9600);

// setup the LED Visual Display
      pinMode(3, OUTPUT);  //Arduino on
      pinMode(4, OUTPUT);  //Internal Temp
      pinMode(5, OUTPUT);  //External Temp
      pinMode(6, OUTPUT);  //Humidity
      pinMode(7, OUTPUT);  //Pressure
      pinMode(9, OUTPUT);  //Accels

// turn on Arduino LED
      digitalWrite(3, HIGH);  // Leave on while power is on

// Print Column Headers
      Serial.println("Time,Temp1F,Temp2F,RH,Pres,AccX,AccZ");
}
```

Full Sensor Code Testing:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

```
void loop() {
//   put your main code here, to run repeatedly:

//   Turn script running leds OFF at begining of loop
     digitalWrite(4, LOW);
     digitalWrite(5, LOW);
     digitalWrite(6, LOW);
     digitalWrite(7, LOW);
     digitalWrite(9, LOW);

     delay(500);  //Amount of time between samples (milliseconds)

// Log the time
     timeStamp = millis();
     Serial.print(timeStamp);
```

Full Sensor Code Testing:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

```
temp1 = analogRead(A0);
temp1Volt = temp1*(5.0/1023);
temp1C = (temp1Volt - 0.5)/(0.01);
temp1F = (temp1C*(9.0/5.0) + 32);
Serial.print(",");
Serial.print(temp1F, 2);
digitalWrite(4, HIGH);

temp2 = analogRead(A1);
temp2Volt = temp2*(5.0/1023);
temp2C = (temp2Volt - 0.5)/(0.01);
temp2F = (temp2C*(9.0/5.0) + 32);
Serial.print(",");
Serial.print(temp2F, 2);
digitalWrite(5, HIGH);
```

Full Sensor Code Testing:

Space Minor
UNIVERSITY OF COLORADO BOULDER

```
humidity = analogRead(A2);
humidityVolt = humidity*(5.0/1023);
RH = (((humidityVolt/5.0)-0.16)/0.0062);
Serial.print(",");
Serial.print(RH, 2);
digitalWrite(6, HIGH);

pressure = analogRead(A3);
pressureVolt = pressure*(5.0/1023);
psi = (pressureVolt-0.5)*(15.0/4.0);
Serial.print(",");
Serial.print(psi, 2);
digitalWrite(7, HIGH);
```

Full Sensor Code Testing:

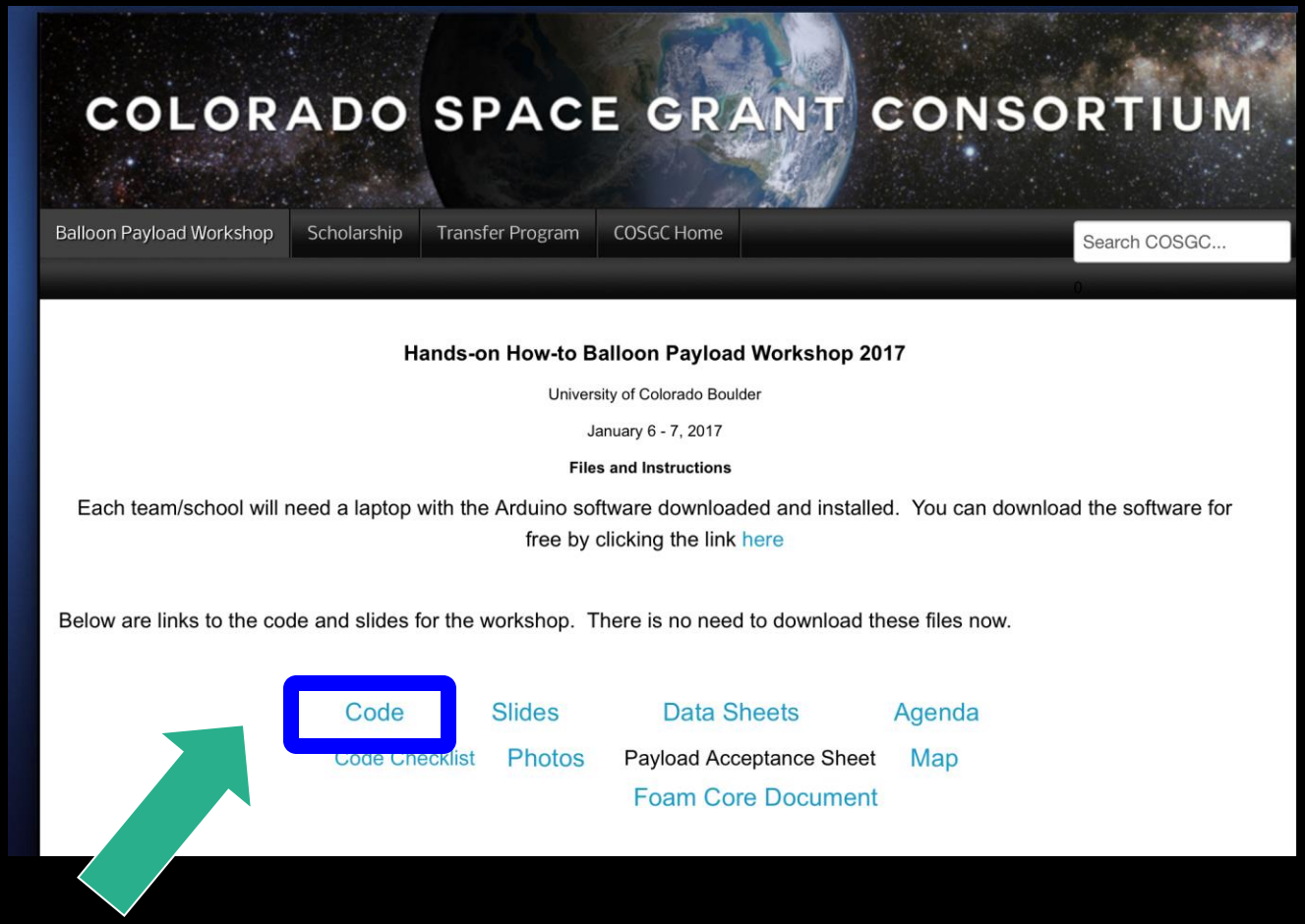
Space Minor
UNIVERSITY OF COLORADO **BOULDER**

```
    accelX = analogRead(A4);
    accelXVolt = accelX*(5.0/1023);
    accelXG = (accelXVolt - (3.3/2))/(0.330);
    Serial.print(",");
    Serial.print(accelXG,3);

    accelZ = analogRead(A5);
    accelZVolt = accelZ*(5.0/1023);
    accelZG = (accelZVolt - (3.3/2))/(0.330);
    Serial.print(",");
    Serial.print(accelZG,3);
    digitalWrite(9, HIGH);

    Serial.println();

}
```

Full Sensor Code Testing:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

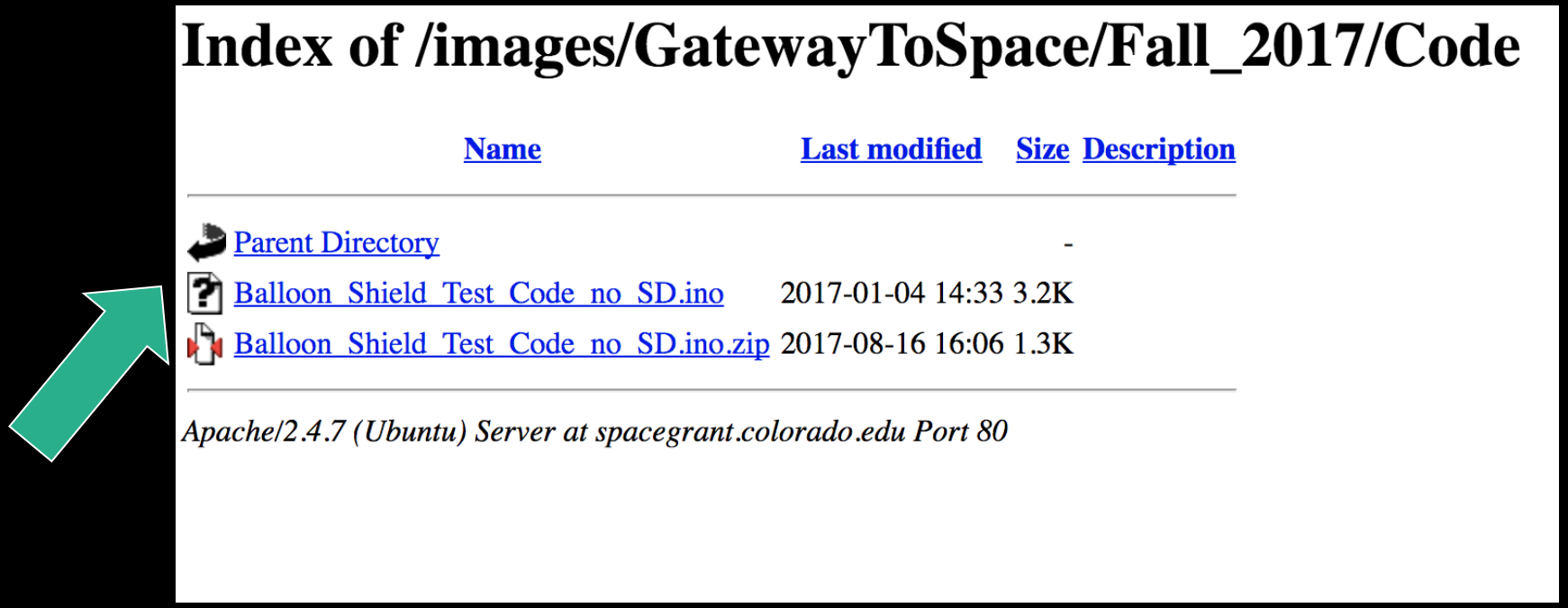
- **Download code or get from desktop and run and verify it works….**



Full Sensor Code Testing:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- **Download code or get from desktop and run and verify it works….**



Index of /images/GatewayToSpace/Fall_2017/Code

Name	Last modified	Size	Description
Parent Directory		-	
Balloon_Shield_Test_Code_no_SD.ino	2017-01-04 14:33	3.2K	
Balloon_Shield_Test_Code_no_SD.ino.zip	2017-08-16 16:06	1.3K	

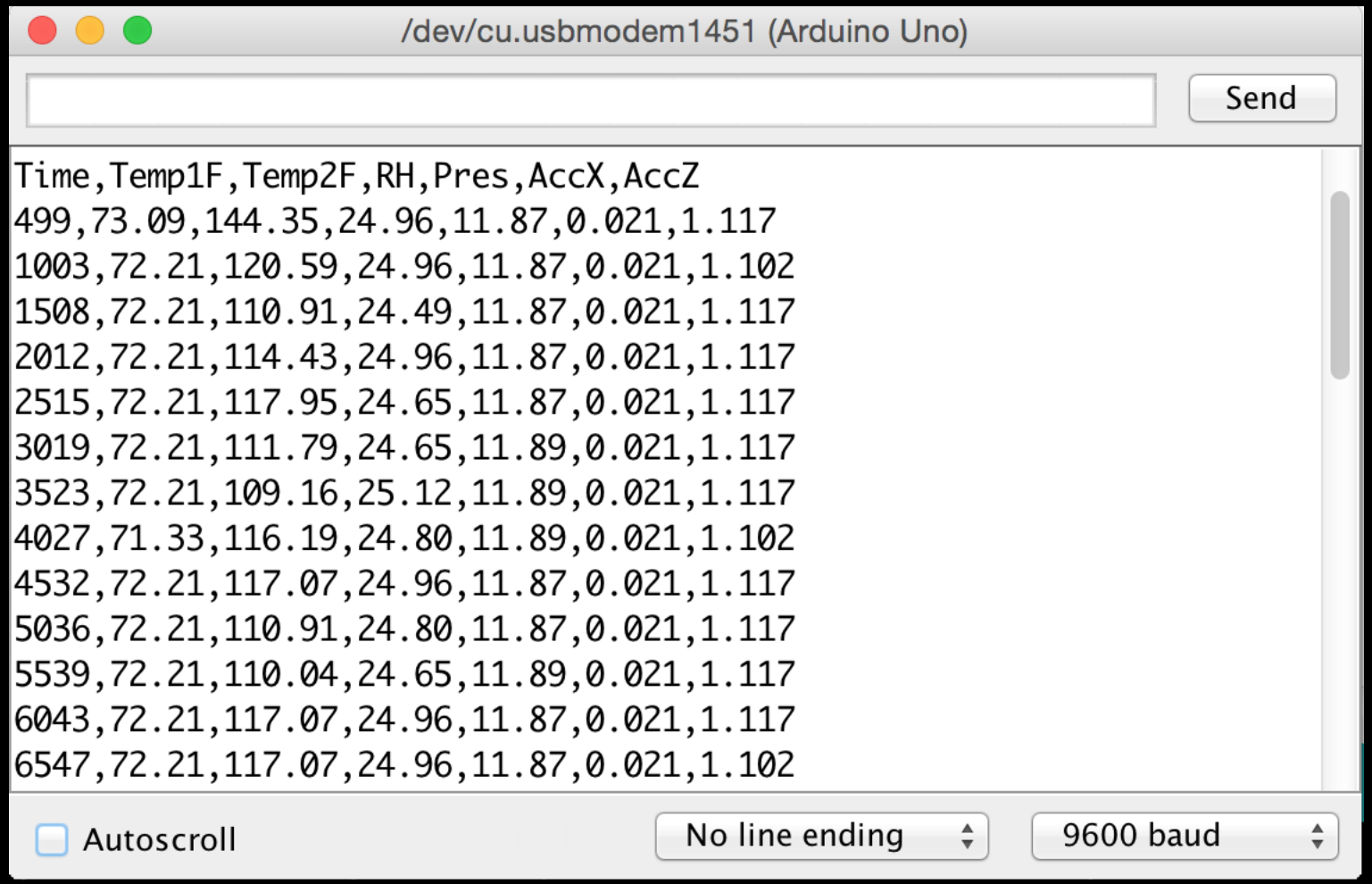
Apache/2.4.7 (Ubuntu) Server at spacegrant.colorado.edu Port 80

If .ino file doesn't work, try downloading the .zip version

Full Sensor Code Testing:

Space Minor
UNIVERSITY OF COLORADO BOULDER

- Should look like this



Part 2 – Arduino Race Track Sensors

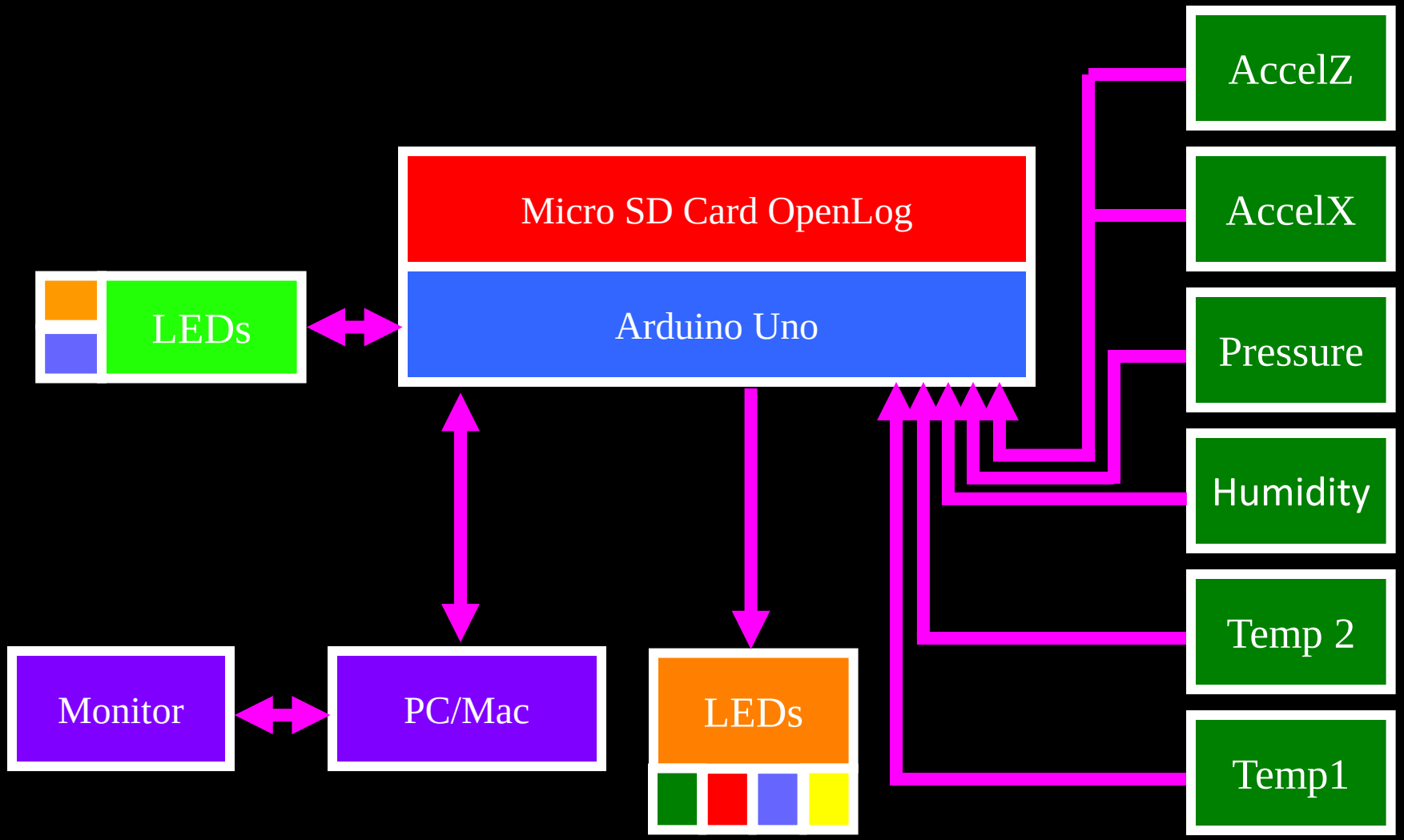
A. OpenLog Integration
B. OpenLog Code Integration
C. Data Retrieval

Part 2 – Arduino Race Track Sensors

A. OpenLog Integration
B. OpenLog Code Integration
C. Data Retrieval

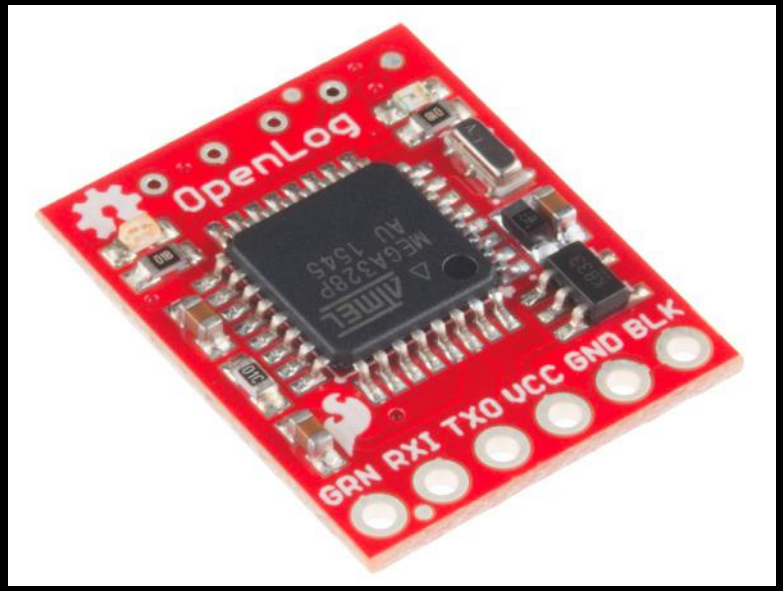
MicroSD Card Shield:

Space Minor
UNIVERSITY OF COLORADO BOULDER



OpenLog:

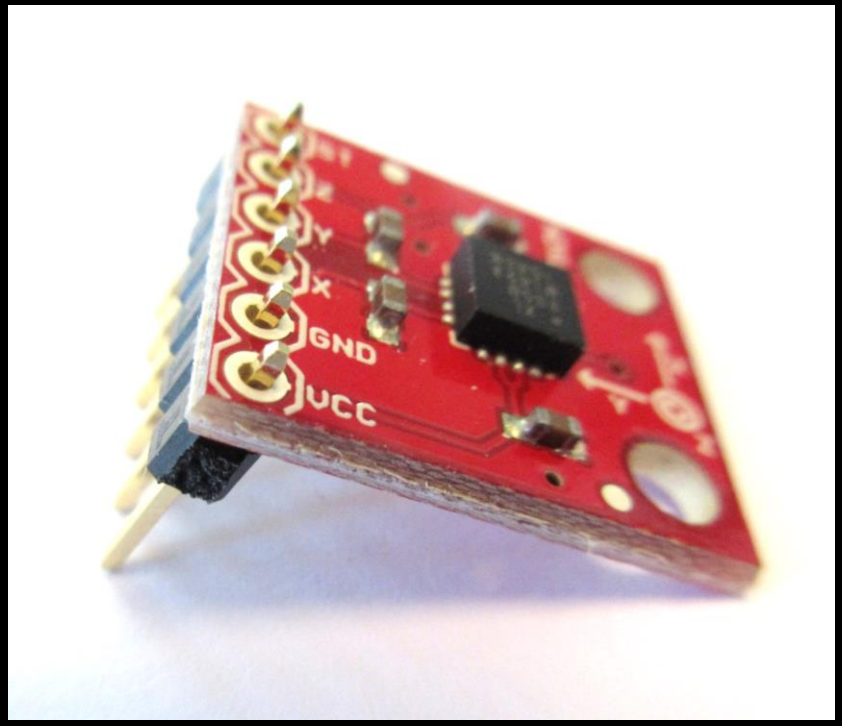
Space Minor
UNIVERSITY OF COLORADO **BOULDER**



OpenLog:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Solder 6 pin header to board
- Short side through the bottom of the board
- Keep header perpendicular to board

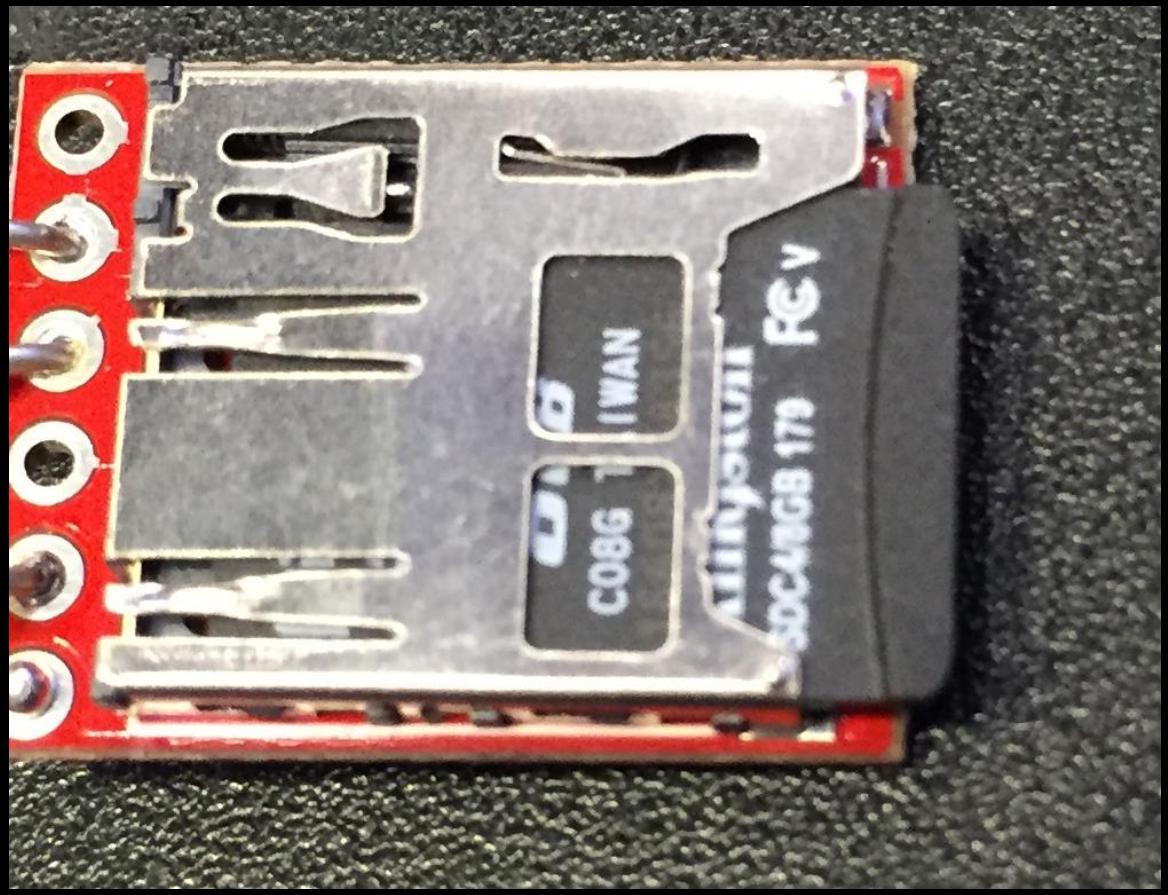


Similar to accelerometer shown here.

Micro SD Card OpenLog:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

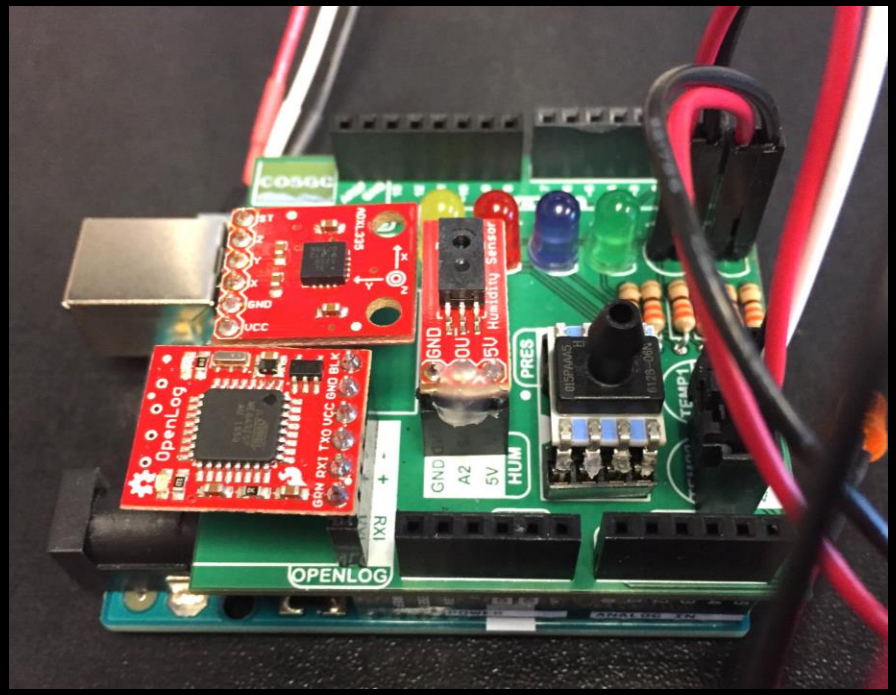
- **Insert MicroSD card as shown**



Open Log:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

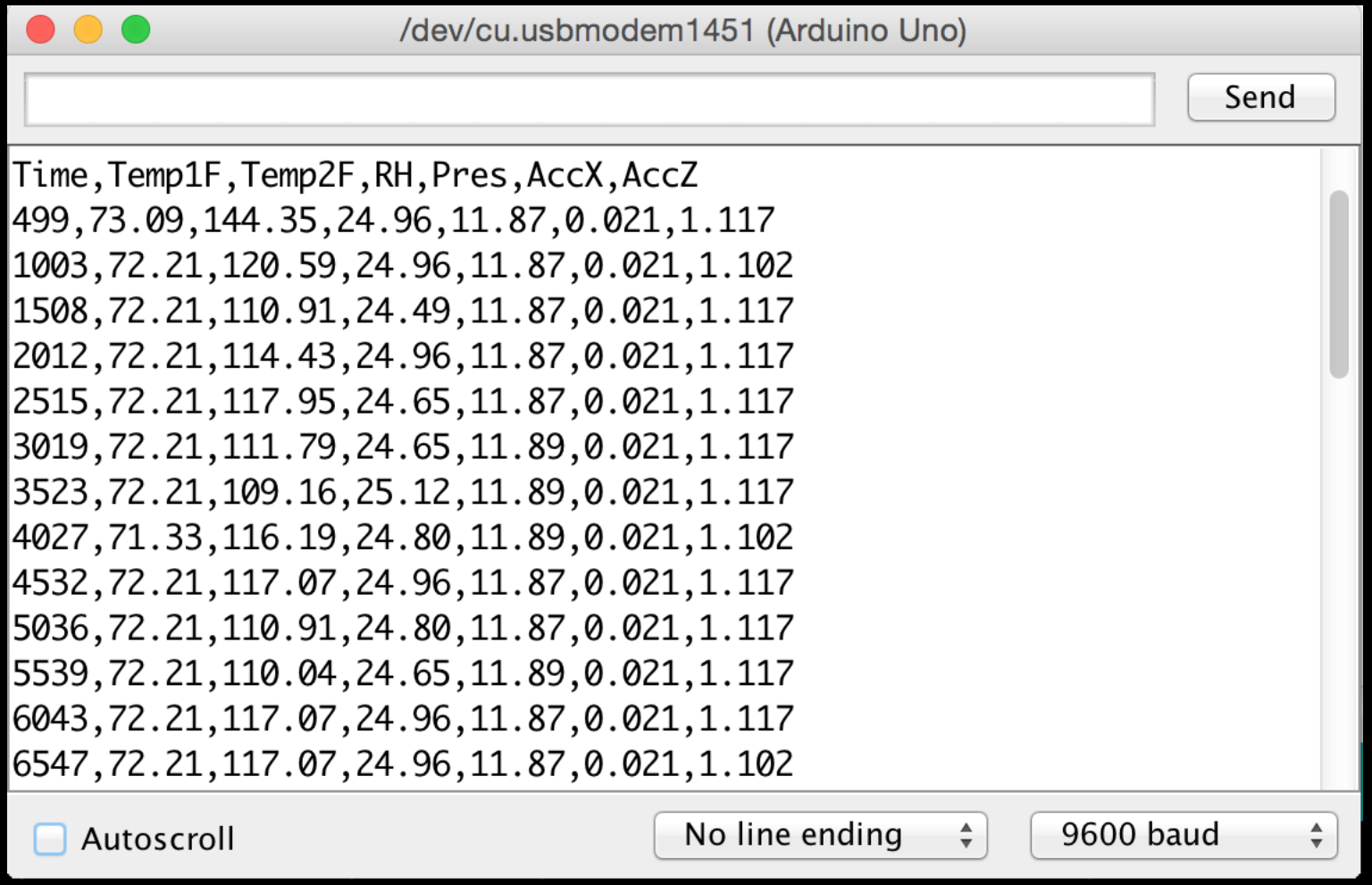
Place OpenLog in correct spot on Balloon Shield



Open Log:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Reconnect USB and rerun same code**



Part 2 – Arduino Race Track Sensors

A. OpenLog Integration
B. OpenLog Code
C. Data Retrieval

OpenLog Code:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Now let's explore the code needed to record this data to the OpenLog**

OpenLog Code:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **The super cool thing about OpenLog is that anything you serial print is written to the OpenLog**

- **A new file is created if power is removed**

- **A new file is created if sd card is removed and re-inserted**

- **Can eject sd card while powered**

Part 2 – Arduino Race Track Sensors

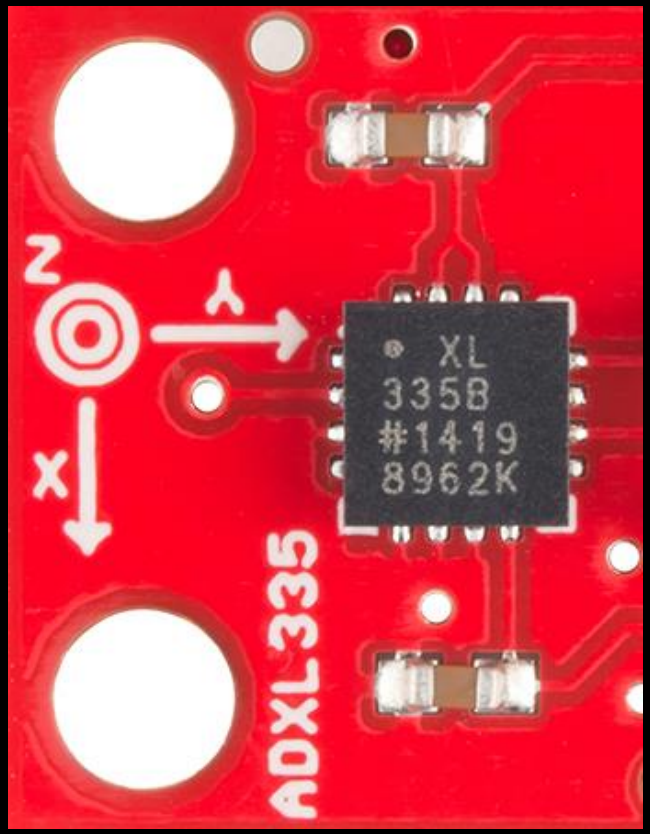
A. OpenLog Integration
B. OpenLog Code
C. Data Retrieval

Sensor Testing:

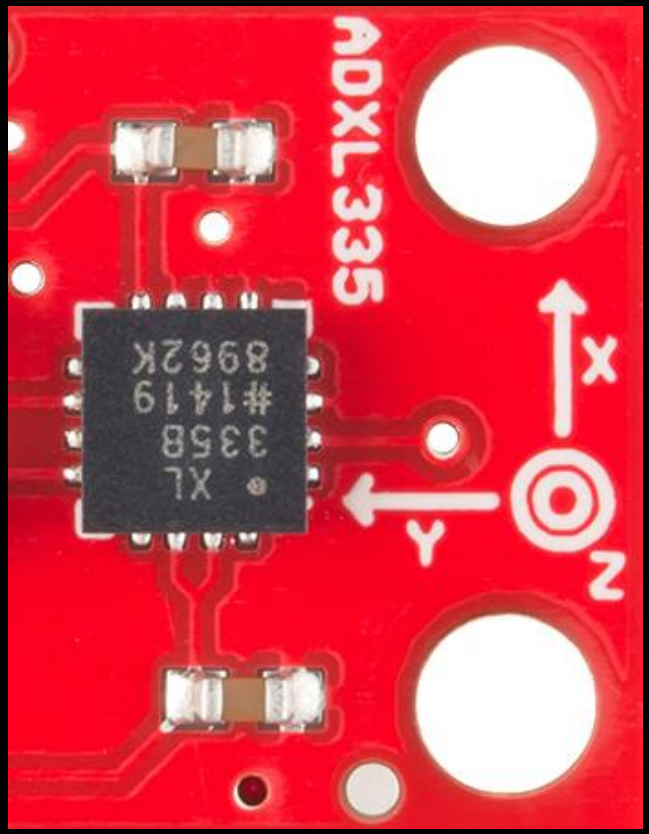
Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Rotate your accelerometer like…

4. X Down



5. X Up

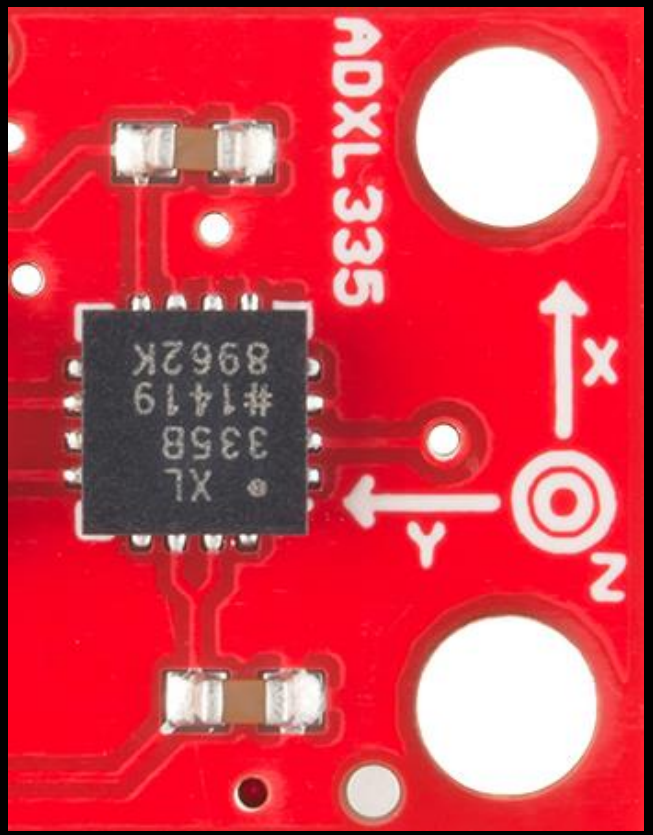


Sensor Testing:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

8. Z Down

9. Z UP



Data Retrieval:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

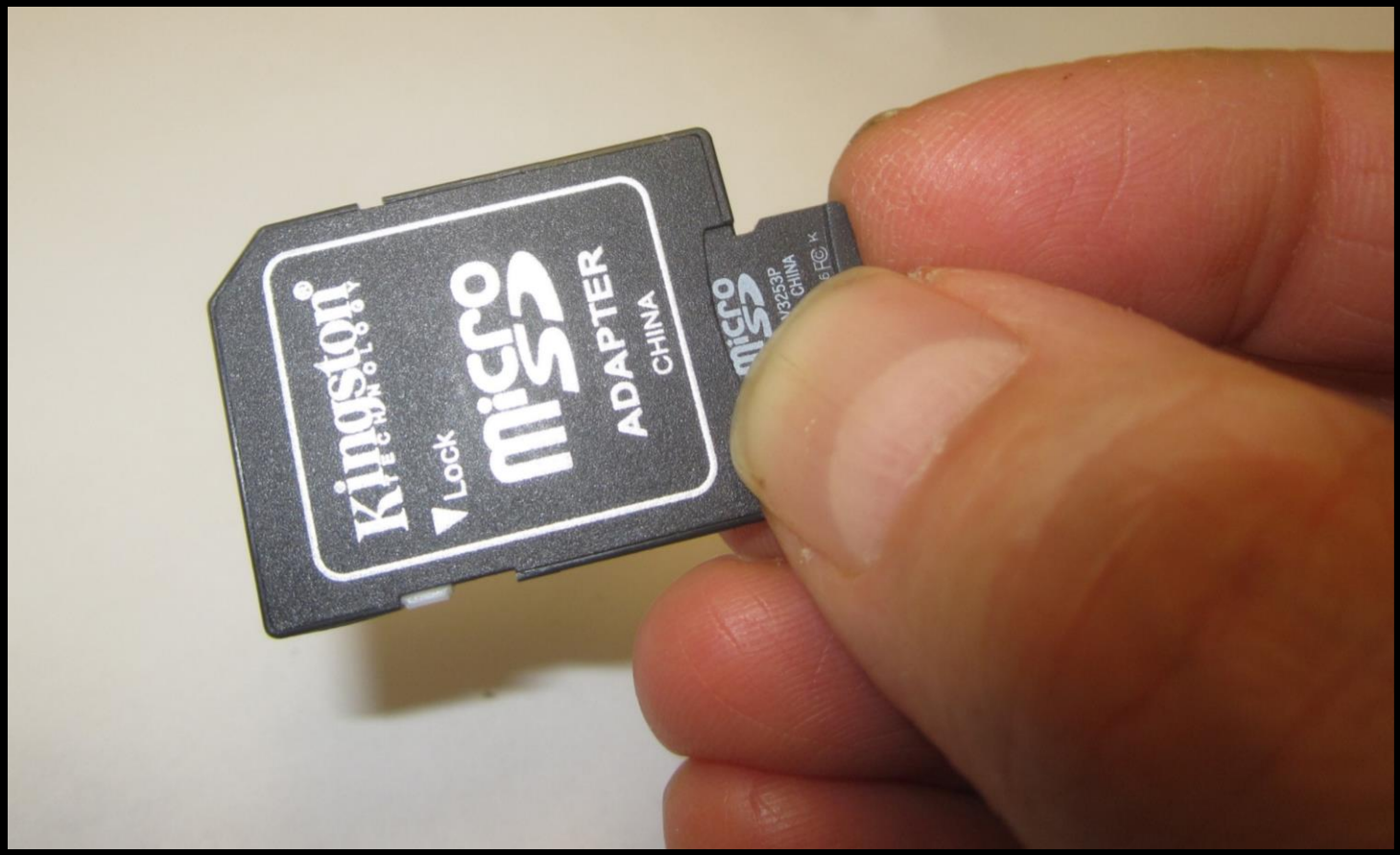
- **Eject the SD card and re-insert.**
- **Then record data as follows:**

1. **Breath on your humidity sensor twice**
2. **Suck on pressure sensor twice**
3. **Touch both temp sensors for 5 seconds each**
4. **Orient your accelerometer (Z up/down, X up/down) 10 seconds each direction**
5. **Breath on your humidity sensor twice**
6. **Suck on pressure sensor twice**
7. **Disconnect USB from Arduino**

Data Retrieval:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Remove microSD card from Uno and insert into SD card adapter**



Data Retrieval:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Remove microSD card from Uno and insert into SD card adapter**

Data Retrieval:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

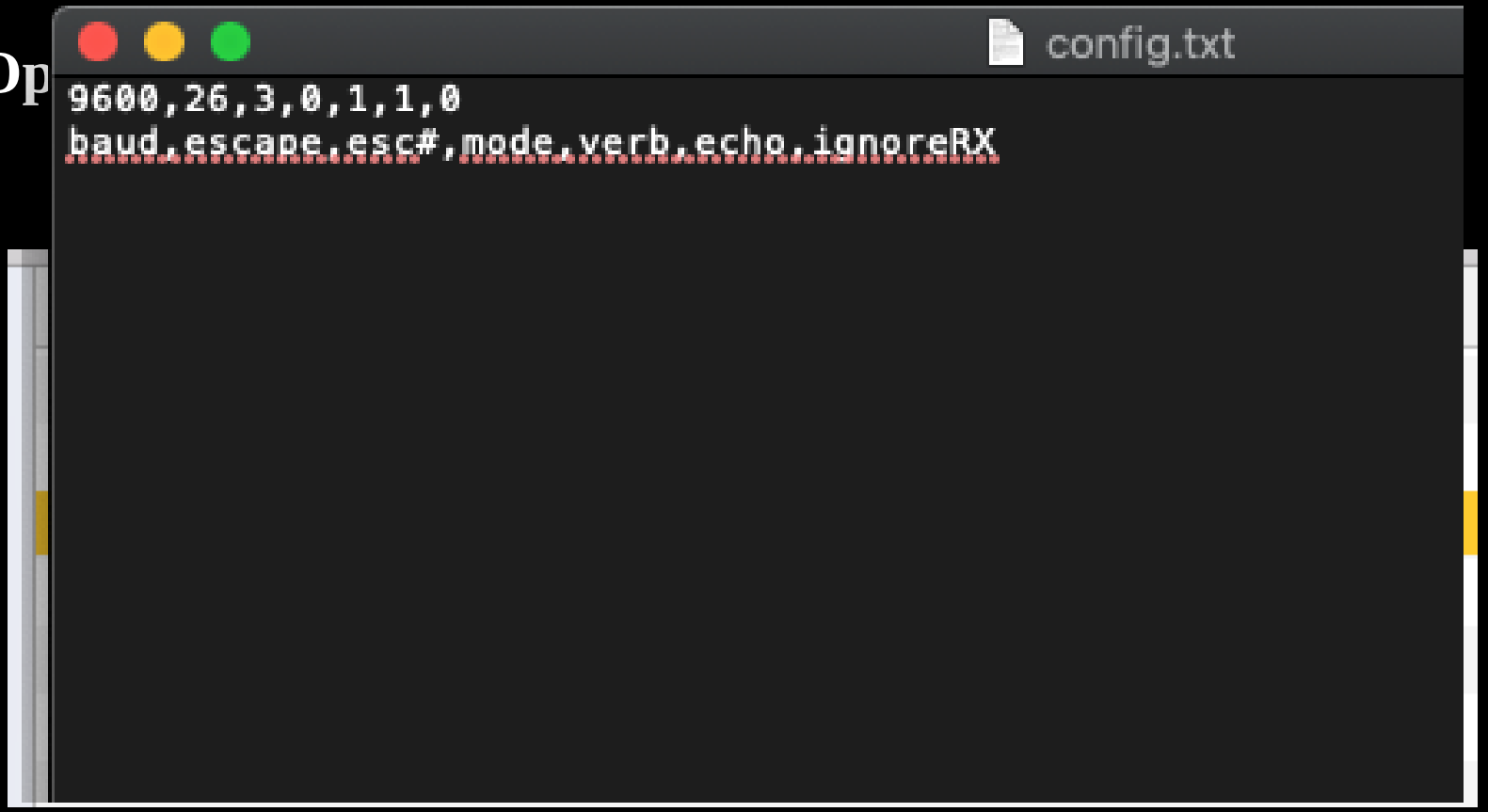
- **Insert SD card adapter into your laptop**

Data Retrieval:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Navigate to card and copy last LOG file to your **desktop**

- Op

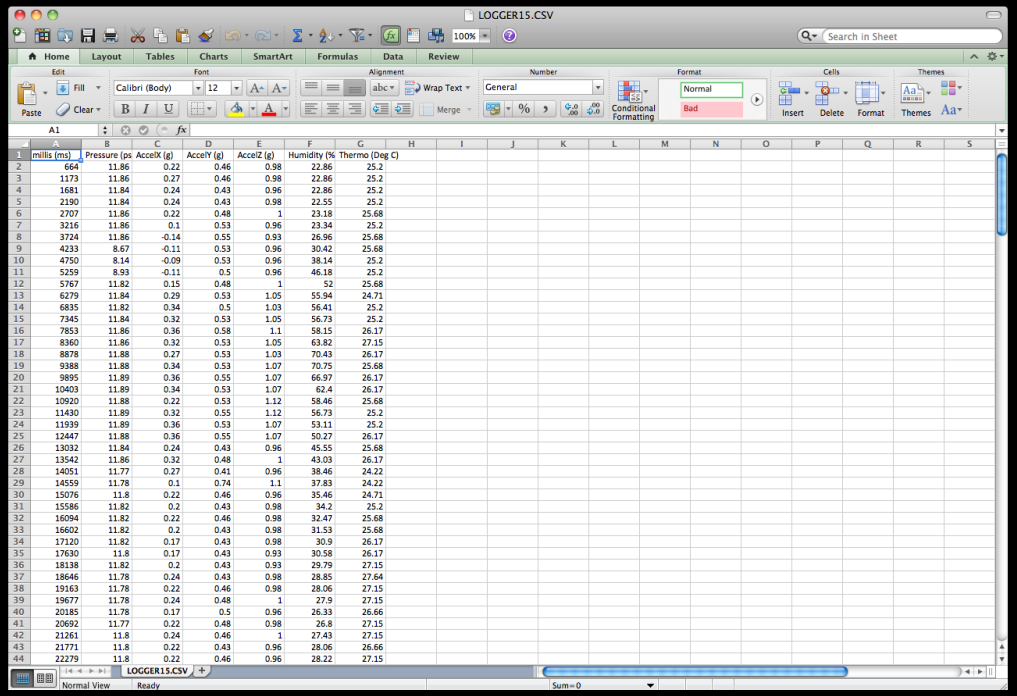


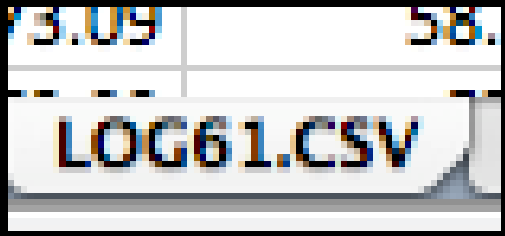
Data Retrieval:

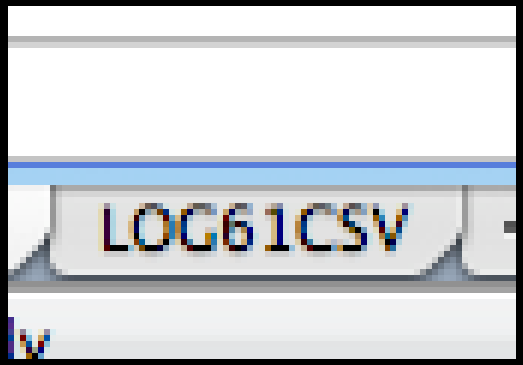
Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- Graph all data minus the time stamp (Using Excel)

- Mac Users you must change tab name to remove “.”



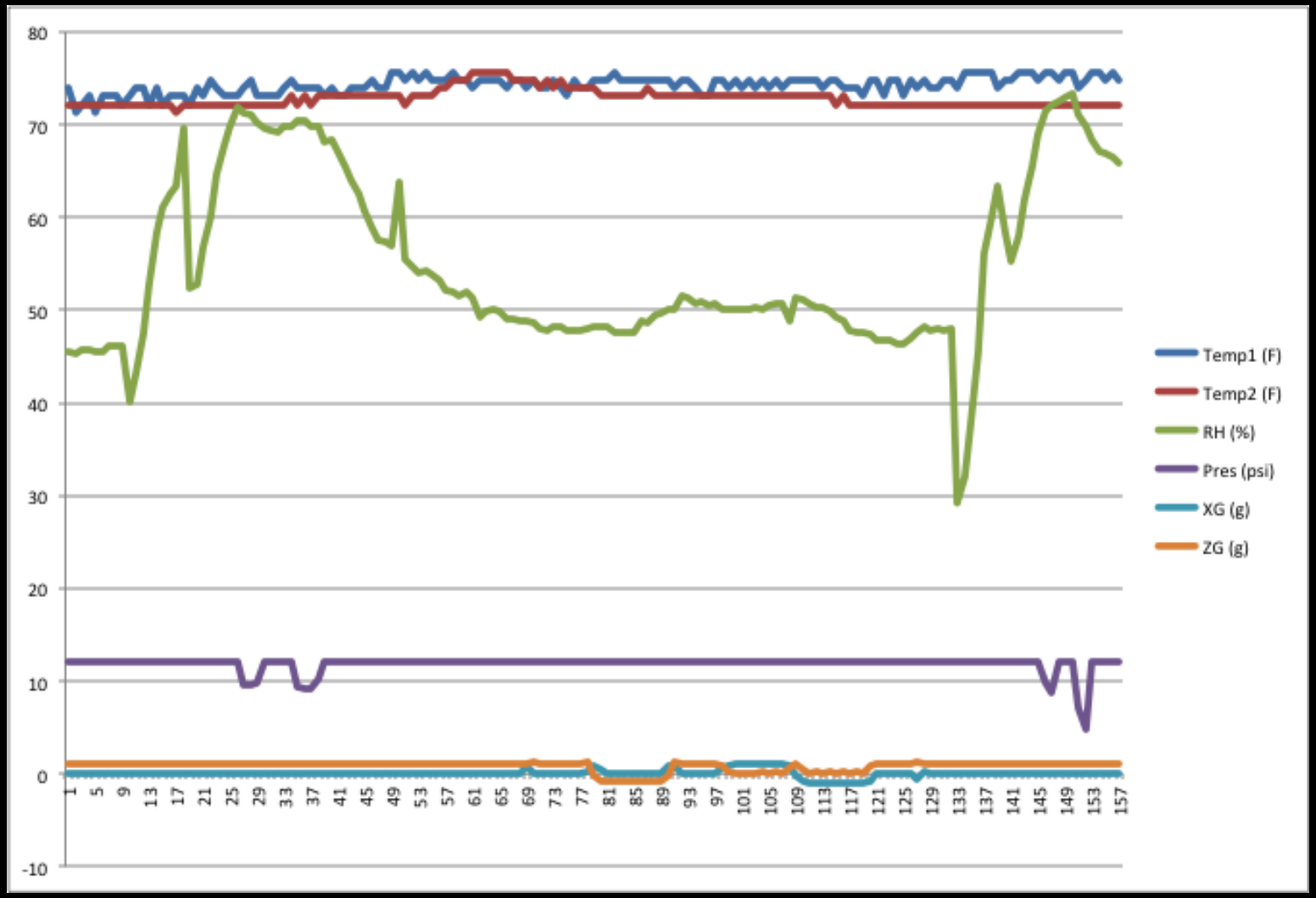




Data Retrieval:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

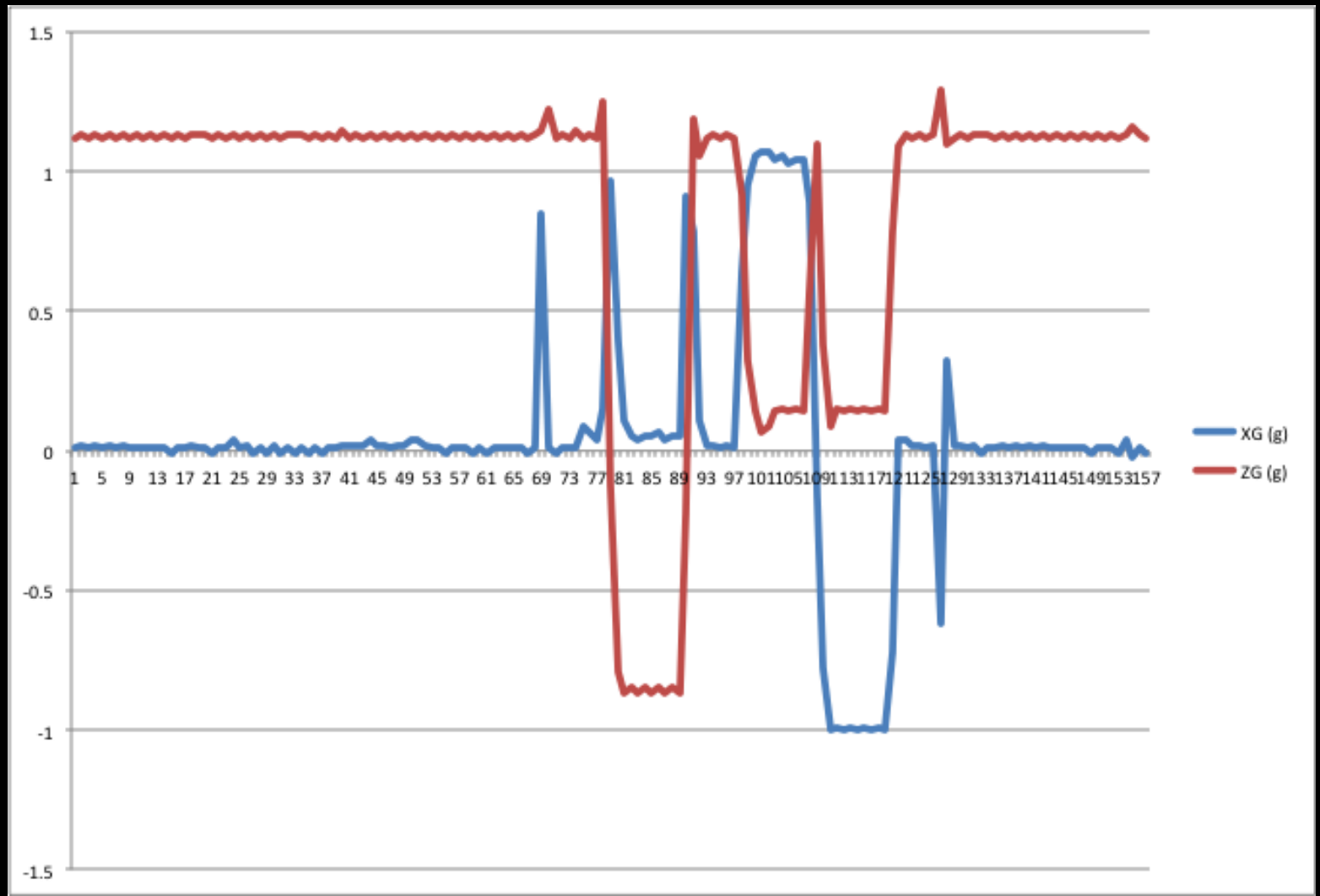
- Do you see your data markers?



Data Retrieval:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

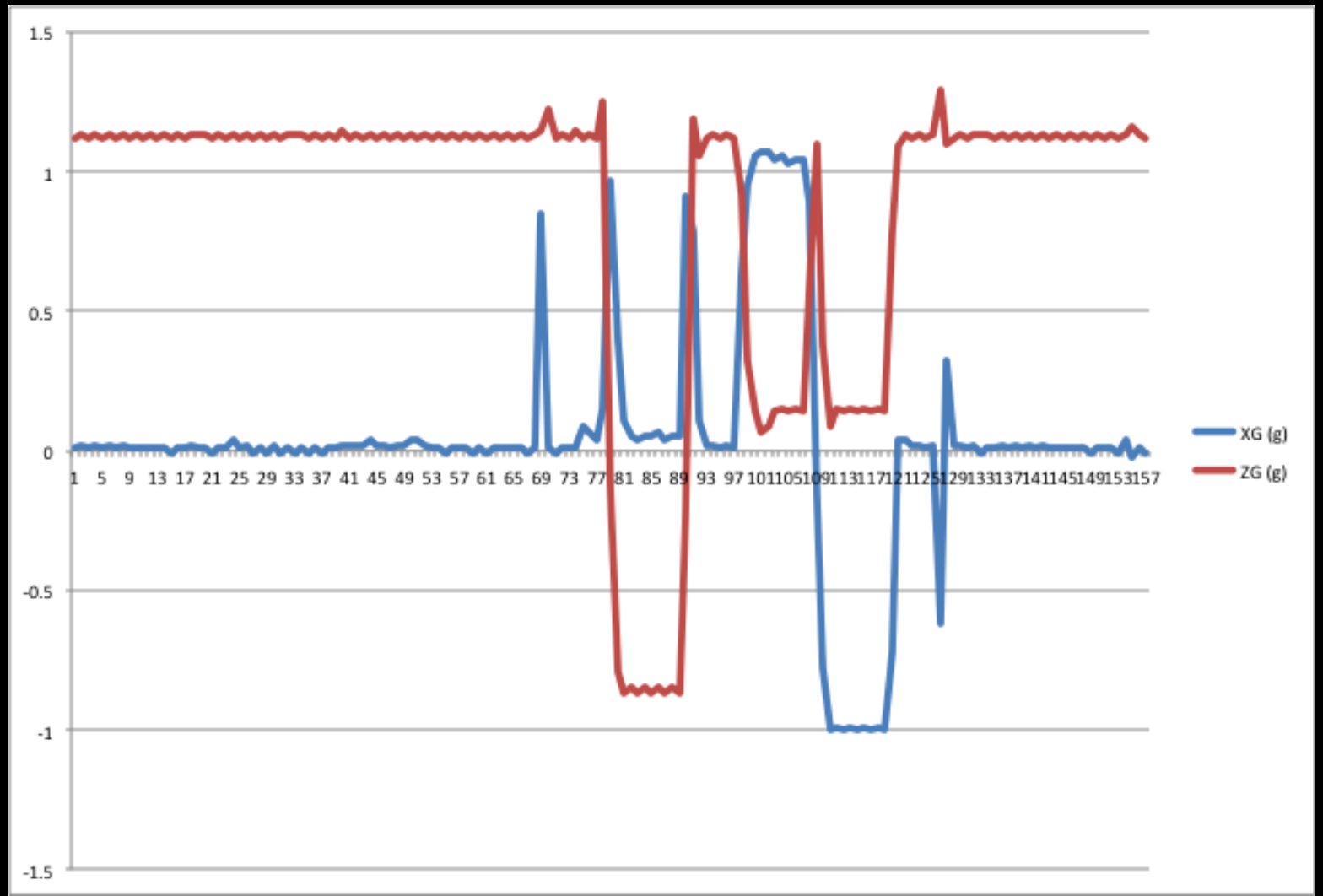
- **Re-plot just your accel data**



Data Retrieval:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- How can you use this data?



Part 2 – Arduino Race Track Sensors

A. OpenLog Integration
B. OpenLog Code
C. Data Retrieval

SUCCESS

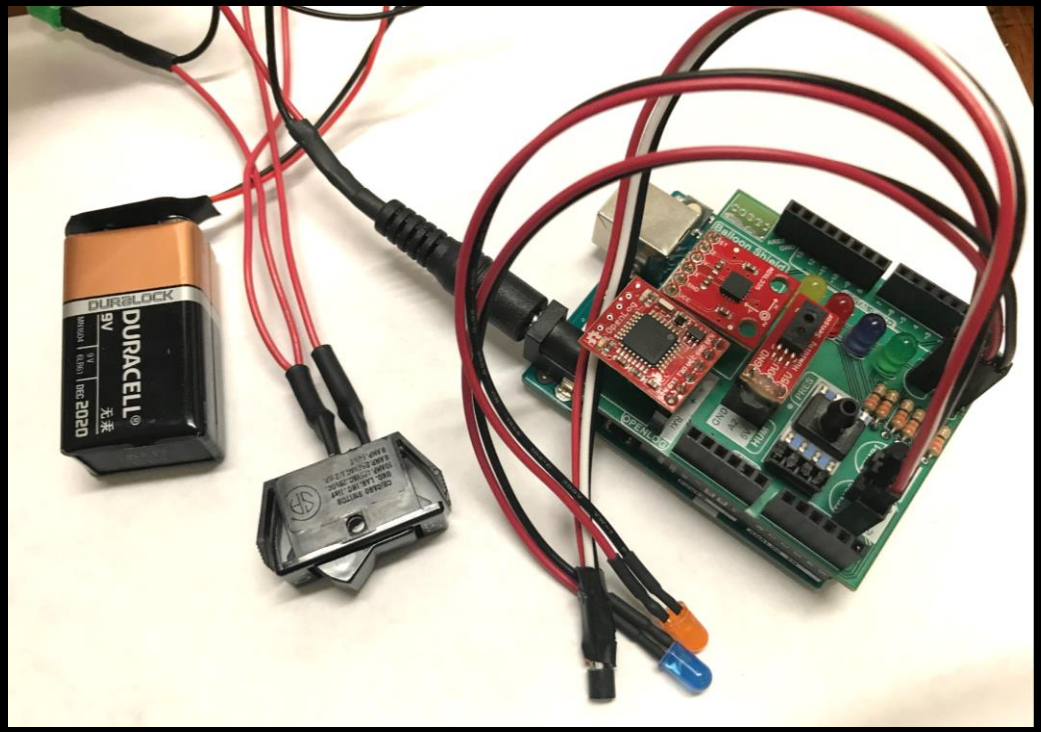
Because you too can own this face of pure accomplishment

Alternate Power:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

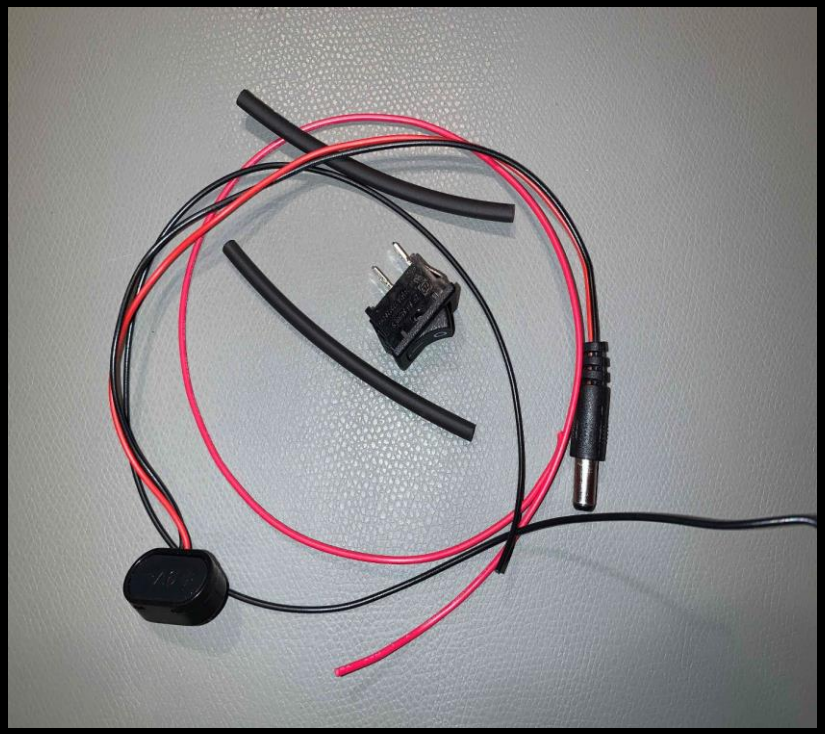
- For balloon flight, need to power Arduino with 9V battery

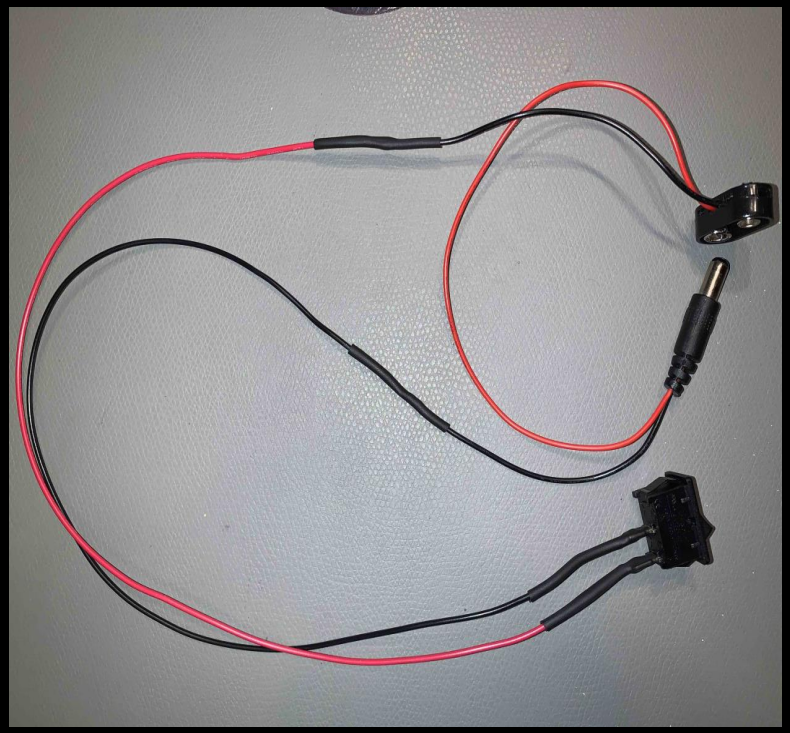
- Do not connect USB and 9V ever



Alternate Power:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**



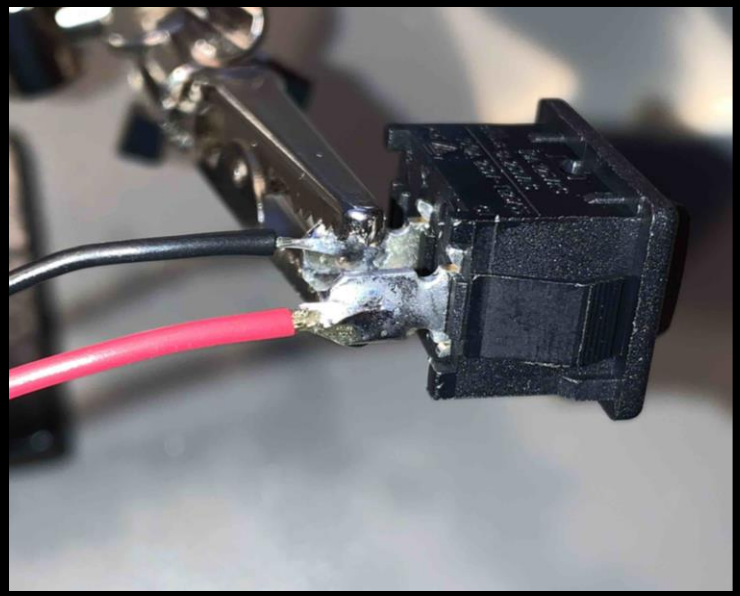


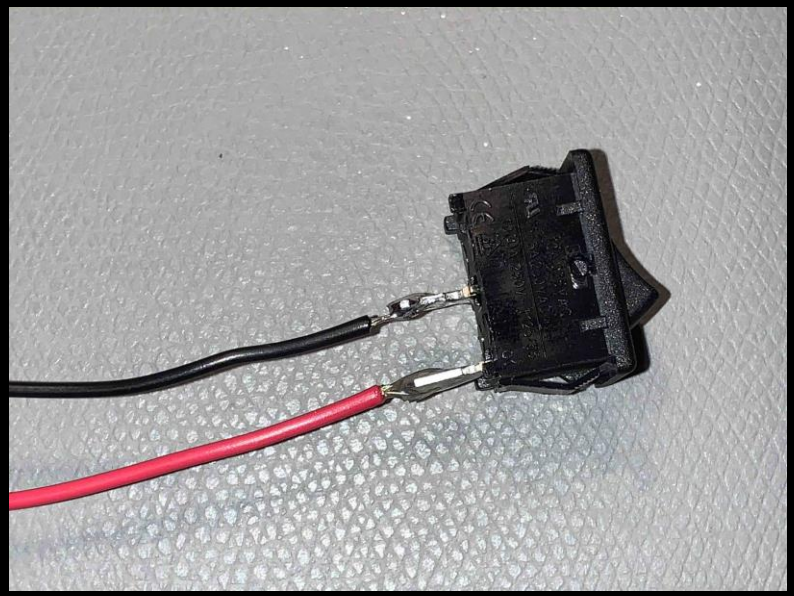
Alternate Power:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Splice red and black wires onto switch terminals and solder taking care not to shrink tubing**

- **Take care not to overheat the switch**

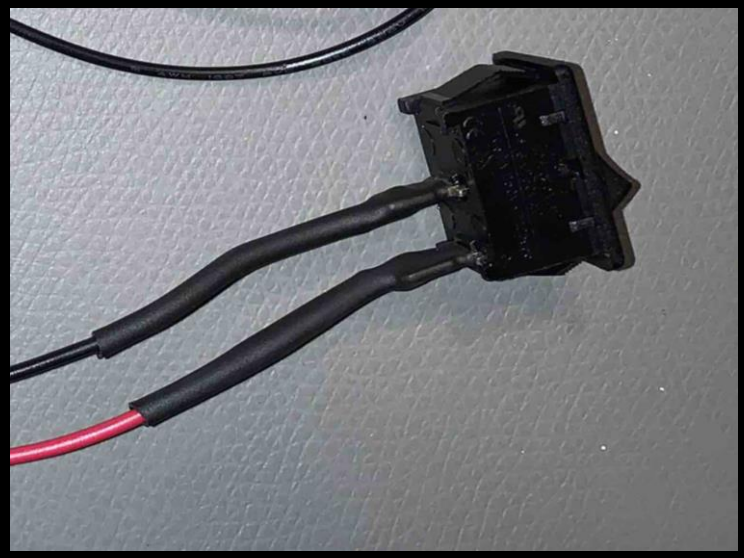




Alternate Power:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

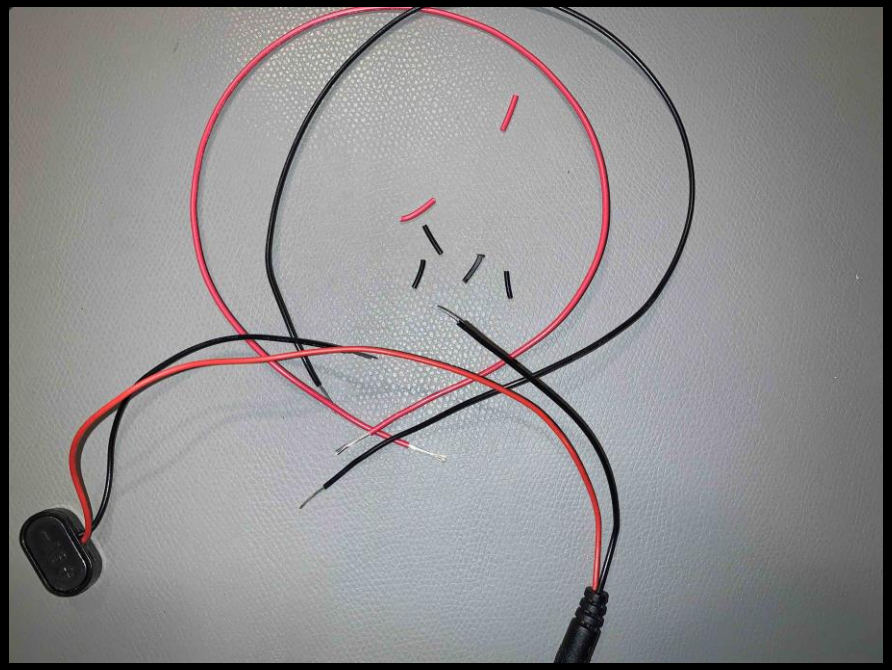
- **Place heat shrink tube on black and red wiring at switch terminals**
- **Heat to shrink tubing, taking care not to overheat the switch**



Alternate Power:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

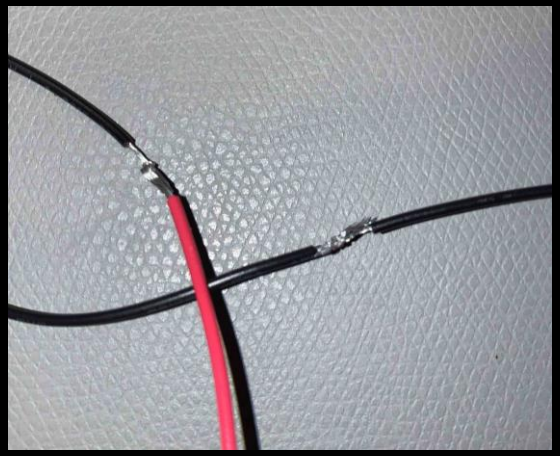
- **Cut Red and Black wire to ~1 foot in length**
- **Cut black housing on barrel connector to reveal wires, being careful not to cut wires.**
- **Cut barrel connector black wire in half**
- **Strip ends of cut wire back ~1/3 inch**

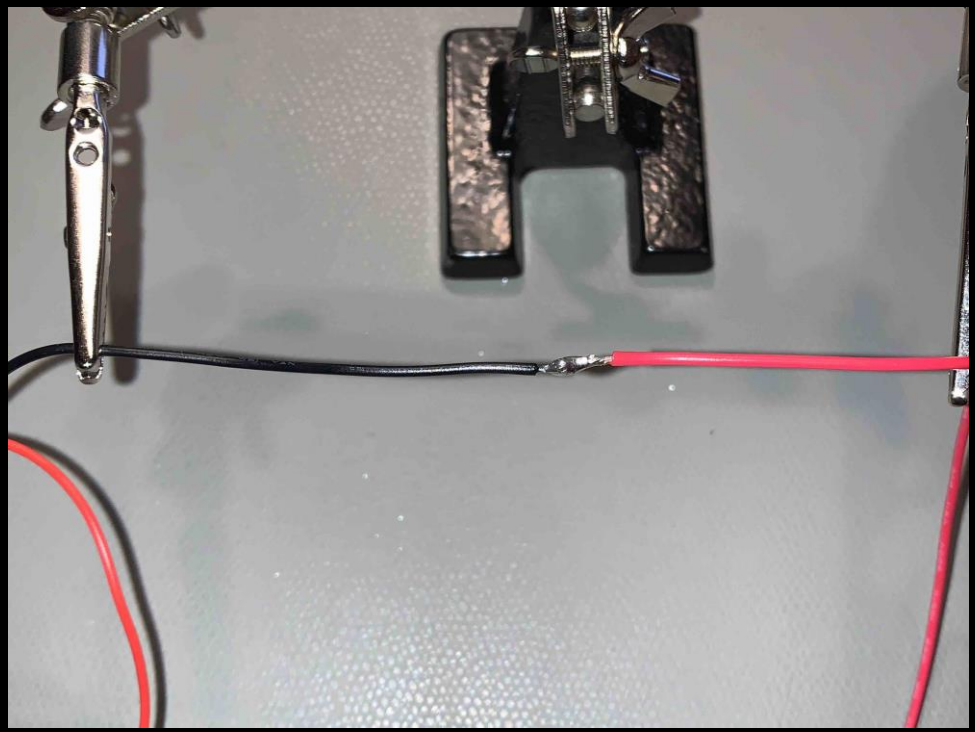


Alternate Power:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **Place heat shrink tubing on one side of wires that will be able to cover connections.**
- **Splice red and black extensions into connector and solder**

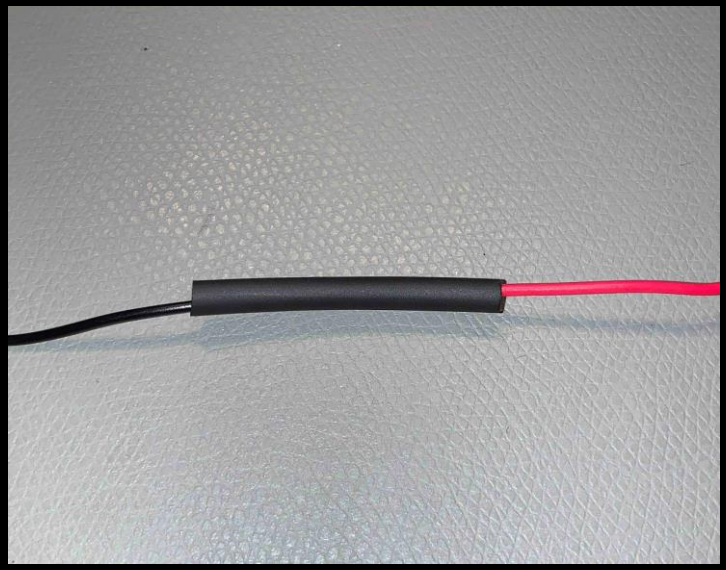




Alternate Power:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

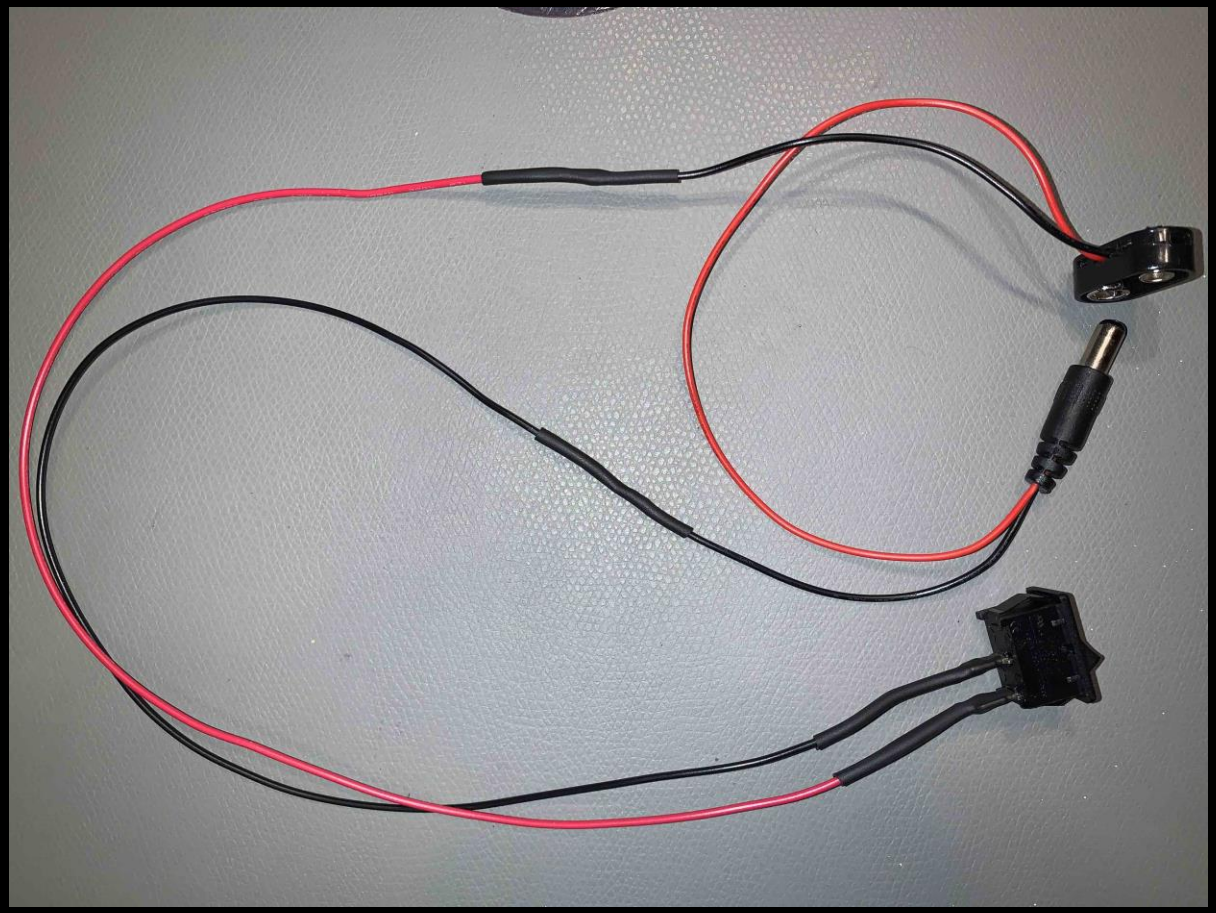
- **Place heat shrink tube around solder joint and heat**



Alternate Power:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

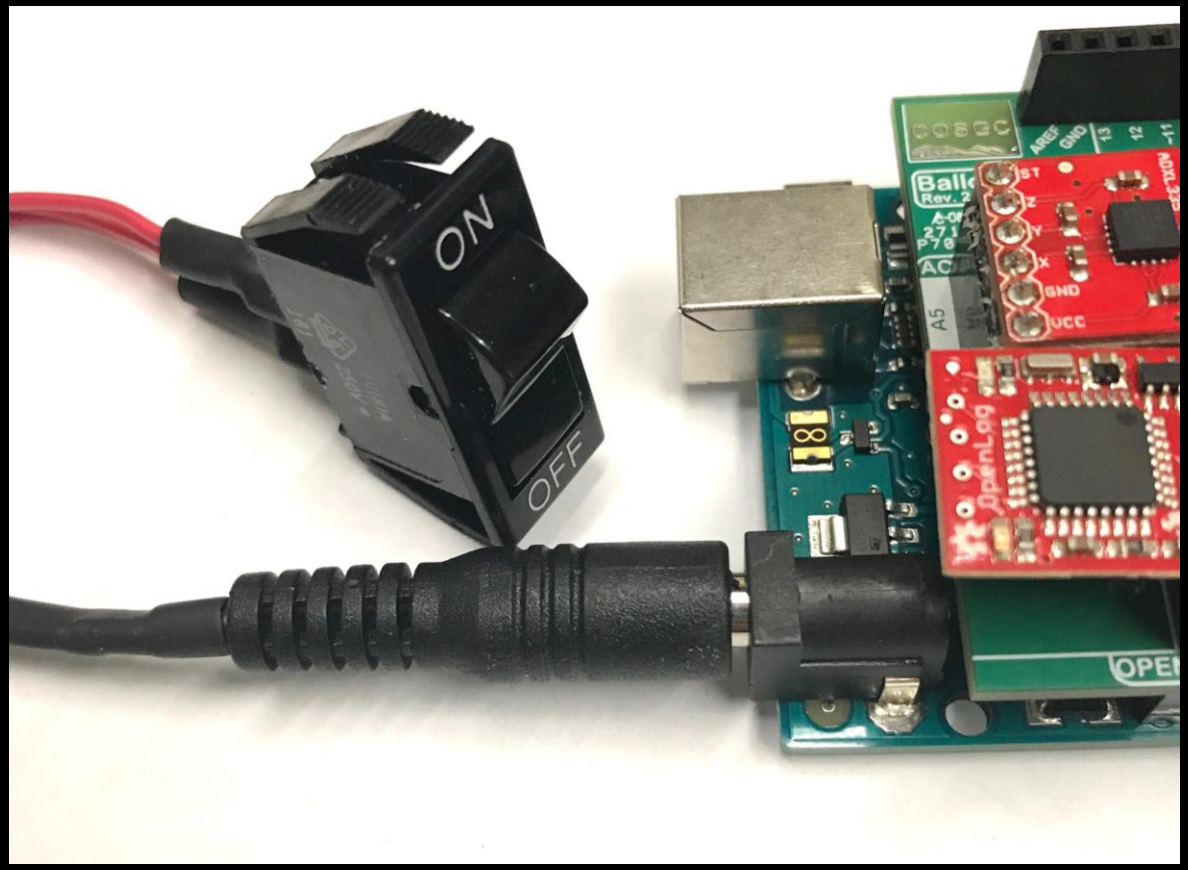
- Should look similar to this at the end



Alternate Power:

Space Minor
UNIVERSITY OF COLORADO **BOULDER**

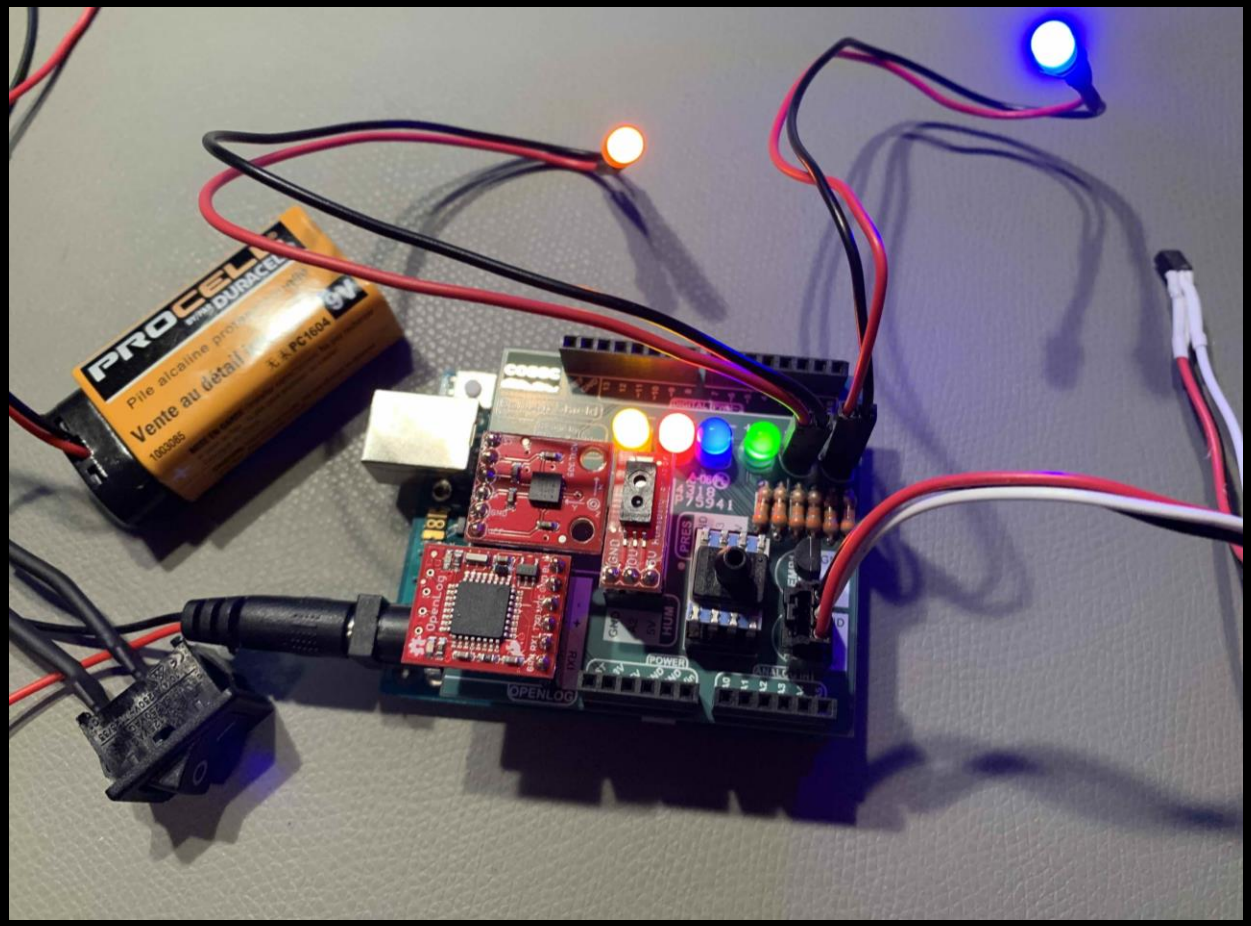
- **Plug battery and switch into Arduino (Remove USB cable)**
- **Flip the switch ON**



Alternate Power:

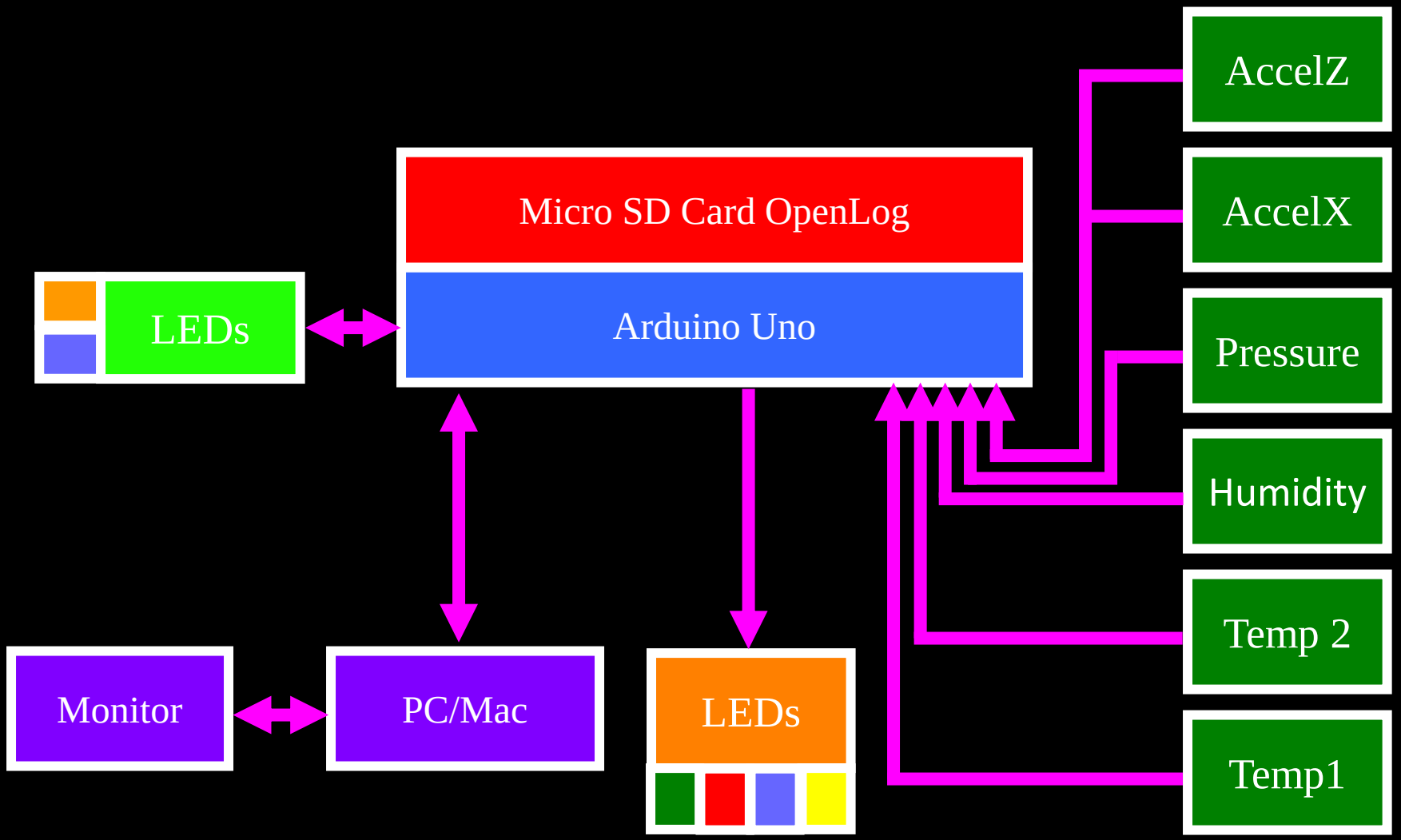
Space Minor
UNIVERSITY OF COLORADO **BOULDER**

- **You are now recording data until power is lost**



Part 2 – Arduino Race Track Sensors

A. SHIELD Integration
B. SD Card Code Integration
C. Data Retrieval


AccelZ
AccelX
Pressure
Humidity
Temp 2
Temp1
Micro SD Card OpenLog
Arduino Uno
LEDs
Monitor
PC/Mac
LEDs