# ENGR 112: Introduction to Arduino

### 1. Overview

To support your data acquisition needs for the tethered balloon, the instructional team is providing each team with an Arduino-based microprocessor and several environmental sensors. These devices will support your data collection effort when engaging with your stakeholders. All sensors will not be provided at the outset of the project (as not all teams need all sensors) but will be available on an as needed basis. The table below lists the Arduino processor and the environmental sensors. Each column describes the interfaces supported by the device, a brief description of its behavior, and a web link to the manufacturer page.

**Table 1: Basic Sensors for the Weather Balloon Kit**

| Name | Interfaces | Description | URL Link |
|---|---|---|---|
| Sparkfun Blackboard | I2C, SPI, Analog, PWM, Serial | Arduino based board used for interfacing the environmental kit sensor | https://www.sparkfun.com/products/retired/14669 |
| Triple Axis Accelerometer | I2C/QWIIC | Three axis accelerometer (x, y, and z) that measures gravitational forces in each axis. | https://www.sparkfun.com/products/14587 |
| Environmental Board | I2C/QWIIC | Sensor board for various environmental conditions of temperature, pressure, humidity, altitude, VOCs, and eCO2. | https://www.sparkfun.com/products/14348 |
| UVA/B Sensor | I2C/QWIIC | Sensor board to measure light levels at UVA (320-400nm) and UVB (280-320nm) | https://www.sparkfun.com/products/14748 |
| Ambient Light | Analog | Ambient light sensor that changes output voltage based upon the measured luminosity | https://www.sparkfun.com/products/8688 |
| Carbon Monoxide | Analog | Carbon monoxide gas sensor between 20 and 2000 ppm | https://www.sparkfun.com/products/9403 |
| Microphone | Analog | Analog microphone with response range between 100Hz and 10kHz | https://www.sparkfun.com/products/12758 |

### 2. Background

This section provides necessary background material on the main board and sensor interfaces in your weather balloon kit.

#### 2.1 Sparkfun Black Board

The computer board provided in your kit is a Sparkfun Black Board. This board is a clone of the popular Arduino microprocessor and can be used directly from the Arduino software as with any other Arduino board. While this board is “Arduino-compatible”, some upgrades have been performed to make this board more robust. Notably several interface pins have different functions, the power regulator has been upgraded, and the serial chip has been switched with a different version. These differences will only be noticed by someone who has dived deeply into a previous Arduino architecture, thus, for all intents and purposes, we can call this board an “Arduino”.

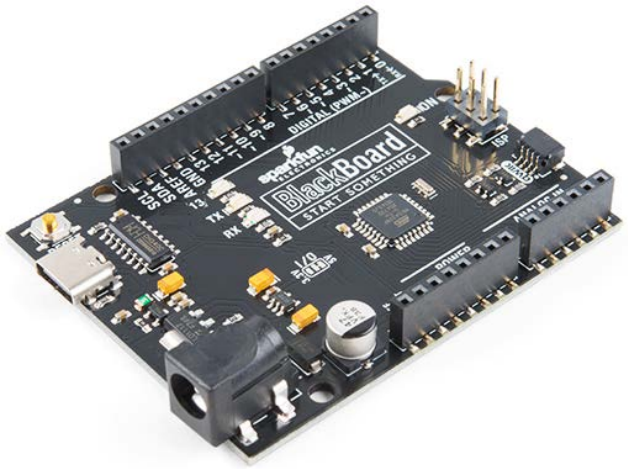


**Figure 1: Sparkfun Blackboard**

For teams in the course, however, here is one major difference with this board: the QWIIC connect system (https://www.sparkfun.com/qwiic). You will notice the QWIIC connector as a four-pin interface on the end of your Blackboard. This QWIIC system allows for easy connection to various sensors through a single cable system. This QWIIC interface provides a single cable to access traditional $I^2C$ components (this may not mean anything to you and that is OK) and will be used to connect the environmental, UVA/B sensor, and accelerometer to the Blackboard. Due to the design of the QWIIC system, it does not matter what order you connect these three sensors to the board. It only matters that they are connected in a single chain to the Blackboard. We will discuss the QWIIC interface in more detail in Section 2.2.

In addition to the QWIIC interface, the Blackboard supports many additional interfaces such as SPI, UART, Digital I/O, PWM, and Analog Input. If these interfaces are not familiar to you, that is OK. The other sensors (Ambient Light, Microphone, and Carbon Monoxide) will use the Analog interface. We will discuss the Analog interface in more detail in the next Section 2.3.

### 2.2 QWIIC Interface

One of the reasons we selected the Sparkfun Blackboard was for its QWIIC interface. This single cable system allows for easy access to a traditional microprocessor interface called $I^2C$. With the QWIIC interface, all devices that support the QWIIC system can be connected together in a single chain, but still communicate individually with their Blackboard. As an example, Figure 2 shows a single Blackboard (on the far left) connected to three sensors connected in a "daisy-chain" configuration. Each sensor is "chained" to the following sensor, but sensors can still each communicate with the Arduino individually.

***Figure 2: Sample Arduino Board with QWIIC Connections***

The major advantage of the QWIIC system is that it removes a significant headache of creating your own unique wiring configuration between the sensors and the main Arduino board. Additionally, it removes any

resistors or other support components that may be needed. Each team will be supplied with several QWIIC connectors that can be used to connect these sensors. An example QWIIC connector and QWIIC compatible sensor are shown in Figure 3.

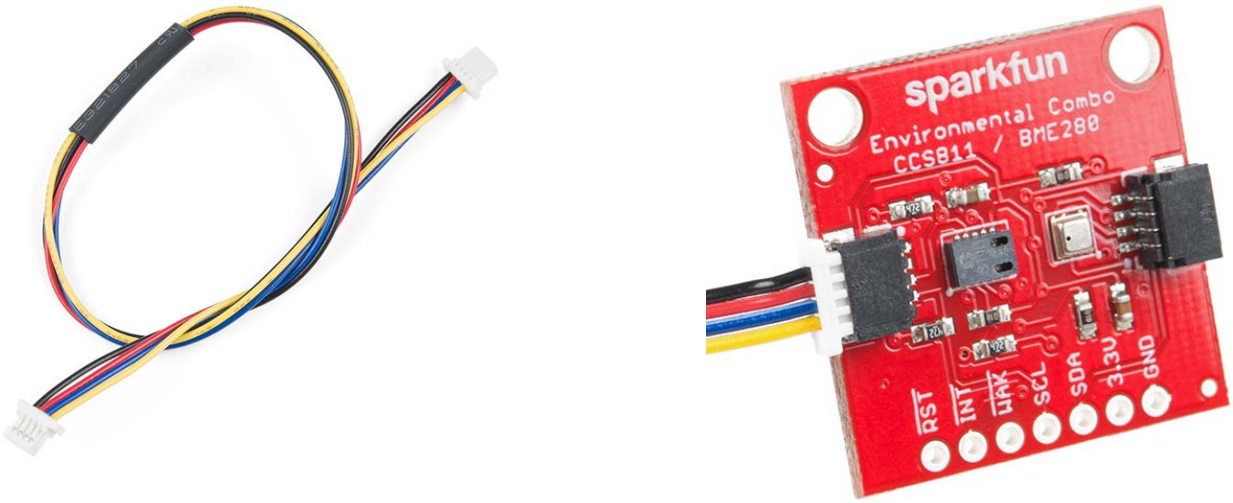


*Figure 3: QWIIC Connector and Compatible Board*

### 2.3 Analog Interface

A second interface that will be used on the Blackboard is the Analog interface. This interface allows the conversion of a voltage reading into discrete number values. The interface is important as many sensors produce some voltage based upon measurement, impact, and/or environmental condition and that voltage can be measured to infer some reading or value. The Analog interface on the Blackboard is supported by several Analog Input pins which are labeled across one side of the Blackboard. Figure 4 shows the Blackboard with the Analog Input pins highlighted.

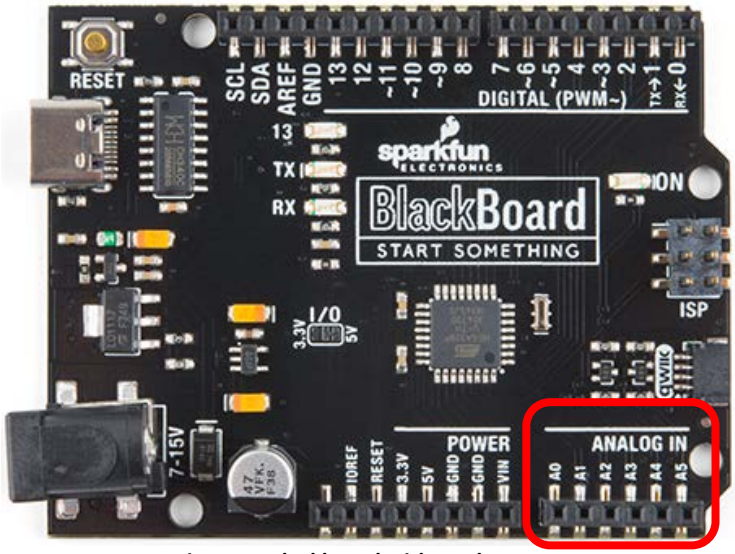


*Figure 4: Blackboard with Analog Input*

There are six Analog Input pins available on the Blackboard (A0-A5) and each pin will translate a received voltage between 0V and 5V into an integer value between 0 and 1023 using the analogRead() function call (https://www.arduino.cc/reference/en/language/functions/analog-io/analogread/). **NOTE: That due to the modifications of the Blackboard pins A4 and A5 should not be used for analog to digital conversion as they are part of the QWIIC system. To avoid any problems, do not use pins A4 and A5 at all.**

In general, the analog interface linearly converts a measured voltage between 0V and 5V into an integer between 0 and 1024. Thus, if the voltage 0V is applied the pin will report 0; if 5V is applied it will report 1023; and for any values in between it will be the linear scale between 0 and 1023. For example, if 2.13V is applied to pin A3 then that pin will report a value of 435 by scaling the voltage 2.13V between 0 and 1023. (For the math: $\frac{2.13V}{5.0V} * 1023 = \lfloor 435.798 \rfloor = 435$.). The result of this operation will always be an *integer* meaning that decimal values are dropped and there is always some error in the calculation.

**Please not that applying a voltage above 5V or below 0V will damage the analog interface.** Please consult with your instructors about how to properly connect various sensors to the Analog interface.

**3. Getting Started with your Blackboard**

Your Sparkfun Blackboard is an Arduino-compatible board and should be easy to use on various operating systems such as Windows, Mac OSX, and Linux. To get started with your board please follow the Sparkfun RedBoard QWIIC Hookup Guide (https://learn.sparkfun.com/tutorials/redboard-qwiic-hookup-guide). Yes, your board is Black and theirs is Red, but they are extremely similar for the basic tasks you are to perform.

**Step 1:** Follow the RedBoard QWIIC Hookup Guide through Example 1 and ensure you can blink the LED on the board. In truth, 80% of microprocessor programming is simply getting a light to blink.

**Step 2**: Modify your Blink program to make the on-board LED blink at different rates. Try replacing *delay(1000)* with different values such as 10, 500, and 10000. See what results you get.

Some tips on getting Blink running:

- Before launching Arduino make sure your board is already plugged in. Sometimes the Arduino software does not “see” your board if it’s plugged in after the software is launched.
- Make sure the board is plugged in. Yes, some will forget this.
- If you are on Windows and have a choice of COM ports then choose the port with the highest number. If you are on OSX choose the one called “usbserial”. Linux will likely only have a single choice.
- Ensure you have the Arduino Uno/Genuino selected as your board. If the wrong board is selected then nothing else will work.

**4. Conclusion**

Following this guide you should have a basic introduction to the Sparkfun Blackboard and two simple sensors for this course. There is much more to learn about this platform but these instructions will begin your progress. Looking forward consider how you might capture sensor data from the accelerometer and environmental sensor and use those for your project.