GNG1103[D] – Engineering Design
Course Project
Group C7

Project Deliverable F:

Prototype I and Customer Feedback

Sammy Fakhouri
Kevin Jia
David Marion
Benjamin Millan
Shiyu Yuan

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Introduction

Our client meetup on Monday, February 22, proved to be extremely helpful. Following the feedback and criticism we received from the JAMZ team, we altered our schedule and improved our prototype designs for the climate sensor add-on. In this deliverable, we will thoroughly explain the changes made to our project, and the objectives for the first prototype. We will then present our prototype I design, with appropriate images and descriptions. To conclude this deliverable, we will display and debate the implications of the results from our testing phase.

Client Feedback

The JAMZ team provided critical feedback that necessitated a few changes to our original plans. Originally, our group had planned to incorporate our own Arduino board into the drone design. However, JAMZ informed us that we are to use the on board Arduino already included in the design of the drone. Additional considerations included guidance regarding the chosen temperature sensor of our design; although they commended the fact that our sensor had both humidity and temperature sensory capabilities, they suggested that we choose a sensor with more frequent readings. Consequently, after further discussion with the client, we decided that our best option would be to have multiple sensors to ameliorate our reliability.

Description

As detailed in our last deliverable, our first prototype will be focused on demonstrating the feasibility of the global concepts we put forward. It will be a very rudimentary test to ensure that the sensor that we will be using is able to be configured to suit our needs. This will be done by testing the sensor in regular room temperature conditions to get a grasp on how we will approach the coding of the sensor alongside the Arduino. We will also create a demo-box prototype that will be used in our testing and demonstrations moving forward. This model will serve purely as a proof of concept for what is to come with our next prototypes. Unfortunately, we are not able to have a comprehensive and complex prototype due to the COVID-19 restrictions that prohibit us from meeting in person.

Sensor System Code/System Prototype

Figure 1: Arduino Code for sampling temperature at 2 Hz (Program will be submitted)

```
DHT22_SensorPrototype1Code

//DHT22 Sensor Testing Code

#include "DHT.h"        // Importing DHT sensor library
#define DHTPIN 2        // Digital pin 2 connected to the DHT sensor
#define DHTTYPE DHT22   // Defining the type of sensor for the library

DHT dht(DHTPIN, DHTTYPE);

void setup() {
  Serial.begin(9600);
  Serial.println(F("Testing DHT22"));   //PrintF means the statis string is stored in program memory, not ram.
  dht.begin();
}

void loop() {

  delay(2000);   // Wait 2 seconds before each read as the sensor update roughly every 2 seconds

  // Reading temperature/humidity can take up to 250 milliseconds, so the total is up to 2.25 seconds
  float humidity = dht.readHumidity();   // Reading the humitidy as a % and storing in variable humidity
  float temperature = dht.readTemperature();  // Reading the temperature as Celcius and storing in variable

  // Checking if any reads failed, exits early to loop again when failed
  if (isnan(humidity) || isnan(temperature) ) {
    Serial.println(F("Failed to read from DHT sensor"));
    return;
  }

  float heatIndex = dht.computeHeatIndex(temperature, humidity, false);   // Computing heat index in Celsius (isFahreheit = false)

  Serial.println(F("************************************************************"));

  Serial.print(F("Temperature: "));   //Printing temperature
  Serial.print(temperature);
  Serial.println(F("°C"));

  Serial.println(F("Humidity: "));      //Printing humidity
  Serial.print(humidity);
  Serial.println(F("%"));

  Serial.print(F("Heat index: "));     //Printing heat index
  Serial.print(heatIndex);
  Serial.println(F("°C "));
  Serial.println(F("************************************************************"));
  Serial.println();
}
```

Using the library provided by the manufacturer of the DHT22 sensor, a prototype for the data collection program has been designed. This program will set up all the necessary variables and initializations to establish a basic one sensor system. After setting up, the loop will continuously read temperature/humidity information from the sensor every 2 seconds and print the results to the serial monitor in a neatly formatted layout. This sensor system prototype will be physical and focused; its main purpose is to verify the feasibility of the DHT22 sensor and its corresponding Arduino library. To test, the above program is uploaded into an Arduino Uno that is connected to a DHT22 sensor. This will be discussed in more detail in the following sections.

Figure 2: Prototype Test Circuit Set-up

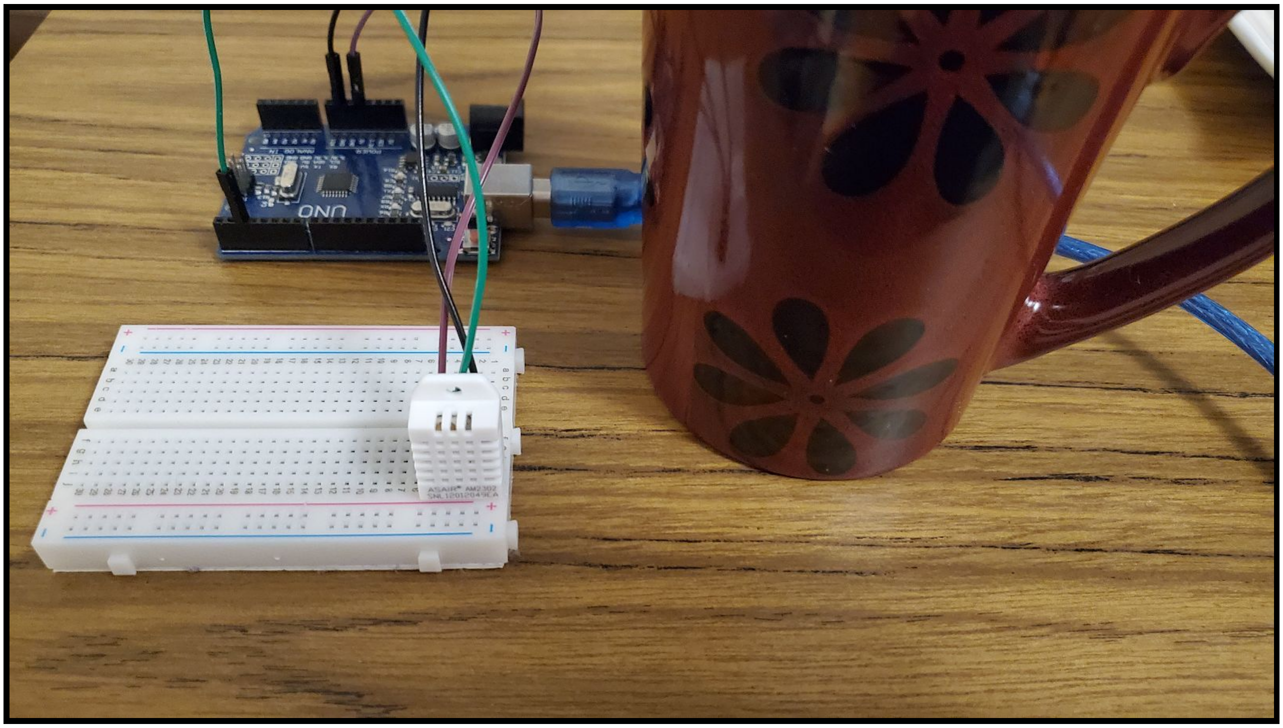


Table 1: Sensor Prototype Results

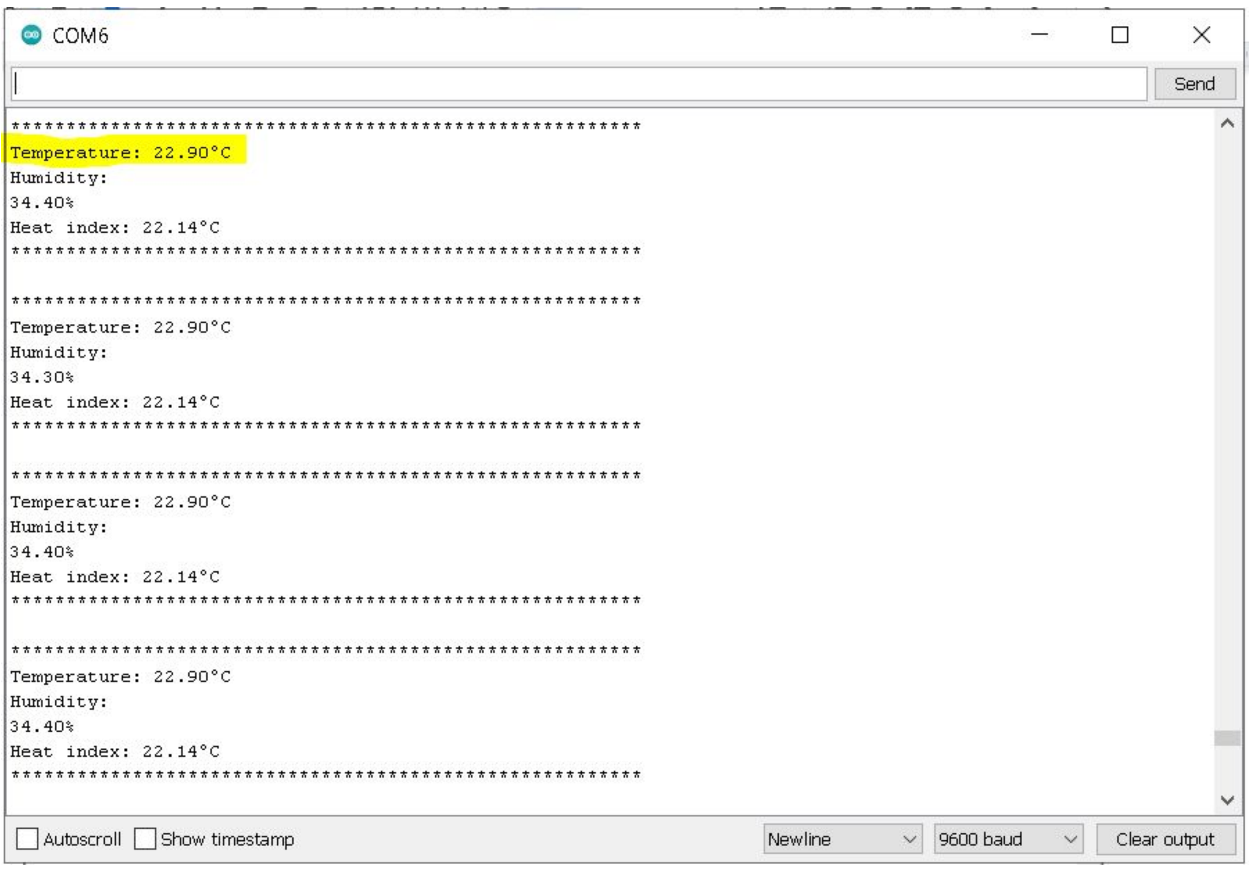
Test Case	**Description**	**Criteria**	**Results**
Connection Established	Checking to see if **any** data is being relayed from the sensor regardless of accuracy.	True	Passed
Accurate Reading	Comparing the results from the sensor and a control to verify accuracy	+/- 1 Degree Celsius	Passed (0.2 difference)
Senses Change	Placing a hot cup of water beside the sensor and observing change in collected data.	True	Passed

To test the aforementioned program with the sensor, a physical circuit with the sensor was constructed (**Figure 2**). One of the advantages of the DHT22 is that it contains built-in pull up resistors. This eliminated the need for any additional components and rendered the circuit extremely straightforward to construct. All that is essential are 3 wires, an arduino uno, and the DHT22 sensor. The first feasibility test is to simply upload the code and see if any results regardless of accuracy can be received in the serial monitor. In other words, this test was just to verify if any connection was established between the sensor and the PC. All results will be recorded in the table above (**Table 1**).

The second proof of concept test was to see that temperature and humidity collected were accurate and reliable. This test was done by comparing the results obtained from the DHT 22 to the temperature reading off a normal mercury thermometer. The obtained results from the sensor is shown below in figure 3, note that each read is about 2 seconds apart. The collected data indicates a temperature of 22.9 degrees while the thermometer shows a reading of around 23.1 degrees. These results suggest that the sensory is as marketed, accurate to +- 0.5 degrees celsius.

Unfortunately, due to the unavailability of a household humidity sensor, the humidity accuracy can only be extrapolated from the average and recommended humidity data. The recommended humidity level in a home in the winter is between 30% to 40%. This range aligns with the collected results of 34% humidity from the sensor and conclusively verified the accuracy of the DHT 22 sensor.

Figure 3: Serial Results From Sampling Static-Open-Environment Temperature at 2 Hz



*****There was a small error with the formatting of the print statement causing humidity % being displayed in the next line. This has since been fixed. *****

The third proof of concept test will revolve around the sensor's ability to detect temperature and humidity change. This change was facilitated by placing a hot cup of water beside the sensor. The results of this experiment are shown in **Figure 4** and **Figure 5** below, note that each read is about 2 seconds apart. In reviewing the results, it can be clearly seen that the sensor was able to detect the change in the ambient climate. This change was reflected in the serial results almost immediately, about 2-4 second delay after the cup was placed. Note the highlighted parts of the figures below, these values correspond to the change in the serial results after the cup was placed. Based on these results, the sensor's ability to readily detect change has therefore been verified.

Figure 4: Serial Results From Sampling Changing Temperature at 2 Hz

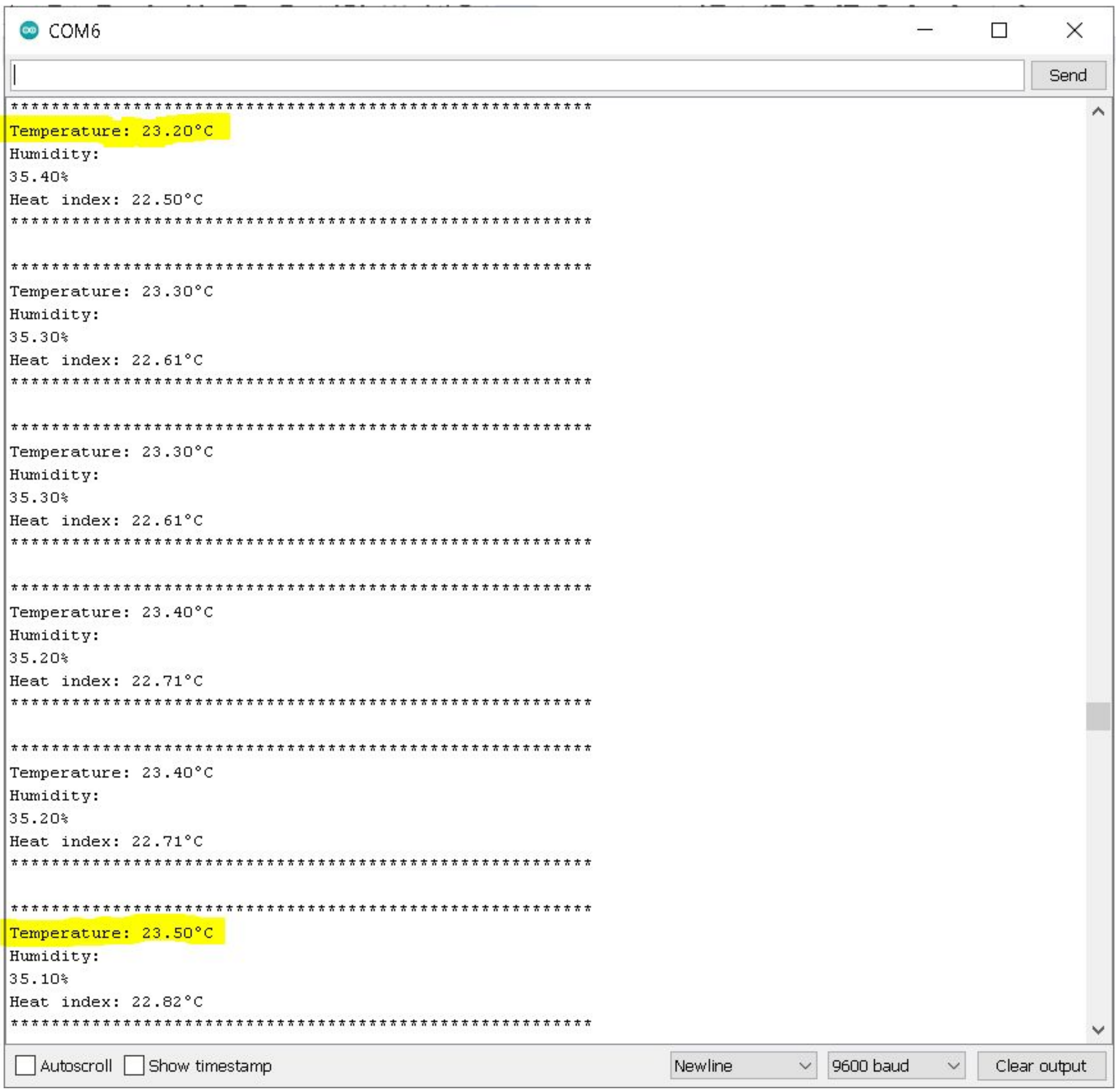
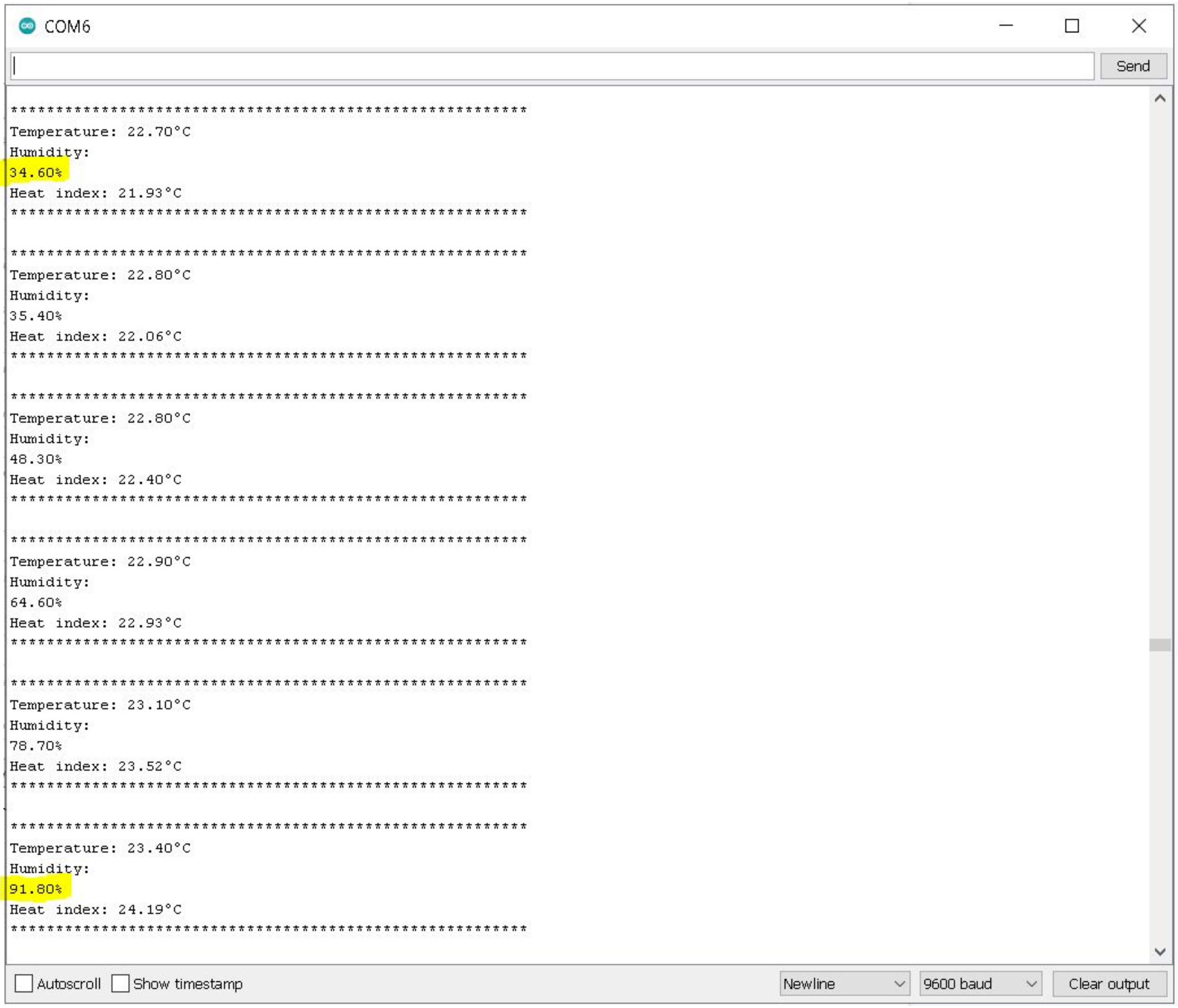


Figure 5: Serial Results From Sampling Changing Humidity at 2 Hz



Demo-box Prototype

In efforts to reduce the cost of this first prototype, our goal is to use a cardboard box similar in size as the cargo container; and test temperature and the functionality of the sensors. In future testing, the placement of each sensor will be further analysed to ensure optimal performance. The box will be used for future prototyping as well to provide a closed environment for the sensor to operate in. This first model of the demo-box will be a focused and physical prototype, constructed with low cost resources found at home. As we are unsure of the exact dimensions of the JAMZ delivery box, the prototype box will undeniably lose fidelity. As for the testing being done, it will be a focused prototype.

Figure 6: Photos of the prototype box used for demonstrations

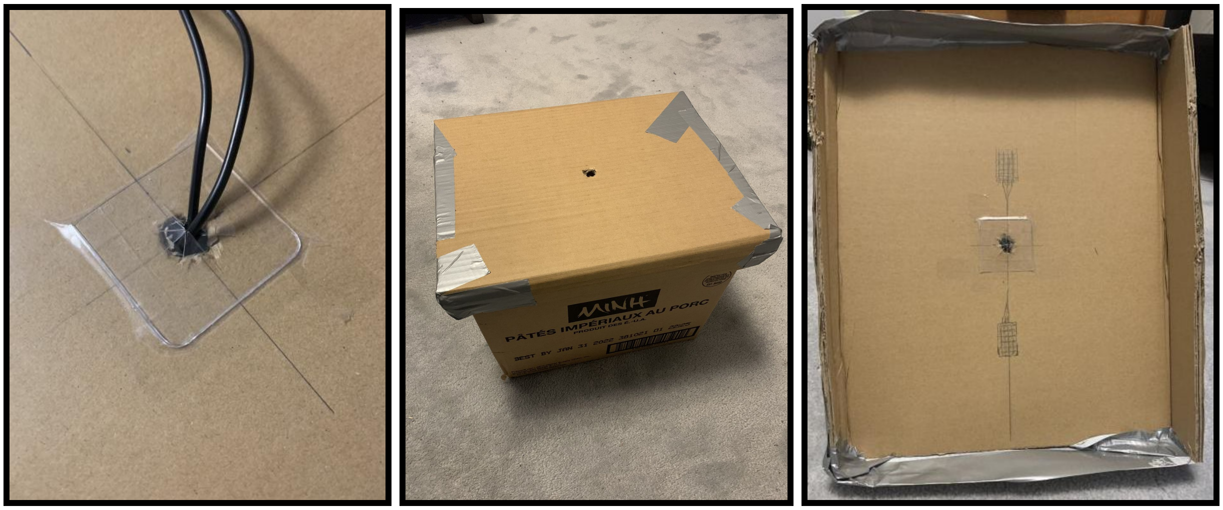


Figure 6 depicts the prototype box and lid. At the center of the lid is the through hole where wires will be pushed through. The malleable flaps have been taped to the underside of the lid to mimic the rubber flaps we are hoping to include in future prototypes. This will help further insulate the box and to prevent friction between the edge of the through hole and the sensor wiring. As cardboard retains less heat than the materials being used for the JAMZ cargo compartment, the difference will lower the fidelity of the model. As previously stated, the dimensions of both the lid and box are not accurate to the JAMZ model and will also contribute to the low fidelity. The box is not part of our design model but needs to be part of our prototyping—providing a closed environment to test the humidity and temperature sensing.
In future models we hope to use stronger insulating materials such as styrofoam and to adjust to the correct box dimensions.

Conclusion

Our first prototype, although a crude and incomplete design, already displays numerous successes and proof of concept. With the satisfying results obtained from our preliminary testing phase, we are confident that our second and third prototypes will be able to address and improve any shortcomings or gaps in the achievements of Prototype I. Although untested, the box design proves to be useful and tangible to our objectives. It serves as a visual aid to ground our ideas and build a concrete design in real life. Additionally, the coding phase and sensory results were positive reflections of our hard work and concept development. Despite the unrefined aspects of the software, it already returns accurate and satisfactory results. With further feedback from the invaluable JAMZ team, and a dedicated effort from our group, we can remain optimistic that our final prototype will be the ideal design.

Reccomended Home Humidity Link
https://www.bayviewwindows.ca/blog/indoor-temperature-vs-humidity-levels/extreme_temperatures#:~:text=During%20the%20winter%20months%20in,volatile%20temperatures%20outside%20the%20house.