Final Report - Concept, Design, and Execution

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Abstract

This project called for us to implement skills taught and mastered throughout the class. These skills include design, programming, and professionality. Although project requirements were given, we also had to implement our original ideas throughout the project, mainly in terms of design.

With coding being a big portion of the overall project, we first got introduced to the Arduino programming system. We made ourselves familiar with the C++ language through multiple exercises and were eventually able to create codes of our own. We then got introduced to the other parts of the design, including the photocell, these resistors were very essential to understand because measuring lux was going to be a part of the final project.
Configuring the WeMos Board circuit was arguably the most important part of the project as it was used to run our code and used to implement our hardware designs. After repetitive assignments having us configure the WeMos Board Circuit, it was easier for us to utilize the board and verify our algorithms for testing different settings (i.e. lux, temperature, humidity).
The hardware portion of the project called for us to create an enclosure to hold the WeMos Board system, while still looking sleek and professional. While it may seem the possibilities are endless with these requirements, the print time had to be under a certain time so it added a level of difficulty and creativity. We took the simple route and decided to create a box-like shape with an open top for the board that fits the exact size of the system in a snug way that makes it look well in any professional setting. The design performed well, holding the box and still running the code without any interference. The biggest innovation and redesign came from our enclosure

where we created a design too complex and had to simplify it to not only keep the look classy and professional but also lower the print time to fit the conditions of the project.

Introduction

Our enclosure and design have several requirements. Most notably, our design must comfortably enclose the WeMos board without hindering any of the sensors or measurements and should be connected to a temperature and humidity sensor along with a photoresistor to measure lux. Additionally, the enclosure design should be sleek and demonstrate some degree of professionalism in its design and deployment.

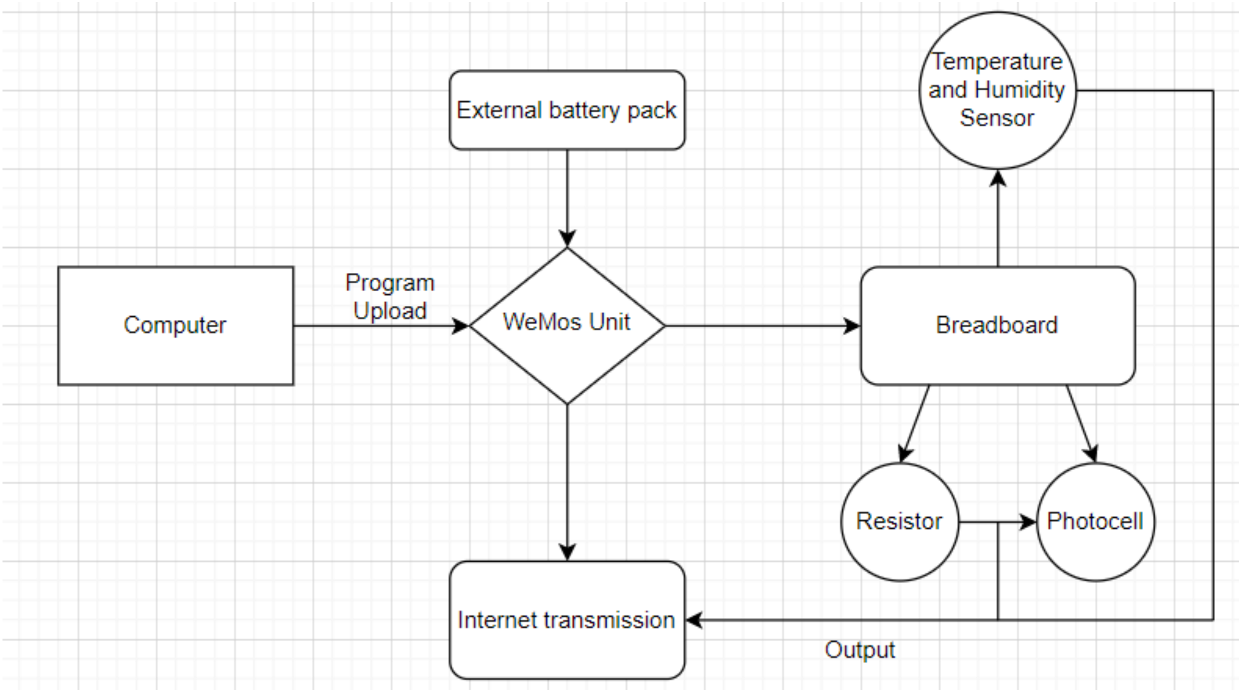
In regards to our revisions and alternate designs, our initial design ended up being fairly similar to our final design–from the beginning, we had planned for the enclosure to hold some sort of latching cover. After a few revisions, however, we did end up simplifying a few aspects of our design. Most notably, we initially planned to create an additional latch to hold the battery pack in place, but we decided to scrap this idea after complications with print time and bridging. We also had planned a more elaborate support structure for the latch, but we again ran into printing complications and decided to simplify the support so that the latch is supported only on one side. Since these features were hanging in the air, they would have required complicated printing bridges to construct and this would have taken far too much time to print. We also ended up thinning all of our walls to further optimize the print time.

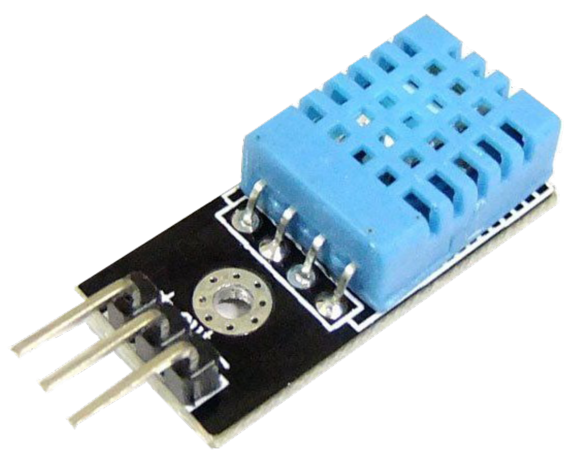
After several revisions, we ended up with a minimalistic box design with a latch that slides open on the top. The latch has singular rectangular support etched in near the top of the box, and the WeMos board fits comfortably in the middle of the box with the battery pack standing next to it.

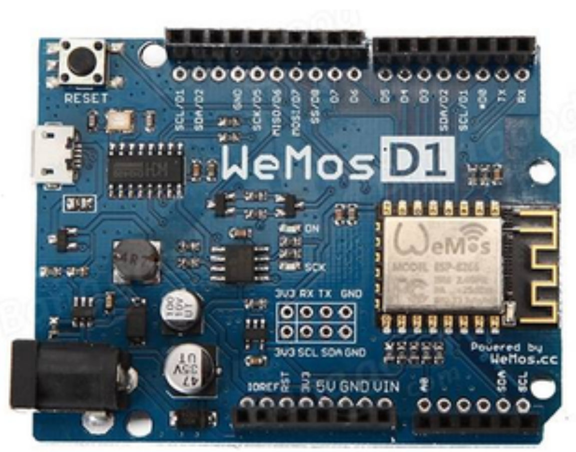
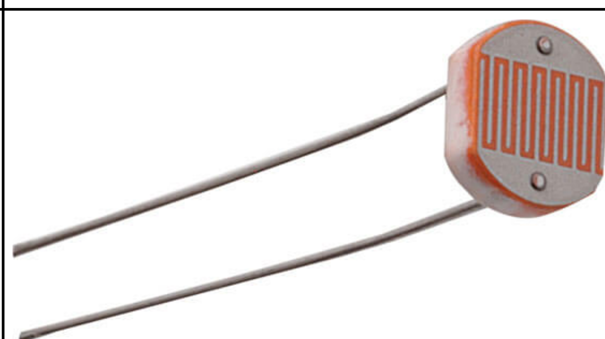
Final Design Description

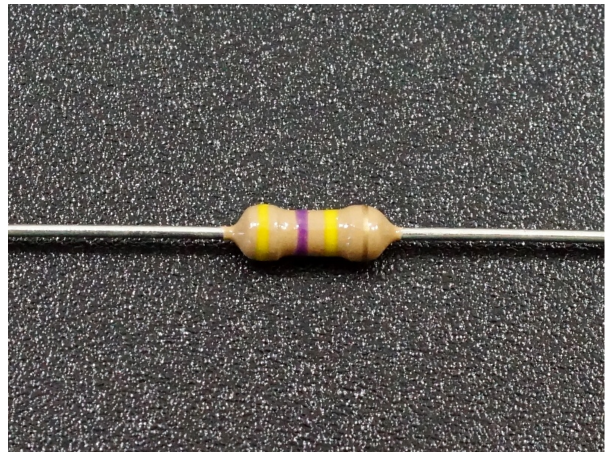
System Description and Architecture

Our overall design and system contain three primary components: the enclosure, circuit board, and software. The software is uploaded to the WeMos board and then runs every ten minutes or so. The WeMos board holds the code and then transmits the recorded data to the Stevens server using its onboard internet chip and MAC address. The board is also connected to an external power source so that it can run and transmit data remotely for days on end. The enclosure then holds all of the circuity and protects most of the board from the outside while also allowing the sensors to be exposed to the outside air. A system block diagram has been attached below to explain the system's overall functionality.


External battery pack
Temperature and Humidity Sensor
Computer
Program Upload
WeMos Unit
Breadboard
Resistor
Photocell
Internet transmission
Output

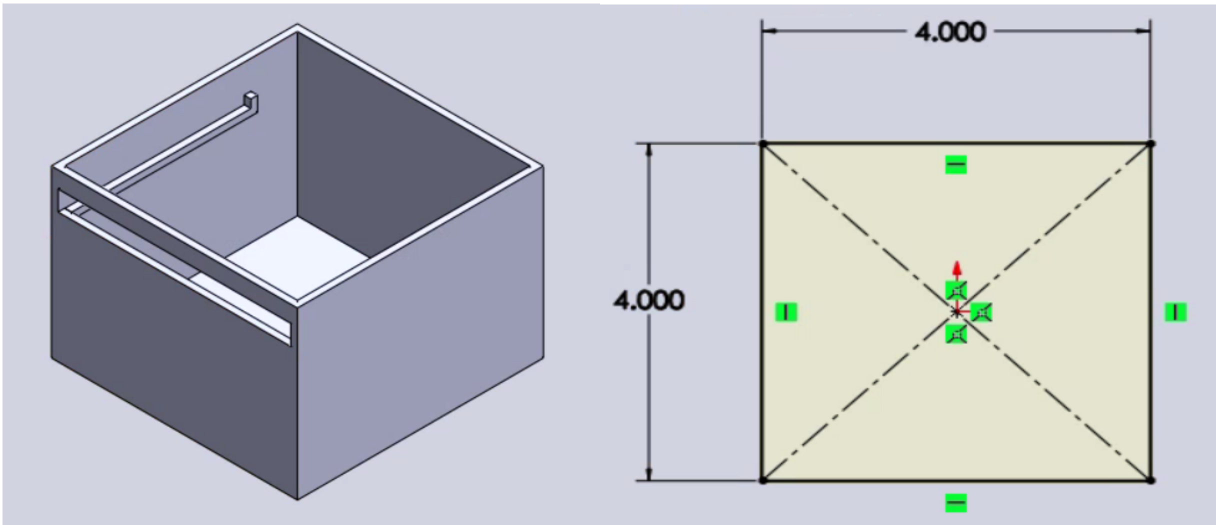
DHT 11	

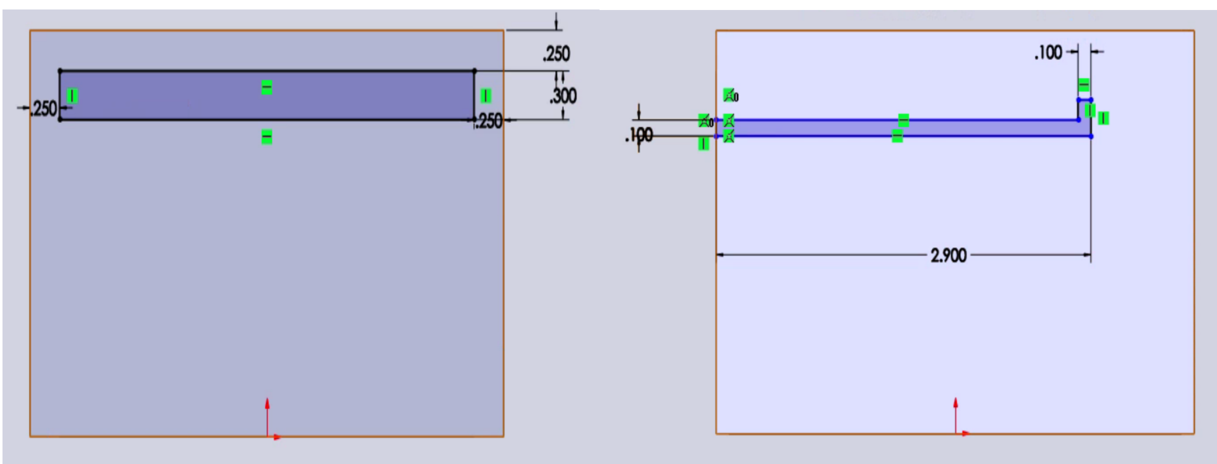
Rechargeable Battery	
Wemos Board	
Photocell	

Resistor	
Wire	

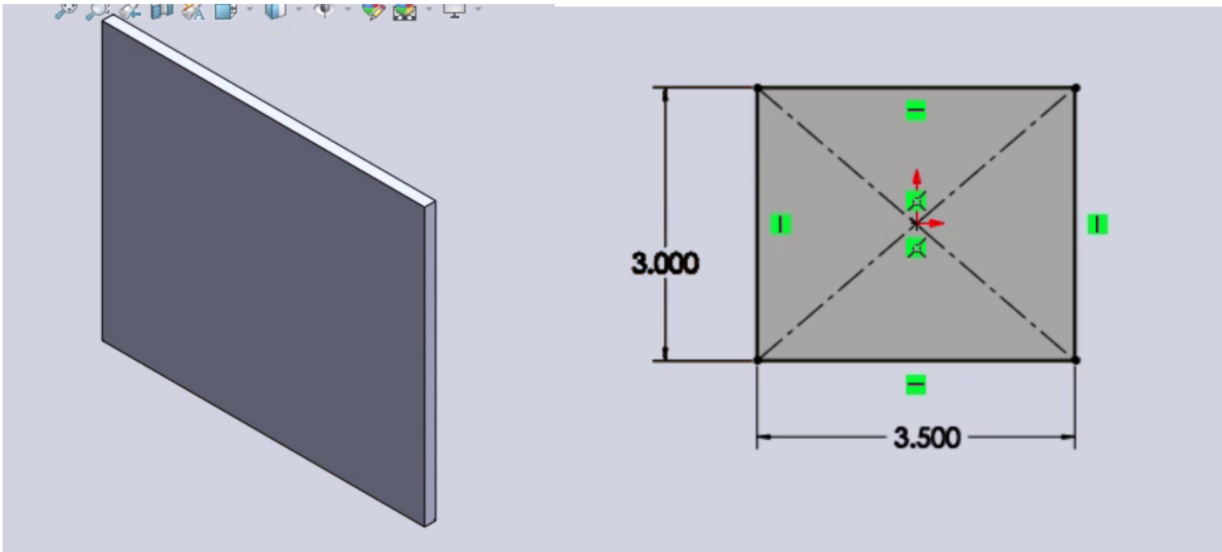
Mechanical Design

Our enclosure consisted of two mechanical components–the container and the latch. The container is a simple box design with an opening on the top and a slit in the front to allow for the cover to enter. There is also additional support etched in near the side to hold up the sliding latch. The container designs, sketches, and dimensions have been attached below.

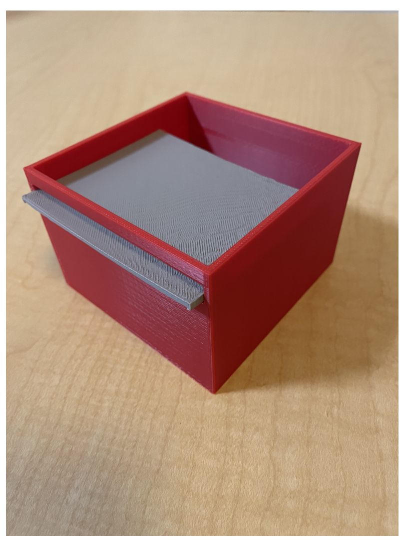




The latch component is a simple cover that slides into the slit and fits into the support. The latch designs, sketches, and dimensions have been attached below.



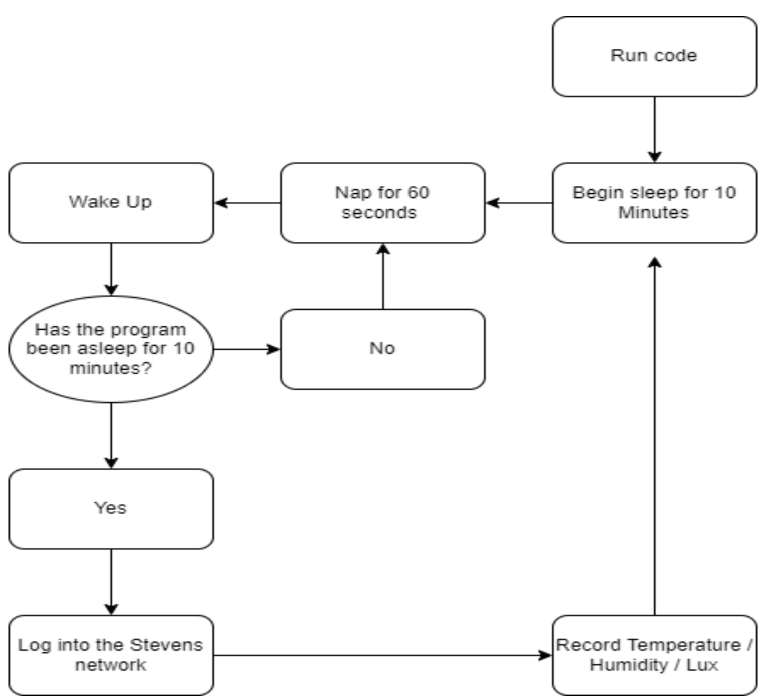
When fully assembled and operational, the lid covers almost the whole WeMos board and the enclosure has a small opening in the back to allow wiring and sensors to stick out. A picture of the full, operational design has been attached below.



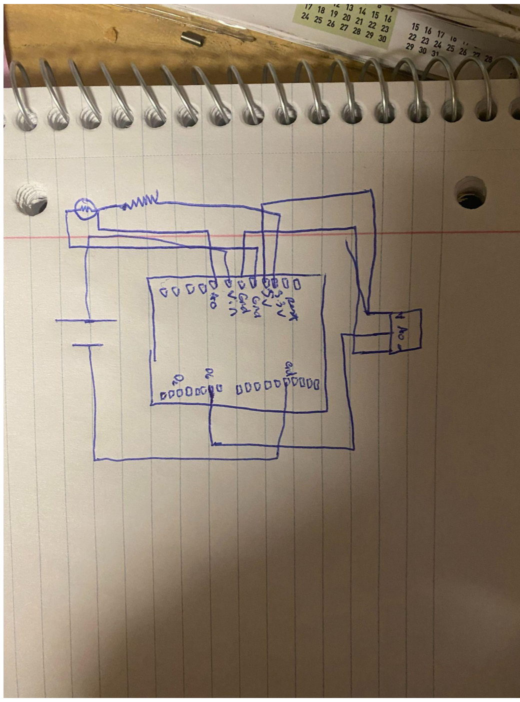
In regards to printing time, we had designed the enclosure with thin walls (0.1 inches in thickness) to ensure moderate printing time. We also set the structure to a solid fill to make the enclosure sturdy and durable against weather and the environment. We had to experiment with various thicknesses and dimensions to find the right balance between sturdiness and printability, but eventually, we found a solid design fulfilling all of these requirements. In the end, the container took just over four hours to print while the latch took around fifty minutes to print.

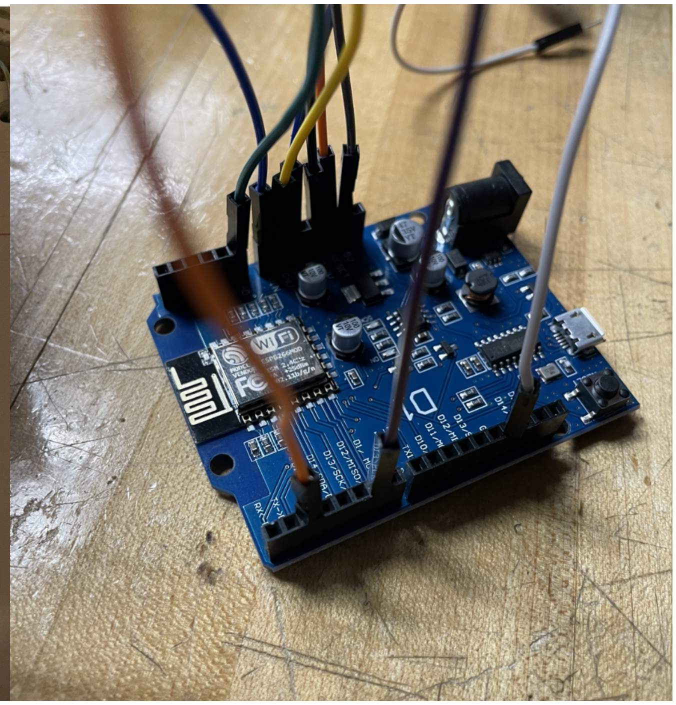
Software Design

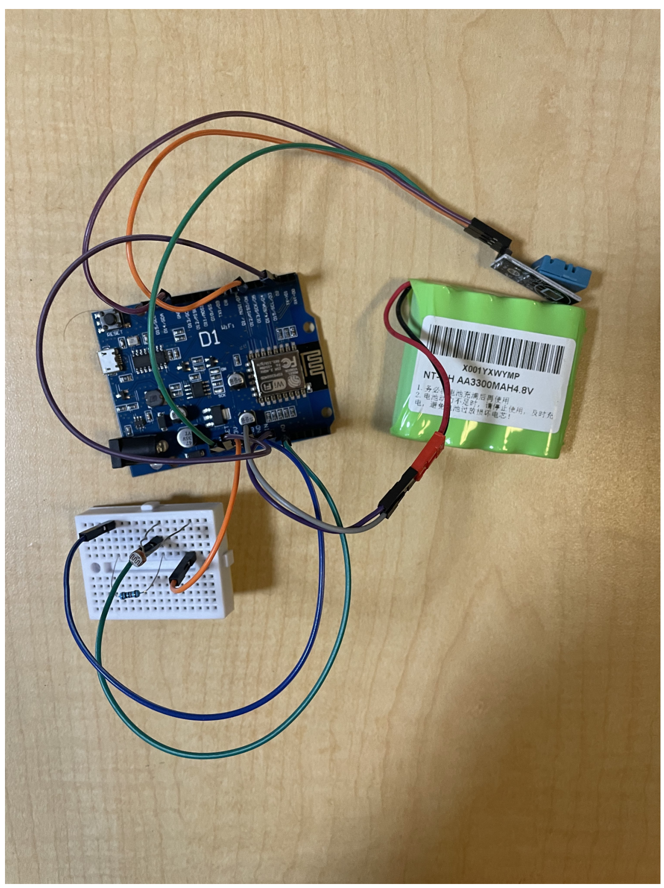
Once the program was uploaded to the WeMos board and began to run, the first thing the program did was put itself into a deep sleep for 10 minutes. The software was produced to be energy efficient by reducing the amount of time it is on through sleeps and naps. By waiting this long, our program produces 6 data points every hour for lux, temperature, and humidity. Every 60 seconds, the program would check to see if 10 minutes has passed. If it had not, the program would return to a 60-second nap. If the device had been asleep for 10 minutes, the program would then wake up and attempt to connect to Stevens wifi. Then, it would record temperature, humidity, and lux values. Then, the program uploads this data to the cloud, which can be received from another device if it has the mac address of the Wemos board. After the data is sent to the cloud, the program will return to a deep sleep state. This process will repeat forever, or until the device runs out of power.



Electrical Circuit/Wiring Diagram



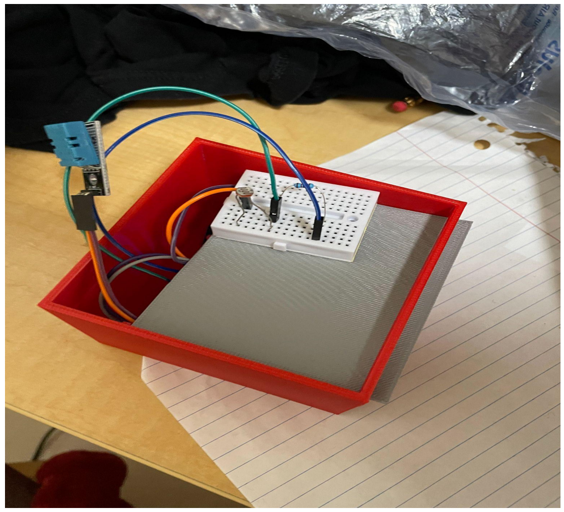




Assembly and Prototyping

When we actually printed out the enclosure components and began the final assembly, we discovered an issue with our latch width. Since we had designed the latch to be the same exact width as the slit, we couldn't initially fit it into the enclosure. We ended up having to sand and smooth off a portion of the latch, then we were able to insert it and complete the mechanical design.

Our final system was assembled by then putting the circuit setup into the enclosure. Our circuit included an Arduino board, a temperature and humidity sensor, a resistor, and a photocell. To set up our circuit, we first had to set up the battery to the VIN slot and ground slot. Then, the sensor is connected by connecting the 5V pin to the + pin of the censor, GND to the - pin, and the D6 pin to the output pin. The 3.3V pin was connected to the photocell. The photocell was connected to both the resistor and AO and the resistor was connected to GND. Our enclosure included a box with a slit in it for the cover piece to go. Our circuitry was then put into the enclosure with the sensor and photocell sitting on the top. The battery pack was also propped up to the side against the WeMos board.



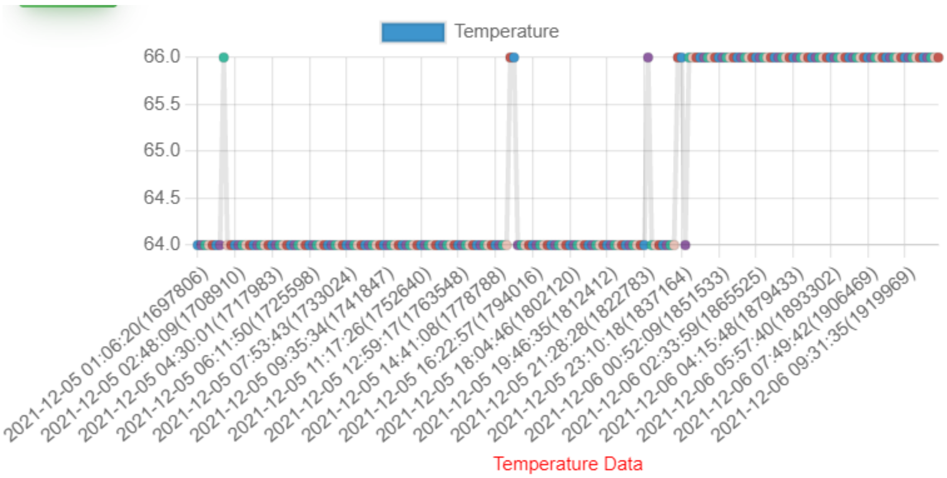
Performance Reporting

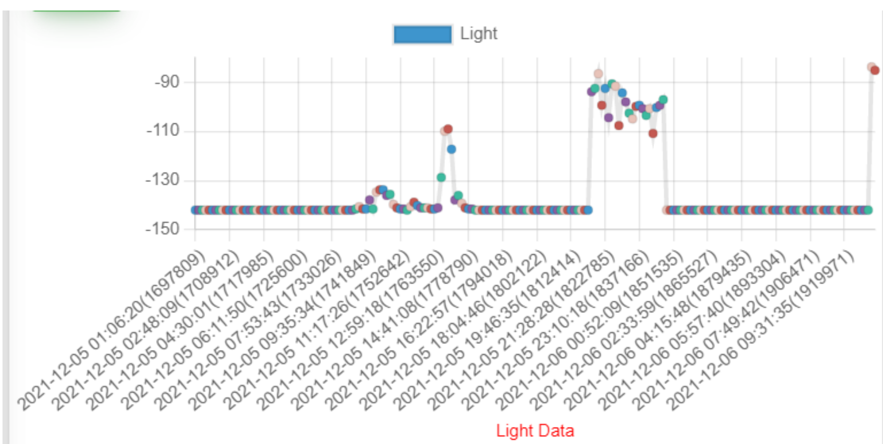
Below are the graphs of our data. Overall, our data proved to be reliable. Throughout the entire five day period, our program collected a continuous distribution of data with very little anomalies.

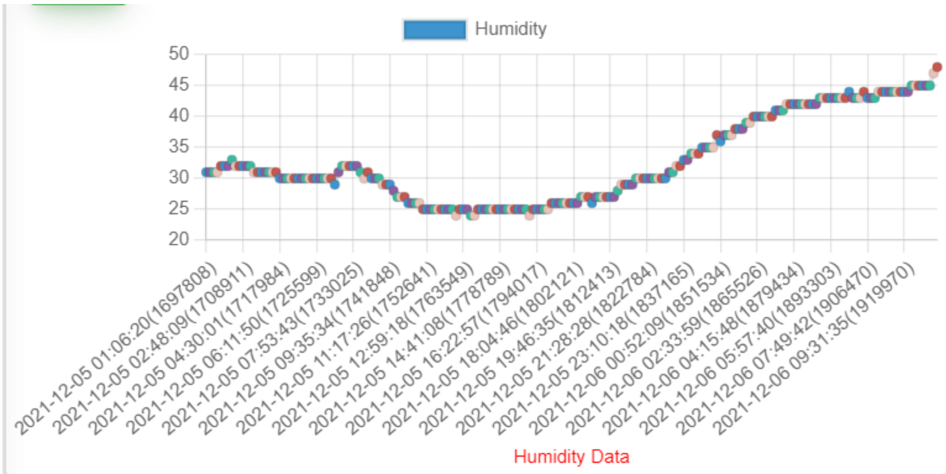
The temperature recordings proved to be extremely consistent, which makes sense considering the system was deployed inside a building with constant room temperature. For the first three days or so, the temperature remained constant at around 64° F, but then rose to 66° F and remained at that temperature for the rest of the time. This subtle temperature increase is likely due to the fact that the heat was turned up a bit due to the cold weather.

The humidity varied a fair bit throughout the five days, but, as shown from the graph, the recorded humidities were continuous, so there is nothing alarming or incorrect about the data. Humidity also tends to fluctuate more than temperature, so these fluctuations are nothing out of the ordinary.

Our lux recordings are perhaps our only source of error. While we initially modeled our lux calculations off of a linear regression using previous lux recordings, this model proved to be faulty when deployed in the actual environment and we ended up recording negative values. Though, even these negative values make sense relative to one another. For the most part, the lux remained at a constant value, which makes sense given that the light was kept off most of the time. Then, however, there was a small period where the room's light was turned on, hence the spike in lux around the third day.







Concluding Remarks

In summary, our design proved to be effective at recording temperature, humidity, and lux. While we ran into a few technical difficulties regarding the enclosure printing and software design, we were ultimately able to deploy our WeMos unit and reliably record data in the environment.

Our unit managed to run and stay powered for over five days, indicating that our software and sleep mode controls were effectively implemented. Our data was also continuous and smooth, showing how the program ran without interruption over the entire period.

While our design and program have been shown to work effectively, the true scope of our project lies in its potential for upscaling and production. As technology advances, the design can be potentially useful for products for anybody. In terms of global impact, energy conservation was taken into consideration with low power modes. The low power mode puts the system in a “sleep” where energy isn’t being used without having to disconnect the entire system.

Recording temperature, humidity, and lux is just the beginning as the system could be used to record other aspects of a room that could be used to help people. For example, an allergen-prone individual would aid from a device that records the dust level in rooms to tell when there is too large of an amount. When discussing the integration of social practices and technology, a common ground is helping society with everyday life, whether by making it easier or by providing essential aid.

With it being such a useful system, accessibility to others is an important thing to consider as having a system connected to a laptop isn’t very practical. Making the system mobile and easy to transport would allow it to be used in different settings and not just confined to one room, making it more useful and desired. Overall, through the implementation of design, hardware, and software, an effective and practical system was created to record light, temperature, and humidity, but with these same concepts of engineering, the possibilities are truly endless.