<u>Weather Station</u>

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Introduction

When considering what to do our project on, we first wanted to do something fun and enjoyable that we would possibly use personally even after this course. We each came up with ideas accordingly and narrowed our ideas by considering overall cost, design, and difficulty. With those in mind we settled upon designing a weather station. Our station will be capable of measuring temperature, humidity, and air pressure. We will design a casing that will be weather resistant so that the internal components will not get damaged. Our project has two goals. The first is to understand the general weather conditions for our area. The second is to be able to remotely access this information through a wifi connection.

Problem Identification

Problem:

Our goal is to understand weather conditions through temperature, air pressure, and humidity. Temperature is a manifestation of thermal energy and helps to tell how hot or cold something is. Temperature is important in weather applications because it can inform you about climate so that you may know how to dress comfortably for the weather. Additionally, temperature can tell you a lot about the ecological condition of an area. For example, we know that increased carbon dioxide emissions have led to increased build up of greenhouse gases which trap thermal energy, thus causing higher temperatures worldwide. Among many other reasons, temperature is important because we as humans require certain temperatures to survive and also desire certain temperatures for comfort.

Air pressure is the force over an area due to the weight of air above a surface. Air pressure is felt all around all bodies and its effects can even be felt through other fluids. Air pressure is important because it affects various aspects of weather predictions. Areas can have low pressure which can lead to strong winds, storms, and even cyclones. High pressure systems are generally our desired weather climate consisting of clear skies, dry air and cool winds.

Humidity is a measure of the amount of water vapor present in the air. High levels of humidity can indicate rain, fog, and dew. It is important to note that all of our desired measurements are affected by each other. Even though these are independent measurements, no one is truly independent of the others.

To measure our variables we will need to make a device that has the capacity to measure temperature, air pressure, and humidity. We will use various sensors to measure each variable. The device will also need some form of weather resistant casing and sturdiness in order to project the internal components from water, debris, and anything else that would impede performance. Additionally we need a power source and wifi-connectability to receive the data. We seek to accomplish this through minimal costs and efficient teamwork despite distance difficulties.

Sensor Constraints:

Prior to choosing which sensors to use, we first considered what range we should measure our parameters by. We seek to make a device that is usable in most climates. With that in mind, we based our constraints off worldwide highs and lows for each parameter. The highest and lowest recorded temperatures are 56.7 °C (134.06 °F) and -89.2 °C (-128.56 °F) respectively. We chose our temperature range to be -89 °C to 57 °C. The highest and lowest recorded pressures are 108.38 kilo-Pascals and 87 kilo-Pascals. We set our pressure constraints to a minimum of 87 kPa and a maximum of 108.4 kPa. Choosing a constraint for the humidity which is a percentage of the concentration of water vapor present in the air was unnecessary because being a percentage, it is already constrained to be from 0% to 100%. We did consider minimum and maximum recorded humidities world wide and found the lowest ever humidity recorded was 1% and the highest was 86%. See Table 1 for more about our sensor constraints.

Sensor Options

The different types of temperature sensors we chose from are a RTD, Thermistor, and thermo-couple. An RTD functions as a thermo-resistive sensor which shows temperature change as its resistance value changes. RTD’s are highly stable over long periods of time and produce a more linear relationship between resistance and temperature, but their response time is slower in comparison to other types of temperature sensors in addition to being more expensive and heavily affected by self heating. Thermistors are smaller and have a much faster response time than RTD’s and a smaller temperature range. However they can sometimes have high resistances and are usually much more fragile. Thermo-couples are much more rugged than the previous options but output a much lower voltage which can be more difficult to read and process.

The different types of humidity sensors we chose from were capacitive, resistive, thermal, optical humidity sensors. Capacitive sensors depend on the permittivity due to moisture. These are fast in response, accurate, and small in size, but they are easily affected by high temperatures. Resistive humidity sensors are good for measuring relative humidity (RH). They are cheap but are easily affected by harsh conditions. Optical Humidity sensors are the most accurate and stable, but they are also the most expensive type.

The different kinds of pressure sensor we chose from were piezoresistive, capacitive, and magnetic pressure sensors. Piezoresistive pressure sensors are stable and rugged but can use more power than other types of pressure sensors. Capacitive pressure sensors use a much smaller amount of power, have a fast response time, and can operate in a large range of pressures. However they are extremely non-linear in their output. Magnetic pressure sensors are very sensitive and are almost insensitive to temperature. These types of sensors require much more complex circuitry and electrical interference.

Use of Logic

The arduino and the sensor itself did the majority of the signal processing. By checking for appropriate values and choosing sensors built for the purpose of being used with an Arduino, very little signal processing was needed besides making sure the sensor worked. A website called PushingBox ended up being used to push the data to the Google script and into the spreadsheet. Pushing box calls on the script to parse the string of data points. This allowed us to route the data to a shared google document automatically without the need for constant human intervention as well as providing an avenue for remote use. We analyzed the data on the document and made charts, tables, and graphs accordingly.

Logic was implemented in various aspects prior to the signal processing. Most of our sensors already had the logic portion included. This simplified our task by minimizing the amount of coding needed to understand the data. The code also contained a number of safety nets for debugging and coding best practices involving logic in order to provide feedback on problems during runtime of the system. Logic has a key function throughout the device in that it analyzes the sensor output and provides it to us in a usable format.

Flow Chart

See the Appendix for the flow chart.

Final Engineered Solution

To properly decide which equipment to use, we had to make some compromises to our desired constraints. When choosing the constraints we did not consider the probability of any of the sensors reaching those extreme values. We chose sensors that operated within a reliable range so that we would measure accurate data.

The hardware we chose for this assignment was the DHT22 Digital Temperature and Humidity Sensor in order to measure the temperature and humidity as the name implies. It measures the temperature through a thermistor located on the back of the unit; see Data Sheet 1. In addition the capacitive humidity sensing element is next to it on the back of the unit. While there are many options, a thermistor option seemed the most reasonable because it is small yet can work with high resistances which makes it ideal for making a small weather station. Additionally, it is relatively cheap to make, and interfaces with other parts of the station with ease. All of these benefits make it easier to reproduce if someone wanted to manufacture it. Also, due to its small size thermistor temperature sensors respond quickly. We chose an option with a capacitive humidity element because it seemed to be the safest and most common way to measure the humidity. After working with the sensor we came to realize that it also had the capability of detecting the heat index. This sensor came with much of the logic built in so much of it is controlled by the computer once it is gone through the arduino.

The next sensor we used was the BMP 280 pressure sensor; see Data Sheet 2.It contains a piezo-resistive pressure sensing element. We chose something with a piezo-resistive element because they tend to be strong and withstand great amounts of pressure. Additionally, they tend to be less susceptible to vibration and shock which reduces the potential for loading error. Also, they tend to be small and of low cost to the consumer.

In order to do signal processing and logic, we had to have a microprocessor which ended up being an arduino; see Data Sheet 3. It is easy to use and there are many resources out there to help in the tricky spots of the processing. It was great for connecting to the wifi and thus making the project accessible anywhere.

For the breadboard, it became essential after purchasing the DHT22 temperature sensor as it is not able to directly connect into the arduino. The breadboard with jumper wires were necessary to make the sensor operational for our weather station. You can see this in the image below. We did not have any particular reason for choosing the breadboard we did as most breadboards do not vary by much. However its size was very beneficial for keeping the station compact.

Lastly, we chose the LMioEtool ABS Plastic Dustproof Waterproof IP65 Junction Box; see Data Sheet 4.had to consider the casing in which our station would go in. It needed to be small, strong, and capable of keeping unwanted things out like bugs and water. We were looking for something that would do all of those things and came across a casing that was made from hard plastic that closes tightly and is of a reasonable size. It closes tightly to keep out water and bugs.

Results:

After testing and multiple iterations; our project is a success in all but one area; measuring pressure. To begin, our weather station works properly and outputs data is a decent form. Table 4 shows the raw data from the station and Chart 1 graphs those parameters over time. We took that raw data and adjusted it by time so for comparability with actual weather measurements. The constraints we settled for are shown in Table 3. We believe that these sensor constraints will be more reasonable for most climates that we would encounter.

In measuring temperature, our device does provide a fairly accurate reading; see Table 6 for the error. Overall we calculated a relative error of 9.4%. The temperature readings from our device does have a similar shape over time when compared to actual temperature readings. See Charts 3 and 3A for our temperature data..

Humidity was our least accurate, its data is shown in Charts 4 and 4A. We had a relative error of 17.8%; see Table 6. The good is that again the graph of our data resembles that of the actual data; see Chart 4A.

Heat Index data can be seen in Charts 6 and 6A. Again the values we measured are not exactly the same as the actual, but the graphs have similar shapes showing similar trends throughout the day. We calculated the error in this reading to be 11.6%; see table 6.

We were not able to measure pressure, which is explained later. We were able to graph the actual trend of pressure over time on Charts 5 and 5A.

We believe the error may be more irrelevant to our findings. It should be noted that the areas we tested in and the area we chose our actual data set to be from are similar in origin, but are not the exact same. Since the weather can vary location to location, we chose a weather station closest to our test site. This yielded similar values but not the exact same values. With this being the case, the error is not as important as it would be and should not be factored heavily into our project's success.

Some problems we encountered were having a limited number of measurements we can take from the arduino without having to pay for more inputs. To accommodate this we ran another test at a lower time frequency so we can compare our results and not go over our maximum allotted outputs. Another issue we faced was our pressure sensor did not work at all. Amazon sent us what appears to be a counterfeit pressure sensor that ended up not functioning with any Arduino library we tried using. So we are not able to measure pressure. We attempted various arduino codes and soldering techniques but the sensor is either faulty or simply incompatible with our project.

Overall, our project is successful because it mimics weather actual trends over time. Additionally the aspects of the sensor we were able to control completely worked. To better gauge our sensor more testing would need to be done.

Entrepreneurship and Societal Impact

Manufacturing Technique (For mass production)

Mass production of our device does not seem attainable. In order for mass production to be attainable, we need more reliable tools such as those found on factory floors which would ease the building portion. Additionally, our software would need to be easily adaptable for any one who desires to purchase our product. The software also needs to be readily downloadable so that it can simply be uploaded onto any microprocessor we choose to use. Then we will need to consolidate the size and space of our final product, while also giving it a more attractive final appearance.

Finally, our sensor first needs a lower production cost. We spent around $75 on the materials and hardware alone. To make profit with that high of a production cost would be extremely difficult. To achieve a better cost we could make all components in-house or source to a mass manufacturer. This is especially true because there are already other technologies that can do what our device does.

Development Impedances

There is truly no market for our device. Most weather stations are much more robust with solar powered rain intensity, lightning strike energy, and a variety of other measurements. Similarly, they rely on proprietary technology that much surpasses your time and money, making our project peanuts compared to them. Similarly, other technology like phones, computers, and even some watches can provide the same information our device can provide, and even perform more tasks than our device can. Additionally, the information our device provides is readily available through local and global weather services and applications that can be downloaded onto your phone. Lastly these other technologies and media provide our same information at a lower cost than our product does.

Societal Impacts

Our device has a very minimal impact on society. This is because it is not widely useful due to its cost, design, and lack of innovative technology. Locally, our product created an opportunity to practice engineering design and apply the ideas and concepts we have learned throughout this course. Although, our device could be used in rural or 3rd world communities due to its space and cost effectiveness, as well as areas that lack weather data due to their remoteness. Additionally it will also earn us some points towards our final grade in the course. Globally, our product may be useful to some low income person(s) who desire solely the outputs that our device provides. Additionally, our product was fairly simple to build and could be used as a practice or improved design project for someone interested in sensors or weather.

References

We did not use nor reference any kind of weather sensors. Our sensor system may differ from others in size and compactibility. Additionally our sensor system more than likely outputs data with a higher percentage of error than other factory made weather stations. The compatibility of our weather station does help it be easily transported but its uses are not nearly as wide as that of other weather stations'. All designs for the sensor are our original ideas.

Materials

- DEYUE Prototype Breadboard
https://www.amazon.com/DEYUE-Solderless-Prototype-Breadboard-Points/dp/B07NVWR495/ref=sr_1_1_sspa?dchild=1&keywords=breadboard&qid=1596020632&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUFaUzRCQjRTQ1FJSzcmZW5jcnlwdGVkSWQ9QTA0MzkwNzAyTVQ5NThPNzgySVg4JmVuY3J5cHRlZEFkSWQ9QTA4MDQyNjJSV1VVWjBIOEhXVUUmd2lkZ2V0TmFtZT1zcF9hdGYmYWN0aW9uPWNsaWNrUmVkaXJlY3QmZG9Ob3RMb2dDbGljaz10cnVl
- DHT22 Digital Temperature and Humidity Sensor
https://www.amazon.com/Aideepen-Digital-Temperature-Humidity-Replace/dp/B01IBBFOF0/ref=pb_allspark_session_sims_desktop_147_4/142-7698776-6637402?_encoding=UTF8&pd_rd_i=B01IBBFOF0&pd_rd_r=65dbeed1-3f5d-457a-a4a7-d3f1f749b634&pd_rd_w=C8rex&pd_rd_wg=jzKtF&pf_rd_p=6dab4af8-14d2-4d59-b0a2-dd973ff1f166&pf_rd_r=Q8DESQYD2HTN287Q1S7Z&psc=1&refRID=Q8DESQYD2HTN287Q1S7Z
- ARDUINO UNO R3 [A000066]
https://www.amazon.com/Arduino-A000066-ARDUINO-UNO-R3/dp/B008GRTSV6/ref=sr_1_4?dchild=1&keywords=arduino&qid=1596020666&sr=8-4
- LMioEtool ABS Plastic Dustproof Waterproof IP65 Junction Box Hinged Shell Universal Electrical Project Enclosure Gray, with PC Transparent Clear Cover 5.9 x 3.9 x 2.8inch(150 x100 x70mm)
https://www.amazon.com/LMioEtool-Dustproof-Waterproof-Electrical-Transparent/dp/B07PK8K8S2/ref=sr_1_1_sspa?dchild=1&keywords=waterproof+enclosure&qid=1594910077&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyQjQ1WDA4VllJNFJYJmVuY3J5cHRlZElkPUEwMjcxODI1Mk1UODdUWEQ2NTNFMiZlbmNyeXB0ZWRBZElkPUEwNDAwNDI3M0xDWTJGQldaT0w5SSZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=
- Adafruit BMP280 I2C or SPI Barometric Pressure and Altitude Sensor
https://www.amazon.com/dp/B013W0RR6Y/ref=cm_sw_r_cp_api_i_HuggFbGNGDYX6

Sources

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Woods, Catherine. “8 Things You Didn't Know about Humidity.” *PBS*, Public Broadcasting Service, 31 July 2015, www.pbs.org/newshour/science/8-things-didnt-know-humidity#:~:text=The%20highest%20dew%20point%20temperature,reading%20of%2086%20in%202005.

“World: Highest Temperature.” *World Meteorological Organization's World Weather & Climate Extremes Archive*, wmo.asu.edu/content/world-highest-temperature#:~:text=World%3A%20Highest%20Temperature,-Record%20Value&text=That%20temperature%20(often%20cited%20by,Libya%20on%2013%20September%201922.

“World: Lowest Temperature.” *World Meteorological Organization's World Weather & Climate Extremes Archive*, wmo.asu.edu/content/world-lowest-temperature.

“Marietta, GA Weather Historystar_ratehome.” *Weather Underground*, www.wunderground.com/history/daily/us/ga/marietta/KMGE/date/2020-7-29.

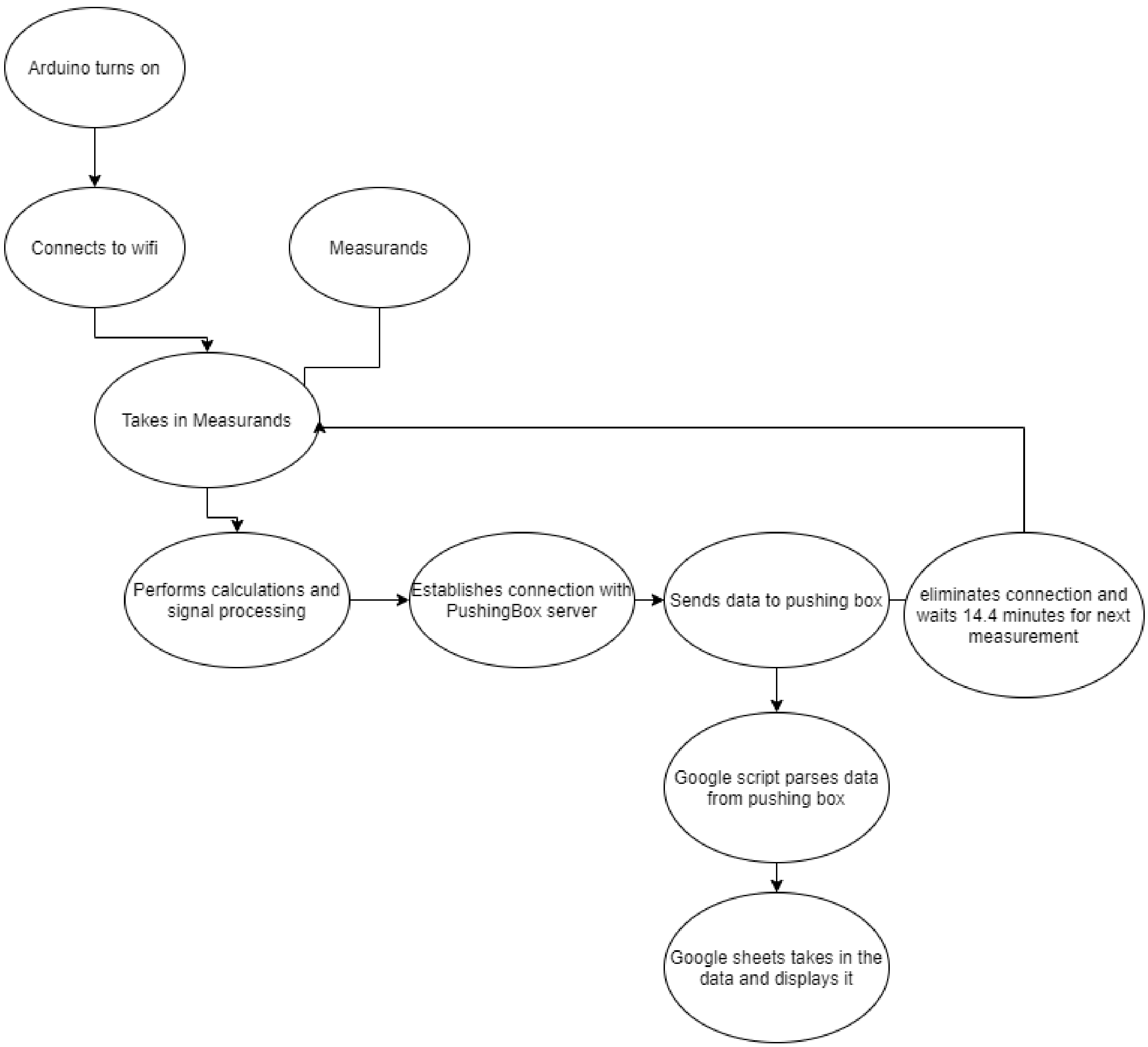
US Department of Commerce, NOAA. “Heat Index.” *NWS JetStream*, NOAA's National Weather Service, 27 Aug. 2019, www.weather.gov/jetstream/hi.

Appendix

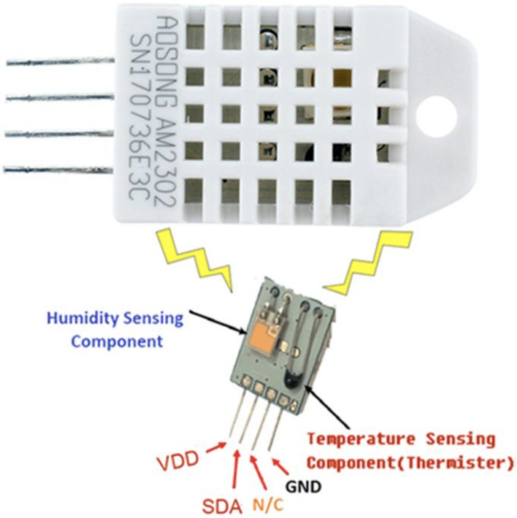
Data Output Document

- https://docs.google.com/spreadsheets/d/1ySFO-ku6ypC8xmhBC6v1FgCiXWkhtTYzsSWtzPl_Ao0/edit?usp=sharing

Flow Chart



Data Sheets



Model	DHT22
Power supply	3.3-6V DC
Output signal	digital signal via single bus
Sensing element	Polymer capacitor
Operating range	humidity 0-100%RH;
	temperature -40~80Celsius
Accuracy	humidity +-2%RH(Max +- 5%RH);
	temperature <+-0.5Celsius
Resolution or sensitivity	humidity 0. l%RH;
	temperature 0. lCelsius
Repeatability	humidity +-1%RH;
	temperature +-0.2Celsius
Humidity hysteresis	+-0.3%RH
Long-term Stability	+-0.5%R H/year
Sensing period	Average: 2s
Interchangeability	fully interchangeable
Dimensions	small size 14*18*5.5mm;
	big size 22*28* 5mm

Data Sheet 1: Temperature/Humidity Sensor

Table 2: Parameter specification

Parameter	Symbol	Condition	Min	Typ	Max	Units
Operating temperature range	T_A	operational	-40	25	+85	°C
		full accuracy	0		+65	
Operating pressure range	P	full accuracy	300		1100	hPa
Sensor supply voltage	V_{DD}	ripple max. 50mVpp	1.71	1.8	3.6	V
Interface supply voltage	V_{DDIO}		1.2	1.8	3.6	V
Supply current	$I_{DD,LP}$	1 Hz forced mode, pressure and temperature, lowest power		2.8	4.2	µA
Peak current	I_{peak}	during pressure measurement		720	1120	µA
Current at temperature measurement	I_{DDT}			325		µA
Sleep current[1]	I_{DDSL}	25 °C		0.1	0.3	µA
Standby current (inactive period of normal mode) [2]	I_{DDSB}	25 °C		0.2	0.5	µA
Relative accuracy pressure V_{DD} = 3.3V	A_{rel}	700 … 900hPa 25 . . . 40 °C		±0.12		hPa
				±1.0		m

Data Sheet 2: Pressure Sensor

OVERVIEW | TECH SPECS | DOCUMENTATION | FAQ

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Data Sheet 3: Arduino

- **Product Name : Junction box; Waterproof rating : IP65.**
- **Material: ABS,PC ; Net Weight: 180g; Main Color: Light Gray (For Box Body), Transparent （For box cover)**
- **The Enclosure box features two or three plastic latches for added security and locking; moisture proof, sunscreen, anti-corrosion, durable for years use.**
- **This electrical junction box is easy to operate and repair, no cable cutting, more convenient.**
- **Outer Size(Approx.):5.9" x 3.9" x 2.8"/150mmx100mmx70mm (L*W*H); Inner Size(Approx.): 5.2" x 3.2" x 2.6"/132mm x 82mm x 65mm(L*W*H)- - (Allowable Error: 2mm).**

Data Sheet 4: Weather Resistant Casing

Daily Observations

Time	Temperature	Dew Point	Humidity	Wind	Wind Speed	Wind Gust	Pressure
12:56 AM	76 °F	71 °F	85 %	SW	7 mph	0 mph	28.90 in
1:56 AM	75 °F	71 °F	88 %	SSW	6 mph	0 mph	28.90 in
2:11 AM	75 °F	72 °F	89 %	SSW	5 mph	0 mph	28.90 in
2:56 AM	74 °F	71 °F	91 %	SSW	3 mph	0 mph	28.89 in
3:56 AM	74 °F	72 °F	92 %	WSW	5 mph	0 mph	28.89 in
4:56 AM	74 °F	71 °F	89 %	W	7 mph	0 mph	28.90 in
5:56 AM	74 °F	71 °F	88 %	W	7 mph	0 mph	28.90 in
6:26 AM	75 °F	70 °F	83 %	W	6 mph	0 mph	28.90 in
6:56 AM	74 °F	70 °F	88 %	W	6 mph	0 mph	28.91 in
7:56 AM	75 °F	71 °F	88 %	WSW	3 mph	0 mph	28.93 in
8:53 AM	75 °F	70 °F	83 %	CALM	0 mph	0 mph	28.93 in
8:57 AM	76 °F	70 °F	83 %	CALM	0 mph	0 mph	28.93 in
9:51 AM	77 °F	72 °F	83 %	SSW	2 mph	0 mph	28.93 in
9:56 AM	78 °F	71 °F	79 %	SW	5 mph	0 mph	28.93 in
10:35 AM	79 °F	72 °F	78 %	SW	3 mph	0 mph	28.93 in
10:42 AM	79 °F	72 °F	78 %	W	8 mph	0 mph	28.93 in
10:45 AM	77 °F	72 °F	83 %	W	6 mph	0 mph	28.93 in
10:48 AM	77 °F	72 °F	83 %	W	5 mph	0 mph	28.93 in
10:59 AM	76 °F	72 °F	87 %	W	2 mph	0 mph	28.93 in
11:04 AM	77 °F	72 °F	83 %	WSW	3 mph	0 mph	28.93 in
11:32 AM	77 °F	73 °F	89 %	SSW	7 mph	0 mph	28.93 in
11:43 AM	77 °F	73 °F	89 %	S	6 mph	0 mph	28.93 in
11:57 AM	78 °F	73 °F	85 %	SSW	6 mph	0 mph	28.93 in
12:57 PM	79 °F	74 °F	83 %	S	8 mph	0 mph	28.92 in
1:56 PM	83 °F	73 °F	71 %	S	6 mph	0 mph	28.90 in
2:16 PM	84 °F	73 °F	70 %	S	8 mph	0 mph	28.89 in
2:45 PM	82 °F	72 °F	70 %	SW	15 mph	0 mph	28.88 in
2:56 PM	79 °F	73 °F	81 %	WSW	9 mph	0 mph	28.88 in
3:20 PM	77 °F	73 °F	89 %	SW	2 mph	0 mph	28.87 in
3:56 PM	83 °F	73 °F	73 %	VAR	3 mph	0 mph	28.85 in
4:56 PM	84 °F	73 °F	69 %	SSW	8 mph	0 mph	28.84 in
5:56 PM	83 °F	72 °F	70 %	S	7 mph	0 mph	28.84 in
6:56 PM	83 °F	72 °F	68 %	SSW	7 mph	0 mph	28.83 in
7:56 PM	81 °F	73 °F	76 %	SSW	6 mph	0 mph	28.84 in
8:56 PM	79 °F	71 °F	78 %	S	5 mph	0 mph	28.85 in
9:56 PM	77 °F	73 °F	86 %	SSW	5 mph	0 mph	28.88 in
10:56 PM	77 °F	73 °F	89 %	CALM	0 mph	0 mph	28.89 in
10:57 PM	77 °F	73 °F	89 %	CALM	0 mph	0 mph	28.89 in
10:58 PM	77 °F	73 °F	89 %	CALM	0 mph	0 mph	28.89 in
11:56 PM	77 °F	74 °F	90 %	S	3 mph	0 mph	28.89 in

Data Sheet 5: Recorded Weather Data (Marietta, GA)

Tables

Global Weather Phenomenons (Table 1)		
	Min	Max
Temperature	-89.2 °C	56.7 °C
Air Pressure	87 kPa	108.38 kPa
Humidity (RH)	1%	86%
Heat Index	----	81 °C

Chosen Sensor Constraints (Table 2)		
	Min	Max
Temperature	-89 °C	57 °C
Air Pressure	87 kPa	108.4 kPa
Humidity (RH)	0%	100%

Given Sensor Constraints (Table 3)		
	Min	Max
Temperature	-40 °C	80 °C
Air Pressure	95 kPa	105 kPa
Humidity (RH)	0%	100%

Raw Measured Data (Table 4)				
Date & Time	Temperature [°C]	Humidity [%]	Heat Index [°C]	Pressure [kPa]
7/29/2020 16:38:24	30.2	53.5	31.95	NA
7/29/2020 16:59:29	26.9	62.4	28.12	NA
7/29/2020 17:13:51	26.8	65.5	28.2	NA
7/29/2020 17:28:12	29.2	61	31.54	NA
7/29/2020 17:42:33	29.9	60.4	32.72	NA
7/29/2020 17:56:54	30.3	60.6	33.54	NA
7/29/2020 18:11:15	30.4	61.1	33.85	NA
7/29/2020 18:25:36	30.5	61.3	34.11	NA
7/29/2020 18:39:57	30.2	61.7	33.58	NA
7/29/2020 18:54:17	30.1	62.1	33.46	NA
7/29/2020 19:08:38	30	62.3	33.3	NA
7/29/2020 20:51:40	28.9	58.8	30.69	NA
7/29/2020 21:06:02	28.9	59.5	30.79	NA
7/29/2020 21:20:22	28.8	63.2	31.18	NA
7/29/2020 21:34:43	28.6	63.9	30.93	NA
7/29/2020 21:49:04	28.5	64.4	30.82	NA
7/29/2020 22:03:25	28.3	64.8	30.52	NA
7/29/2020 22:17:46	28.1	65.2	30.23	NA
7/29/2020 22:32:06	28	65.4	30.08	NA
7/29/2020 22:46:28	27.9	65.8	29.96	NA
7/29/2020 23:00:48	27.8	66	29.81	NA

Utilized Measured Data (Table 4A)				
Date & Time	Temperature [°C]	Humidity [%]	Heat Index [°C]	Pressure [kPa]
7/29/2020 16:59:29	26.9	62.4	28.12	NA
7/29/2020 17:56:54	30.3	60.6	33.54	NA
7/29/2020 18:54:17	30.1	62.1	33.46	NA
7/29/2020 19:08:38	30	62.3	33.3	NA
7/29/2020 20:51:40	28.9	58.8	30.69	NA
7/29/2020 22:03:25	28.3	64.8	30.52	NA
7/29/2020 23:00:48	27.8	66	29.81	NA

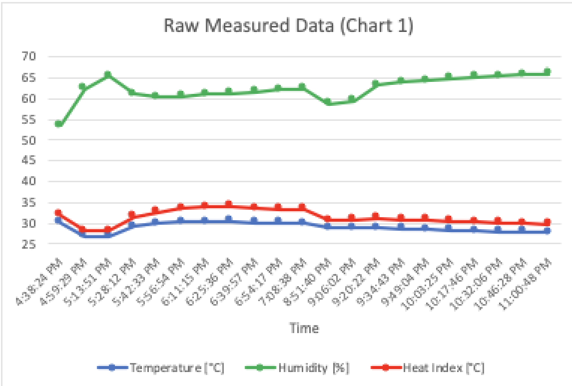
Adjusted Measured Data (Table 4B)				
Time	Temperature [°C]	Humidity [%]	Heat Index [°C]	Pressure [kPa]
5:00 PM	26.9	62.4	28.12	NA
6:00 PM	30.3	60.6	33.54	NA
7:00 PM	30.1	62.1	33.46	NA
8:00 PM	30	62.3	33.3	NA
9:00 PM	28.9	58.8	30.69	NA
10:00 PM	28.3	64.8	30.52	NA
11:00 PM	27.8	66	29.81	NA

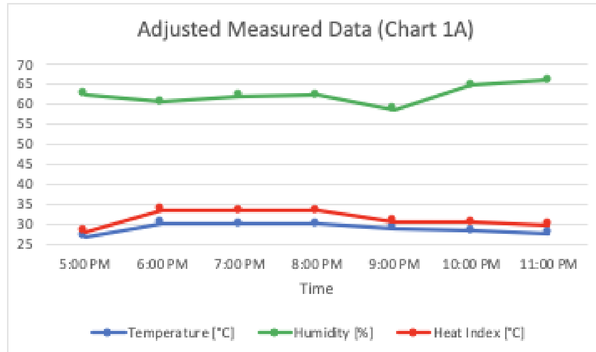
Raw Actual Data (Table 5)				
Date & Time	Temperature [°C]	Humidity [%]	Heat Index [°C]	Pressure [kPa]
7/29/2020 16:56:00	28.9	69	32	97.67
7/29/2020 17:56:00	28.3	70	31	97.67
7/29/2020 18:56:00	28.3	68	31	97.63
7/29/2020 19:56:00	27.2	76	30	97.701
7/29/2020 20:56:00	26.1	78	28	97.803
7/29/2020 21:56:00	25	86	26	97.84
7/29/2020 22:56:00	25	89	26	97.84

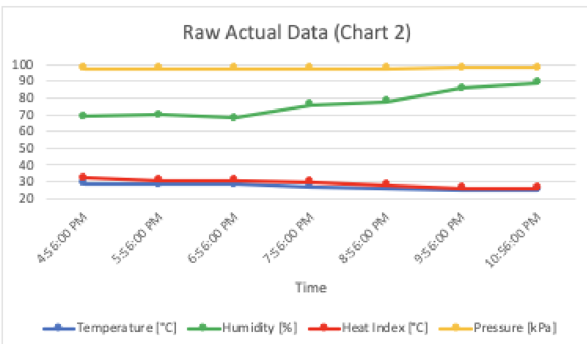
Adjusted Actual Data (Table 5A)				
Time	Temperature [°C]	Humidity [%]	Heat Index [°C]	Pressure [kPa]
5:00 PM	28.9	69	32	97.67
6:00 PM	28.3	70	31	97.67
7:00 PM	28.3	68	31	97.63
8:00 PM	27.2	76	30	97.701
9:00 PM	26.1	78	28	97.803
10:00 PM	25	86	26	97.84
11:00 PM	25	89	26	97.84

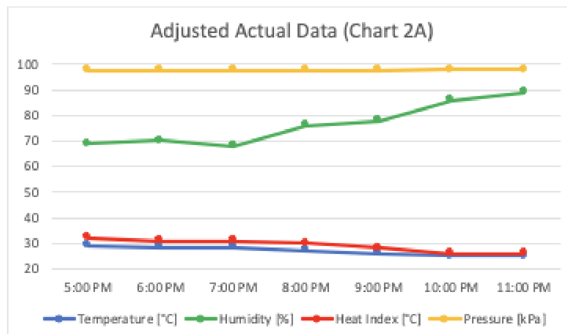
	Percent Error [%] (Table 6)			
Time	Temperature	Humidity	Heat Index	Pressure
5:00 PM	6.920415225	9.565217391	12.125	NA
6:00 PM	7.067137809	13.42857143	8.193548387	NA
7:00 PM	6.360424028	8.676470588	7.935483871	NA
8:00 PM	10.29411765	18.02631579	11	NA
9:00 PM	10.72796935	24.61538462	9.607142857	NA
10:00 PM	13.2	24.65116279	17.38461538	NA
11:00 PM	11.2	25.84269663	14.65384615	NA
AVG Error	9.395723437	17.82940275	11.55709095	NA

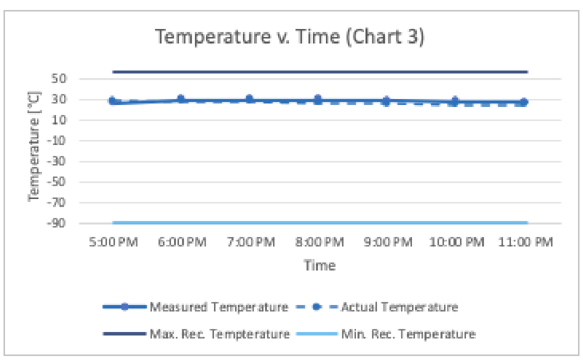
Charts/Graphs

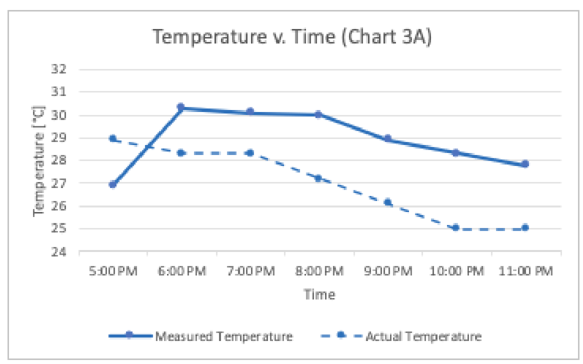


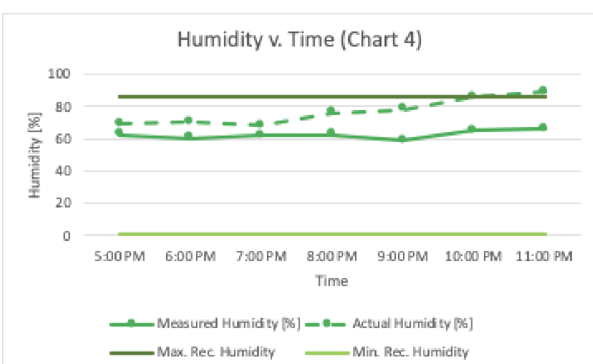


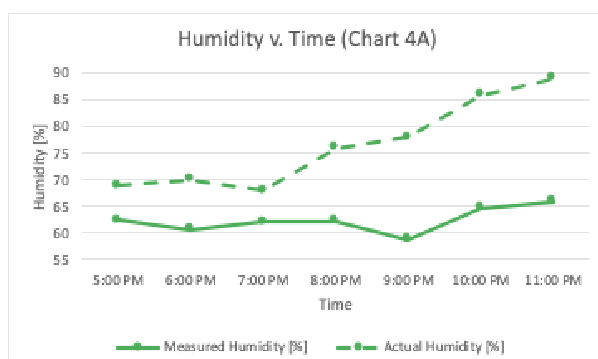


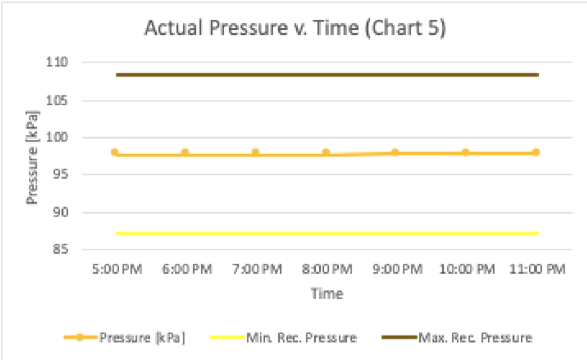


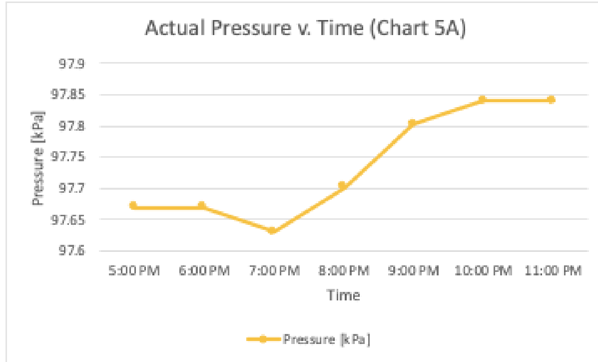


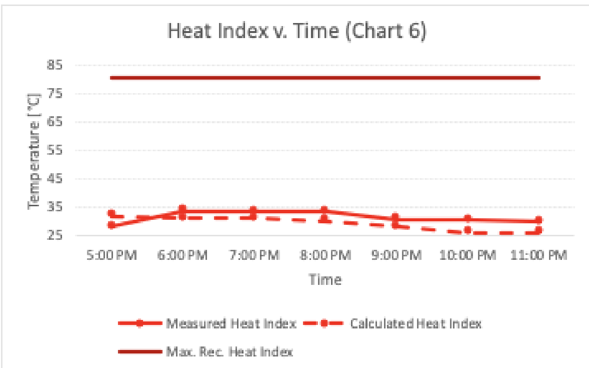


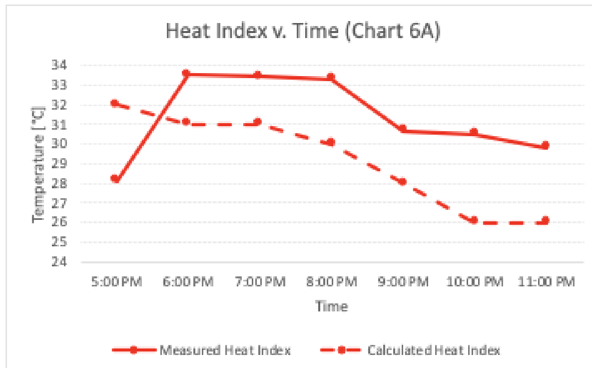




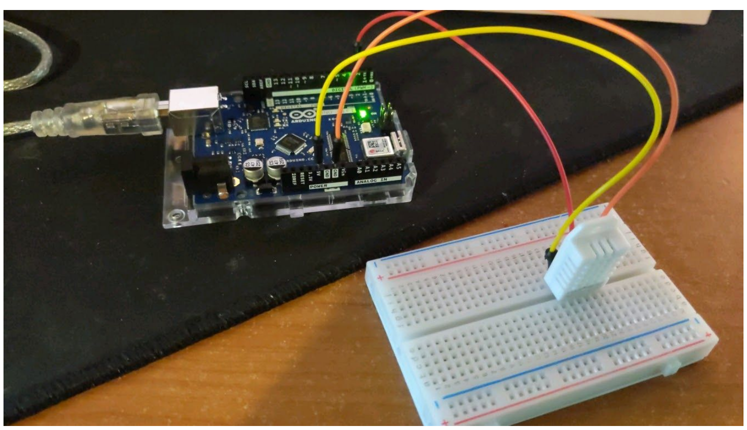




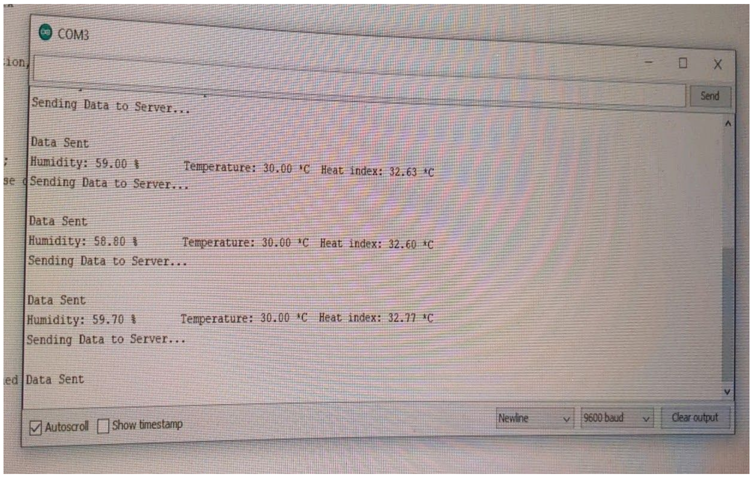




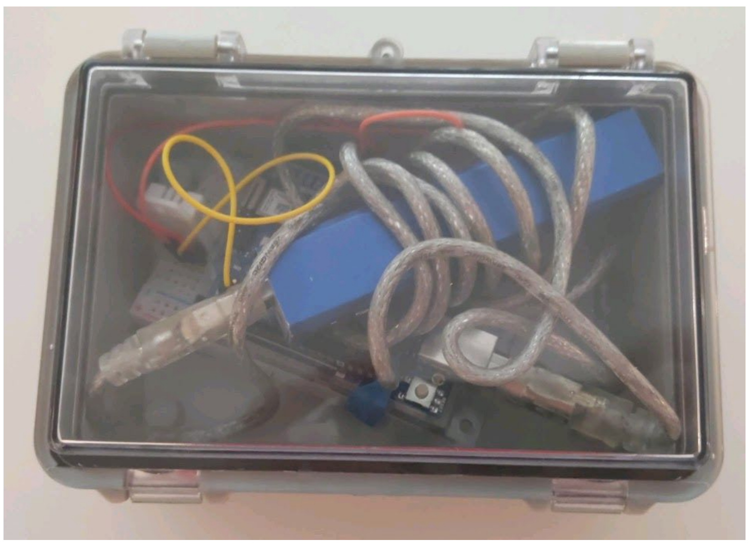
<u>Photos/Images</u>



Img. 1: Weather Station outside of its casing.

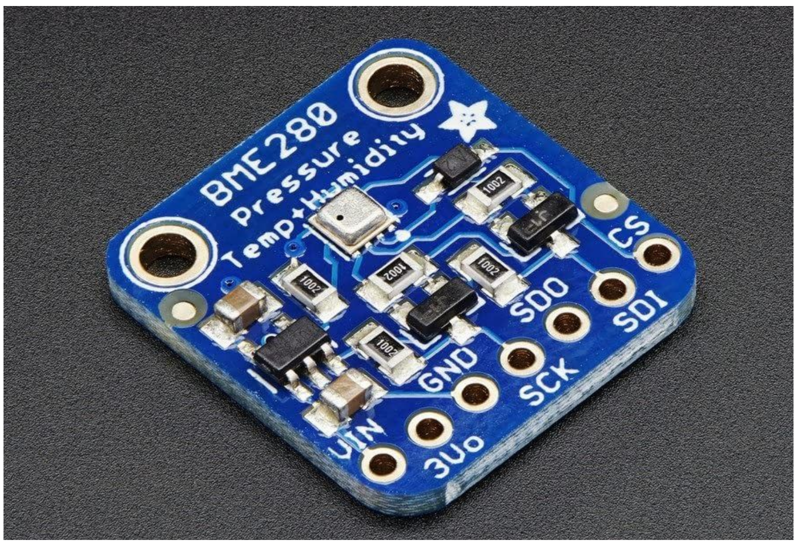


Img. 2: Screenshot of first successful data outputs from the weather station.


Img. 3: Completed weather station (topview).


Img. 4: Completed weather station (side view).

Img. 5: Weather station outside gathering data.



Img. 6: The pressure sensor we thought we ordered from Amazon.

Img. 7: The sensor Amazon sent us instead of our desired sensor.