

GNG 1103: Engineering Design

Design Project User and Product Manual

Submitted by:

Before the Pale, B17

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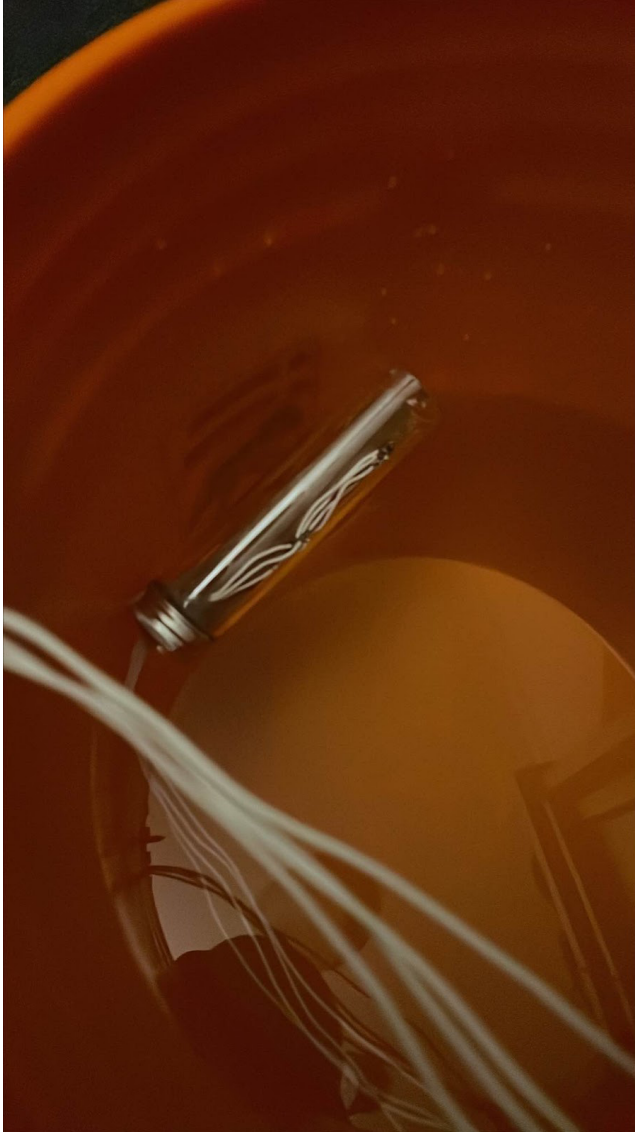
1. Introduction

The following document will showcase the needed procedure to create a tilt-based hydrometer(TIBH). Based on its tilt while floating, it gives the user an accurate reading of specific gravity, which is then translated into Plato. The document will show a rough step-by-step construction of the device and possible troubleshooting problems someone may encounter. The document is formatted numerically for a user to understand the process of building the device. The intended audience is anybody who already has the device or decides they want to build it for themselves. Excel was used to make the device work, so if that impedes any personal safety concerns with Excel, use Google Docs instead.

This User and Product Manual (UPM) provides the information necessary for <established users > to effectively use the <TIBH> and for prototype documentation.

2. Overview

The problem that TIBH is trying to solve is to automatically measure the specific gravity of a liquid, with the limitation that it cant be free-floating, checks for specific gravity every ten seconds, and the data is easily accessible and storable. The client that the device was originally made was Shane, who ferments beer. As stated previously, we were given certain limitations and demands, which resulted in the present product. The device is differentiated by its approach to measuring specific beer and its way of processing its data. First, the device measures specific gravity using two different sensors one accelerometer and a temperature sensor. The accelerometer gathers the real-time y-axis tilt, and the temperature sensor, of course, measures temperature in real time. These two sensors are inside a pill that sits on top of the liquid of choice. For these two data points, the data is sent from an Arduino to a computer choice and processed via excel sheets.



The device architecture is a plastic pill that inside has two sensors plastered onto a piece of MDF, the pill is sealed silicon and has a metal cap. Plastic wire comes out of the pill, which is connected to an Arduino. The Arduino sits inside an MDF wood box which allows for modularity; the box is then stuck onto a circle that sits on a port. The Arduino box has a micro-USB port to allow it to connect to a computer via USB. The USB needs to be connected to a USB that can both input and output.

1. Conventions

There is the stylistic choice of instead labeling each picture as a figure; we left them unnamed since some pictures of the device are reused.

2. Cautions and Warnings

Use the device in a real fermentation process at your own risk. We are not liable for any damages done by the design to a person or goods. The finished product was not tested using beer but with water. The design was not safety tested for extreme conditions or temperatures, please keep the device in liquids that range from 10-40 celsius and non-extreme ambient temperatures to protect electronics and silicon seals.

3. Getting Started

The instructions for the use, set up and removal of the device are as follows.

1. Configuration Considerations

The equipment used includes:

The device inside the tank is made up of an Accelerator/Gyroscope, a Temperature Sensor, silicone, wire and the pill cell where all these parts are located.

The data transmission part of the device is located outside the tank and includes a Node mcu Wi-Fi Module, a USB Cable, USB-AC Adapter and a computer with access to a Microsoft Excel program with add-in capabilities.

2. User Access Considerations

Users include but are not limited to anyone who is a part of the brewing process at a small to medium size brewery. The system is designed for one tank and to be used for the entire brewing process before its removal to start the cleaning process.

3. Accessing/Setting-up the System

To set up the device the first thing to do is to put and attach the device to the tank through the port. The device is removable and is secured to the tank by a clamp over the port. The next steps would be to plug the device into a computer, from there the user would need to ensure that they had excel open and the add-in named Data streamer can run on your computer.

4. System Organization & Navigation

To record and graph data from the device you must ensure that the device is plugged into a computer that can run a Microsoft Excel program that is compatible with add-ins. Then ensure that the data streamer add-in is operational and change the settings to add-in COM so data can be recorded. Once all of this is completed create a table with the desired titles. Go to devices and select the correct one, once the device is connected click the start recording button at the top of

the screen. After about 10 seconds the first data should be recorded in the table previously created. When you wish the data to stop or the brewing process is complete then click the stop recording button. Then ensure that the sheet has been saved to the computer or an external device before disconnecting the device.

5. Exiting the System

To turn off the system press stop recording data on the excel sheet. Unplug the device from the computer. From there once the tank is empty you can remove the device from the port for cleaning and/or maintenance. Always remember to reclose the port on the tank or put back the device before starting the brewing process again.

4. Using the System

- Placing the tube into the tank

In order for the process to start, the user needs to place the tube containing the gyroscope and the temperature sensor into the tank of liquid, when placed, the tube will tilt based on the specific gravity of the fluid contained in the tank. The tube is not free-floating so the user does not need to worry about it disappearing into the tank, or getting lost in the system, since it will be attached to the port at all times with a wire. Other than this one simple step, there is nothing much the user needs to do other than load up their computer and open their excel file which all the data from the sensors will be sent to automatically in real time.

1. (Excel)

When the excel file gathers the data from the gyroscope and temperature sensor, it will place the data into the excel file. Let me go over some of the specific features that are outlined.

Data In (From USB-SERIAL CH340 (COM4))

Data coming from the current data source will appear below as it is received.

Current Data

TIME	Angle	Temp	CH3	CH4	Specific Gravity	CH6	CH7	CH8	CH9	CH10
11:31:06.40	234.2	24.71			1.085968503					

Historical Data

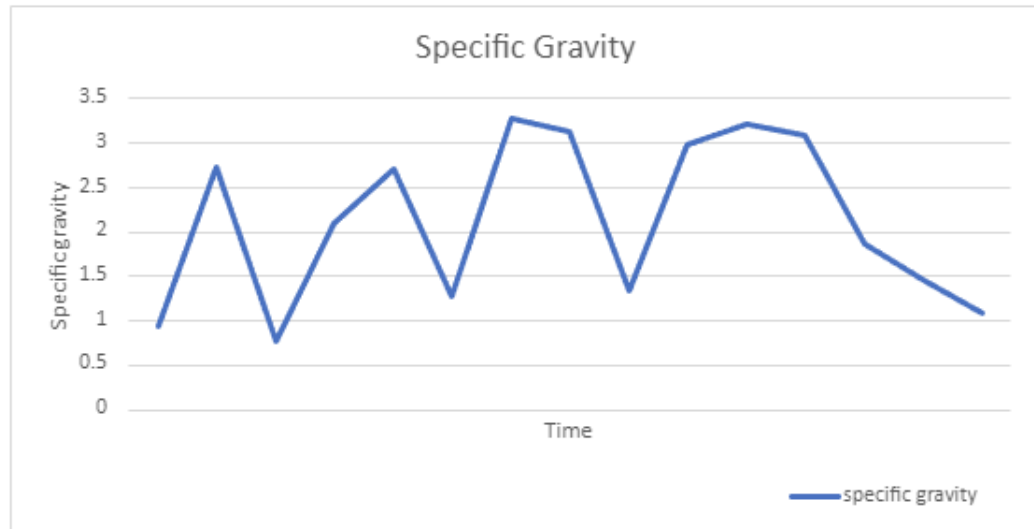
TIME	Angle	Temp	CH3	CH4	Specific Gravity	CH6	CH7	CH8	CH9	CH10
11:28:46.00	26.23	23.76			0.940520342					
11:28:56.10	27.49	23.82			2.721217458					
11:29:06.12	29.9	23.89			0.781023748					
11:29:16.14	22.69	24.01			2.092881109					
11:29:26.17	30.62	24.14			2.699450515					
11:29:36.19	7.27	24.26			1.283111858					
11:29:46.20	9.32	24.34			3.286822447					
11:29:56.24	358.28	24.42			3.127027811					
11:30:06.26	353.66	24.55			1.329719817					
11:30:16.29	352.11	24.66			2.98891524					
11:30:26.31	40.87	24.77			3.222323709					
11:30:36.33	135.27	24.79			3.079094156					
11:30:46.36	137.08	24.76			1.875329224					
11:30:56.36	126.59	24.68			1.464472413					
11:31:06.40	234.2	24.71			1.085968503					

Firstly we have the angle, this is received from the gyroscope inside the pill in the fluid, the angle of the tilt changes based on the specific gravity of the fluid, and it is sent to our excel file. In this screenshot, the values are very different from the angle because we were testing its correctness and moving it in different angles to test its accuracy and response time to real time motion.

The part of the table above, which is called current data, is real time data and it is auto-updating automatically, the user does not have to do anything but watch and monitor it, while the information below that is the historical data, because our client also wants to keep track of all the data stored.

The specific gravity of the fluid is listed there as well, that is what the client is mostly concerned with and what our design project was about. The formula used to calculate the specific gravity is a formula used in fluid statistics of chemical engineering which relates the pressure of curved surfaces and their angles with the specific density of the fluid. So it takes the angle received and uses the formula to keep auto updating it with new information.

GRAPH



Another function which was requested by Shane was to add a graph to display historical specific gravity of the beer, so we added a graph to our excel, which receives the information from the historical data column above, and beautifully displays it.

5. Troubleshooting & Support

1. Error Messages or Behaviors

If nothing is displaying to the make sure that:

- That there are two green LED lights on writhing the pill (one is the temp/humidity sensor and the other is the accelerometer/gyroscope)
 - If the lights are not on, there is something wrong with the device or the port it is plugged into
- You have the Microsoft Data Streamer Plugin installed on Excel
- You have selected the right USB port when clicking connect a device
- You have clicked the Start Data button
- You have clicked advanced and changed the baud rate to 115200

If nothing continues to display then there may be a problem with the device itself.

2. Special Considerations

If you are getting inaccurate or wrong readings from the device make sure that:

- You have inputted the correct volume of the liquid into the Excel sheet
- You have inputted the correct area of the liquid into the Excel sheet
- There is no build up on the pill that might affect the buoyancy
- There is no build up on the wire that might affect the tilt of the pill

If you are still getting inaccurate or wrong readings from the device, the device may be broken.

3. Maintenance

After every use of the device, the pill and submerged wire must be cleaned thoroughly using soap and water and also scrubbed thoroughly with a sponge if there is any build up on the pill or wire.

4. Support

If emergency assistance or system support is required for the device you can reach out to any of the five group members who made the device via email or to Professor Knox via email as well. When emailing us please include whether it is a problem with the device or a problem within the Excel program, also let us know what is wrong with and as much information as possible.

6. Product Documentation

1. Device Pill

1. Bill of Materials

Table 6.1.1: Device Pill Bill of Materials

Material	Quantity	Total Cost (CAD)	Source
MDF	1	-	MakerLab Store
Accelerator/Gyroscope	1	11.00	Amazon Link
Temperature Sensor	1	13.44	MakerLab Store
Silicone	1	16.35	Amazon Link
Wire	5 feet	5.00	MakerLab Store
Pill Cell	1	1.63	Amazon Link
	Total	47.42	

2. Equipment List

Soldering Iron

Soldering is necessary to connect wires to node mcu and sensors within the pill.

Drill Press

The metal cap of the pill requires an opening to allow for wires to pass through. Drill press is necessary to create this opening.

3. Instructions

When it comes to the pill, there are a few steps to put it together. First off, you would need the pill cell that has a screw on top. An example of such is below - *Figure 6.1.3*.

Figure 6.1.3: Pill cell housing example



Then you need to use a drill press to create a hole in the screw top that would allow for wires to pass through. The next step would be to create a board that sensors would be attached to. You will need to cut a 1 inch by 5 inch rectangle from MDF. You may use either a laser cutter or a saw. Once the piece of MDF is ready - it needs to be glued to the screwtop and then the location of sensor pins need to be mapped out. Pins have to go through the MDF pins and come through on the other side. Next step would be to solder the pins to the wire and pass it through the screw top. Since the pill will be floating in the water, it must be properly sealed. After all the pill components are put together, the screwtop can be screwed back in place. The whole that the wire is coming through must be sealed with the food grade silicon and left to cure for at least 24-48 hours. Then the pill setup is complete.

2. Node MCU Housing

1. Bill of Materials

Table 6.2.1: Node MCU Housing Bill of Materials

Material	Quantity	Total Cost (CAD)	Source
MDF	2x2 feet	-	MakerLab Store
Wood Glue	2 mL	-	MakerLab Store
Node mcu Wi-Fi Module	1	6.33	MakerLab Store
USB Cable	1	7.00	MakerLab Store
USB-AC Adapter	1	7.00	MakerLab Store
Total		20.33	

2. Equipment List

Laser Cutter

Laser cutter is needed to allow for quick and precise cutting of MDF for node mcu housing.

Glue

Glue is used to put housing pieces together that were laser cut.

Screwdriver

Screwdriver is needed in some occasions where the glue does not hold and screws may be necessary.

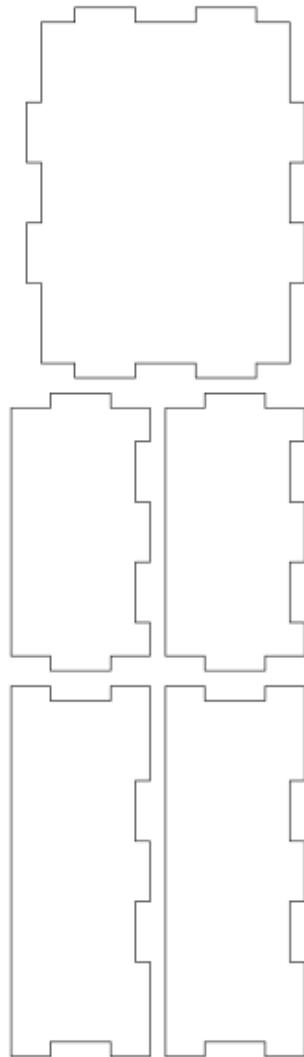
Soldering Iron

Soldering is necessary to connect wires to node mcu and sensors within the pill.

3. Instructions

Node MCU housing is a box made of MDF that keeps it safe and secure on top of the port. In order to put this box together, first a piece of MDF needs to be laser cut. Below is the image of what the file for print for this box looks like - *Figure 6.2.3*.

Figure 6.2.3: Node MCU housing mockup file



After getting all the pieces laser cut, it is now time to put them together. By using wood glue and placing it near the fingers of the sides, put the pieces together. Once the box is fixed, let it dry for a few hours to secure it. Then you need to create an outing for the wire to pass through by using a drill press. Once all is completed, node mcu needs to be soldered in place with the wire to complete the connection to the pill.

3. Tank Port

1. Bill of Materials

Table 6.3.1: Tank Port Bill of Materials

Material	Quantity	Total Cost (CAD)	Source
MDF	2x2 feet	-	MakerLab Store
Wood Glue	2 mL	-	MakerLab Store
Silicone	1	16.35	Amazon Link
Total		16.35	

2. Equipment List

Laser Cutter

Laser cutter is an efficient tool for port creation. We used a laser cut to create pieces of the port that we later glued/screwed together.

Glue

Glue is used to keep the components of the port together.

Screwdriver

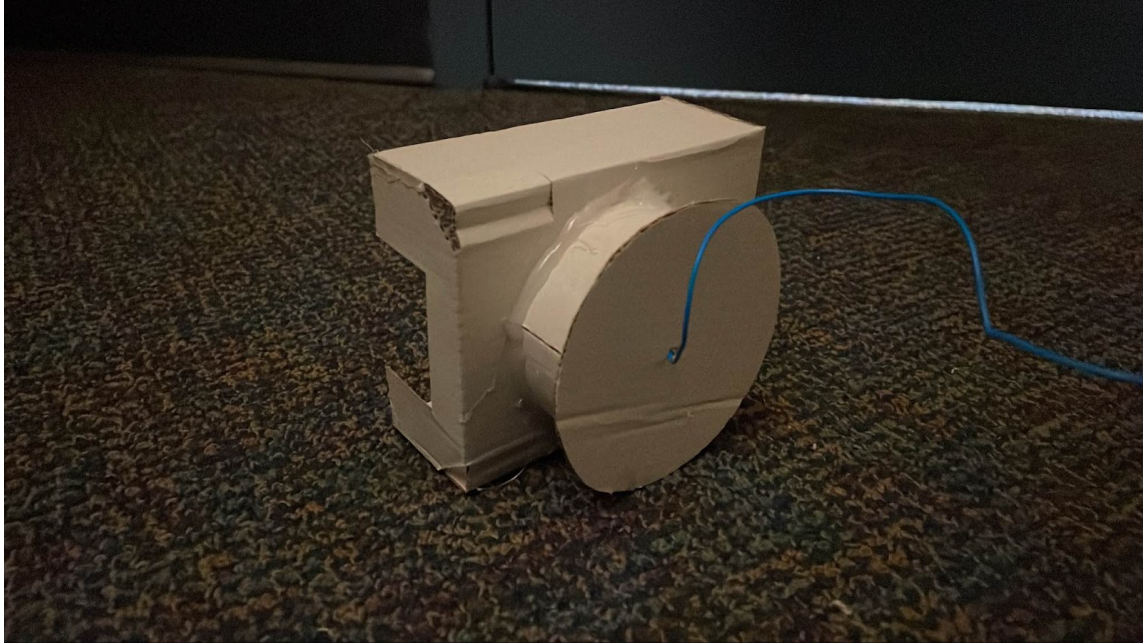
Screwdriver is needed in some occasions where the glue does not hold and screws may be necessary.

3. Instructions

The port is used to close the tank opening through which the wire passes through. It is secured using clamps. For this prototype, a thicker version of MDF was used. However, that is not a perfect material choice. Going forward, metal or plastic is recommended.

By using a laser cutter a 2.78 inch circle in diameter needs to be cut. Using the drill press, an opening needs to be made for the wire to pass through. The port can then be attached at the back of the node mcu housing box using either wood glue or screws. If wood glue is used, it needs to be set for at least 1-2 hours to secure it. For the setup, refer to the image below - *Figure 6.3.3*.

Figure 6.3.3: Node MCU Housing and Port setup

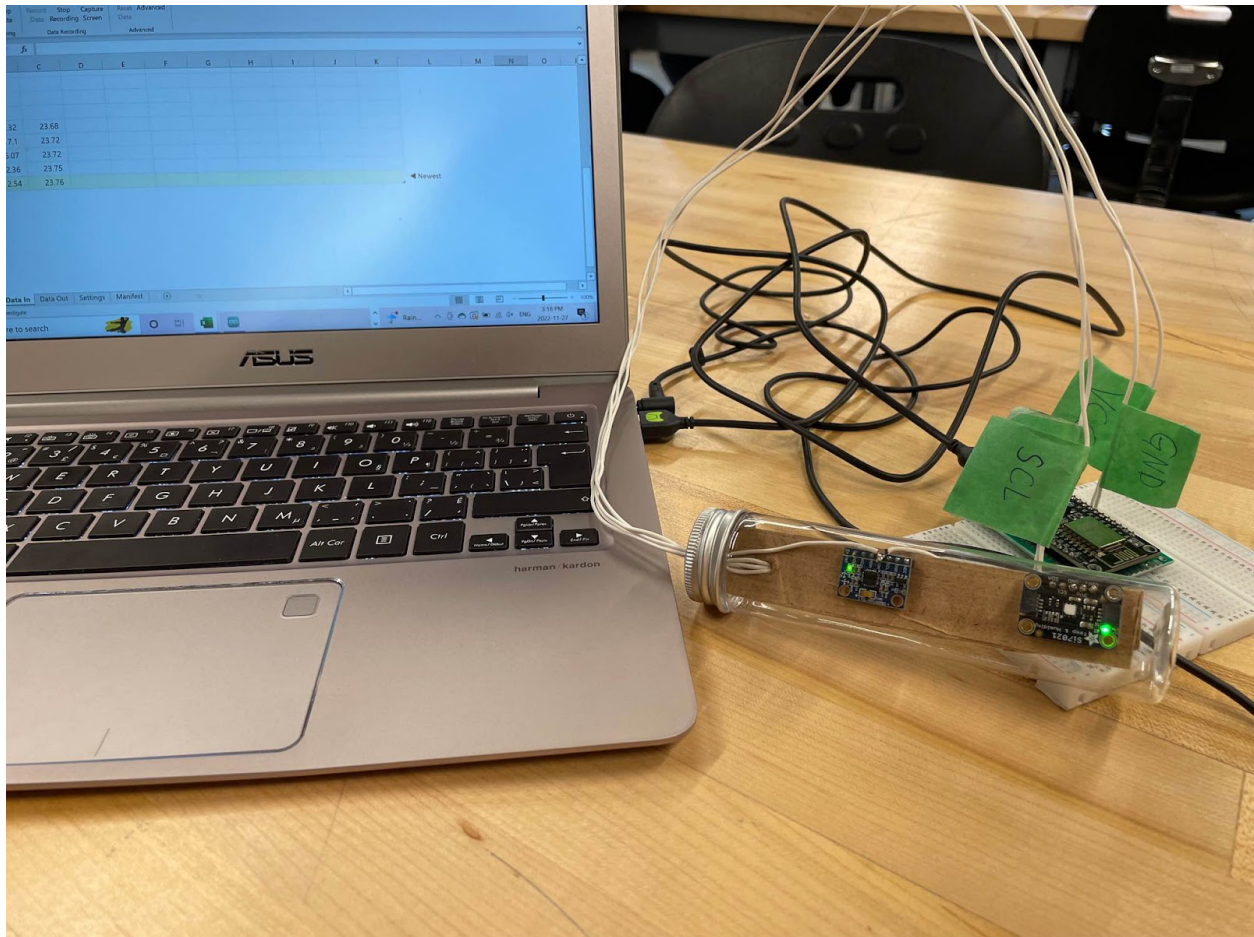


4. Testing and Validation

There are a few different tests that have been performed on this device to ensure secure and aesthetic set up but also proper functionality. First off, our team verified the performance of the pill cell. Since all the components such as sensors will be securely sealed within the pill, it had to be perfectly waterproof to prevent any damage to the sensors. To verify that it was secure, we used food grade silicon to close all the spaces where the water could possibly leak through, let it cure for 24 hours and then submerged it in water for 15 minutes. Since we cannot 100% confirm the seal without a visual indicator, the pill was filled with paper that upon contact with even a small amount of water would become visibly wet. Upon visual inspection, we noticed that the pill was secure and no water was inside. We then proceeded to install the sensors and seal them within the pill.

The next few tests involved the functionality of the pill - *Figure 6.4.1*. The first sensor that was connected within the system was the temperature sensor. We collected a few air temperature readings to confirm whether it was working properly. The temperature was referenced to a regular thermometer and was accurate. Hence the temperature sensor passed the test and was functioning properly.

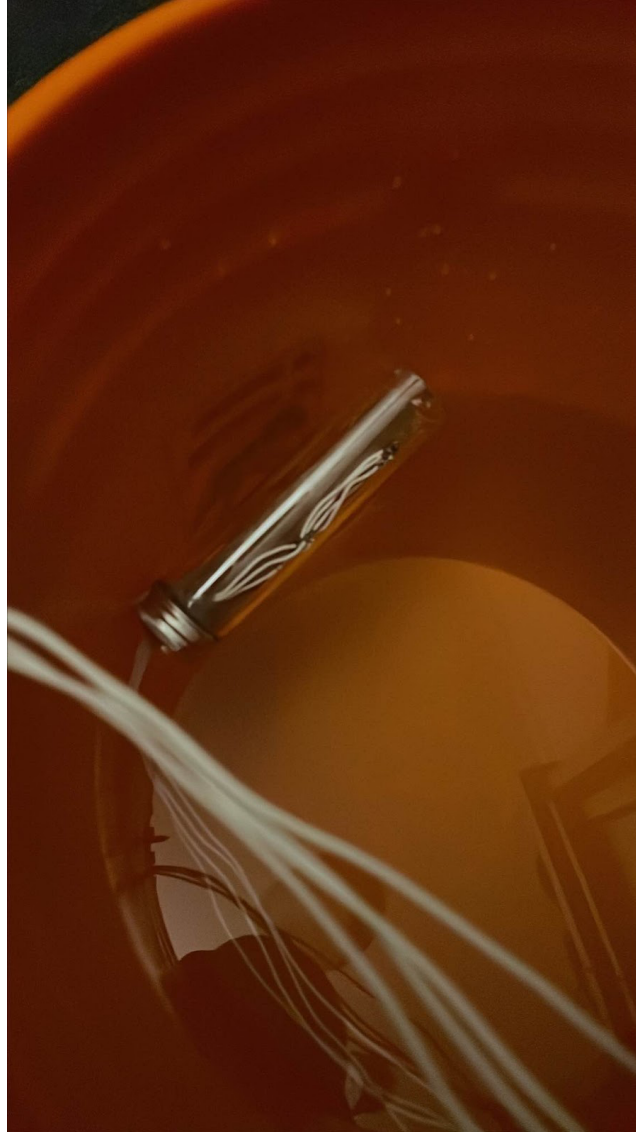
Figure 6.4.1: Functionality Testing



The next step was to evaluate the performance of the gyroscope and accelerometer. Once they were added to the system, we also collected a few measurements. We used 90 degrees and 45 degrees angles measured using a ruler, to compare the accuracy of the readings received. Both the accelerometer and gyroscope received decently accurate readings. However, one reading was not enough to receive an accurate result. We noticed that readings usually came within a range, so to get the most accurate answer, an average of all readings must be taken.

Once we ensured all the parts of the system were functioning, we tried to receive a few measurements in a bucket of water. Unfortunately, due to limited project time, we were not able to collect a significant amount of readings to estimate a proper measurement error. However, the device was indeed collecting angular and temperature measurements within the bucket of water

Figure 6.4.2: Image of the final test



7. Conclusions and Recommendations for Future Work

In conclusion, our team believes we made great progress with the time and budget provided. However, there are quite a few things we wish to improve upon. First off, we would like to 3D print the insert for the sensors within the pill. We believe it would attach to the screw on the cap better. It can also be weighted to provide more accurate measurements.

Secondly, we think making the node mcu housing from plastic or metal would make it more secure and aesthetically better looking. Additionally, adding an acrylic top to be able to see inside the box would provide a more professional look. As for the port, going forward we would like to see better materials such as metal or plastic to ensure a device that would be more durable.

Finally, better sensors and further testing can help make this device better for our client. We were limited on time with how much we could test our device. However, placing it into different liquids and collecting measurements can help calibrate it to receive more accurate measurements.

APPENDICES

8. Appendix I: Design Files

Table 9.1: Referenced Documents

Document Name	Document Location and/or URL	Issue Date
Needs and Problem Statement Identification	https://makerepo.com/sofiyafonareva/1329.gng1103b17beforet hepale	October 2, 2022
Design Criteria and Target Specifications	https://makerepo.com/sofiyafonareva/1329.gng1103b17beforet hepale	October 9, 2022
Conceptual Design	https://makerepo.com/sofiyafonareva/1329.gng1103b17beforet hepale	October 16, 2022
Project Schedule and Cost	https://makerepo.com/sofiyafonareva/1329.gng1103b17beforet hepale	October 23, 2022
Prototype I and Customer Feedback	https://makerepo.com/sofiyafonareva/1329.gng1103b17beforet hepale	November 5, 2022

Prototype II and Customer Feedback	https://makerepo.com/sofiyafonareva/1329.gng1103b17beforet hepale	November 13, 2022
Prototype III and Customer Feedback	https://makerepo.com/sofiyafonareva/1329.gng1103b17beforet hepale	November 27th, 2022