University of Ottawa
GNG 1103-B00: Engineering Design

Project Deliverable D:

Conceptual Design

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Abstract

In this deliverable, each group member created and presented conceptual designs based on the design criteria and target specifications set in the previous deliverable. Each conceptual idea was evaluated and discussed by the group, in order to combine the concepts to create three complete project concepts.

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Introduction

In the previous deliverables, the user's needs were identified, and from this a list of design criteria was established. In this document, each group member presents a conceptual design based on the previously identified design criteria. Once these concepts are presented, we will evaluate and combine them to come up with three complete project concepts as a group, which we can present to our client, and eventually choose as our final concept. We divided our concepts into three groups, an input subsystem that shows the external factors of the product. The data processing subsystem that shows how the calculations and coding software will work, and finally the output subsystem which will show how the data is displayed to the user.

Conceptual designs

There will be three separate complete designs with multiple designs of subsystems made by each member.

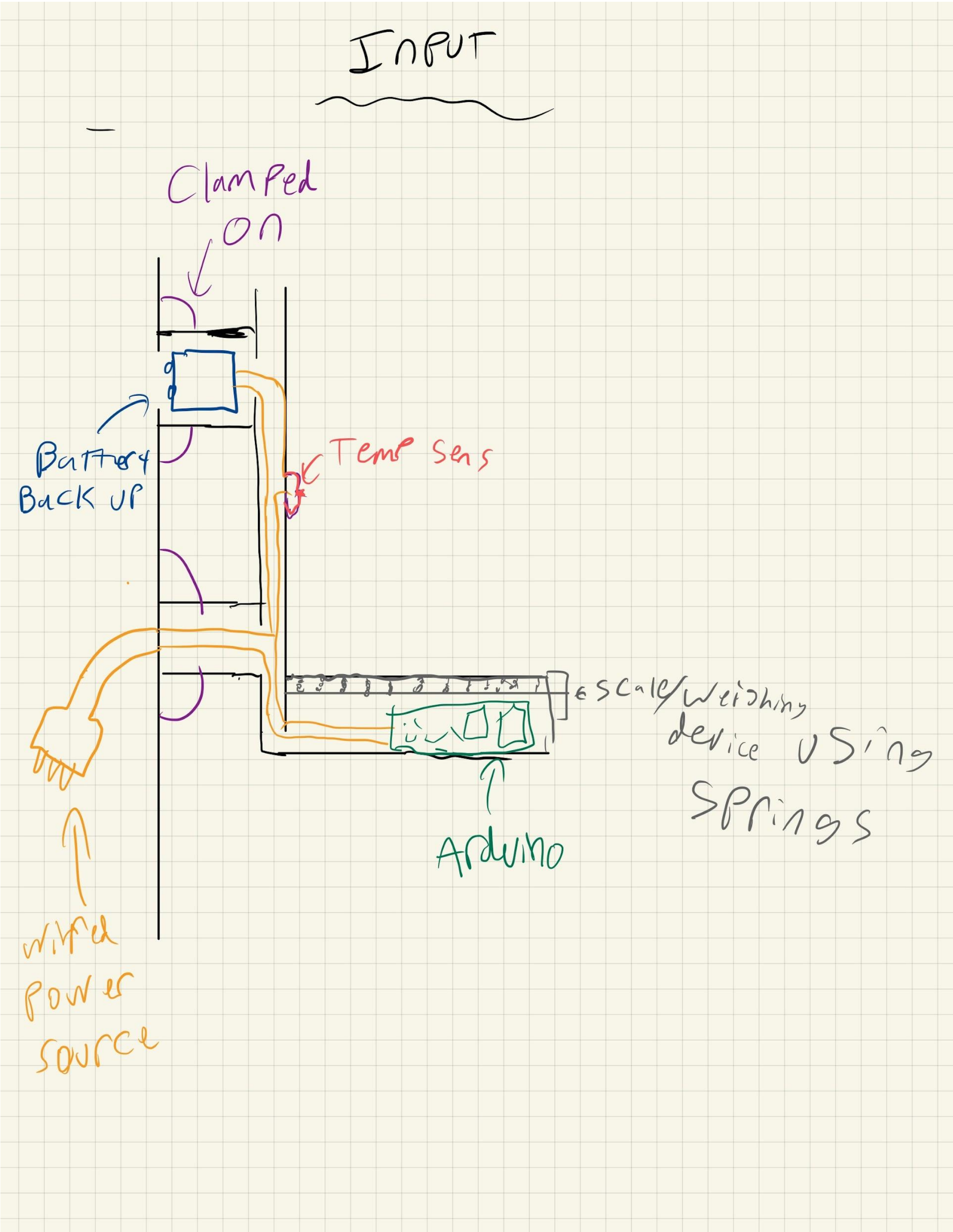
- **Input -** The First subsystem known as the input/microcontroller is the subsystem that shows in detail what will be used to measure certain aspect of the beer and how they will be measured. It is also used to show how the product will be attached to the tank. (External parts)
- **Data Processing -** The second subsystem is known as the Data processing subsystem which is how the data taken from subsystem 1 is used to calculate the data needed by the user. It is to demonstrate the calculations and how the coding will work.
- **Output -** The third subsystem is known as the output of the device. The design of this subsystem should show what the data should look like after being outputted from the second subsystem. (What the User will see when looking at the wanted data)

1. First design
    a. Input
    b. Data processing
    c. Output
2. Second Design
    a. Input
    b. Data Processing
    c. Output
3. Third Design
    a. Sensor and Microcontroller
    b. Data Processing
    c. Outputs

First Design

A. Subsystem 1 (input) - Designed by Christopher Al-Rahi

This subsystem is meant to show that the device wil be clamped on to the fermentation tank from two different support layers. Both of which are hollow for the purpose of having the wires and energy source running through them. The battery is placed on the higher support and the wired power source runs through the lower support and into an outlet. The temperature sensor will be near the middle of the device to get the temperature of the beer and to measure the pressure near the center. The scale at the bottom is meant to measure the weight by using the distance at which the beer moved the springs to calculate the weight of the beer inside of the design. The arduino will be placed in the small space left below the spring and it will be connected through the hollow space left around the edge of the product to connect all the wires of all sensors together.



B. Subsystem 2 (Data Processing) - Design by Christopher Al-Rahi

The data processing aspect will be within the coding software we develop. This coding software will take the temperature, mass, and pressure logged by the arduino and input it into the formula SG = m/1000 which was obtained by doing calculations with all the constants in several formulas to obtain the formula of specific gravity. The specific gravity obtained and the temperature given by the arduino will then be graphed using the software and sent to the output subsystem.

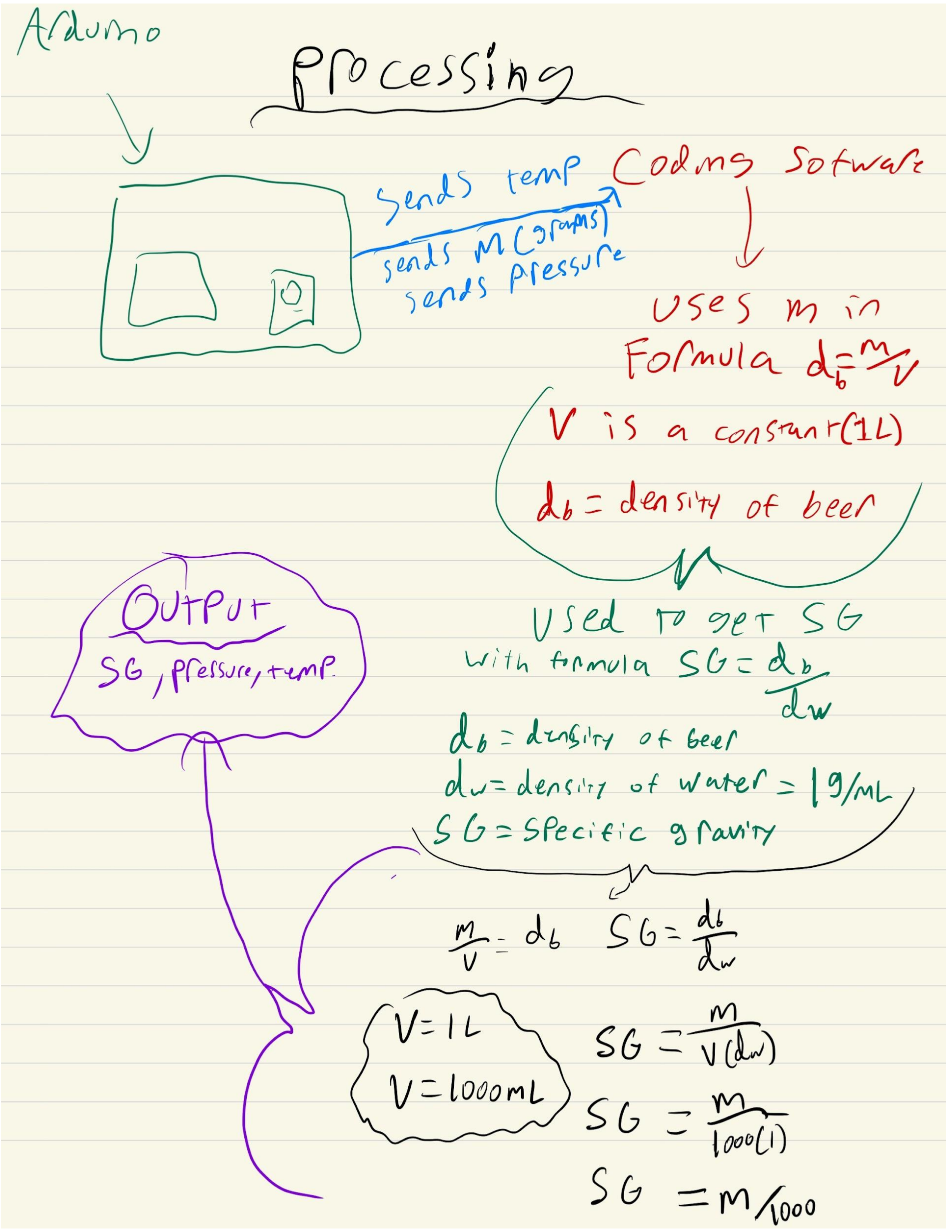
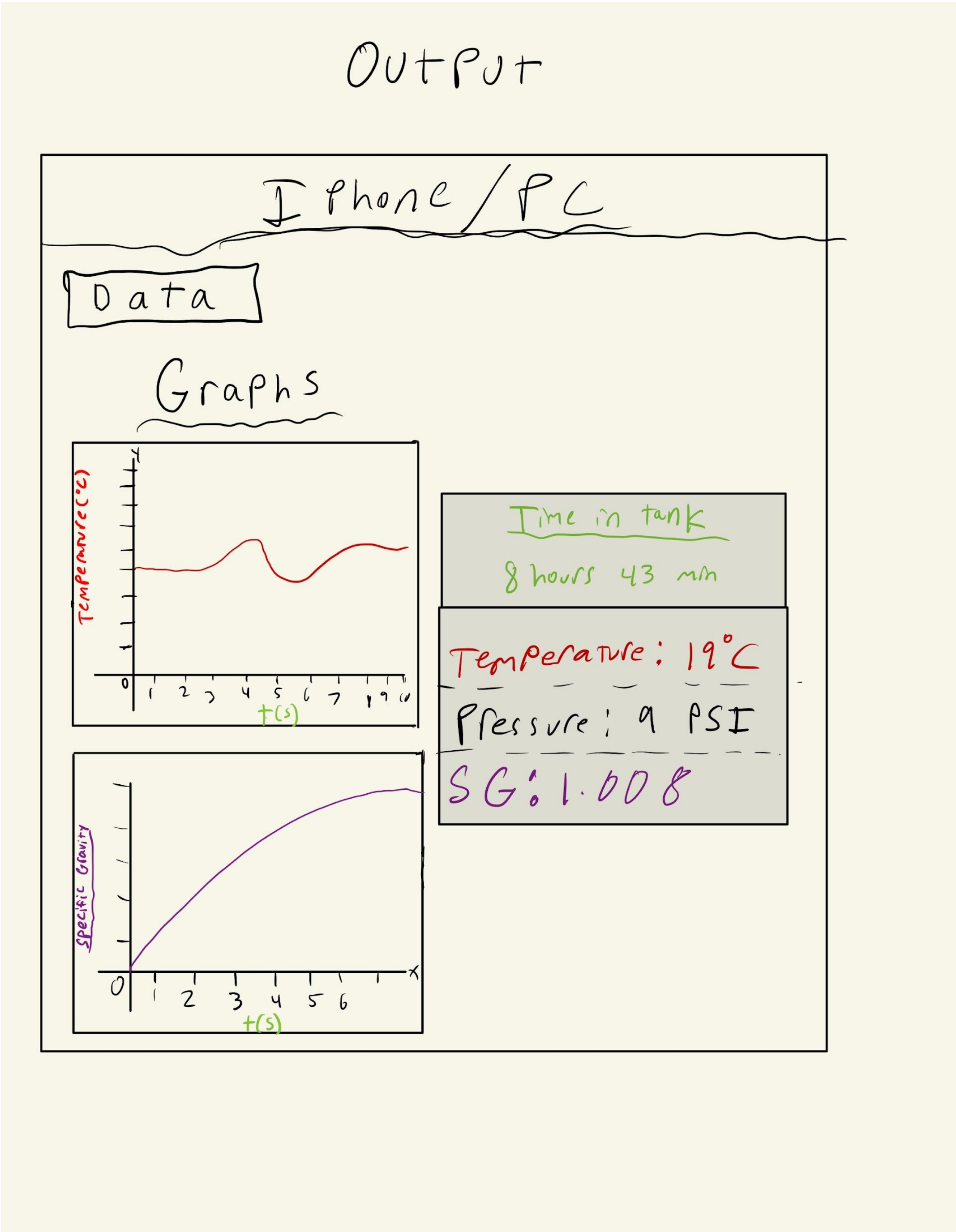


Photo above explain how the coding software calculated the formula for specific gravity using the mass. V is a constant because the volume of our device will always stay the same.

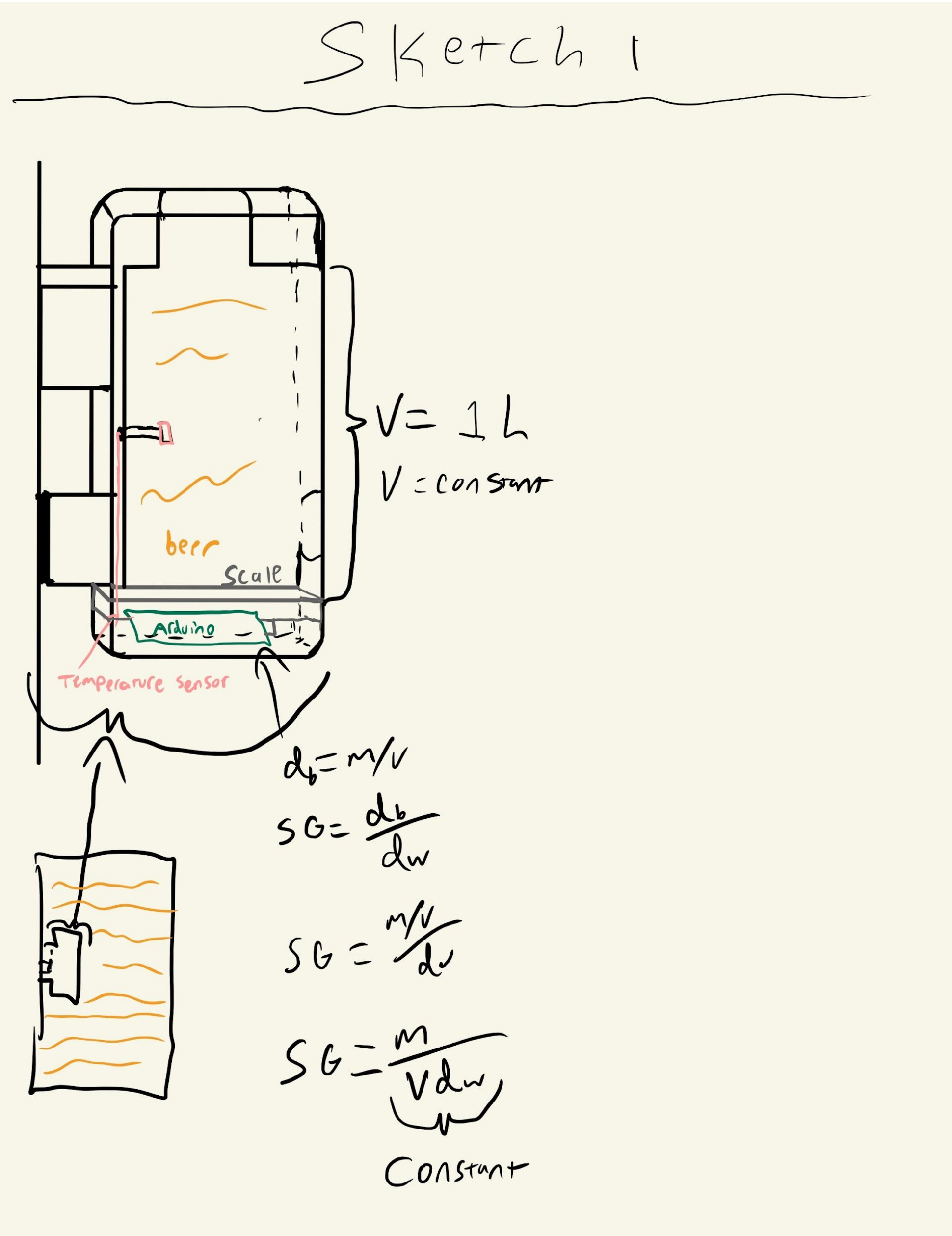
C. Subsystem 3 (Output) - Designed by Christopher Al-Rahi

The third subsystem displays how the information will be displayed to the user. After the second subsystem sends all the needed info, it will be outputted on an app created by us that will show 2 graphs, the temperature, pressure, and specific gravity. The app will also give you an option to click on “data” to check the previous logged data from whatever dates you desire.



D. Completed design 1 - Designed by Christopher Al-Rahi

The final sketch is created after combining all three subsystems. This product will be attached to the side of the fermentation tank and will measure the temperature, specific gravity and weight of the beer. This data will be transferred to a software that will calculate the specific gravity using the mass. All the final data will be sent to the output subsystem that will display all the data in a favourable display.

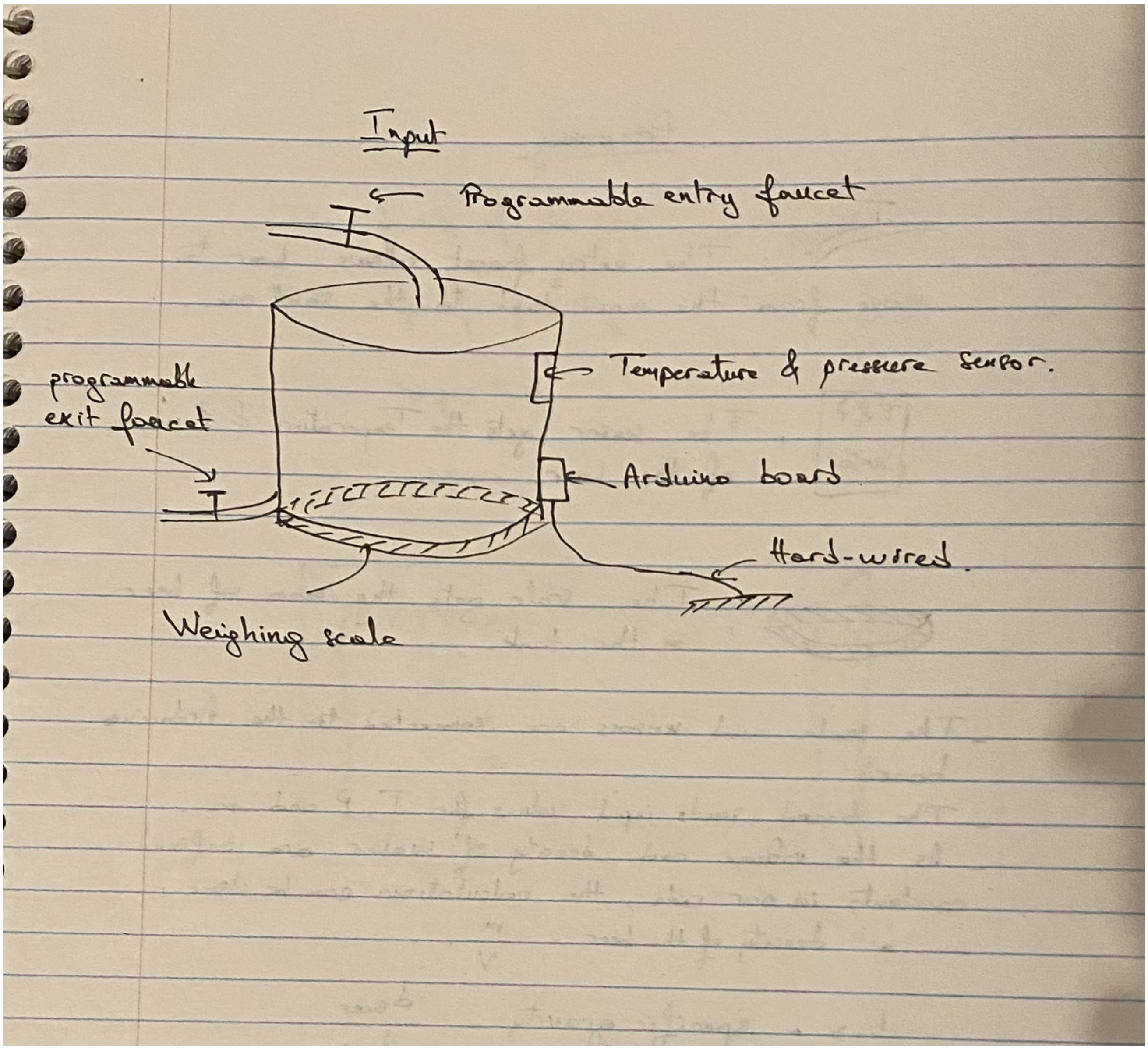


The photo above shows what the product will look like close up as well as how it will be while attached to the fermentation tank (bottom left)

Second Design

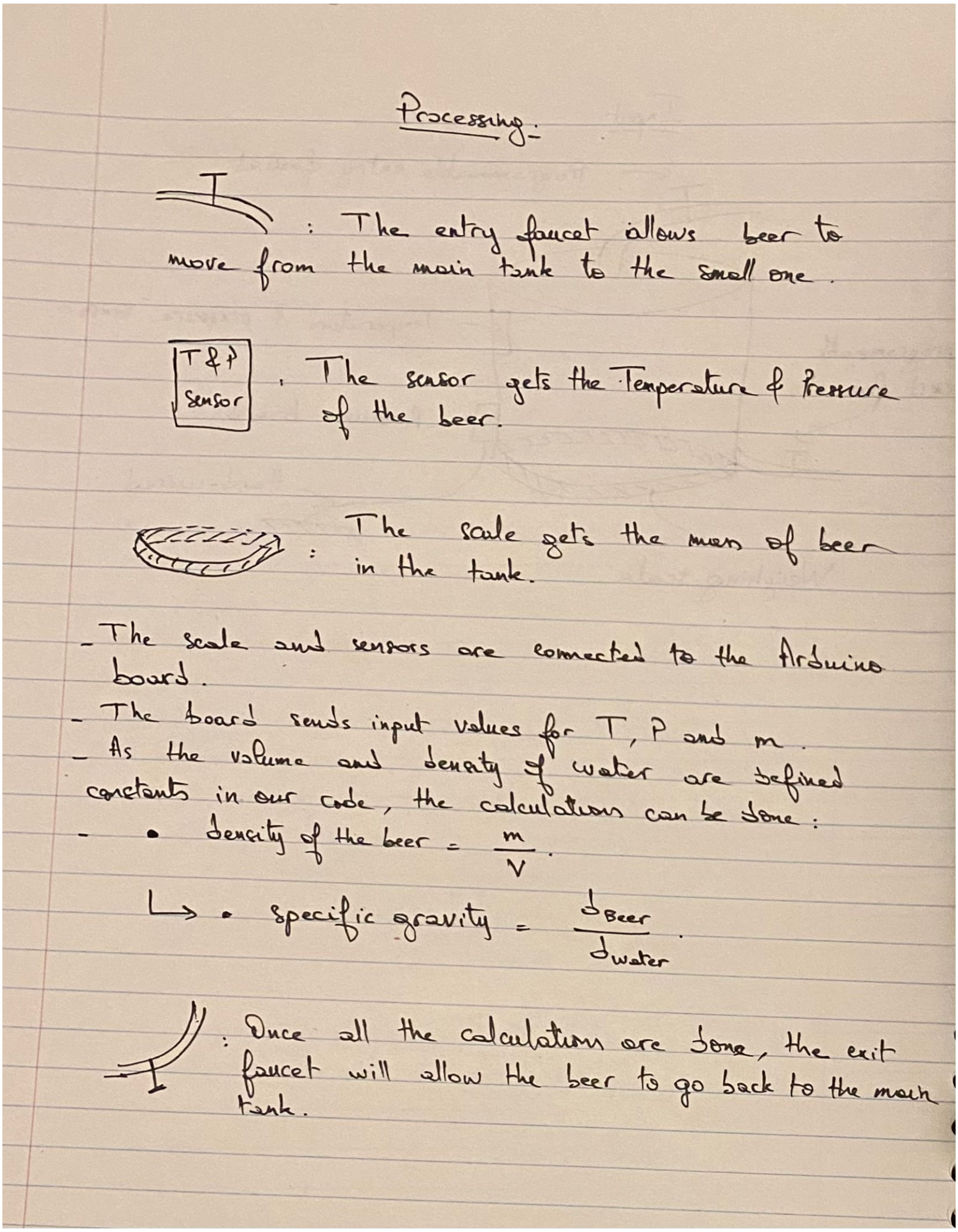
Designed by Mohamed Reda Raki

A. First subsystem (input)



The weighing scale and the temperature and pressure sensor are going to get the input values for the mass m, the temperature T and the pressure P.

B. Second subsystem (processing)



Processing:

: The entry faucet allows beer to move from the main tank to the small one.

T&P Sensor

: The sensor gets the Temperature & Pressure of the beer.

: The scale gets the mass of beer in the tank.

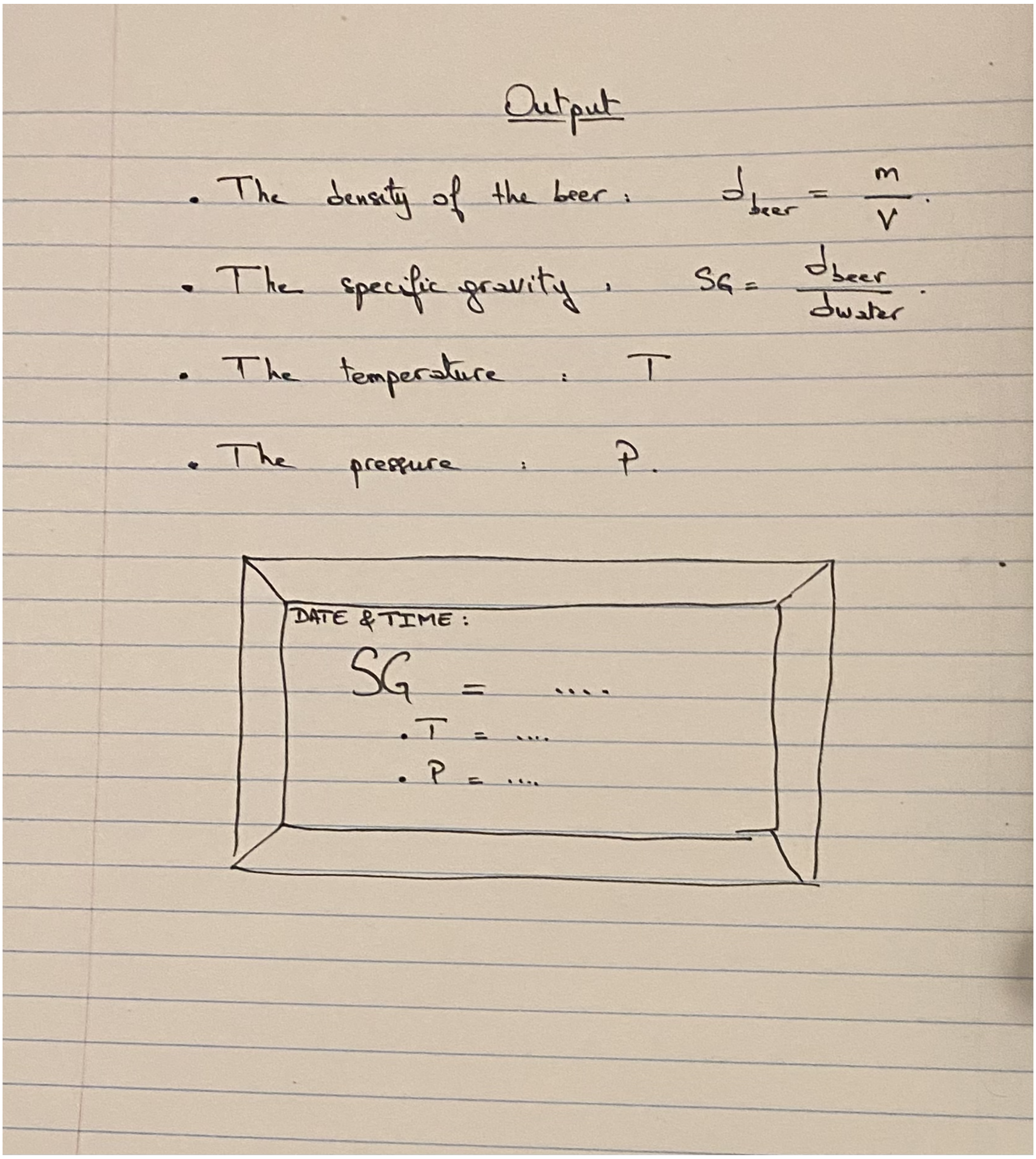
- The scale and sensors are connected to the Arduino board.
- The board sends input values for T, P and m.
- As the volume and density of water are defined constants in our code, the calculations can be done:
  - density of the beer $= \frac{m}{V}$.

  ↳ • specific gravity $= \frac{d_{Beer}}{d_{water}}$.

: Once all the calculations are done, the exit faucet will allow the beer to go back to the main tank.

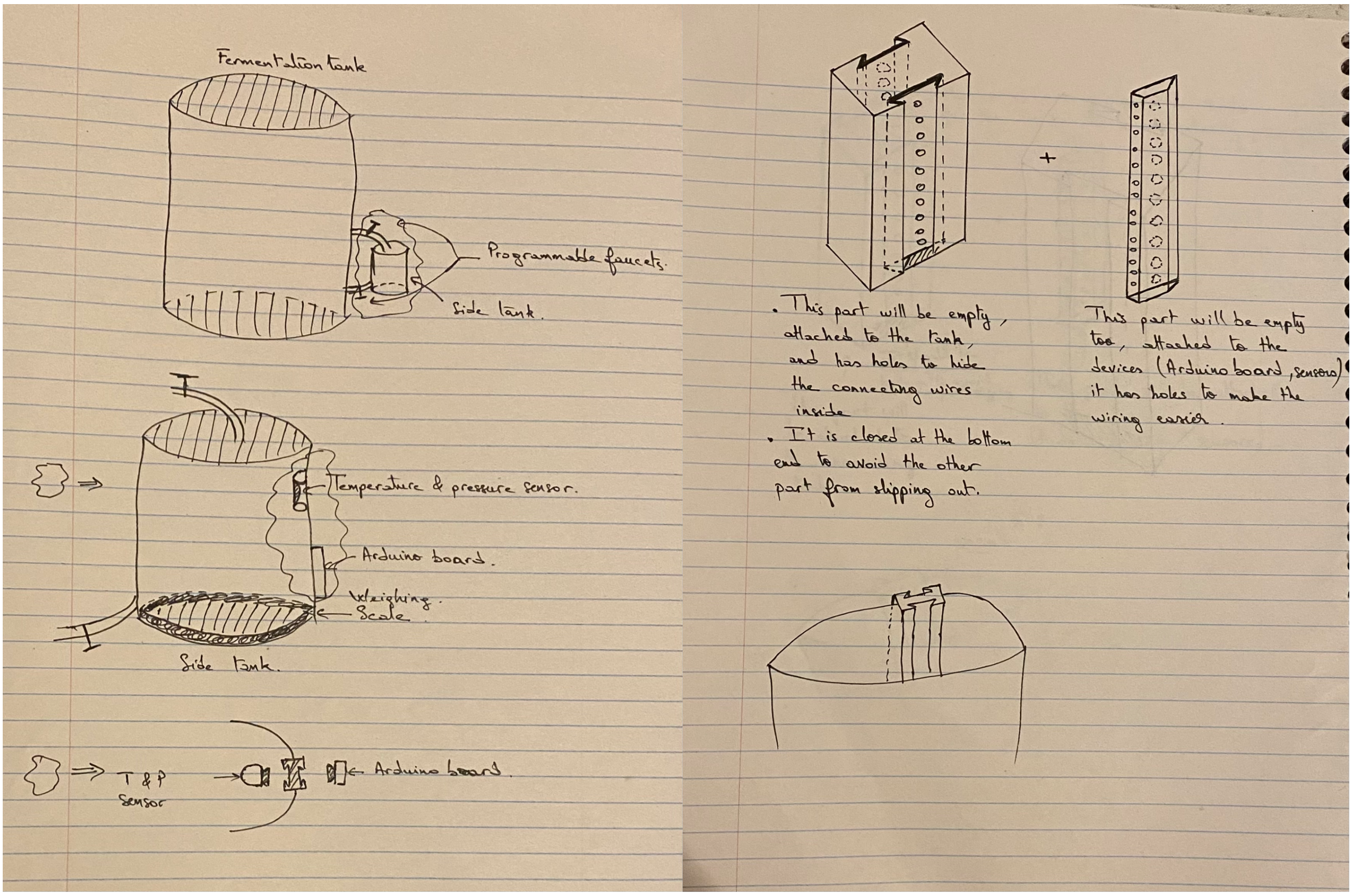
Through the arduino board, the input values are going to be used by our program to calculate the specific gravity.

C. Third subsystem (output)



Once all the calculations are done, the output screen should display the value of the specific gravity, as well as the values of temperature and pressure measured by the sensor.

D. Completed design 2



In this sketch, the device is basically a small tank that is attached to the big fermentation tank, to make sure the process happens in a closed system. Each connecting part has a programmable faucet to control the transfer of the liquid between the two tanks. The small tank contains a weighing scale at its bottom, a temperature and pressure sensor mounted inside, and the arduino board mounted outside. The sensor and the board are going to be mounted using a sliding system that allows wiring as well, so that the device remains aesthetically pleasing.

Once the input faucet is open, the small tank is filled with beer and the scale weighs it. Since we already know the volume of the tank, we can easily get the beer's density by dividing the mass by the volume. The specific gravity is then calculated by dividing the density of the beer by the density of water.

Third Design - Pressure Sensor

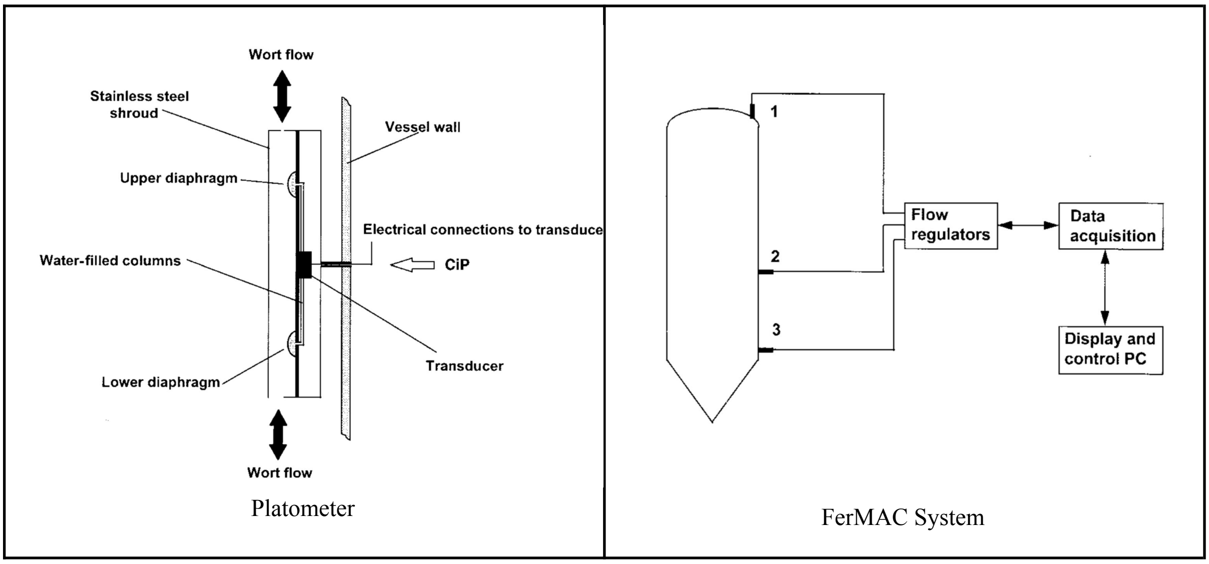
Design by Rebecca Kimbell and Abby Falkenham

Sensor and Microcontroller

Method of finding the specific gravity:

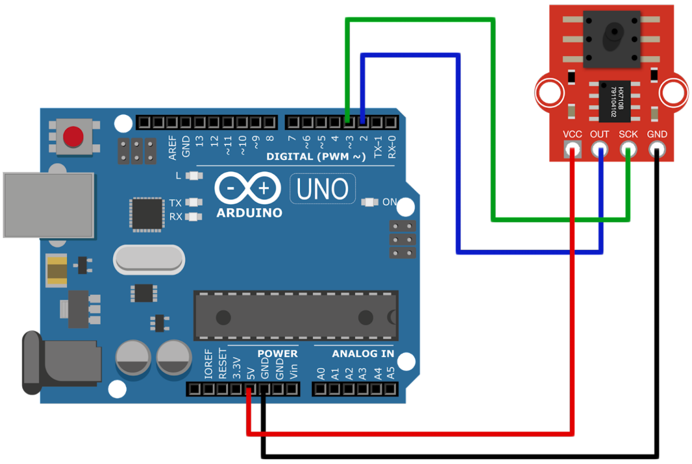
One method of finding specific gravity is using pressure sensors within the tanks to measure difference in pressure. Difference in pressure measured at different depths within the vessel is a direct function of the density. This method of measuring specific gravity has been explored before. For example the FerMAC system uses three pneumatic pressure balance transmitters located in the tank. Comparison of output from the top and bottom sensors provided a level reading and the difference in pressure of the two lower sensors could be related to specific gravity. The Platometer used diaphragms to sense the pressure, which was transmitted to a transducer and converted into an electrical signal. (Boultan and Quain, 2005)

Figure 1: Existing systems that use pressure measurements to find specific gravity.



(Boultan and Quain, 2005, p.411, 412)

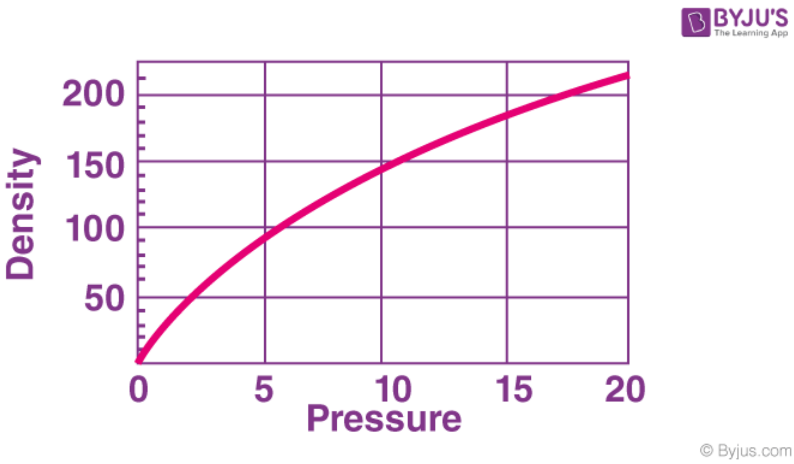
For the microcontroller in this idea we would have to have something that has inputs and outputs. We need this so that the information coming from the pressure sensors could be connected to the arduino board and then process the data to be sent to the computer storing the data. Our output from the arduino board in this design would be a cable from the arduino board to the computer where it is being processed in the IDE software. The ideal arduino board that can process our data would be an Arduino Uno Rev3.



The above picture shows the input being from some kind of a pressure sensor. This image does not exactly describe our design as our pressure would be measured using our sensor instead of what is shown. We would need to use the IDE software to code for the arduino board on how it would be processing the data.

Data Processing

$$P = \frac{\rho V g}{A g_c}$$



As briefly described above with the sensor, the specific gravity can be found by taking two pressure measurements at different heights. For the data processing in this design we would use the Arduino to get the data and this data would be processed and coded using the Arduino IDE. This code would have to take the two pressure sensors and would use the pressure formula for fluids(shown above) to find the density of the liquid. This code would then take the density found and divide it by the density of water (1) to find the specific gravity.

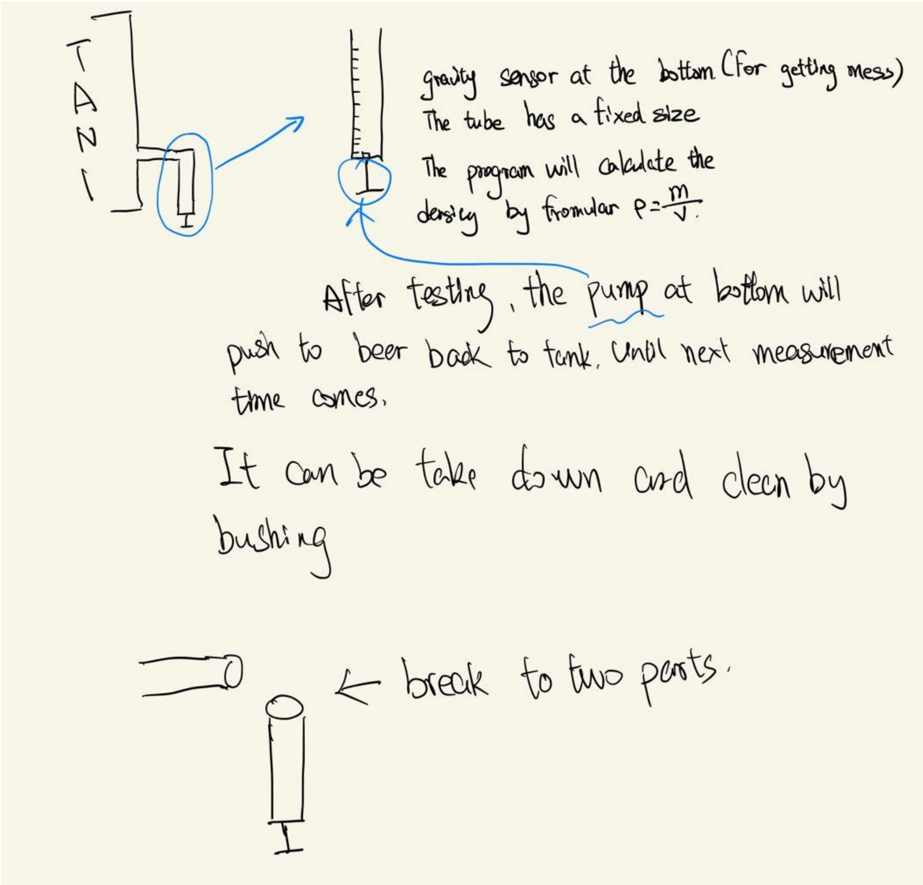
Outputs

To store and display the data, a database and graphing software is needed. Data can be stored using an SQL database, which would maintain and provide access to data. To display the data, a graphing software is needed to call on data in the database, and display it as a graph. These graphs need to be stored forever. A software that would be compatible with these needs is grafana graphing software.

Figure 2: Example of Grafana display of plant growth data using Arduino sensors.

(Huckova, 2021)

Rough draft of input/sensor (Alan's sketch)



This device contains:

1. two tubes
2. one pump
3. one sensor

The tubes will connect together like an "L" shape. It will stick to the tank with the longer side down. The sensor is at the bottom of the tube. Once the beer flows in, it will gain the data (gravity). Since we already know the volume of the tube, the formula of density is satisfied. We will use a program to calculate the density and plot it on a graph depending on user request.

Once the breeding is down. The device can be plugged off and taken apart to two parts. Each one of them can be cleaned easily with a brush.

Conclusion

Based on the design thinking process we are following, we have created several sketches of subsystems for our product based on our problem statement. We used all the data acquired during our last deliverable of benchmarking and developed several paths of how our product could look like. We laid out several subsystems that all of our group members came up with, and we also explained three fully thought out designs. These designs will later on be presented to the client so that we can decide on our final product.

Wrike

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=7x2dIVpYQ6cKaDcZhVZgXSW3MNig0ZJb%7CIE2DGNRTGEZTMLSTGE3A

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