Deliverable E - Project Plan and Cost Estimate

GNG 1103
Introduction to Engineering Design

To:
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Wrike Link: https://www.wrike.com/open.htm?id=969517643

1.0 - Introduction

The following deliverable addresses the cost estimate, the equipment/software required, and final design for the specific gravity measurement device. The conceptual design was chosen in the previous deliverables from 3 main subsystems: 1. Measuring the gravity, 2. Display the results, and 3. Connectivity and Physical Build on the device. With these subsystems in mind, we decided to choose Alec's method of measuring the specific gravity, Gabby's method of displaying the results, and Alec's method of physical build/connectivity. In addition, an extra feature of adding a buzzer in order to demonstrate when the specific gravity reached a critical value was thought to be included. These ideas changed to a green and red led light design once feedback was received from the client at the 2nd client meeting.

2.0 - Final Design

Recap of our Design selection:

1. Measuring the Specific Gravity = Alec Plourde's Idea: Orifice plate
2. Display of the results = Gabrielle Graceffa's idea: LED Screen display the visible specific gravity number
3. Physical built and connectivity = Alec Plourde's idea: physical built for plate and pressure tubes
4. Extra Features included = red and green LED lights (to indicate when the specific gravity is in a good or bad range)**

***Note: The buzzer idea was replaced with visible LED lights after feedback from client meeting 2. This is in regards to the loud noises present at the brewery wich makes having visible lights superior*

The circuit design for this project can be seen below to which the volumetric flow meter, the differential pressure sensor, the LCD screen, and the LED lights can be theoretically wired (see Figure 1). This design will allow us to understand the required pins, voltage, and current required to fully operate this device. Likewise, a final 3D sketch of our device can be seen below. Our prototype will be separated into various parts in order to accommodate all sections and requirements. In order to accurately fit the volumetric flow meter in between our pipe design, parts 1 and 2 will fit the device in between them. The first part (see figure 2.0), which will be connected before the volumetric flow meter, is ½" inch tap threaded and will be a total of 1" in length. The non-edged threaded side will be used to secure a tri clamp with the in-line system along with a filter. The second part (see figure 3.0) will include the first pressure tap along with a plate to attach secure the orifice plate. The other part for the orifice plate (see figure 4.0) will have the second pressure tap along with the same plate for the orifice. The specific orifice plate design can be see in figure 5.0. To see how parts 2&3 will fit with the orifice plate, figures 6.0 and 7.0 demonstrate the assembly and drawing layout of these parts. In order to transport and

safely store all items, a custom box design was created (see figure 8.0) with an elevated platform for easy accessibility to the LCD screen. A schematic layout of our device between each part interaction/connection can also be seen in figure 9.0.

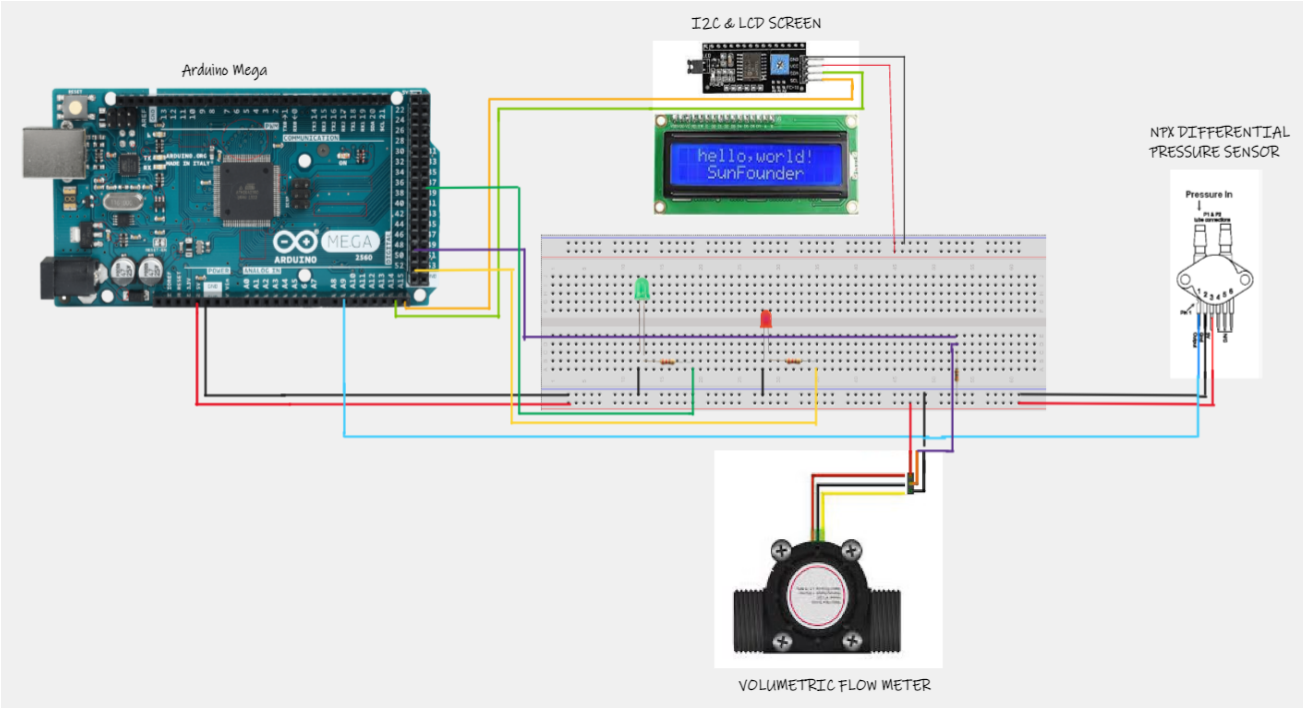

Figure 1: Circuit Diagram for Final Design

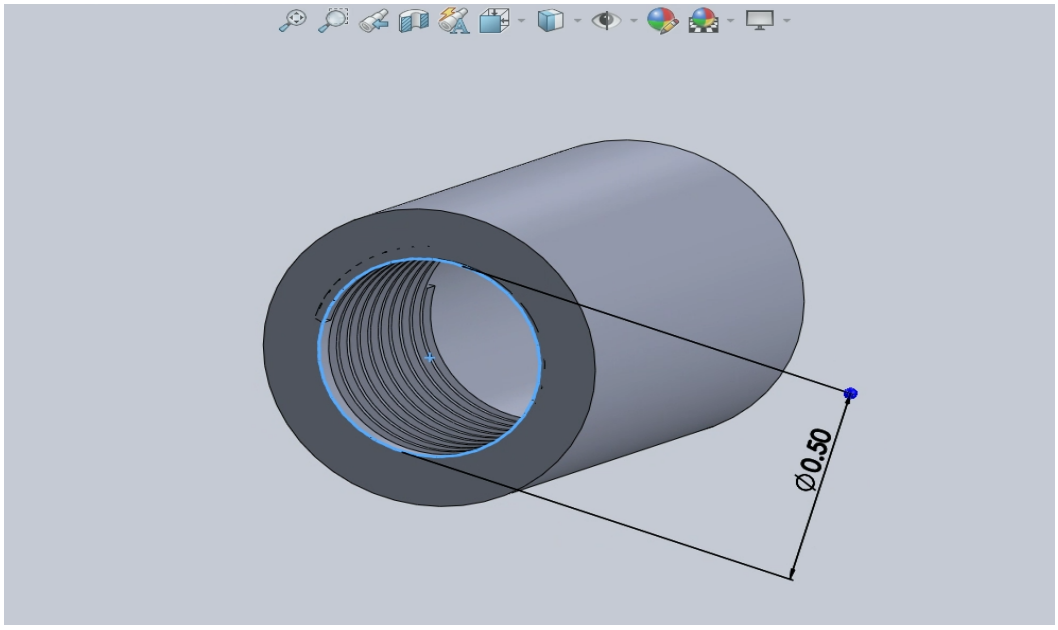

Figure 2.0 - SolidWorks Part 1 pipe Design

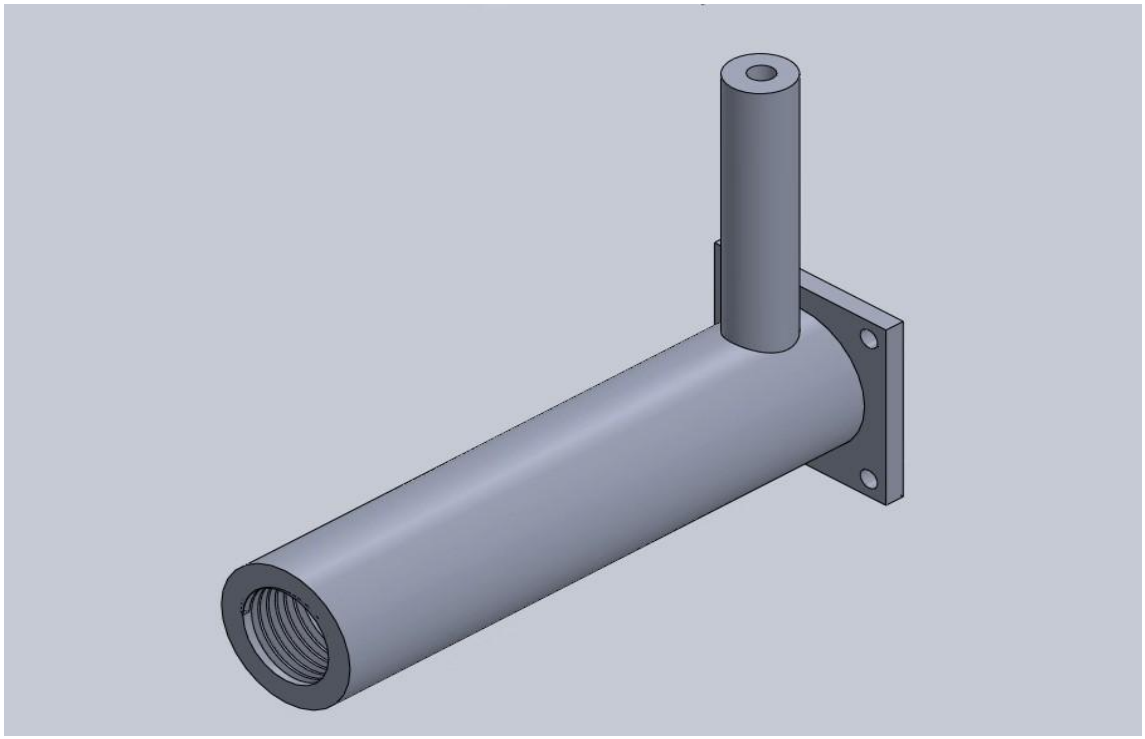

Figure 3.0 - Part 2 of design (left end connected to Flow meter and right end connected for orifice plate)

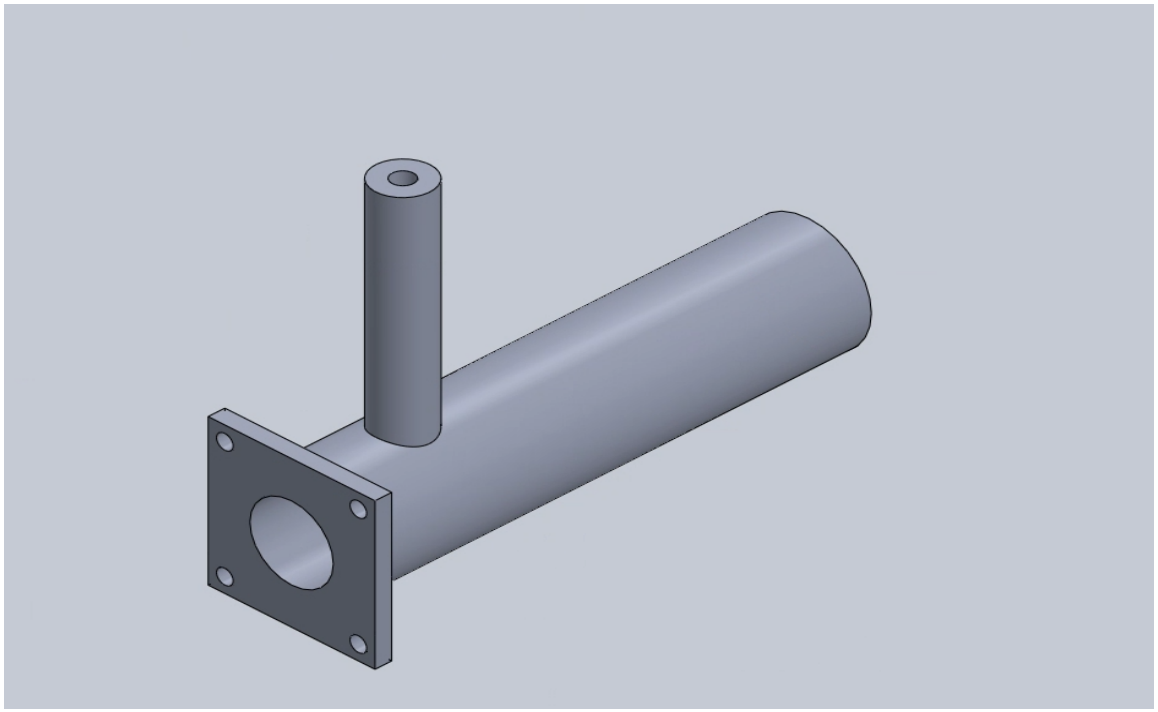

Figure 4.0 - Part 3 of the pipe design (the right side of the orifice plate)

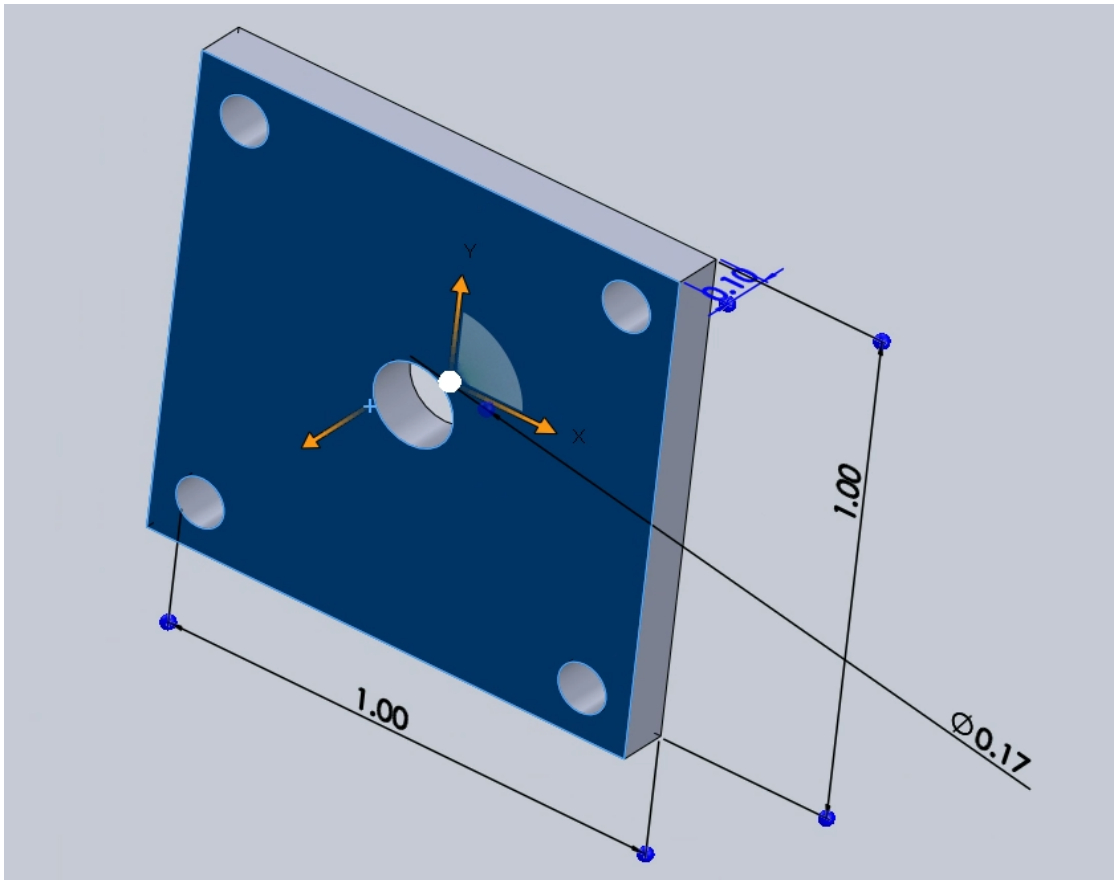

Figure 5.0 - Orifice plate Design

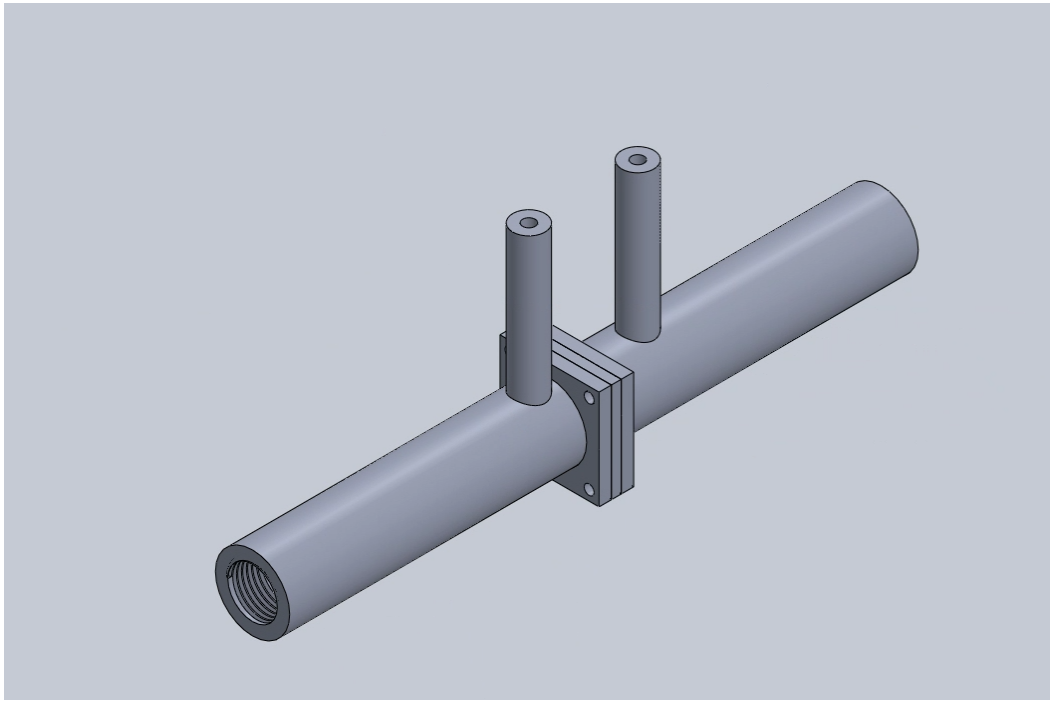

Figure 6.0 - Assembly of the orifice plate and parts 2&3

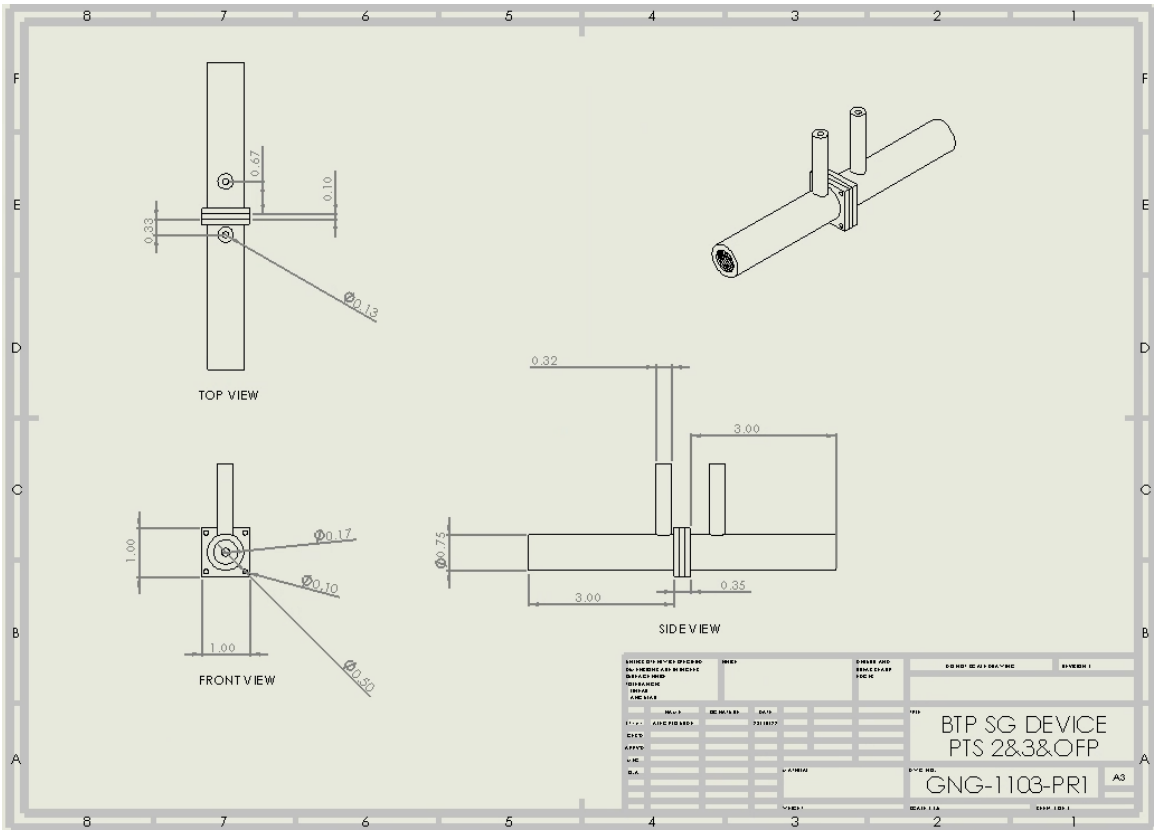

Figure 7.0 - Parts 2&3 with the orifice plate design

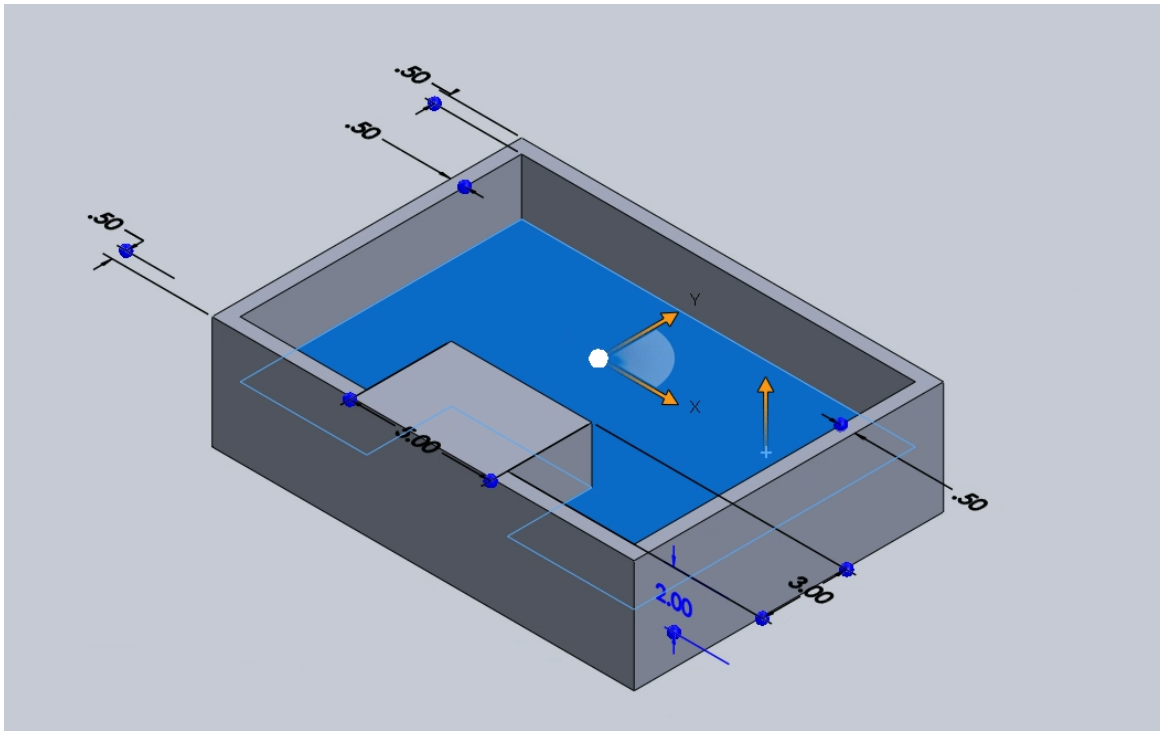

Figure 8.0 - Box to Hold parts along with platform for LCD screen

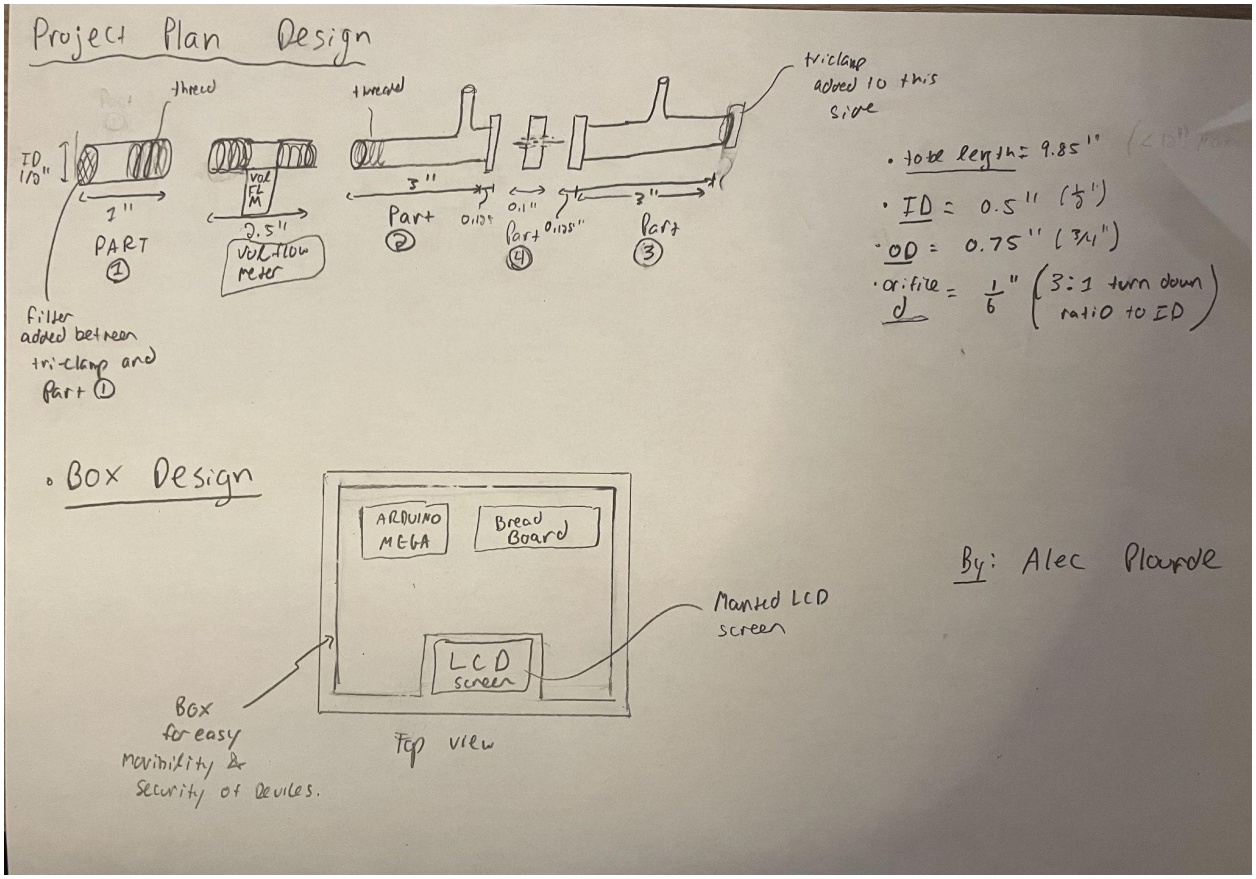

Figure 9.0 - Schematic Layout of Part Interactions and Layout

3.0 - Bill of Materials Table

Amount of materials	Device Name	Estimated cost $CAD	Explanation	Source
1	Arduino Mega 2560 Rev3	0	Alec has one; an arduino mega is needed because there are a lot of sensors that need to be plugged in to it	Arduino
1	Pipe and Design Material (Plastic)	0	The pipe and physical design will be made with recycled plastic and 3D printed plastic parts from the Uottawa printers	N/A
4	Filters	9	To capture all the yeast	Filter
1	Breadboard	0	Alec has one: in order to connect all required sensors and devices to the arduino	N/A
2	LED light (green and red)	0	Alec has one; to demonstrate the specific gravity and to blink the correct color that goes with the specific gravity	N/A
3	Resistors (2x10kOhm) and 1(220ohm)	0	Alec has them; they will be used to correctly wire the LED lights along with the volumetric flow meter	N/A
1	Orifice plate	0	The protoype is 0.5” ID in diameter; therefore, the orifice plate must be smaller. The plate is designed by onshape CAD and produced by a 3D printer on makers lab offered free for UOttawa students	N/A
1	Differential sensor plate	38	To read the difference in pressure between the 2 pressure points (one before and one after the orifice plate)	Differential Pressure Sensor
1	Tubes	10.49	To transfer the pressure readings from the taps to the differential pressure sensor device (5mm ID is required)	Tubes
5	Pneumatic Hose Fitting	15	To connect the tubes into the piping device based on the 3/16” ID of the tube and the slot created for the fitting	Tube 3/16” fitting
1	Volumetric Flow Meter	26	To calculate the amount of liquid that is passing through the straight pipe (in mL/s) to give us the value “q” in our main equation to find the specific gravity	Flow Meter
Total		**98.49$**		

4.0 - Required Softwares, Libraries, and Hardware

- **Softwares and Libraries:**
    - SolidWorks: Solidworks will be used to design the parts in 3D in order to understand how they will be constructed and printed using 3D printers. This software will be used in prototype 1 and 2 in order to correctly design the physical model of our device.
    - ArduinoIDE: This coding software will be used to code the arduino programing throughout all 3 prototypes in order to correctly ensure each prototype is working as predicted.
    - LiquidCrystal This is a required arduino library that will be used to connect and display the results onto an LCD screen in prototype 1 (and continued throughout prototypes 2 and 3)
    - Matlab: In order to solve and decipher the complex math equation to which density is required.

- **Hardware Required for Prototypes:**
    - Plastic/PVC recyclables found in house will be used to create the prototype in earlier models in a cost effective manner
    - 3D printed materials will be used to complete the final prototypes in the later stages of the prototyping test plan
    - A bread board will be used to accurately wire the arduino and its sensors. This will be incorporated throughout all prototypes
    - Possible Liquid Sealants like caulking and Glue will be used to connect each physical part in the design (will be required for prototype 2 and 3)

5.0 - Significant Project Risk

Table 1.0 - Significant Project Risks Analysis

Risk #	Significant Project Risk Description	Contingency Plan
1	The sensors may lack accuracy (due to its small size and room for error)	Adequate calibration and testing will be done to ensure the sensors are working at maximum capacity
2	When solving for the density value (and coding), mathematical theories and equations are required, so the theory and formula must work in order to provide the mandatory density value.	Test the equations and theories to make sure the align, and meticulously code so there are next to no errors
3	The system may not seal properly, causing pressure losses in the pipe and/or leaks in the piping system	Use more than one seal method. For example, a silicon sealant on top of the original seal
4	The system may require too much current from all of the sensors	Calculate each current requirement from each sensor while also possibly looking into a wall adapter for the arduino
5	The estimated dimensions may be inaccurate due to its difficulty estimating all sizes without physical pieces in hand	Reprinting of parts is necessary, or solutions like thread tape, sealant, glue, can be experimented with to accomplish necessary sizing requirements.

6.0 - Prototyping Test Plan

Table 2.0 - Prototyping Test Plan

Test ID	What is it	What it tests (Objective)	Results Recorded	Test Duration & Start Date
1	A design created on SolidWorks, (or a sketch), by Alec for prototype 1	Gives us an idea of what our design is going to look like, the materials and parts needed, and also how everything in our design is going to be wired. This probably won't be exactly what our final design looks like, but gives us a good basis into prototyping.	The design layout and circuit design for the arduino wiring/sensor placement is correct	The duration will be 2 days (starting on Monday, October 24th)
2	Test the LCD screen and code	The printing of a message on the LCD screen in order to ensure the code/screen is fucntioning	Correct printed message appears on screen ("This is good")	Test duration will be 2 days (starting 25th)
3	Testing the volumetric flow meter and its code	We need to ensure the volumetric flow meter can correctly measure the flow of liquid per second	Measurements of "ml/s or L/s" is read and processed by the arduino	Test duration (2-3 days) once material arrives
4	Testing the LED green/red lights	Ensure the lights are properly connected and work based on a range of values	Correct light turns on then off (green if #<10 then red if #>10)	Test will take 2 days (starting October 25th)
5	Tests the differential pressure sensor and the orifice plate.	The differential pressure sensor and the orifice plate is the most critical aspect of our design so it is important that we test if this works. We have to make sure that the orifice plate creates enough of a difference in pressure for our equation to be able to measure specific gravity.	Correct sealing of the plate and pressure sensors in the prototype 2 design	Testing will take 3-4 days (starting November 4th)

6	Tests the display and calculations of our data.	Once we are sure the specific gravity can be measured using our design, we have to display this data. This prototype will test our coding for the calculation of specific gravity, displaying the value on the LED screen.	Correct Specific gravity value is shown on the screen (in Plato) for prototype 2	Testing will be (3-4 days) starting on November 5th)
7	Ensure the prototype is correctly built	Check if the physical design of the built is fully functional with no apparent leaks	No water leaks of any kind	Test will take 1 day (start on November 7th)
8	Add all final touches and design specifics into final prototype	After we have ensured that we can measure specific gravity and have a way of displaying it, we can put the two together into one last prototype. This will allow us to see everything working all together and will be close to our final design.	All parts are connected and work under normal operating conditions	This test will last 4 days (beginning on November 8th)