Conceptual Design

Genius Troop

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Abstract

This document defines the subsystems of the hydroponic and the requirements for theses subsystems. Then, the document features the designs of each team member for the subsystems. After analyzing the general design ideas for each subsystem, a final design is decided upon. The main purpose of this document is to come up with a design that is the best solution to the design criteria outlined in deliverable C.

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List of Tables and Figures

Only figures for final design are listed:

Hydroponic Sub-subsystems

The design of the hydroponic is broken into three different subsystems. These include the structural system, the delivery system, and the nutrient system

Structural System

The structural system is the physical structure of the hydroponic. The structural system is responsible for supporting the weight of the growing plants and storing the nutrient solution. According to the design criteria this structure must be space efficient, be easy to transport and easy to assemble. This system does not include the structure that houses the nutrient system's electronics, fertilizer, and sensors.

Delivery System

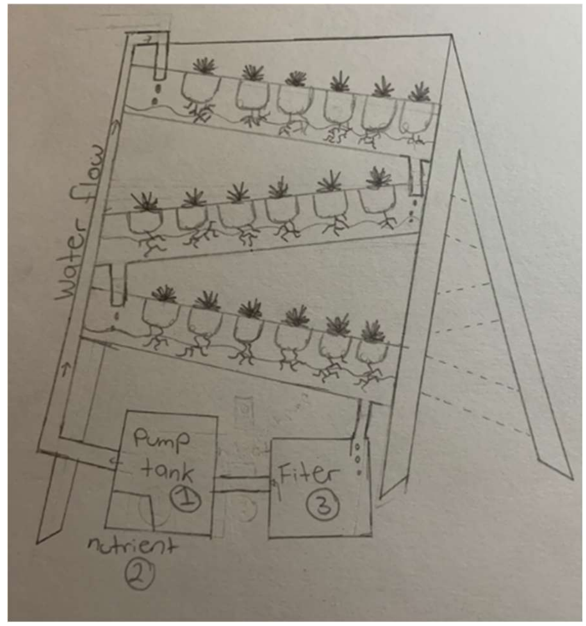
The delivery system is responsible for transporting the nutrient water solution to the roots of the plants. Thus, this system is responsible for anything to do with the moving or distributing of the nutrient solution to the roots of the plants. Some components of this system would be the pump, piping, nozzles, etc. The delivery system must be easy to set up and must be reliable to avoid the plants in the hydroponic dying.

Nutrient System

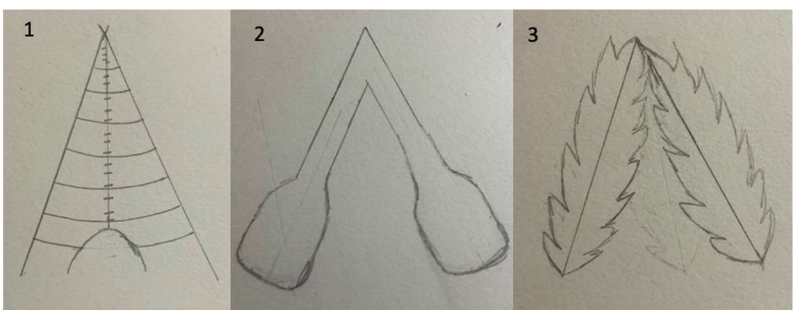
The nutrient system is responsible for ensuring that the nutrients solutions maintain optimal nutrient levels for plants. In addition, the nutrient system should have the capability to replace the nutrient solution once a week to ensure maximum efficiency of the hydroponic. The nutrient system should be user friendly and easy to program nutrient levels.

Design Ideas

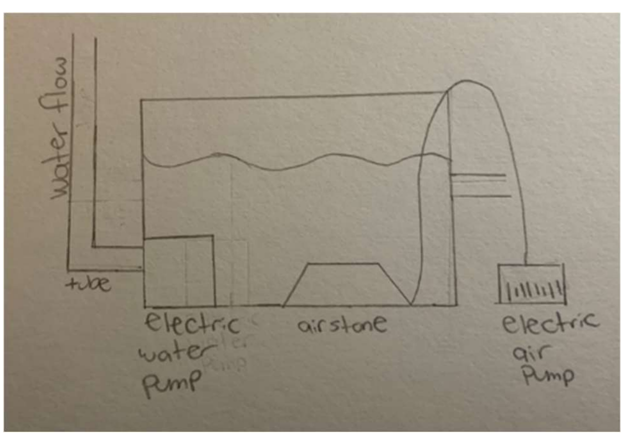
Dora Kam:



Structural system: The hydroponic system type is specifically nutrient film technique. There will have different layers of compartments stalked spaciously top of each other. It is strategically placed on an angle to allow constant running water to reach the plants roots. The goal is to be able to hold 20+ plants each rack with holes to insert potted plants. The ideal for each layer is that it sits on a removable rack for maintenance and harvesting. On the floor there would have tanks to collect the dirty water and go through multiple sub-systems where clean nutrient solution would be pumped back into the plants.

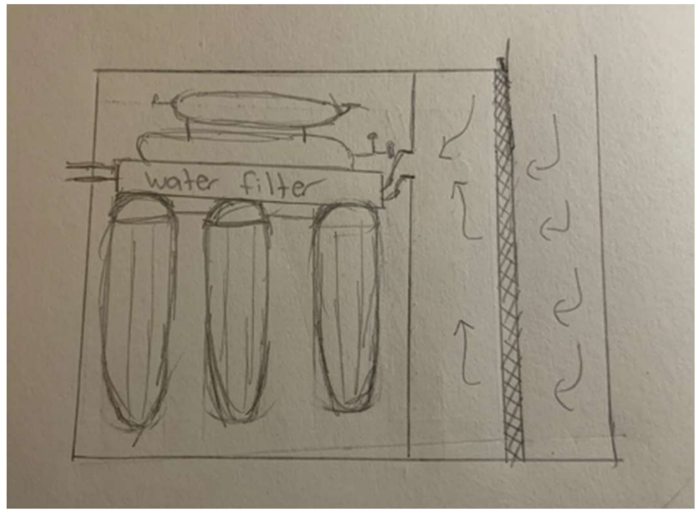


Aesthetic design Bonus: Since the hydroponic is for an Indigenous Organization, it would be creative to include traditional shape items. Pictures one, two and three are side profiles of my hydroponic system stand. One is designed as a tent; two is designed as paddles; three is designed as feathers.

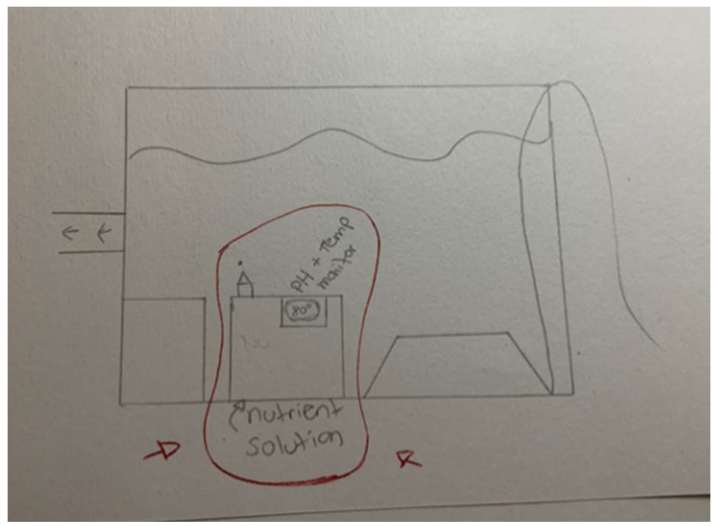


Delivery (Pump) System: The pump system is important since by using a water pump, it transports water upward through the structure with a continuous flow of water. The water will be flowing down each level. Once reaching the end, the circulating water will be collected in another tank where the whole cycle restarts. In my design, there is an air stone which is beneficial for plants. The way it works is it will be powered by an air pump which will create tiny bubbles filled with oxygen that will help increase the growth in a shorter amount of time.

Delivery (Filter) System: It is important to have a filtration system to reduce the risk of disease and maintain a clean water supply for plants. My main concern is for debris, dirt, broken off roots, etc... to be circulating through the whole system. With this concern in mind, I have decided to have a tiny netting placed vertically when dirty water enters which can slide out to be cleaned/changed. Then the water will be filtered through a filter. The filter that is recommended would be the brand *Reverse Osmosis Filter* since it filters a large amount of water quickly.

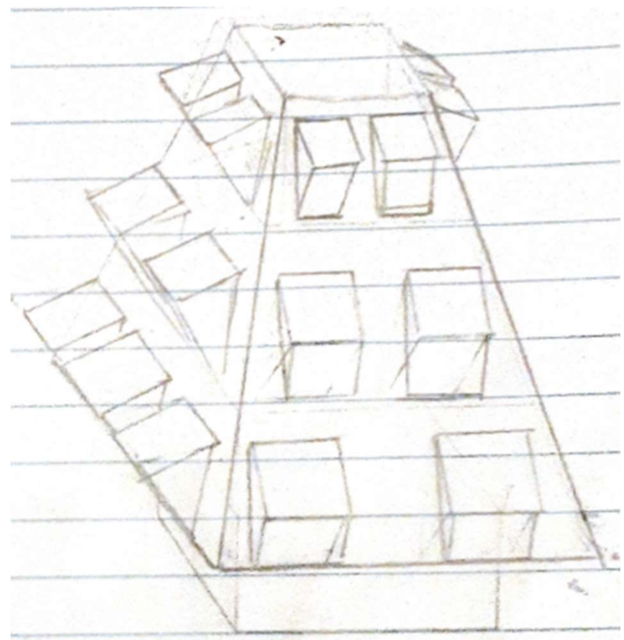


Nutrient System: The goal for a nutrient system is to make sure the plants are getting a sufficient amount of nutrients in order to thrive. My idea was to have a nutrient system in the pump system that will have a temperature regulator/reader along with a pH reader. In the sketch, there is a nozzle that pokes out on top of the nutrient system and its main function is to disperse nutrient solution when necessary (auto-adding).

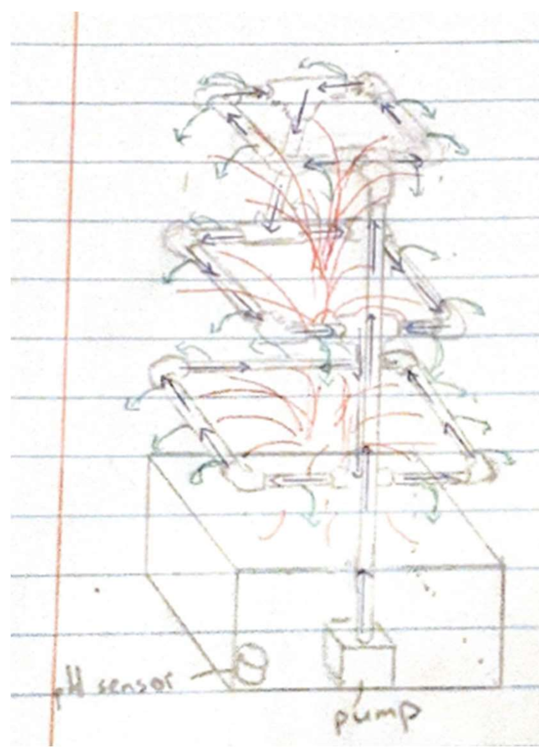


Jeffery Xia

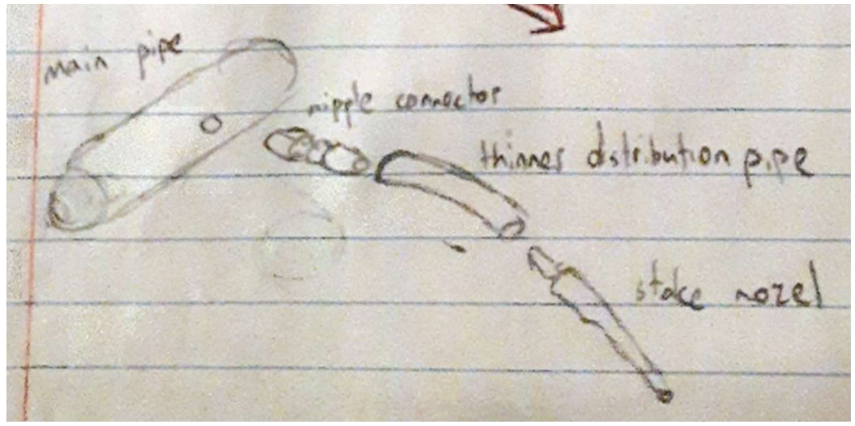
Structural system: The system sits on a 300 gallon nutrient system reservoir. Square in design, the system itself stands 2 meters tall, and tapers from a square top to a square bottom. The top body is split into 3 horizontal sections, carrying 8, 8, and 10 carrying spots for vegetable boxes. As of now, the top section contains smaller carrying boxes compared to the bottom 2, but this can change as the design polishes up. If feasible, a single vertical cut on one side opposite the main vertical tube with a hinged system on the other side to allow for the system to be opened up for inspection and maintenance would be ideal. Internally, a skeleton system as shown will hold up and keep in place the internal piping. For each carrying hole, there are guiding cutouts that will hold the removable vegetable carrying boxes in place. The carrying boxes themselves are simply cubical in nature, with a cutout on one side for the stake nozzle to be inserted at root level, and have a drainage hole at the bottom to which a small pipe is connected to direct run-off back into the recirculating system.

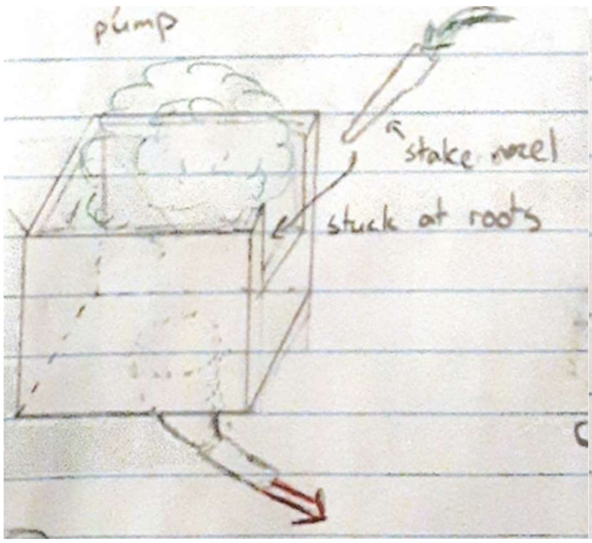


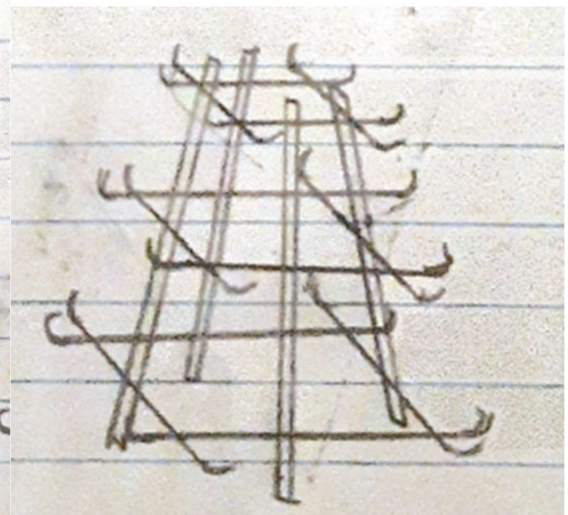
Delivery system: The delivery of nutrient solution is done by an electric pump attached to the bottom of the nutrient reservoir, and delivered vertically through a 2 meter pipe. At the top, it splits via t-nozzle to create a rectangular loop. On the side opposite the main vertical pipe, another t-nozzle pointed down directs the flow to the next level where using t-nozzles, it branches into a slightly larger rectangular loop, where again on the opposite end, a t-nozzle directs the flow to the 3rd level where the final loop ends the flow. On each level, small holes are drilled into the side of pipe. Nipple connectors are attached, and direct to a smaller tube, to which a stake nozzle is attached. This stake nozzle is placed at the root area of the plant box, where it delivers the nutrients from the drip system. The run-off from each carrying cube is drained internally back into the nutrient reservoir. The periodicity of the pump periods depends on the plant medium.



Nutrient system: Ideally, a nutrient system is implemented to minimize pipe clogging. Since this is a recirculating system, it is imperative that the pH and nutrient levels in the reservoir are monitored through the use of pH monitors and the like. Further testing is required to determine the feasibility of a recirculating system, the amount of maintenance needed, and if a non-circulating system should be implemented for convenience' sake.

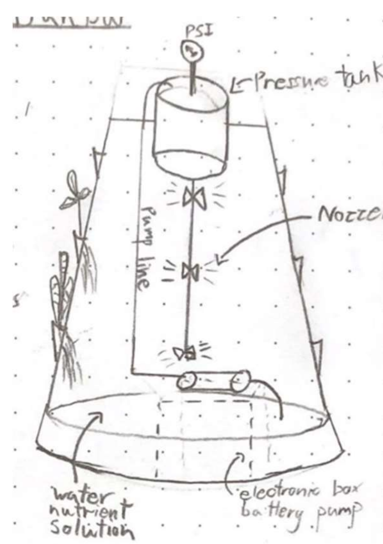




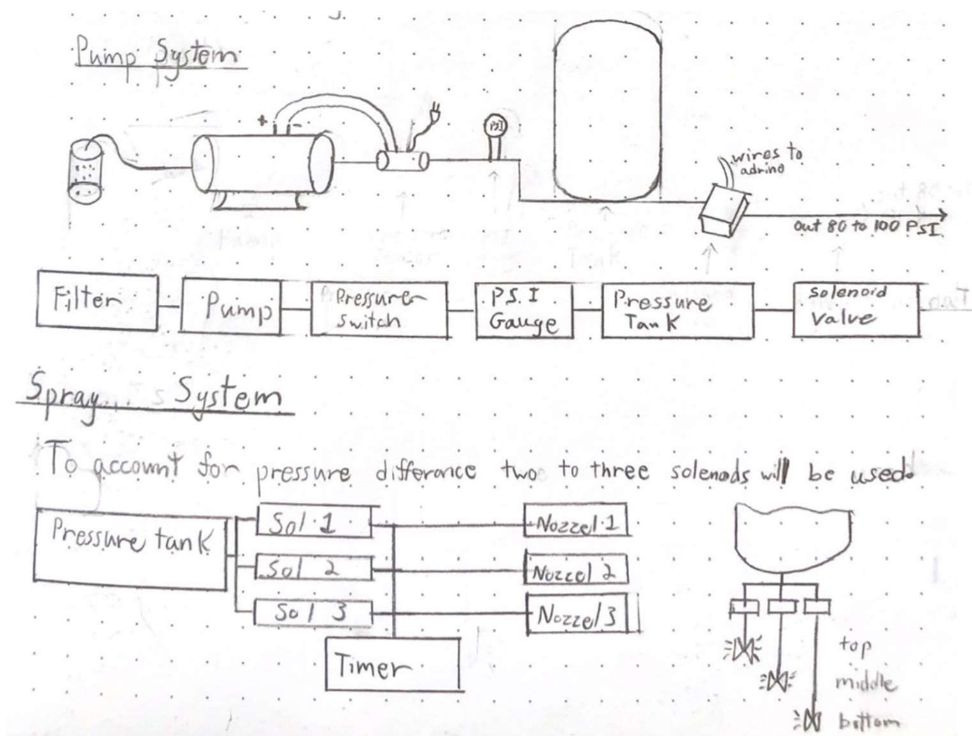


Steven Dunbar

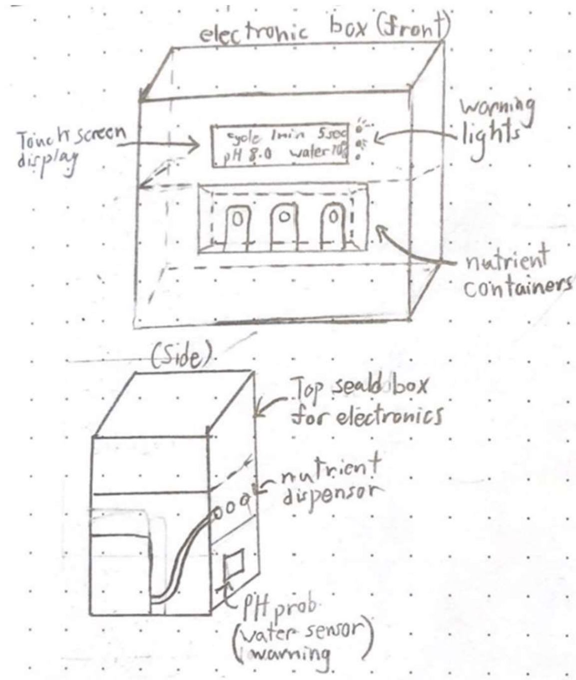
Structural System: The shape of the structure is an upward facing cone which allows for sunlight and stability. The base would be a diameter of 3 ft tapering off to 2 ft at the top with a height of 6 ft. The body would be split into four sections to allow for transportability. The sections would be attached to each other through a joint between each section. On the exterior of the body little cups could be inserted into the sided of the structure to hold the plants. In total this structure could hold 35 to 40 plants. Also, the structure would be able to hold a 5 gallon pressure tank at the top of the structure. Unfortunately, because of the cone shape of this design, it is not efficient in using space.

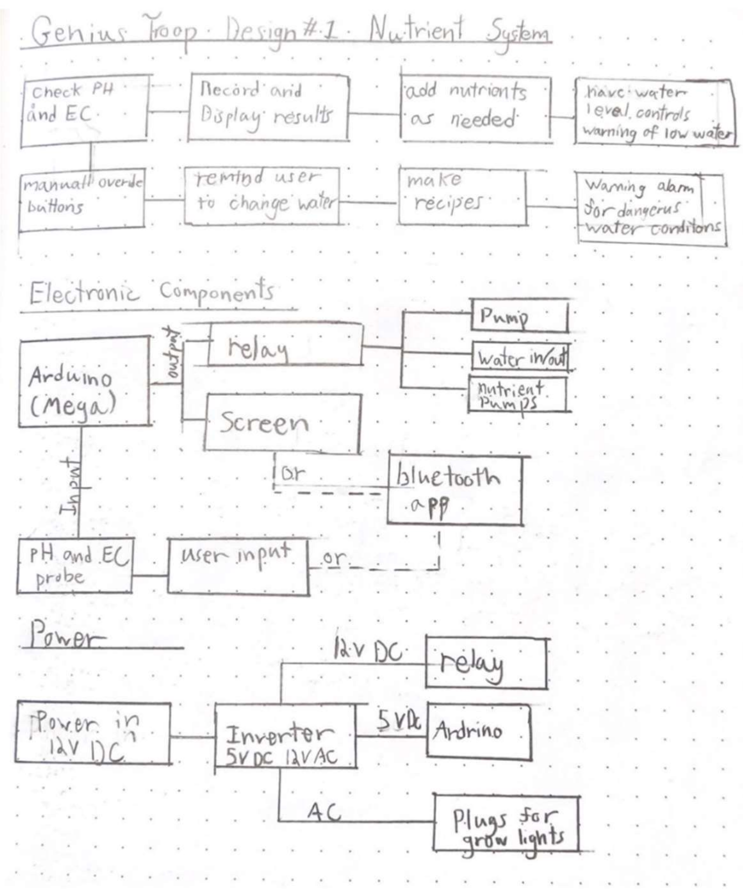


Delivery System: The delivery system is designed based on an aeroponic system. An aeroponic system sprays a fine mist on the plants using pressurized water and mist nozzles. Because the water needs to be pressured a pressure tank must be used. This means that the pump only has to turn on periodically to fill up the tank increasing the lifespan of the pump. Ideally, the pressure in the hose should be 100 psi which can be hard to achieve with a 5 gallon pressure tank. Therefore, the tank will be elevated at the top of the structure to increase the psi in the lines. To ensure equal pressure at each of the nozzles there will be a separate line for each height of nozzles. Each line will be controlled by a solenoid on a periodic timer to activate the spraying of the system. The down sides to this system are that the fine mist nozzles tend to become clogged with dirt and fertilizer causing the plants to die from dehydration. Also, the nozzles have to be properly calibrated to ensure that the proper amount of water is getting to the plants making this system hard to set up. However, this system allows plants to grow three times faster than conventional methods and use 80% less water.

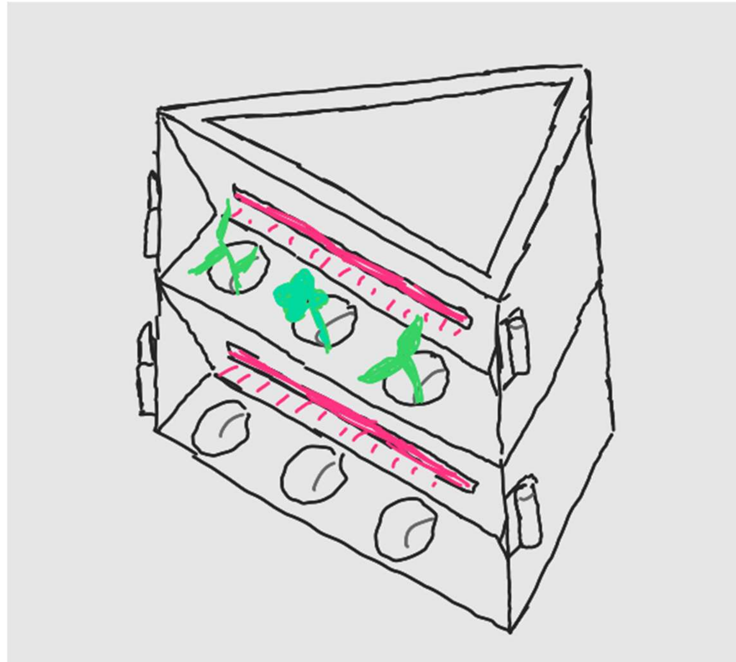


Nutrient System: The nutrient system will be capable of checking pH and EC levels, recording data, and adding nutrient and pH stabilizer as needed. The nutrient system will be controlled by an Arduino which is connected to a touch screen. In addition, the Arduino will have a Bluetooth modulator allowing it to be controlled through a mobile app. The electronics and nutrient containers will be stored in a rectangular box in which the upper half contains the electronics while the lower half contains the fertilizers. To distribute the fertilizer the system will use peristaltic pumps controlled by a relay board connected to the Arduino. In addition, a water sensor will be at the bottom the nutrient reservoir to warn the system of low water levels. On the front of the box there will be plugs which are only supplied power when the it is dark outside. This allows the user to plug in grow lights and if they decide their plants need extra light. This system allows for little maintenance of the hydroponic, however, because of all the sensors and additional pumps the system is more likely to fail.

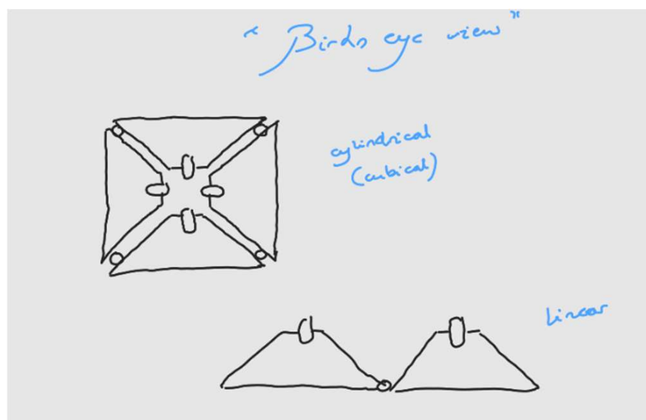




Jean Paul Kazzi



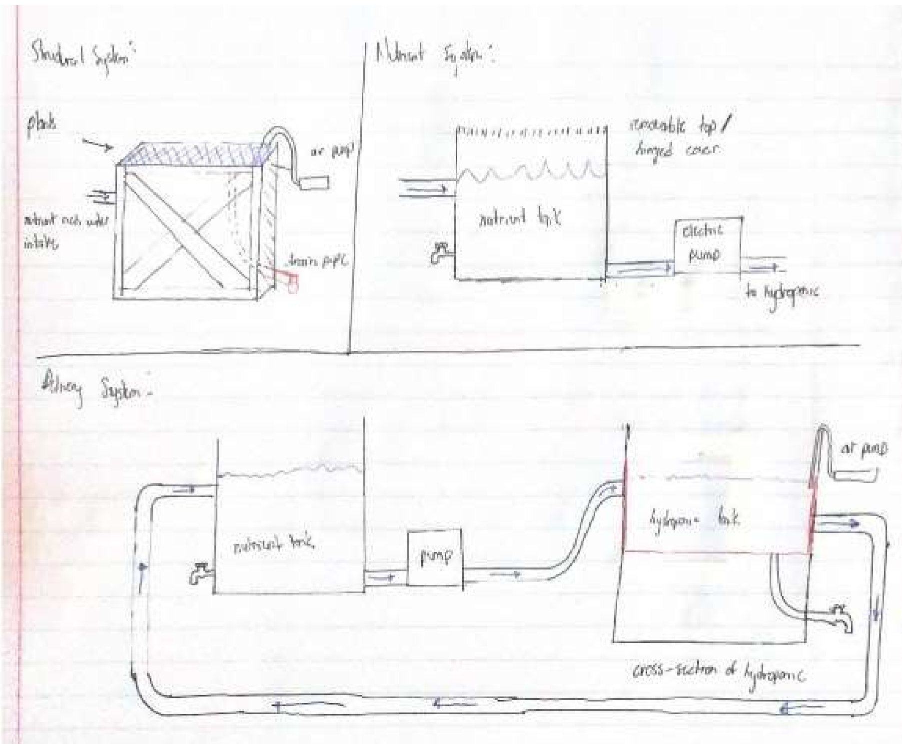
Structural system: triangular units with small cuplike holders on its base. The units will have a hinge system at their edges to fixate them with other units. The units will be stackable both horizontally and vertically, and the hinges will provide flexibility to be able to align them in different conformations. Plants will grow under a red light to provide optimal light absorption. Each stackable tower will be linked to a base that in turn would be linked to a central base through pipes and wires (all running in the same encapsulating tube).



Delivery system: the water will be distributed from the central tank to the bases of one tower and then through to 3 adjacent towers. The towers will have attachable pipes running the water up for distribution and down for draining. The water distribution will be based on a DWC or Ebb and flow system then drained down from each cup down the vertex of the triangle and out from the tower back to the central water tank.

Nutrient system: nutrient levels, water flow rate, pH, and temperature will be regulated in the water tank. When water from all connected towers is drained back to the central tower, the levels of all these are monitored and fixed accordingly. The wiring connection through the hinges provides power for the light to turn on over the plants.

Neven Greguric:



<u>Structural Design:</u> The hydroponic will be a hollow cube made of lumber or pvc. The top face of the cube will be where the plants grow. Inside the cube will be a tank for the nutrient rich water that will be in contact with the plant roots. This tank will have an opening at the bottom (covered with mesh to prevent clogging) that connects to a drain pipe. This will allow the user to completely drain the system and replace it with new water as needed. An air pump outside the hydroponic unit will pump air into the tank and provide oxygen to the plant roots.

<u>Delivery System:</u> The delivery system will be driven by the electric pump between the nutrient tank and the hydroponic tank. The system will work using deep water culture. More water in the system means more stable pH and nutrient levels and less maintenance by the user. The delivery system will be a circle running between the nutrient tank and the hydroponic tank. Every so often, the water in the hydroponic tank can be drained. When the pump is turned on, the nutrient rich water from the nutrient tank can replace the drained water.

<u>Nutrient system:</u> The nutrient system will include a nutrient tank, with a drain valve and a removeable top, either a mesh cover or a solid top with a hinge. This nutrient tank will take in new water, and the user can pour nutrient solution in through the top. The user may also take samples of the water in the nutrient tank to ensure it is at the proper levels to put into contact with the plants in the hydroponic tank. At the bottom of the tank, a mesh- covered pipe will connect to a small electric pump. This pump can be turned on once the user ensures the water's pH and nutrient levels are ideal. The outgoing pipe from the electric pump will lead directly into the hydroponic tank.

Evaluation of Subsystem Designs

Based on the purposed designs, the general design concepts are evaluated in regards to the design criteria and problem statement in deliverable C. Rank is determined on value of capability times importance. The colors represent the capability green 3 yellow 2 and red 1.

Table 1: Structural System

Design Criteria / Global Concepts	Importance	Vertical Pyramid	Vertical Slanted Trough	Vertical Cylinder	Vertical Cylinder Cone	Vertical Triangular	Cube Flat
Variety of Plants	3	Small to medium	Small to medium	Small to medium	Small to medium	Small to medium	Small to large
Sunlight	5	Limited	Limited	Yes	Yes	Limited	Limited
Ease of Transport	2	Yes	Yes	Yes	Yes	Yes	Yes
Easy to Assembly	3	Yes	Yes	Yes	Yes	Yes	Yes
Scalable	3	No	No	Yes	No	Yes	No
Limited Space	4	Yes	Yes	Yes	No	Yes	No
Rank		46	37	<u>55</u>	38	46	39

Table 2: Delivery System

Design Criteria / Global Concepts	Importance	NFT Trough	T-nozzle Sprinkler System	High Pressure Mist	Vertical NFT	Deep Water Culture Tank
Reliable	5	Yes	Yes	No	Yes	Yes
Ease of Assembly	3	Yes	No	No	Yes	Yes
Variety of Plants	3	Yes	Yes	Yes	Yes	Yes
Scalable	3	No	No	No	Yes	No
Rank		28	22	17	<u>42</u>	31

Table 3: Nutrient System

Design Criteria / Global Concepts	Importance	Manual Nutrient System	Fully automated Nutrient System Box Design
Replace water in reservoir easily	3	No	Yes
Control Nutrient Solution	4	Yes	Yes
Temperature Control	3	No	Yes
Lighting	2	No	Yes
Natural Fertilizer	3	Yes	No
Reliable	4	Yes	Yes
User friendly	5	Yes	Yes
Rank		42	<u>62</u>

Proposed Design

Based on the purposed subsystems the team decided on the following combination of systems to create the proposed design.

Structural System Final

The overall shape of the hydroponic will be cylindrical to maximize space while ensuring sunlight is able to get to each plant. The downside to this shape is that the curved surface will add complications to the building the physical unit. For transportability the structural system will be broken into three units. Dimensions of the units will roughly be about 60 cm in height and 70 cm in diameter. The units will all be stacked upon a base that is 50 cm in height. No more than 3 units can be stacked atop each other (structure will stand at about 230 cm). This design allows for the system to be scalable. Each unit will have slots for small cuplike holders for the plants alongside the side periphery of the cylindrical unit allowing for 15-20 plants per unit. The top and bottom will serve as connection/linkage points between the units (units are stackable). Note: figure 2 would have more holes for plant similar to figure 1.

Figure 1: First Draft of Final Design

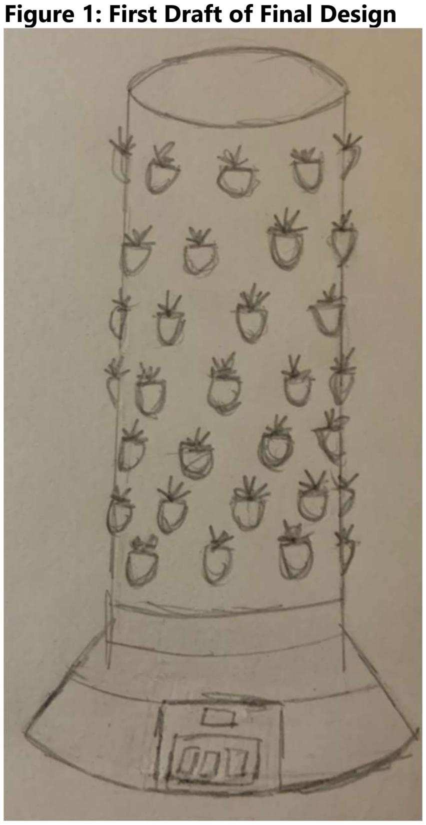


Figure 2: CAD Final Design

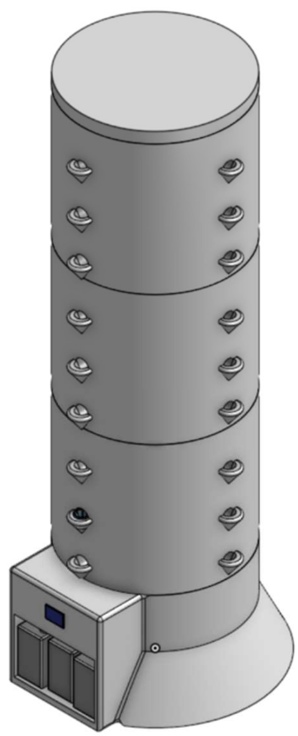
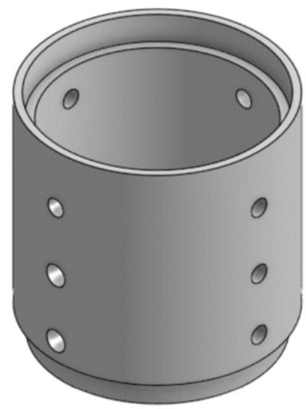


Figure 3: Upper Unit



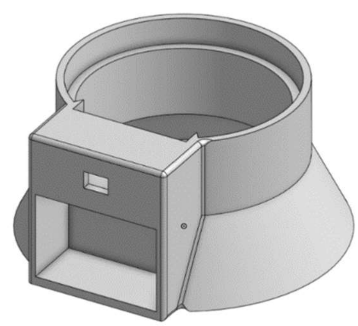
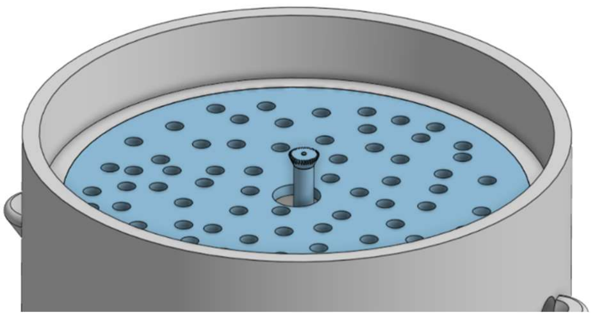


Figure 4: Base

Delivery system Final

The water will be distributed from the base to the top of the structure through a continually running pump. A nozzle on the at the top will spray the water to the sides of the walls. The water will then fall with the weight of gravity and drip off of the plants roots a combination of a NFT and drip and ebb system. To ensure that the water is distributed evenly there will be a plate at each level of the units to distribute the water evenly down the sides and prevent big debris from falling into the water system. This system will provide the plants with a constant supply of water an oxygen. The down side is the plants will die if the pump breaks down for over 4 hours.

Figure 5: Top View Of Water Delivery System



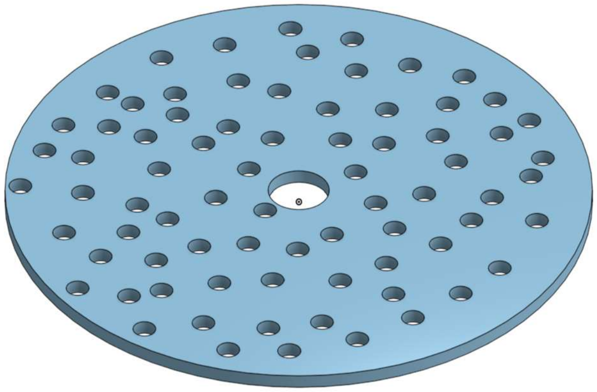
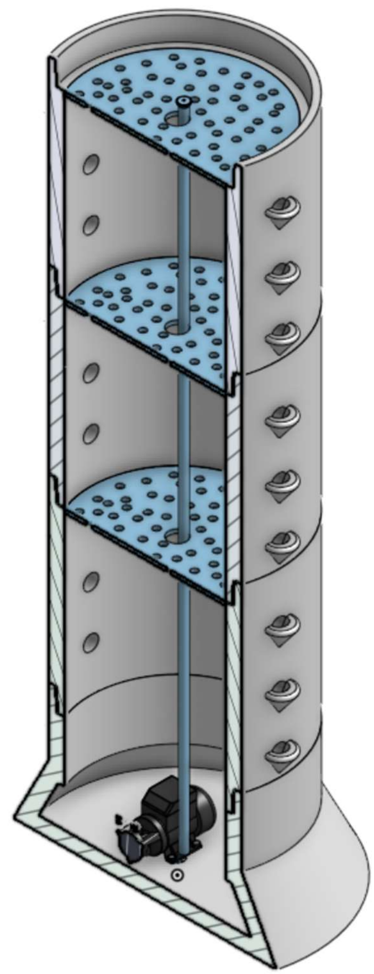


Figure 7: Water Distribution Plate

Figure 6: Split View Delivery System



Nutrient system Final

The nutrient will have the capability of maintaining pH levels, controlling water temperatures, and maintaining nutrient levels. The nutrient system will be held in a rectangle box located at the base of the structural system. The system will have a pH probe, a temperature probe, and a water level sensor which are connected to an Arduino. Based on the input of the sensor the Arduino will turn on and off relays which are connected to the pumps for nutrients, water heater, solenoids (for draining and replacing the water in the system). In the base of the nutrient system fertiliser containers will be connected to peristaltic pumps for adding the nutrients to the water. To program the nutrient system a touch screen will located on the top of the box which will allow user to manually add nutrients and set settings such as water temp pH levels and nutrient content.

Figure 8: Nutrient System Front

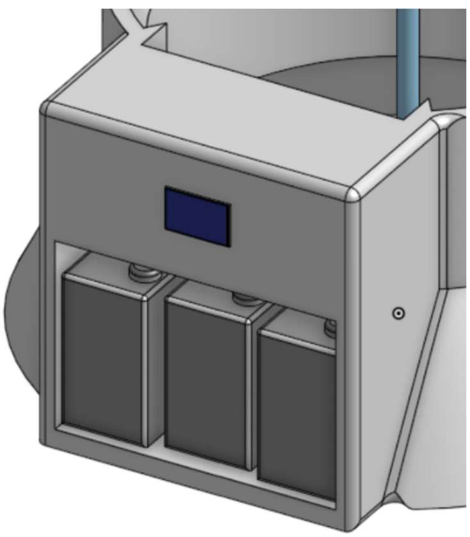
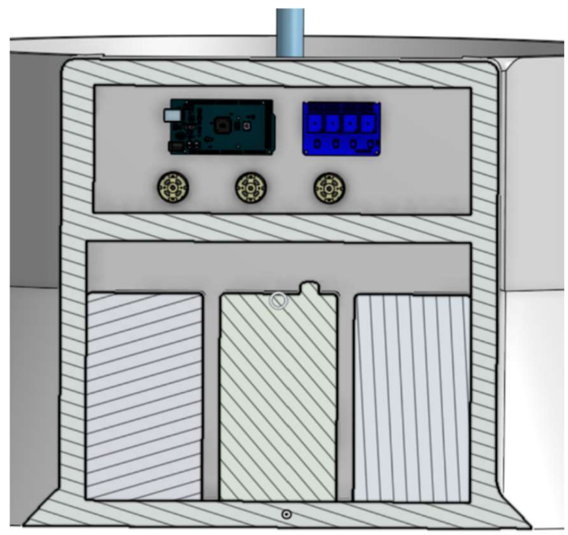


Figure 9: Split View electrical Components



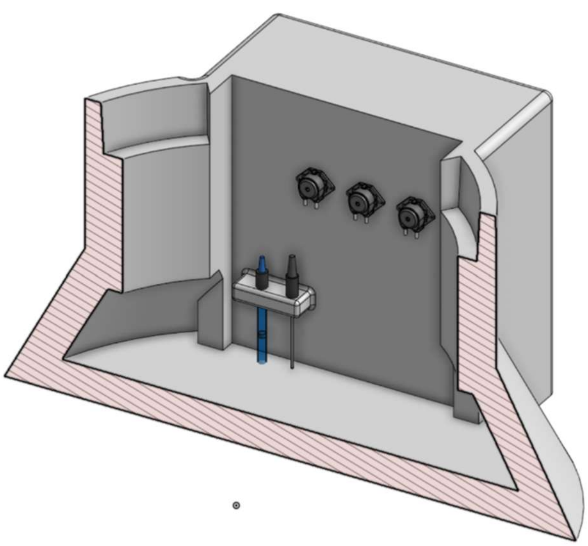
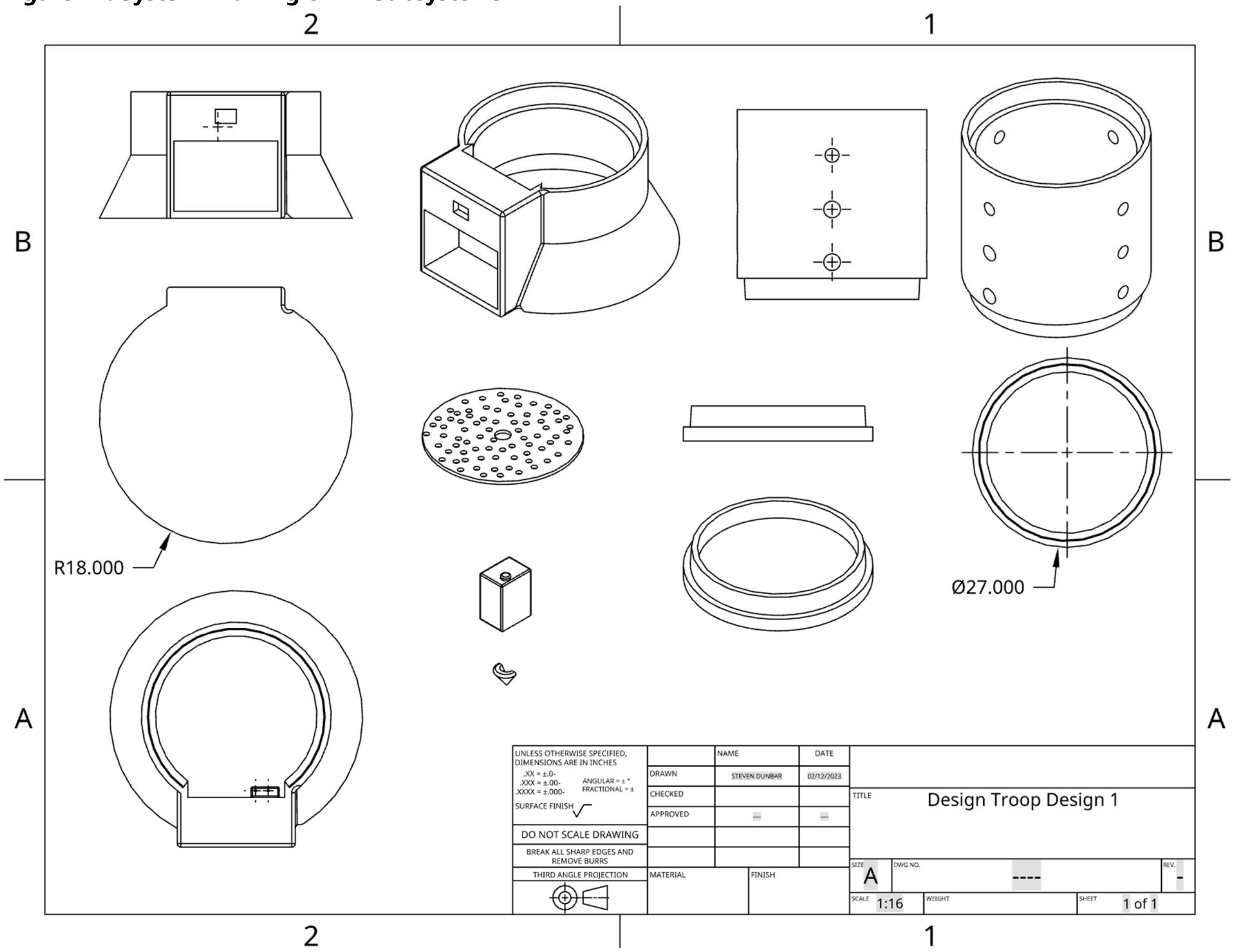


Figure 10: Split View Back of Nutrient System

Figure 11: System Drawing of All Subsystems



Conclusion

Overall, the aforementioned design specifications of the subsystems of the hydroponics, coupled with the limitation that each presented allowed us to narrow down the requirements for an ideal system that would not only be feasible and cost efficient but also simultaneously meeting the needs outlined by the client in our previous deliverables. The final design that was agreed upon highlighted the scalability feature presented by the first and last design (Jean Paul, Steven); thus, allowing a customized distribution of the plants with the opportunity of rapid expansion upon need - a feature the client was very keen on. The delivery system would implement a modified version of the nutrient film technique presented by the second design (Dora), ensuring a constant flow of water reaching the plants' roots. The conical (cubical) compact and vertical standing form of the structure that was emphasized by the third and last designs provides optimized space usage. This design was further developed in the final model by vertically aligning the circumference of the system to avoid an overly large base but not sacrificing the light access (by alternating the plant holders) and stability (by increasing the weight of the base unit. All in all, the merging of difference aspects of each of the designs on our team made for the perfect hydroponic design that satisfies all of our customers needs.