Deliverable G – Prototype II and Customer Feedback

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Table of Contents

Client Feedback after client meeting 3

- The client said that she was happy with our designs.
- She liked how our designs will be integrated into the constructions team's designs.
- She was excited about our designs being in the school and helping kids learn.

Irrigation System

Testing plan

For prototype two, we decided to test the pressure requirement for our water pump, taking into account height variation of the structure (Bernoulli's principle), the effect of the perforations on the water flow at the far end of the top shelf and the diameter of the polyethylene tubing and of the PVC pipes. We also needed to consider the pressure at each of these perforations, to make sure they had enough velocity to evenly hydrate the entirety or at least most of the plant beds.

Based on the results obtained, we planned to choose a water pump suitable for our system in terms of flow rate (or several). We've concluded that a single water pump would suffice, but that it should generate 1200GPH (on the stronger end of the range of water pumps).

Evidence + Description of Testing

The testing took place Saturday March 11th on campus. There was no required material, as this testing involves theoretical calculations only.

Sample solution with a 10 cm hole traveling distance for water with $\frac{1}{16}$ inch holes at a 45°

Figure 1: *Calculating velocity of liquid exiting tube (*Sample calculations using a 10 cm hole traveling distance for water with 1/16 inch holes at a 45° angle)*:Range equation:*

R = $(\frac{v \times sin2\theta}{g})$ → V = $\sqrt{\frac{Rg}{\sin 2\theta}}$

V =

= $\sqrt{\frac{Rg}{\sin 2\theta}}$

= $\sqrt{\frac{0.1m\left(9.8\,\frac{m}{s^2}\right)}{\sin 90}}$

= 0.990 m/s

Calculating radius:Radius =

= $\frac{1}{16}\frac{inch}{diameter}$ x $\frac{diameter}{2\,radii}$ x $\frac{2.54\,cm}{inch}$ x $\frac{0.01\,m}{cm}$

= 7.9375 x 10^{-4} m

Calculating volumetric flowrate:

Volumetric flow rate =

= V x A

= V x πr^2

= 0.990 m/s x $\pi(7.9375\ x\ 10^{-4}\ m)^2$

= 1.960 x $10^{-6}\,\frac{m^3}{s}$

Calculating flow needed for the entire structure:

Structure flowrate =

= $1.960\ \times 10^{-6}\,\frac{m^3}{s}\,\frac{1}{hole}$x $25\ \frac{holes}{tube}$x $27\ \frac{tubes}{structure}$x $\frac{3600\ s}{h}$x $1000\ \frac{L}{m^3}$

= 4763 L/h

Flowrate in g/h =

= 4763 L/h x $\frac{1\ gallon}{3.78541\ L}$

= 1258 gallons/h

Calculating power for going up the pipe:

Density of water: 997 $\frac{kg}{m^3}$

Height at the first plant tray: 27.5 in = 27.5 in x $\frac{0.0254\ m}{in}$ = 0.699 m

Height at the second plant tray: 51 in = 51 in x $\frac{0.0254\ m}{in}$ = 1.295 m

Height at the third plant tray: 62 in = 62 in x $\frac{0.0254\ m}{in}$ = 1.575 m

= [($1.960\ \times 10^{-6}\,\frac{m^3}{s}\,\frac{1}{hole}$x $25\ \frac{holes}{tube}$)($\frac{3\ tubes}{platform}$)(3)(997 $\frac{kg}{m^3}$)(9.8 $\frac{m}{s^2}$)] [0.699 m + 1.295 m + 1.575 m]

= 15.38W

In the previous calculations, the following equations were used:

- The range equation, which states:

$$V = \sqrt{\left(\frac{Rg}{\sin 2\theta}\right)}$$

- The flow rate equation, which states:

$$Flow\ Rate = Cross\ Sectional\ Area \cdot Velocity$$

Power = flowrate x density x gravity constant x height

Table 1: Specification values used in Figure 1.

Specification	***Value***
Hole size (at 45-degree angle)	1/16"
Flow rate per perforation	$1.96 \cdot 10^{-6} \frac{m^3}{s}$
Overall Flowrate Needed	1258 gallons/hour
Power needed	15.38W

Testing Problems/Shortcomings

Problem:

Originally, we had a system of 1404 perforated holes in total, each with a diameter of 0.1”. Using these measurements and a 0.17” inner diameter for the polyethylene tubing, our results obtained using the sample calculations above, relating velocity and surface area showed a velocity of 840m/s, resulting in unreasonable pressure requirements for the pump.

Solution:

Using Excel functions to iterate a range of values for this equation, we determined that when a2=0.006”, we require a velocity of 50.4m/s. This is an optimal result because the velocity is within the range of solutions requiring a single pump and we know from an external project source (a previously done example of drip irrigation systems using bendable perforated tubing) that holes with a 1/16” diameter are acceptably large for allowing water to pass. Below is a section of our table of iterations, with a1 being the constant diameter of the polyethylene tube and with the function v taking into consideration the number of holes in our system. The 7th iteration is the result of our original design, while the 6th iteration is our optimized result.

i	a2	a1	v
1	0.001	0.25	8.4
2	0.002	0.25	16.8
3	0.003	0.25	25.2
4	0.004	0.25	33.6
5	0.005	0.25	42
6	0.006	0.25	50.4
7	0.1	0.25	840

The next steps...

Based on the results of table 1, we’ve determined that our pump must generate 1200GPH in order to produce an adequate flow rate for the furthest tubing perforation of the highest shelf of the grow wall. We found a water pump from Home Depot that satisfies this requirement:

Link To Product

After testing the power requirements of our pump with success, our next step for the irrigation section is to build the structure for our client. This will be possible once all our materials have been delivered, which will take longer in the case of our pump since we will purchase it later than everything else. The key to achieving the next steps is in effective communication with the construction team, which will be making the foundation to support our pipes and tubes.

Grow lights

Testing plan

Test ID	Test Objective (Why)	Description of Prototype used and of Basic Test Method (What)	Description of Results to be Recorded and how these results will be used (How)	Progress
1	Check if the Govee lights can be cut and still work	Cut the Govee lights and plug them in to see if they light up and still have all the feature or not	If they work properly then we can proceed with the rest to place under the shelves	Completed Passed
2	Check if the Govee lights can be reconnected and still work	Connect the 2 separated strips and see if they light up and still have all the feature or not	If they work properly then we can proceed with the rest to place under the shelves	Completed Passed
3	Check if the app works properly with the lights	Connect the strip and use the app	If they work properly then we can proceed with the rest to place under the shelves	Completed Passed
4	Check if the different sections of light work properly with the app	After connecting each strips using the wires, try the app and see if it recognizes each section as it should or not	If they work properly then we can proceed with the rest to place under the shelves	Completed Passed
5	Check if the wires conduct the right amount of electricity	Connect the cut strips with the wires and see if they work or not	If they work properly then we can proceed with the rest to place under the shelves	Completed Passed
6	Check if the polyurethane spray protects the system from water spills	Spray the strips and place water on them and try to light them to see if the work or not	If they work properly then we can proceed with the rest to place under the shelves	Completed Passed
7	Check if the 3M clips can properly stick and support wires	Place the 3M clips and place the wires in them to see if the hold or not	If they work properly then we can proceed with the rest to place under the shelves	Completed Passed
8	Check if the app allows for timers and specific lights presets	Play around with the app	If they work properly then we can proceed with the rest to place under the shelves	Completed Passed

Photo Evidence + Description of Testing

The following tests were conducted on Friday March 10th at one of the group members' houses and lasted 3 hours. The required materials for this test were already supplied except for the LED strip and wiring which were bought on amazon.

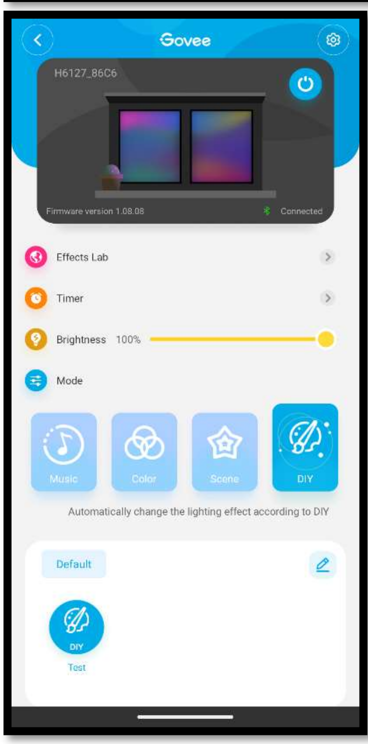
Materials used for testing:

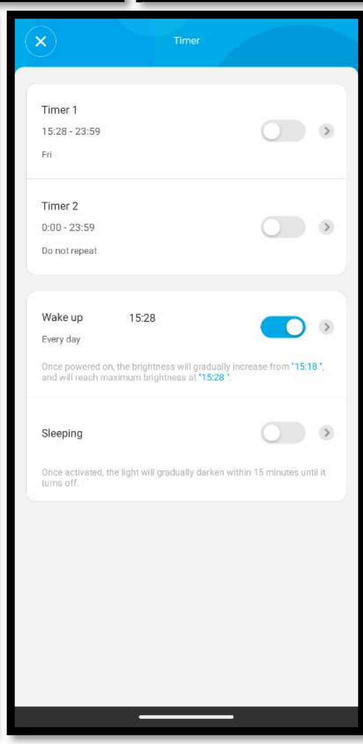
- Govee LED strip
- Smartphone
- Pliers
- Wires
- Wire cutter
- Soldering kit
- Heat shrink
- Heat gun

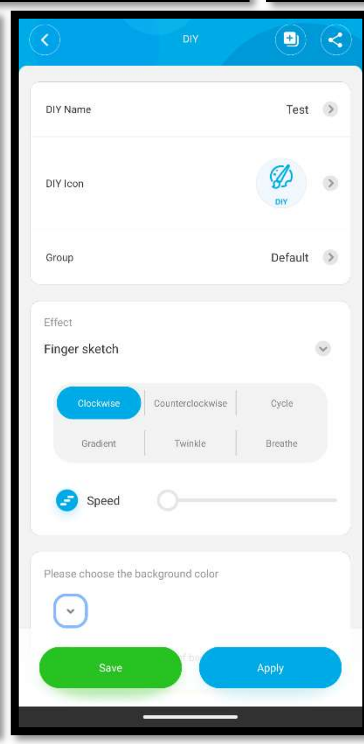
Test 3, 4 and 8:

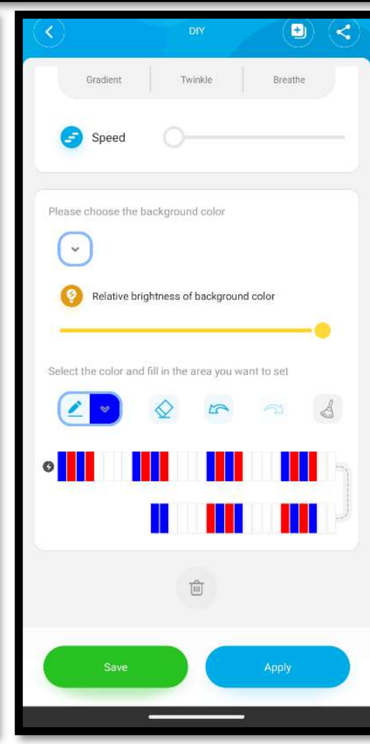
Check to see if:

- The lights turn on
- They work properly with the app
- They can be segmented
- They can be set on timers and allow for wake-up and night-times









Once plugged in, the LED lights immediately turned on an emitted bright light. After downloading the Govee application and connecting to a Bluetooth connection, the LED strip was easily controllable from a smartphone. This allowed us to segment different parts of the light. Also, the application allowed for wake-up and nighttime timers which allowed us to program an artificial sunrise and sunset.

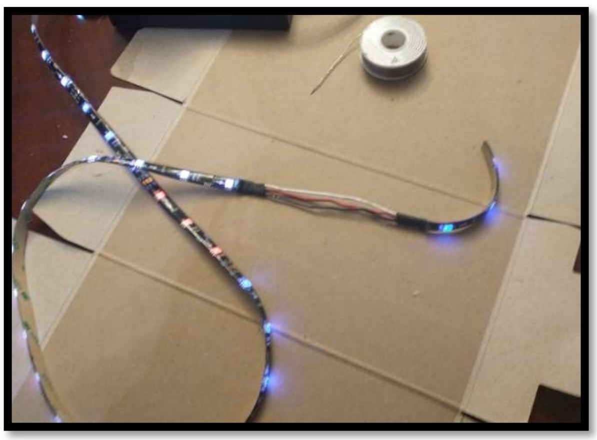
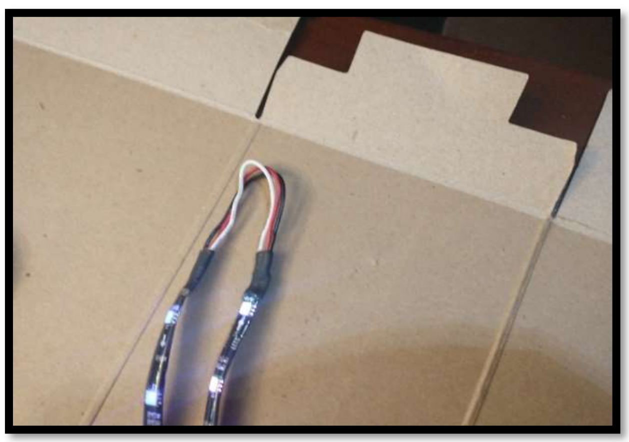
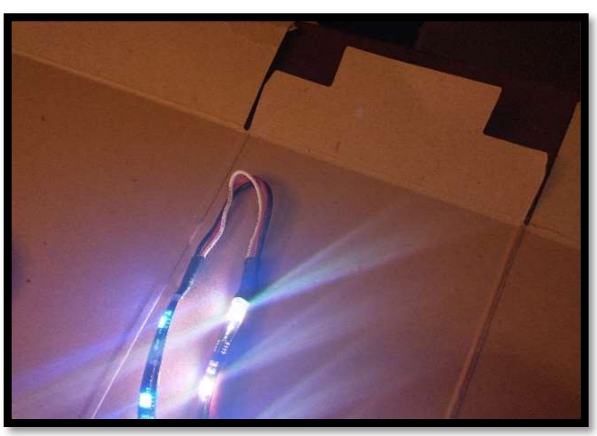
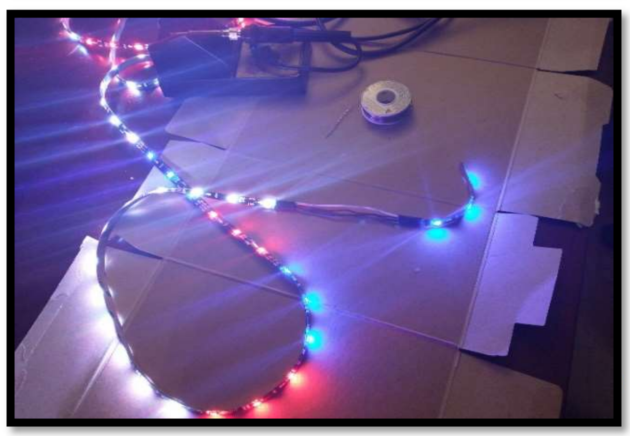
Test 1:

Test to see if the Govee lights can be cut and still function


After cutting the lights, the remainder of the strip still functions properly with all the integrated features.

Test 2 and 5:

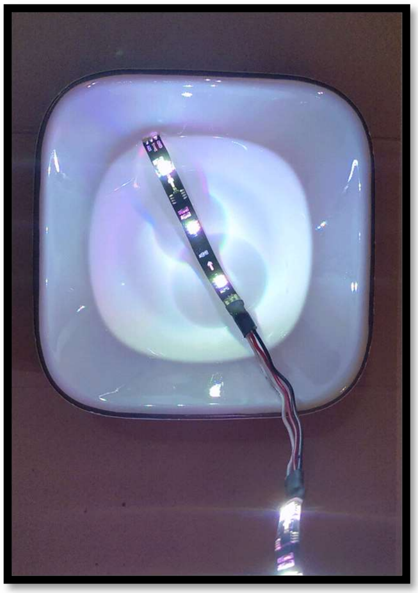
Check to see it the Govee lights can be reconnected and conduct the right electricity to function

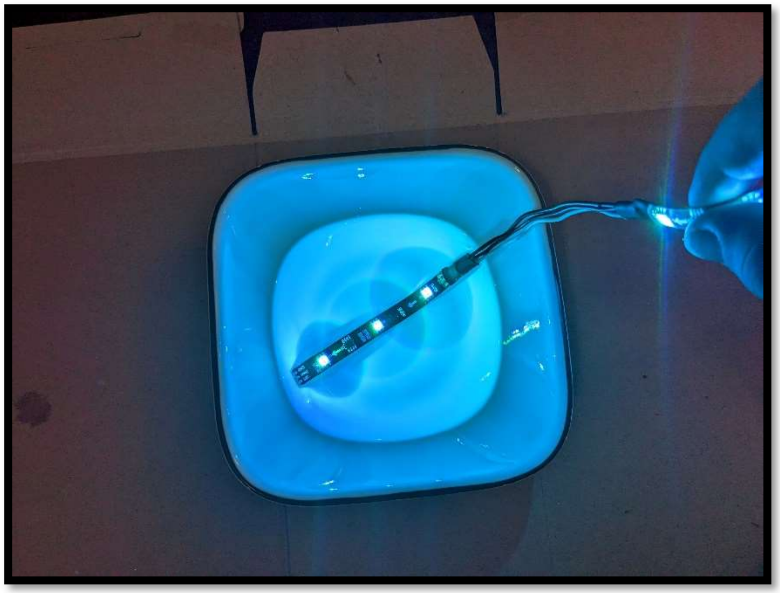





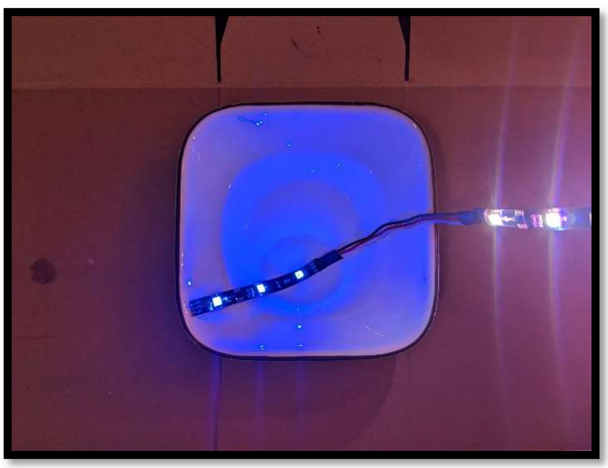
After a little struggle with learning how to solder properly, the lights were reconnected and still functioned properly. As demonstrated in the picture above, the connections still work, and we added heat shrink to solidify the connections and to waterproof it.

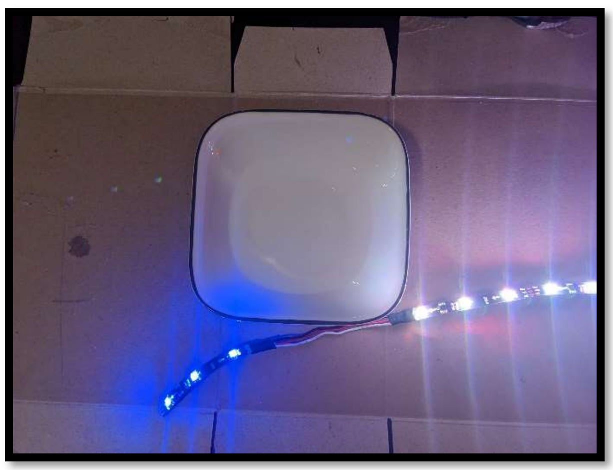
Test 6:

Check to see if the heat shrink will stop water from entering and damaging the soldering









After submerging the LED strip and the recently soldered connections, the lights still function.

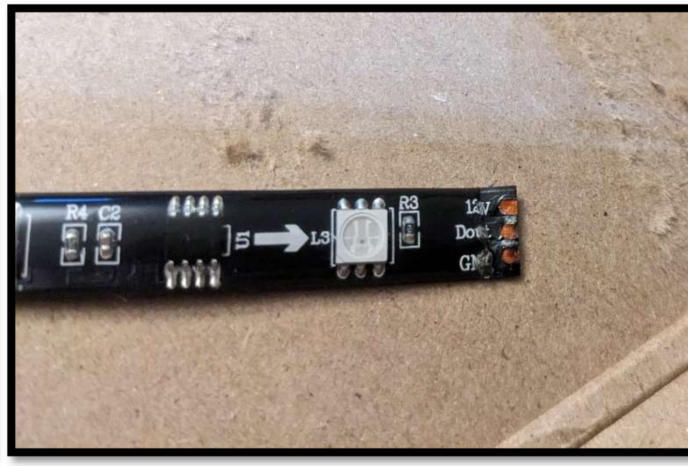
Test 7:

Check if the 3M tape is strong enough

No pictures were taken.

After sticking the strip to a wooden table, it was able to withstand a large among of pulling force

Testing Problems/Shortcomings



Problem:

During our testing period we learned that each segment of 3 LEDs was controlled as a separate section, therefore we were able to make a cut where there were copper connections to re-wire. As we are beginners in soldering, it took us a while to properly re-wire the lights with connections that worked. In that process, we unfortunately **burnt the copper connections and melted the plastic** of one of the LED sections. That resulted in this section of 3 LEDs to break and be unusable.

Solution:

To prevent this from happening again, we need to **learn how to properly solder** electrical connections and avoid from leaving the high heat soldering iron on the copper and ruin its electrical conductivity.

The next steps…

After a successful testing and prototyping, the next step for the grow lights team is to build the real product for the client. This process will take multiples hours to complete because there is a lot of soldering and reconnecting to do. In order to complete this next step, we will use the lab times effectively and possibly personal time at a team members house.

Pot Design

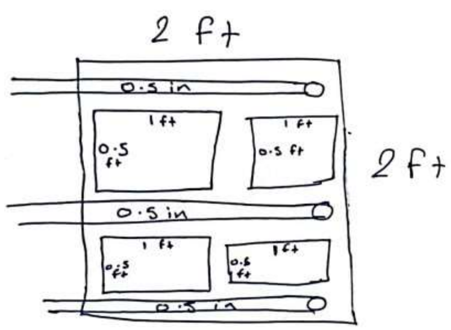
Testing plan

Make sure that the dimensions are right and that each pot fits well in its place.

Shelf size = 2 by 2 ft

Pipes size = 0.5 in (0.04 ft)

Pot size = 0.5 by 1 ft



the shelf is 2 by 2 ft each ~~shelf~~ shelf will have 4 Pots and 3 pipes the Pots will be 0.5 by 1 ft pipes will be 0.04 ft and some extra space will be kept for easy movement