Project Deliverable [F]: Prototype I and Customer Feedback

GNG1103[F]: Engineering Design

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Introduction:

Project deliverable F tasked Team 5 with creating a physical prototype based on the chosen concept from the previous deliverables. This is the first prototype and therefore is lower fidelity than what will be created in subsequent iterations but will give Team 5 a basis to improve from. There will be a physical prototype created from items found around the house and there will be a CAD representation made using Onshape as well. This report will begin with what Team 5 is looking to get out of this prototype in the way of objectives. The next part of the report will describe the tests that will be performed with this and future prototypes and outline the criteria involved such as the data being recorded, the beginning and end points and more. The testing section will end with a detailed plan for the future. Next Team 5's prototype will be shown and discussed. The final part of this report will show the progress in Wrike and the next steps that have been created this week as this project moves forward.

Prototyping Objectives:

Thus far in the design process, the team has been able come up with a design for a snow melting device that will meet the needs of our client. This design has been conceptually designed using sketches and modelled using OnShape. As a preliminary base for our prototyping, the conceptual designs will aid our team in the creation of the first prototype. This prototype will be made using household materials with the purpose of showing a physical representation of our design. The key objectives of this initial prototype will be to show the overall shape of our panels and to show how the assembly function of the design will work, we will also be able to gain knowledge on the proportions of the connecting points in relation to the size of the panels. In order to achieve these objectives the prototype will need to be of similar shape and size to the desired final product or if the prototype is smaller, its functions should be correctly proportionalized to the desired final product's dimensions.

From past design models, we have been able to determine where the connectors should be placed on the panels to easily be capable of expanding to cover multiple different types of areas, such as walkways, sidewalks, and entrances. We were also able to determine that the outer edge of the panels should be gradually inclined to allow wheelchairs to easily glide onto the panels surface. This incline will also prevent pedestrians from tripping over any level changes from one surface to another. With OnShape modelling and the sketches, it was clear that the outer edges of the panels should be gradually inclined and that the connection part of the panels should be square in order for the assembly of the panels to be completely flush as to not allow any water or any other unwanted material in between the panels. The prototypes will be made to show both the inclined edges and the flat edges. Another feature that we gained knowledge on upon creating the preliminary models was the drainage system. In the first prototype we will show the position of the drainage system on the external surface of the panels. The surface will include holes that will allow water to fall through which will then be funnelled away using the pipes in the inner part of the panels. It was previously determined that the direction of the drainage holes should be along each panel with a connecting pipe, in the shape of a 'T' that will take the drained water from the center of the panel out into the sewer. This prototype will illustrate the external functions of the drainage system and will show the shape and assembly of the panels.

Test Objectives and Stopping Criteria

Several test objectives and stopping criteria were established for each of the three (upcoming) prototypes; refer to the table in Appendix C. In the current deliverable, PD-F, Team 5 has constructed a prototype for the overall assembly of the final product, i.e. the heated sidewalk. As per the Prototyping Test Plan table in Appendix C, the stability and durability of the assembly are to be tested. The stability testing objective of the prototype helps determine the maximum threshold of water pressure that the prototype can sustain without impacting its structural integrity. This was tested through experimental means, by subjecting the prototype to six wash cycles, with both hot and cold water. The experimental approach was superior to the analytical or numerical approach, as the behaviour of the material 'in real life situations' can be best simulated and observed through physical experimentation, instead of being analyzed theoretically using the analytical and numerical methods. The second testing criteria was durability and strength of the first prototype. These criteria were tested by adding weights to the material to check its strength and durability. Both an analytical and physical test were required to obtain specific measurements.; weight capacity is physically tested for, whereas volumetric capacity is calculated from physical measurement. The basis structure withheld 35 pound weight capacity and 4.63 gallons of volume capacity. GThe main assumption in this prototype was that the bin material is truly representative of the final designed panel material; i.e. if the bin can continue to withstand load, then the panel can proportionally withstand more load as well. Another assumption was employed during testing, as dishwasher cycles were considered to provide almost equivalent average pressure on the bin as typical precipitation would. This is a fairly reasonable assumption, as precipitation is light with increasing pressure over time, while the dishwasher provides higher pressure in cycles. Therefore, if the prototype can withstand heavy dishwasher pressure cycles, it will be able to withstand the pressure exerted by precipitation events. The stopping criteria for the first prototype were determined by successfully completing the two aforementioned tests, to help determine the overall strength and durability of the outer body of the final design. This is essential, because if the outer body could not sustain high water pressure and weight, then it would collapse, thereby crushing the internal subsystems and failing the entire design. After multiple trials, and through the use of various materials/sizes of bins to represent the outer body of the heated sidewalk panel, it was decided that the bin in the figure set (Appendix A) was best suited to model the panel. To further elaborate on stopping criteria, the first bin was made of cardboard and could not withstand water pressure or carry 35 pound weight, thus wilting and failing as a model prototype. In contrast, the bins used in prototype 1 maintained their structural integrity, thereby reducing risk of failure in the panel. Therefore, the Team could not stop testing until the optimal representative material was found for the prototype. Lastly, the use of the outer bin helped meet client needs such as compactness of the panel, along with durability, etc. When the final panel is constructed after prototype 3, these observations and data will be used at a larger scale. For example, if the bin (which represents the outer body of the panel) can withstand 35 pounds of weight, the actual design panel will be able to withstand the weight of a standard adult male, along with disability vehicles, to prove effective. In the final design, Team 5 will build on the testing methods in prototype 1, and will add additional weights on the panels, along with moving weights, to determine any weakness in the panel design, and to ensure safety and minimal risk for the internal components and users of the heated sidewalk/Finally, as additional testing and prototyping is done, testing and stopping criteria which are outlined in the table in Appendix C, will be further elaborated on, in upcoming deliverables.

Wrike Link:

https://www.wrike.com/open.htm?id=626624970

Conclusion:

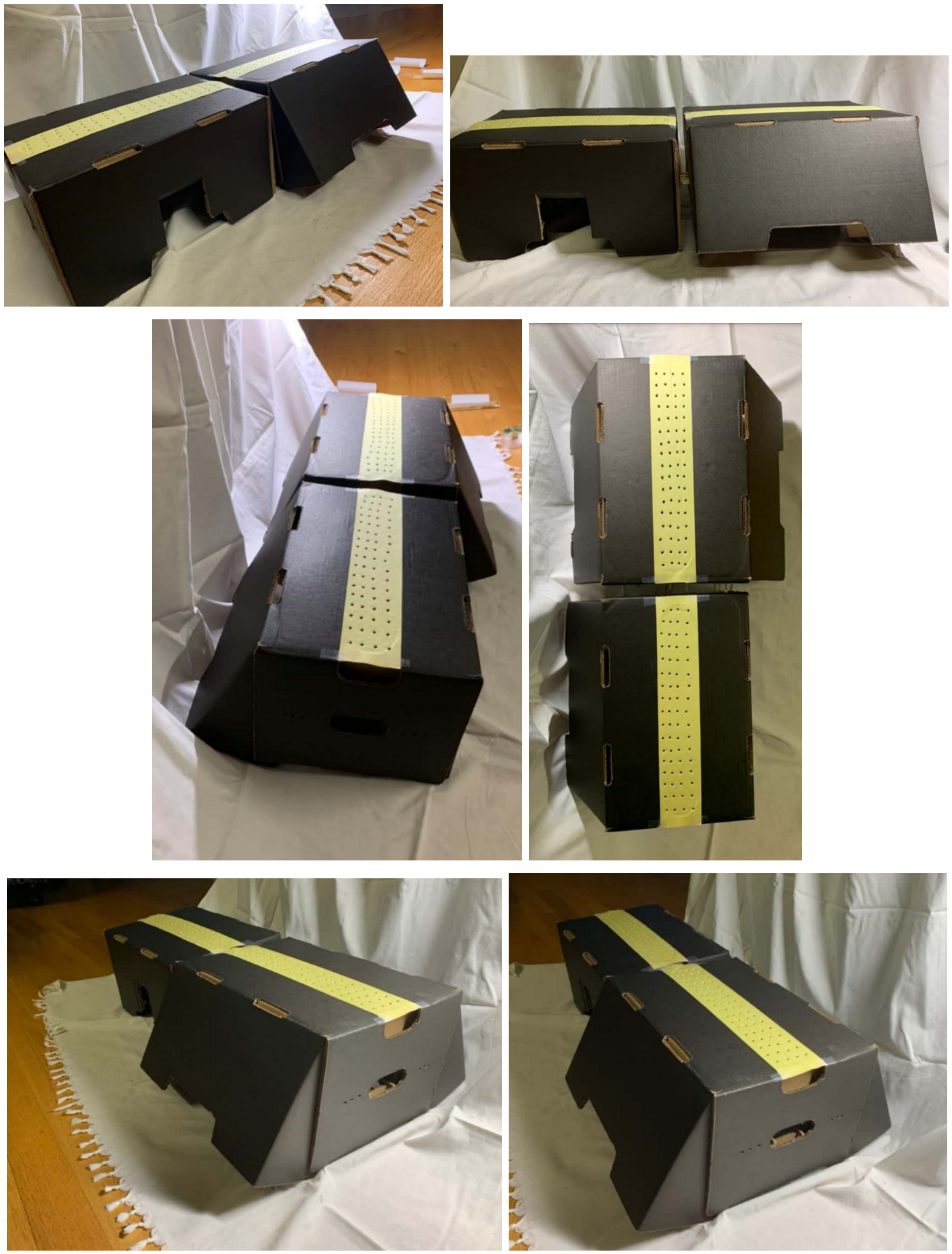
Overall, this week, Team 5 has taken the ideas from previous weeks and turned them into a real life tangible model. We started with our conceptual design and then came up with a series of tests so that we have objectives going into the prototyping stage. These tests will be broken up into four separate categories so that they can be completed on a carefully planned out schedule and it will allow the information gained to be used effectively as seen in the prototyping test plan chart. The tests that have been completed will have carefully recorded data that is relevant to what is being looked into and this will help with subsequent prototypes. After seeing this first prototype it should be apparent the general appearance of the device and also how the assembly will take place between panels. Moving forward, Team 5 is going to complete more of the planned tests and modify the design as seen fit based on the data collected during these tests. The next prototype will focus on another subsystem and aspect of the final product and will progress as such until design day when everything will be completed and the final fully functional prototype is shown. Lastly, as the team has successfully created a prototype to model the panels, along with meeting testing and stopping criteria, there are no missing tasks to be identified in Wrike as of this deliverable.

Appendices:

Appendix A: Physical Prototype 1

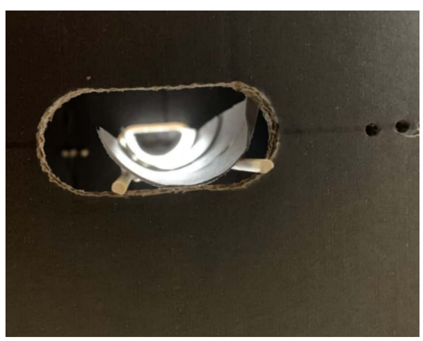
Surface:

The surface of the prototype serves as a visual representation of the grated area parallel to the directional placement of the individual components that make up the heated sidewalk device. The edges will be curved to avoid tripping hazards as well as provide a wheelchair friendly device. The yellow strip that runs down this greater system serves as the open barrier between the external precipitation that has been liquified allowing it into the systematic components of the device. This imported liquid will be disposed of via drainage pipes running throughout the device, the final output will be into sewers of the University of Ottawa and the city.



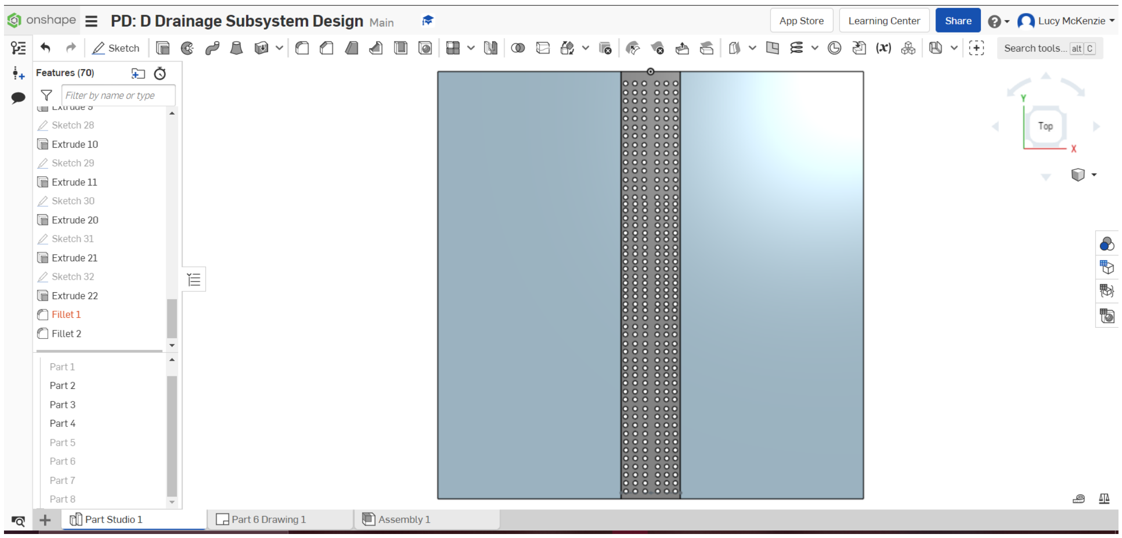
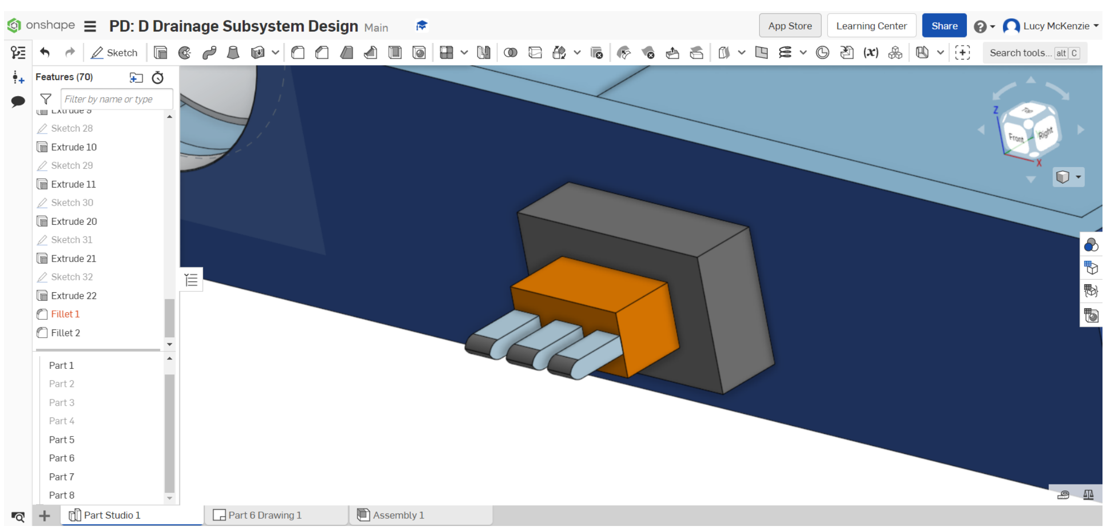
<table>
<tr>
<td>Prong connection:

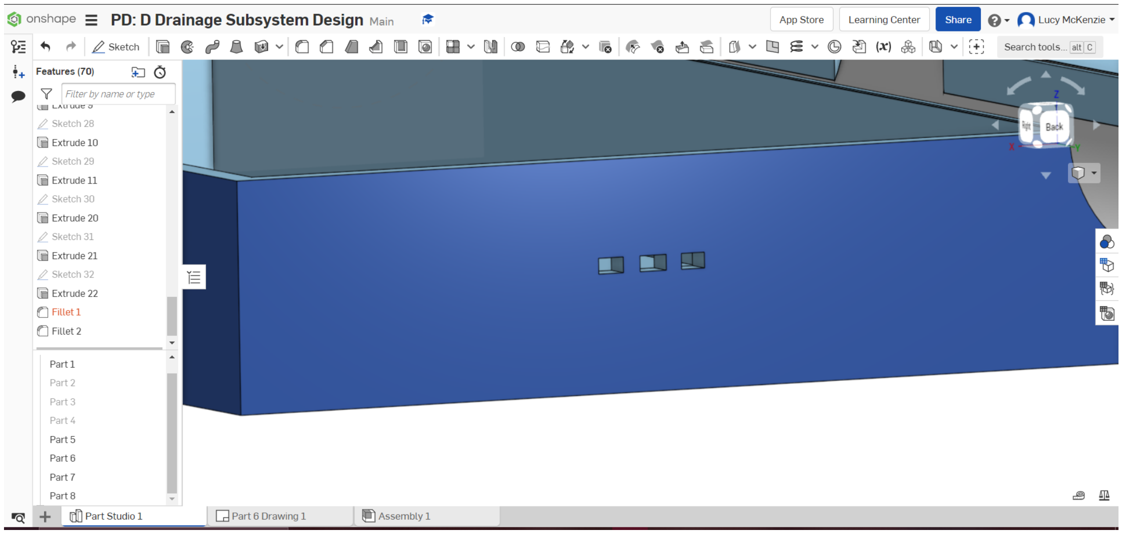
This is the model by which the electrical current will be traveling from each component of the assembly system. This is simply a representation, further insulative measure will be put into place for the final prototype.</td>
<td> </td>
</tr>
<tr>
<td>Structural Drainage:

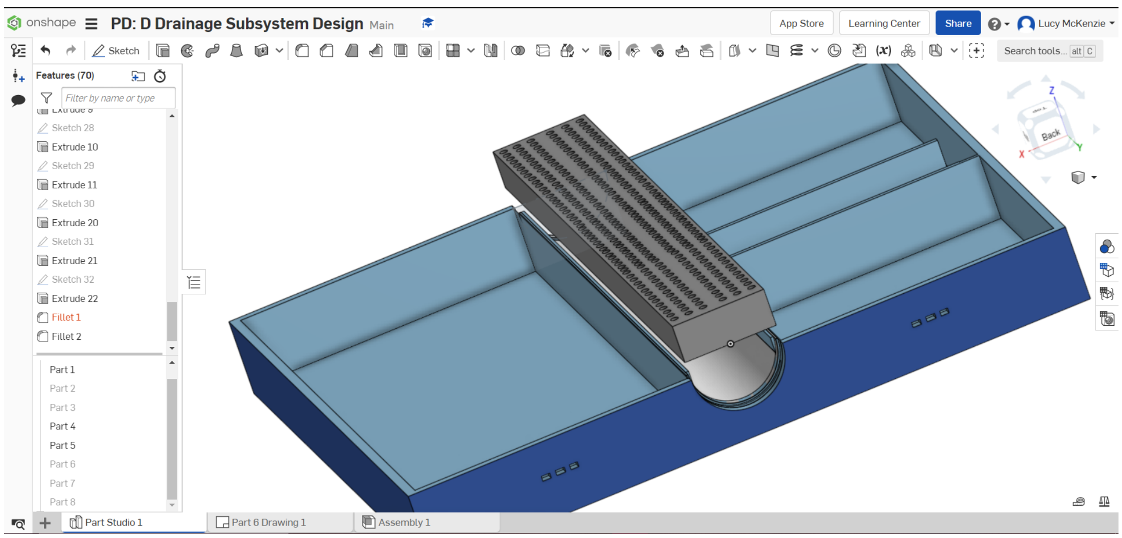
These images serve as a representation for the pipe design within the individual components. There are two different types of pipe placement; (1) regular, parallel piping running along the individual components and (2) T-structured piping which serve as direct output piping design. For the majority of the device, parallel piping will be used, but in locations where the inputted, liquified precipitation is able to exit the system and be disposed of into a sewer, T-structured, perpendicular piping will be implemented.</td>
<td>   </td>
</tr>
</table>

Appendix B: OnShape Prototype 1 Design

<u>Table 2: OnShape Prototype 1 Design</u>

Surface: There was no modification required to the original OnShape Design for the surface layer of the system.	
Prong Connection: The original OnShape design was modified to meet the new requirements of the first prototype design. For the prong connection, the edges of the prongs were filleted, to allow for a more professional look.	

<table>
<tr><td></td><td>
</td></tr>
<tr><td>Structural Drainage:

As few modifications to the structural drainage system were made. Formatting and editing the alignment of the different components.</td><td>
</td></tr>
</table>

Appendix C: Prototyping Test Plan

Table 3: Prototyping Test Plan

<table>
<tr><th>Test ID</th><th>Test Objective (Why)</th><th>Description of Prototype used and of Basic Test Method (What)</th><th>Description of Results to be Recorded and how these results will be used (How)</th><th>Estimated Test duration and planned start date (When)</th></tr>
<tr><td colspan="5">Prototype 1: Assembly subsystem</td></tr>
<tr><td>1</td><td>Stability of assembly</td><td>Determine how much water pressure could the basis structure withstand without any changes to its structural integrity</td><td>Dishwasher cycle was run three consecutive times in a row (3 with cold water and 3 with hot water). No started/corrosion proof was seen. Edges and assembly remained intact. Physical testing will yield better results as analytically calculating the force at any given point through a cycle would overcomplicate the test</td><td>6 hours per water type (hot and cold). 12 hours total (no supervision necessary). Date tested: 03/07/2021</td></tr>
<tr><td>2</td><td>Durability/Strength of material</td><td>Using bus bin structure as the basis, withstandable weight was measured by adding circular weights and recording this data. Place weights at the center of the structure and ensure even distribution for accurate results.</td><td>Both an analytical and physical test is required to obtain specific measurements. Weight capacity is physically tested for whereas volumetric capacity is calculated from physical measurement. The basis structure withheld 35 pound weight capacity; 4.63 gallons volume capacity.</td><td>20 minutes to add weights and record data. Date tested: 03/07/2021</td></tr>
<tr><td colspan="5">Prototype 2: Drainage system</td></tr>
<tr><td>3</td><td>Efficiency of drainage system (water in)</td><td>Holes were made into the bus bin structure (with heat) and the volume of liquid input was compared to liquid caught as output.

This test is made on an initial prototype thus the results are approximations

Testing was done 5 times and the average was used in calculations</td><td>Calculation of results using averages<table><tr><th>Input (L)</th><th>Out (L)</th><th>% Eff.</th></tr><tr><td>1</td><td>0.99</td><td>99%</td></tr></table>Observed that the water imputed flowed relatively quickly through the grate system created.</td><td>30 minutes to input liquid at the greeting system, record initial and final volumes. Date tested: 03/07/2021</td></tr>
<tr><td>4</td><td>Efficiency of drainage system (water out)</td><td>As the piping has not been shipped from the supplier (Home Depot), a similar pipe alternative was used. Determine how much inputted water left the drainage system from a T-sectioned assembly

This test is made on an initial prototype thus the results are approximations

Testing was done 5 times and the average was used in calculations</td><td>Calculation of results using averages<table><tr><th>Input(L)</th><th>Out (L)</th><th>% Eff.</th></tr><tr><td>1</td><td>0.97</td><td>97%</td></tr></table>Observed that the water imputed flowed out of the system relatively quickly.</td><td>40 minutes to set up the T-sectioned assembly as well as input 1 liter of water into the system and record the outputted volume. Date tested: 03/07/2021</td></tr>
<tr><td>5</td><td>Flow of water under different conditions (temperatures of water)</td><td>Determine whether the adhesive used would cause any leakage into separate compartments of the assembly system. Problematic as this has the potential to destroy structural integrity</td><td>High pressure water (hose) is aimed at conjunction between pipe and structural basis (bus bin) for 1 minute before it is untouched. Measure the amount (drops) of water that fall from setup.<table><tr><td>After 3 hours</td><td>After 9 hours</td></tr><tr><td>0 drops</td><td>0 drops</td></tr></table></td><td>9 hours of wait time after initial pressure spray (no supervision necessary)At 3 hours, record observations and the number of drops fallen. Repeat the process at 9 hours. If no drops then physical experimentation is satisfied; but if there is drop(s) after at 9 hours, continue testing in 3 hour increments (determine rate)</td></tr>
</table>

<table>
<tr><th colspan="5">Prototype 3: Electrical Input Control system</th></tr>
<tr>
<td>6</td>
<td>Accuracy of moisture sensor</td>
<td>Determine the minimum amount of moisture required to turn the sensor. This function will allow for the option of an on/off switch turned on by a certain amount of moisture detected. This will work towards reducing the amount of electricity required to heat the overall system.
This will be tested by progressively adding drops of moisture onto the sensor, to see how accurate the reading is.</td>
<td>Progressively adding more water drops onto the sensor until the sensor responds, as well as evaporating the water on the system.
<table>
<tr><td>1 Drop</td><td>5 Drops</td><td>10 Drops</td></tr>
<tr><td>Did not sense liquid drop.</td><td>Detected a small reading of moisture.</td><td>Detected a sufficient reading of moisture.</td></tr>
</table></td>
<td>30 minutes per amount of liquid dropped onto the sensor. 90 minutes total (supervision necessary). Date tested: 03/07/2021</td>
</tr>
<tr>
<td>7</td>
<td>Accuracy of temperature sensor</td>
<td>Determine the minimum temperature the sensor is functional at, as well as the minimum temperature required to turn the system on. This function will allow for the limitations of using their product outdoors to be presented, as well as the option of an on/off switch turned on by a certain amount of moisture detected. This will work towards reducing the amount of electricity required to heat the overall system and reducing the risk of the system failing if the temperature drops below a certain temperature.
This will be tested by connecting the temperature sensor to the arduino kit and decreasing the conditions (place the kit in ice, transfer to the freezer).</td>
<td>Testing the function of the temperature sensor while decreasing the surrounding temperature.
<table>
<tr><td>Ice</td><td>Freezer</td><td>Freezer + Ice</td></tr>
<tr><td>4 degrees C</td><td>-5 degrees C</td><td>-10 degrees C</td></tr>
</table></td>
<td>1 hour per station
3 hours total (supervision necessary). Date tested: 03/07/2021</td>
</tr>
<tr>
<td>8</td>
<td>Rate at which the wire reaches maximum thermal output</td>
<td>Determine the maximum heat output from the wire. The overall system is only required to be heated to about two or three degrees above the freezing point. However, in - 40C weather, the heat output from the system may not be enough to maintain a temperature of 2-3 degrees above 0.
This will be tested by recording the temperature of the overall system while increasing the power source applied to the system.</td>
<td>Testing the function of heat output from the wire by measuring the temperature given off.
<table>
<tr><td>1 hour</td><td>2 hours</td><td>3 hours</td><td>4 hours</td></tr>
<tr><td>Roughly 5 degrees C</td><td>Roughly 10 degree C</td><td>Roughly 15 degrees C</td><td>Roughly 20 degrees C</td></tr>
</table></td>
<td>1 hour per heat level
4 hours total (supervision necessary). Date tested: 03/07/2021</td>
</tr>
<tr><th colspan="5">Final Prototype Testing</th></tr>
<tr>
<td>9</td>
<td>Effectiveness of anti-slip coating</td>
<td>Determine how much liquid on the surface will cause a significant decrease in traction on the surface layer of the system.
This will be tested by sliding an object with some weight across the surface of the system while progressively adding more liquid to the system. This will allow for the friction coefficient of the surface to be tested.</td>
<td>The average of each section was taken (3 trials each):
<table>
<tr><td>1 cup water</td><td>2 cups of water</td><td>3 cups of water</td><td>4 cups of water</td></tr>
<tr><td>Shoe did not slide</td><td>Shoe moved 0.1 cm slide</td><td>Shoe moved 2.5 cm</td><td>Shoe moved 4 cm</td></tr>
</table></td>
<td>5 minutes per trial
15 minutes total supervision necessary). Date tested: 03/07/2021</td>
</tr>
</table>

<table>
<tr>
<td>10</td>
<td>Minimum temperature of the overall system can function at</td>
<td>Determine the lowest functioning temperature the system is able to function at. This will be tested by connecting the system in full and decreasing the surrounding areas of the system (placing in ice and freezer). This goal is for the system temperature to not drop below 0 degree C.</td>
<td>Testing the overall function of the system while decreasing the surrounding temperature.
<table><tr><td>Ice</td><td>Freezer</td><td>Freezer + Ice</td></tr><tr><td>5 degrees C</td><td>2 degrees C</td><td>0.5 degrees C</td></tr></table></td>
<td>1 hour per station
3 hours total (supervision necessary). Date tested: 03/07/2021</td>
</tr>
</table>