Project Deliverable E: Project Schedule and Cost Estimate
GNG 1103F – Engineering Design

Faculty of Engineering – University of Ottawa

Team 3 F01

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Table of Contents

Introduction

The purpose of this document is to show the next step in the design process that our team is working on. The task at hand is to develop a modular product which will remove snow and ice from the campus sidewalks at the University of Ottawa. This would be a replacement for salt which causes severe damage to infrastructure and the environment.

Using the concepts generated in PD D, the team has developed a more detailed design for the product. This will be used to generate the first prototype. The plans for prototyping are also discussed as well as how our concepts will be tested. The last thing the document touches on is an estimated bill of materials which has been researched and calculated.

Detailed Design

The following section discusses the Final design the team has come up with. The Below figures are sketches of the design that we will begin prototyping shortly.

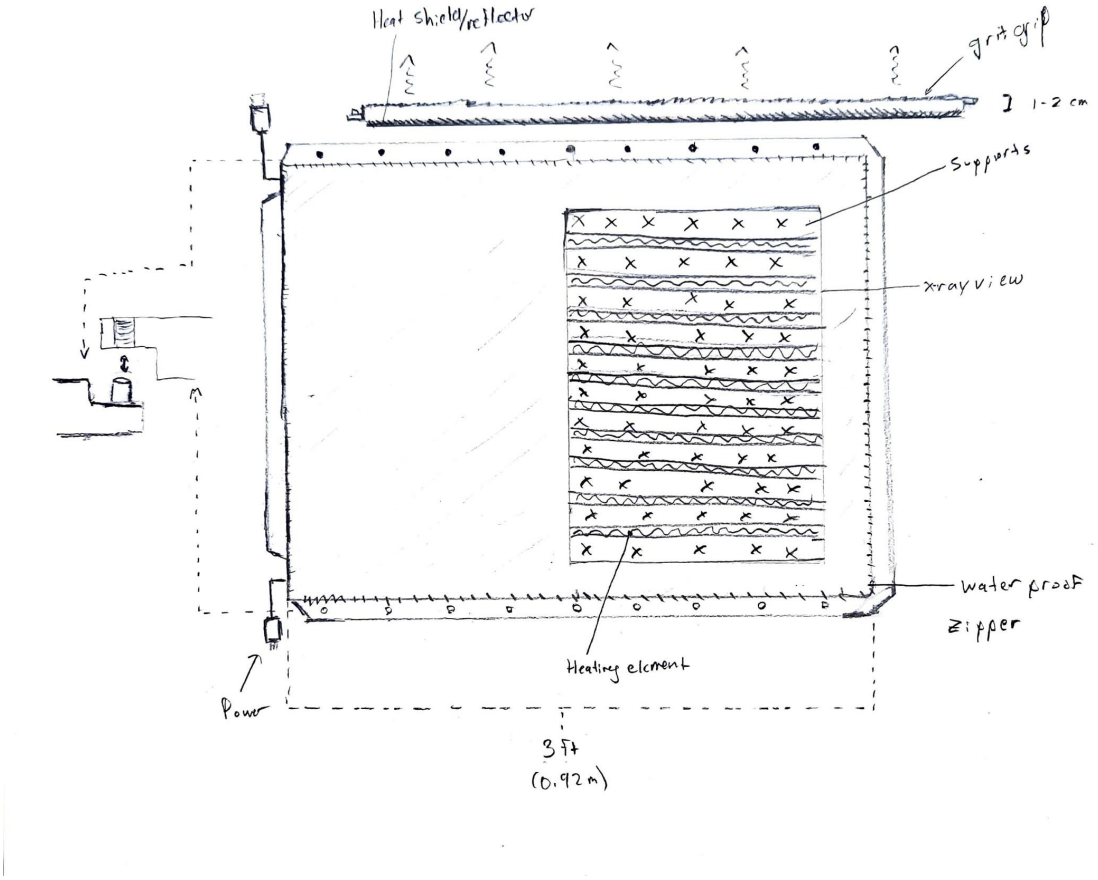


Figure 1. - Top and side view of design

The sketch in Figure 1 is a drawing of the main body of the design as well as an x-ray view of the interior which will be mainly composed of supports for people and the electronic heaters. The top of the module will be covered in a grit grip. This will be created by using an adhesive spray and a sand type grit. This will allow for safe passage over the device while keeping costs down. Additionally, it can be put onto any material we decide to make the design out of. Currently, we are looking at PVC as a promising material as it is cheap and can be heated to the temperatures which we require. For ease of maintenance, we will be sealing the design with a waterproof zipper which will allow for immediate access to the electronic components within the design. For the purely mechanical connection between the modules, we plan on having plastic connectors along the edges of the sidewalks. These will be teeth which nest into

holes on the next module. This is solely for stability and alignment purposes, no power will be passed through this section.

For the heating elements, we are still on the fence on what path to take. We have reached out to suppliers of printed PTC heaters for pricing and perhaps even a sample for prototyping and have yet to receive a response. If these companies do not respond it is likely that we will implement an insulated resistive wire. The options for this range from thin nichrome wires which we can insulate ourselves to a wire used for heating small terrariums for household pets. In the case that we will be implementing a wired heating element, we will be using a microcontroller along with temperature sensors and a soft power switch to control the temperature and keep it at a safe level.

The power will be passed between modules of sidewalk heater using the system pictured below in Figure 2. This is an electrical wire passed through a hose which will be waterproofed through a male-female threaded nut connection. This will allow for safe power transfer between modules.

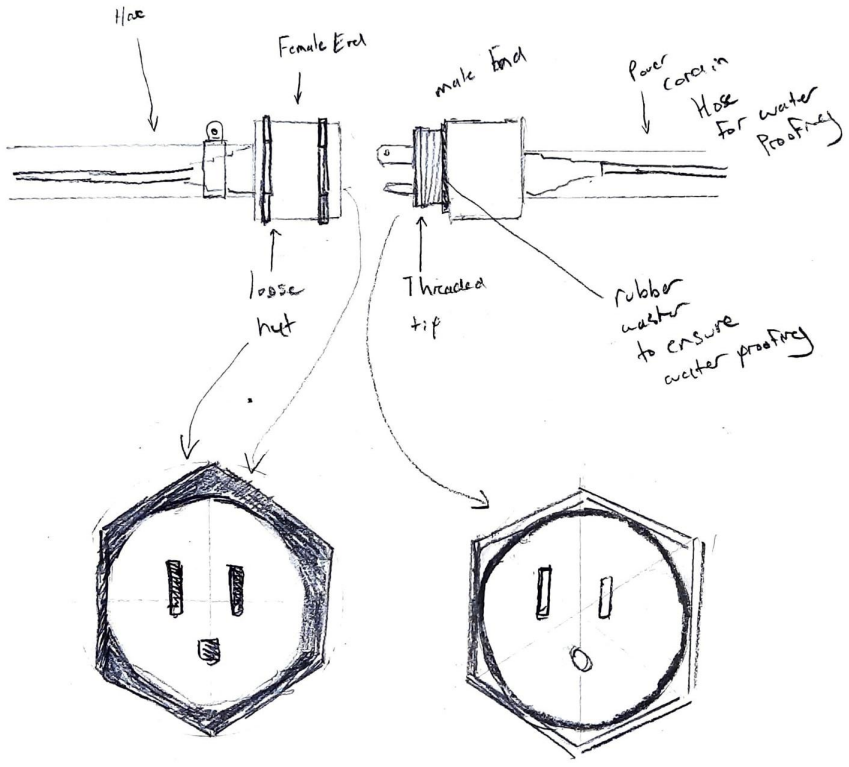


Figure 2. - Power connection between modules

Prototype Plan

The following section outlines the plan we have for prototyping and testing our design. It discusses the purposes and goals of each prototype and how assumptions will be tested.

Prototype 1

For our first prototype, we will be doing a proof of concept, low-fidelity prototype. This will be a simple prototype to show some of the main systems and get a better grasp on the dimensions of the product. It will be compared to standard sidewalks to test the fit of the prototype. We also plan on doing some basic electronic simulations on tinkercad to test how our system will work. We will plan to test grip concepts in this stage looking to find what will work best with the materials we have.

This will also be the stage where we will be in the process of purchasing our materials for further prototypes. This includes heating elements, electronics and other materials.

Prototype 2

The second prototype will be a more indepth exploration of the electronics of the product. This will involve real life testing of the heating element and the system which controls it. This will involve building relevant circuits and testing them for errors and any additional circuit members which were originally overlooked.

This will also be a time when the team will begin to construct the body of the final product for some more condition testing. This will be tested by puting the prototype in the outdoors to see how the elements react with our design. This will allow for us to make any alterations which are required to the casing to waterproof it.

Prototype 3

The final stage in our prototype plan is to mate all of the systems we have tested so far and get things ready for design day. We will be running some more tests to analyze how the systems relate to each other and ensuring they work well. Ideally, this will be a very high-fidelity prototype, essentially functioning as a finished product.

Task	Start Date	End Date
Develop Prototype 1 based on feedback from client meeting 2	2021/03/01	2021/03/07
Purchase materials for further prototypes	2021/03/01	2021/03/28
Customer Feedback for Prototype 1	2021/03/08	2021/03/08
Analyze and revise Prototype 1 based on feedback	2021/03/08	2021/03/08
Develop Prototype 2	2021/03/01	2021/03/14
Test Prototype 2	2021/03/01	2021/03/14
Prepare for client meeting 3	2021/03/13	2021/03/15
Customer Feedback for Prototype 2	2021/03/15	2021/03/15
Develop Prototype 3 based on feedback from client meeting 3 and customer	2021/03/14	2021/03/28
Analyze and test Prototype 3	2021/03/14	2021/03/28

Risk & Contingency Plan

Risk: Arduino board or other electronic components do not work because of contact with water.

Contingency plan: Improve leakproof of case system. When necessary, use electrical tape to cover electronic components or separately design a waterproof case for the Arduino board to ensure that it works in a dry environment

Risk: People may fall while walking because the grip performance of top texture is poor.

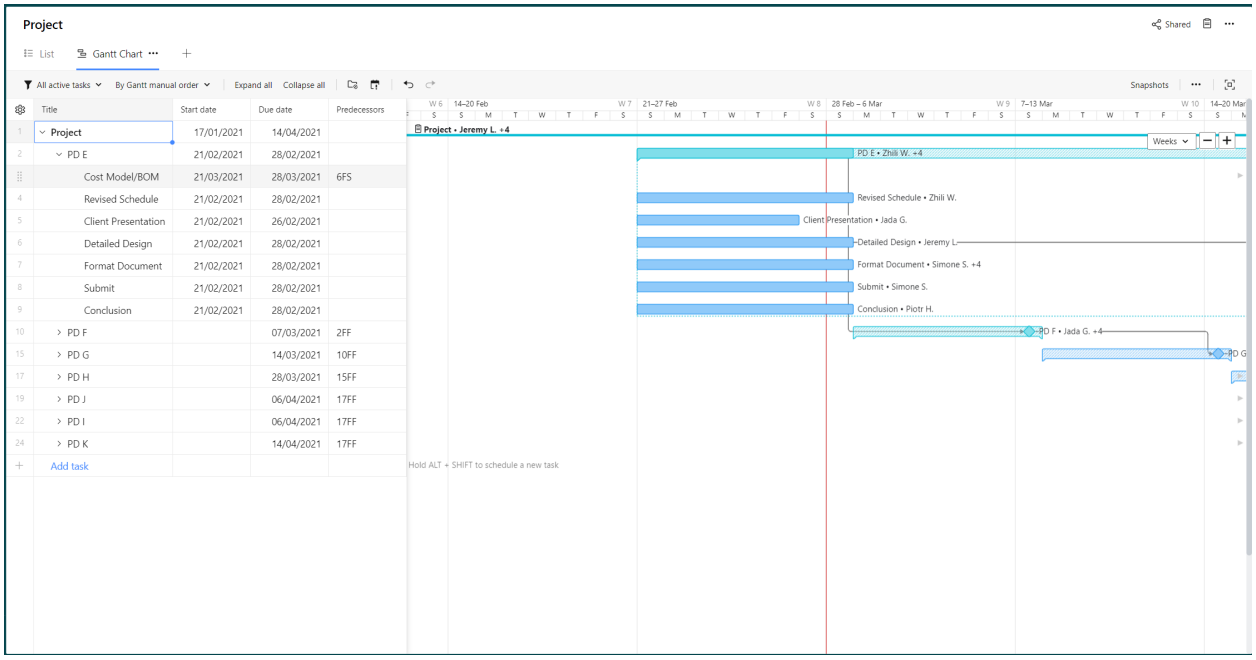
Contingency plan: Our team will design more non-slip textures and test their grip performance. If all the textures cannot provide satisfactory grip performance, we will try to cover a non-slip mat on the top of the shell.

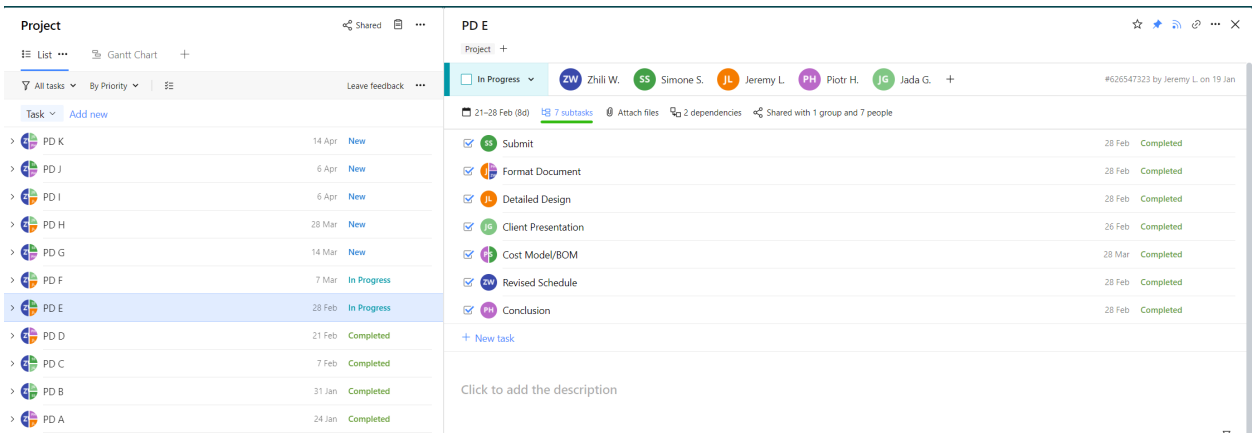
Risk: At the temperature below -40°C , the case made of pvc material may become brittle and easily broken.

Contingency plan: This risk is being discussed in our group. We still have expectations for PVC materials. When developing prototype 2, we will test the low temperature resistance of PVC

materials. In addition, we are also searching whether there are better alternative materials for the case.

Wrike Task Board:





Bill of Materials

Part	Qty	Description	Vendor	Unit Cost	Extended Cost
Mini Arduino	1	Controls electronics	Amazon Link	6.66	6.66
Temperature Sensor	1	Senses the temperature	Amazon Link	9.80	9.80
PTC heater or Insulated Nichrome wire	1	Heating element	PTC link link	17.09	17.09
	1	Heating element	Nichrome link	12.62	12.62
Mosfet	1	Allows for a soft power switch	Amazon Link	1.80	1.80
Circuit wire	2	Insulated wire	Home Depot Link	1.50	3.00
Material for casing (PVC)	2	Durable casing	Home Depot link	5.78	11.56
DC DC converter (Buck Converter)	1	Drop down voltage converter. This will allow for a more specific voltage to be passed to the mat from the initial power supply.	Amazon link	10.99	10.99
Power cord	1	Connects to tiles and power grid	Amazon link	13.05	0
Hose Nozzle (Male and Female)	1	Keeps power connectors in place	Amazon link	1.73	1.73
Hose	1	Power cord protector	Home depot link	10.16	10.16
Coating	1	Gorilla glue	Amazon link	12.48	12.48

Some parts will be able to be 3D printed at makerspace. There, PLA is free and is good in cold temperatures. We also don't have the budget for other filaments and parts such as hose nozzles and teeth connectors between modules. The extended cost of the power cord is put as zero because we will be using power cords that we already own.

Conclusion

A detailed design has been created for our product, which allows us to begin planning for the prototypes, along with the bill of materials. Due to the price limit imposed for this project, some of our ideas for the product had to be changed or scrapped completely for our first BOM. The first prototype will attempt to be a proof of concept which highlights the main aspects of our design.