GNG 1103 [F]

Engineering Design

Course Professor: **Rubina Lakhani**

Deliverable F - Prototype I and Customer Feedback

Prepared by Group: # 4

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Introduction

In this deliverable, we will try to develop prototypes based on our previous test plan. The prototype will help us explore and analyze various aspects of the prototype, so we can improve our design for the next iteration. We had our second meeting with the client, where we put forward our ideas and then got feedback to clarify customer needs and to see if there were any aspects we should change or focus on. Using this feedback we created our first physical prototype using cardboard and 3D models in Onshape to ensure the integrity and authenticity of our heated sidewalk concept.

1.0 Client Meeting

The second meeting with our client provided our team with very valuable insight regarding directions we could take our product. One of the first notions touched upon was the folding aspect in our first prototype plan. Originally, our thought was that folding would be an essential part of the design since it was mentioned in the criteria for the product that it should be compact in storage. However, the client clarified that it would not be an essential part of the design for the product to fold, so if any extreme complications were to arise in the later stages of design involving the folding aspect, it could be dropped from the prototype.

The client also emphasized the point of having a method by which water can be channelled off of the mat, since having water buildup on the mat will reduce both traction and the ability for the mat to transmit heat. This is due to water having a high heat capacity, and thus a coating of water would require a greater amount of heat output to melt additional snow/ice. The client validated our idea of having ridges under the module to allow the passage of water, however, he also pointed out that that this would reduce the amount of surface area in contact with the ground, and thus we would need to account for this in design so that the mats do not slip despite the reduced contact.

In terms of the power supply to our product, the client validated that our idea to utilize a junction box would be applicable in this case and that they could be added to buildings if the product were to become a large-scale operation. He also confirmed that the power sources would be standardized, in that they all output the same amount of power.

Some additional points of caution brought up by the client are as follows:

- That the product should be automated if possible so that workers will have an easier time both working with the product and performing maintenance.
- Security should be a priority since it is doubtless that others will attempt to access/damage the product; however, a lock may not be necessary. A specialized hidden latch would do the job just as effectively.

- The team is encouraged to note down ideas “for the future” in the event the scope of our product is narrowed to the mat alone.
- The goal of the design should be to provide the product with the most flexibility for the client, in that it should be functional in a variety of situations.

2.0 Test Plan Outline

In this portion of the testing phase, we decided to create two prototypes, an onshape design and a cardboard prototype to be able to analyze more features early on. For the cardboard model, we focused on testing the folding mechanism of the mat and verifying that our current design of having one corrugated line down the middle of the mat to fold the mat over will work, while still keeping the internal components safe. Using cardboard allowed us to make quick and cheap iterations in case the folding mechanism didn’t work and we needed to try out new designs.

The onshape drawing was used to visually analyze whether any key components of our design were missing, whether the placement of openings for electrical components theoretically made sense and was optimized, and to help convey our current design plan to the client during future client meetings. During the next prototyping cycle, we will continue to build off this drawing so that we can test more analytical values and measure out the size of each component we will need when physically building it.

3.0 Cardboard model

This prototype was focused on testing the folding mechanism and the protection of the internal components during folding. Immediately during the creation of this prototype, it was apparent that having just one folding point down the middle of the mat would not work since the thickness of the mat would not allow for it lay flat when folded and the edge of the mat would be curved and potentially damage the internal structure.

This prototype was created using styrofoam for the internal columns, cardboard for the external mat structure, tape and phone charger wire to simulate the heating cable as seen in Figures 1 and 2.

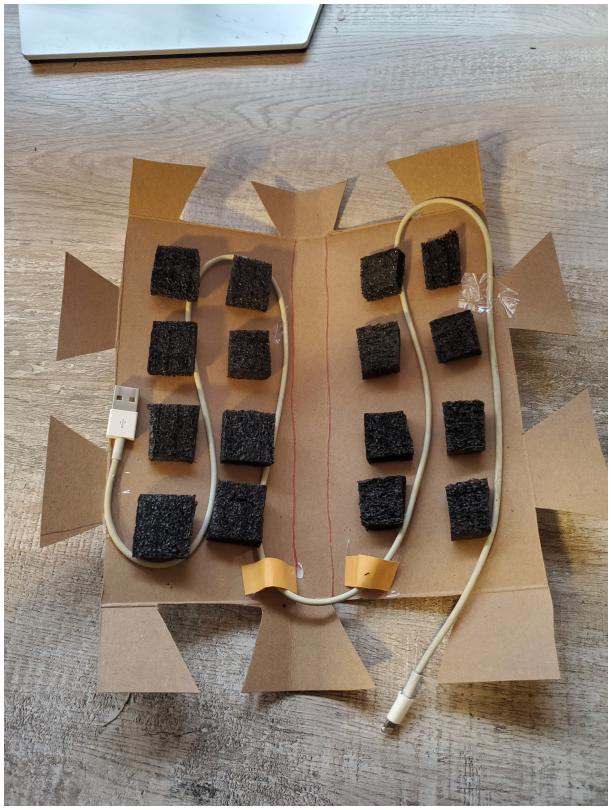


Figure 1. Cardboard prototype of the mat and internal structure

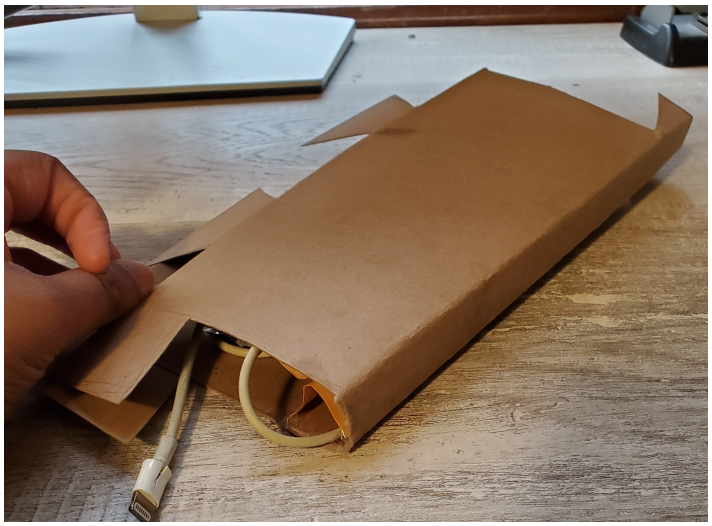


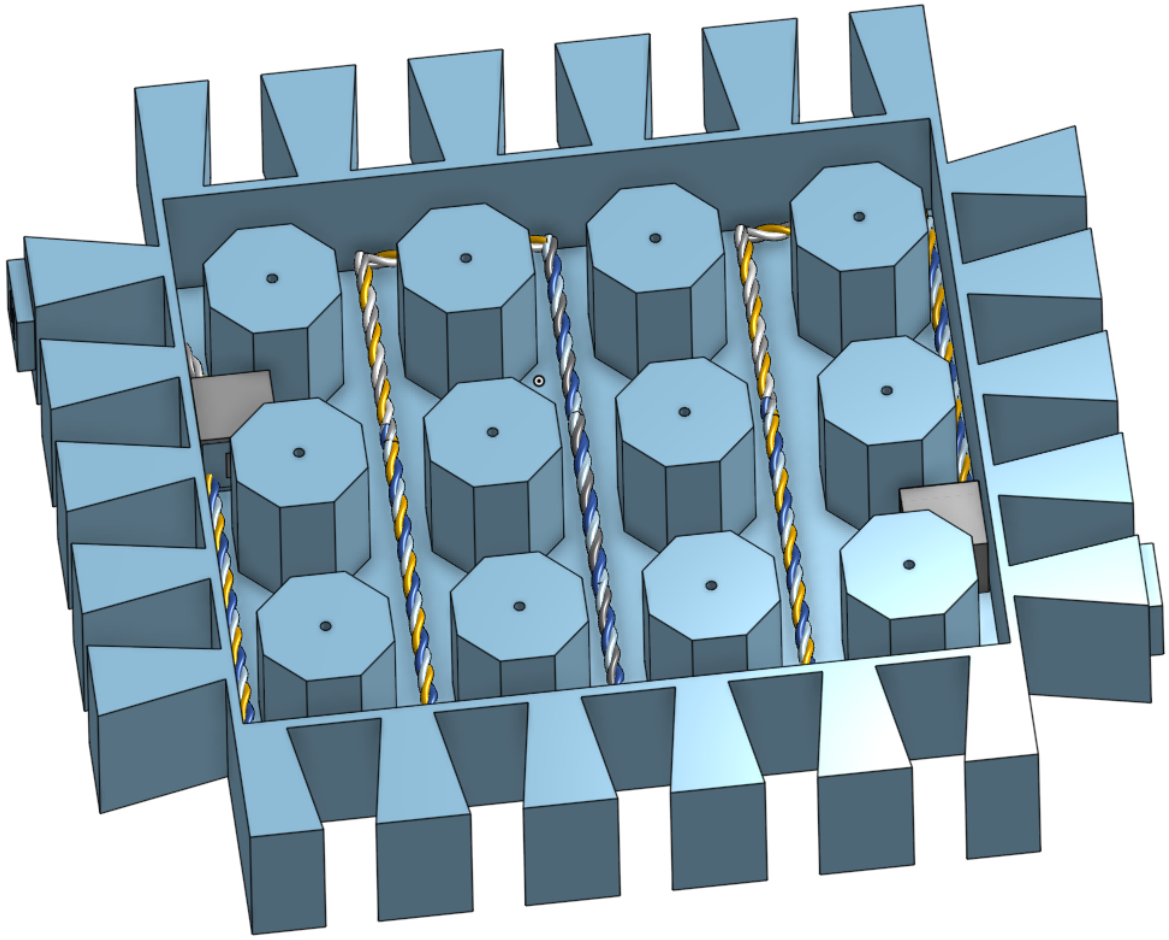
Figure 2. Cardboard prototype to simulate mat when folded

What we learnt from the prototype

- A single folding line in the middle won't work due to the thickness of the mat and the internal components it contains (it either damages the internal components or makes an awkward bend so the mat doesn't lay flat when it's folded)
    - To combat this we created a two line fold that's width is about the same size as the column so that it creates a flat edge along with the folded size which allows the mat to lay flat when folded and protects the internal components
- We used a phone charger cable to prototype the heating element. This wire tend to curl a lot so it was a good test to see if the wire could be held in place using the columns
    - We found that the columns acted as great guides to shape and hold the wire in place
    - Additionally, when the mat was folded, the wires on the right of the mat that would be hanging upside down when folded stayed in place and didn't dangle off the mat even while it was flipped upside down because of the pressure the studs caused on either side of the wire held it in place
- The original plan was to have one compartment near the folding point to thread the wire through
    - With the 2 lines folding system, we will need to loops on the side of each folding point
- One problem with the two lines folding system is that there will be a tiny gap created between the two portions of the mat when folded, this issue will be investigated during the next prototyping phase

4.0 Onshape model

This 3D model was focused on modelling what the interior of the design will look like and how its space can be best managed to provide the peak efficiency possible for the final design. During the creation of the model, it became apparent that space management would prove difficult such as in the case of the folding mechanisms protective cover for the wiring at certain points that would need to take up a decent amount of interior space. Therefore for this 3D model, the folding mechanism was excluded, to allow us to focus on the other interior components of this design. This model was designed and assembled using the Onshape program provided by the school.



What we learnt from the 3D model:

- Interior space management will be crucial in the final product as every interior component will require enough room to function and be accessible. Similarly, wire management will also be important to make sure that we maximize our space by minimizing the amount of wiring used to accomplish the desired purpose.
- The dovetails size is going to prove very important to try and minimize the weight of the design as well as general ease of use. By making the dovetails thinner, it will make them less cumbersome and the design easier to use, but that also would make them less efficient and more fragile. This balancing act with the size of the dovetails will be an important factor in the weight, simplicity, durability and efficiency of the final product.
- Attempting to design the folding mechanism in a 3D environment proved very difficult because of the sheer size of the model not being easily compatible with a

folding mechanism that essentially cuts the entire model down the center.

- Depending on the number of electronics needed for the electrical socket to work properly the design might need to be expanded, but this also raises the question of whether this socket on the interior of the design could be replaced by something more space-efficient.

Conclusion

In summary, based on the feedback provided by our customers, we have gained some benefits. First, he clearly emphasized that ensuring safety is the most important design concept and goal. In addition, folding products can be viewed as additional features we can add on if time allows. Also to allow water to be drained, we can use the method of placing a ridge under the mat to allow water to pass through. Not only that, but the method of using standard voltage junction boxes has also been affirmed and conforms to the circuit standards. After the physical prototype was completed, according to a series of tests conducted on it, we first improved the folding plan and changed the folding line in the middle to two rows of folds to make it straight and protect the internal structure. Flexible cell phone charger cables were used as a prototype of the heating element, which adds a lot of convenience to the test of the internal structure. Whether the cylinder can fix the wires is more intuitively reflected, but the content of the test is much more than that. We will continue to research and strive to make the design more refined and get more satisfactory results in future deliverables.