GNG1103

Design Project User and Product Manual

HEATED MATS

Submitted by:

Thunder Corp, Team 10

Al-WALEED AL-HAMEDI, 300129280

Ahmad Hamad, 300144058

Eric Wan,

Chelse Rose Vadakkeveettilan Hilariyos, 300214163

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List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
TM	Thunder Mat (The product of Thunder Corp)
UPM	User and Product Manual

1 Introduction

Our client, Jonathan Rausseo needed a solution to an ongoing environmental and equity problem on the University of Ottawa campus. During winters, snow on the campus is removed using salt, which is financially draining and environmentally damaging. Furthermore, students with accessibility needs must wait until the snow is removed on campus to go to their classes. These problems can be solved by providing heated sidewalks to the school.

Thunder Corp combined the idea of heated mats and the needs of heated sidewalks on a university campus to create Thunder Mats. The Thunder Mats can be placed over the sidewalks during winter. They can detect temperature drop in their surrounding and maintain a 1 °C to 3 °C temperature to melt the snow. The inbuilt temperature and humidity sensors can detect when there is no need for the mats to be active and turn off, therefore saving energy. Thunder Mats are also light-weight and highly customizable. They serve as an environment and cost friendly solution for our client.

This User and Product Manual (UPM) provides the information necessary for Thunder Mat users to effectively use the Thunder Mat (TM) and for prototype documentation. This documentation provides users information on using the product conventions, troubleshooting, and validation process of the product. It also allows others to expand and improve Thunder Mats in the future. In general, the UPM is to allow others to use, maintain or reproduce the project.

2 Overview

At the moment, the university of Ottawa is using salt to remove/melt the snow. Various disadvantages are associated with this method, that include high cost, environmental issues, and many others. A modular, scalable and deployable heated sidewalk is needed in order to replace the use of salt. There are several needs that are required to exist in this heated sidewalk that include:

- High safety. We want to make sure that it is safe for users and will cause no damage. For example, we want users to walk on it easily without slipping.
- Long lasting. We want it to last for at least five years.
- Environmentally friendly. The main reason why we are shifting from using salt to this alternative solution is to avoid the environmental damages that salt cause when used in snow melting. Therefore, we want the product to be environmentally friendly.
- Cost-efficient. We want it to be cheap and easy to build.
- Flexible and easy to clean and maintain. This product should be flexible so that it could be installed easily during winter and removed to storage when not needed. We also want it be easy to maintain and clean.

In order in provide such a product, we compared between three different solutions/products: solar roadways, snow melting cables, and heated mats, as it shown in table 1.1.

Table 1.1: Benchmarking.

Specifications	Solar roadways	Snow melting cables	Heated mats
Insuring safety	Unknown	yes	Yes
Modularity	No	No	Yes
Metl snow above it	yes	yes	Yes
Scalability	yes	yes	yes
Operating conditions	Effective	Effective	Effective
Energy use	Low energy: 48-watt solar panel using 23.7 % efficient.	High energy: 214 ft2, uses 10.016 kW.	Moderate energy, thermostatic material, it can p
Removal and storage	No	no	Yes
Longevity	Up to 15 - 20 years	Up to 25 - 30 years	ars Up to 7 - 8 years
Cost	Installation price: $7-$9 a watt, so a 5kW system would cost $25,000 to $35,000. Long term pricing is	Additional costs for building a new sidewalk. High capital cost that needs to be paid upfront. Ex.	It can cost around $700 to $1,500 for large mats. Ex. it costs $145 for a 20-inch x 60-inch mat.

	very low.	$2,549 for 214	

After doing the comparison between the different possible products, it is clear that the heated mats win. Saying so, we proposed different designs for this product at the beginning. After that, we tried to group whatever could be grouped, and come up with one final design. In the end, created one single product that contained the features of many. The following pictures illustrate our initial visualization of the product.

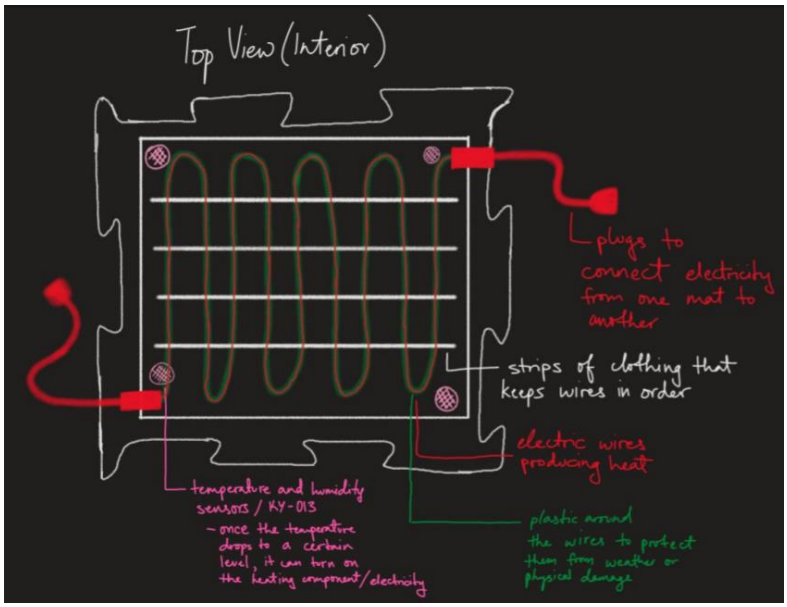


Figure 1: exterior part of the design.

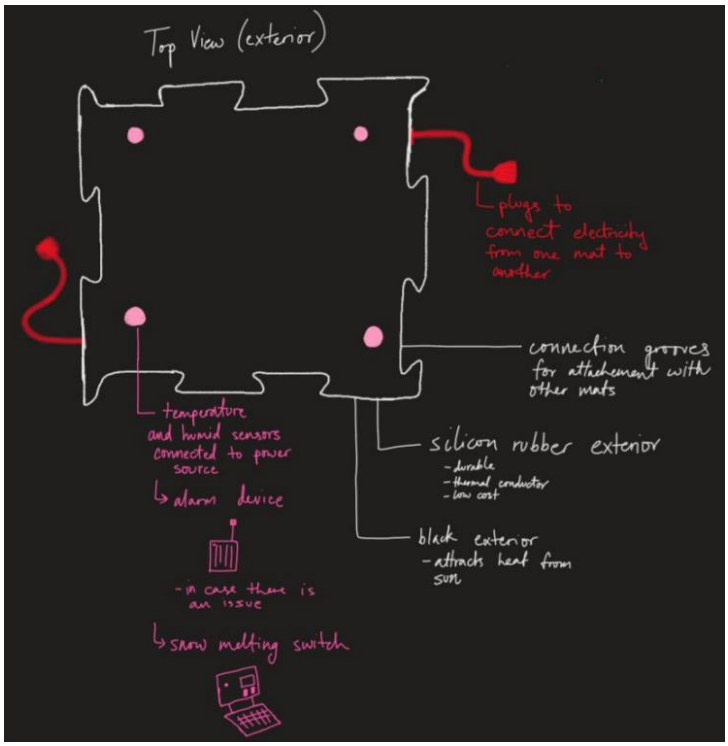


Figure 2: exterior part.

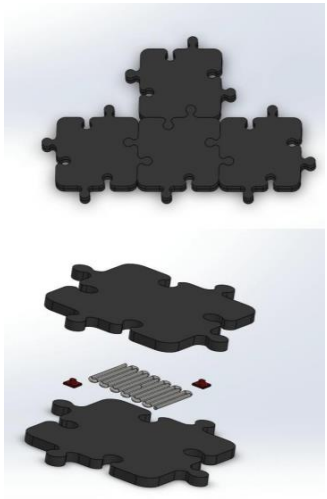


Figure 3: 3D model.

Overall, our last design contained many advantages compared to the other designs.

Table 1.2: advantages and disadvantages of final design.

Advantages	Disadvantages
- Four Temperature and humidity sensors. - Alarm system. - Snow melting switch. - Thermo-plastic for the exterior part. - Connection grooves. - Connecting plugs. - Black exterior to attract heat. - Plastic covering wires for protection.	- Heat might be lost quickly.

A prototype was created to test the functionality of the design, and the following link proofs that the product works: https://www.youtube.com/watch?v=kmGkYxZEqsc

2.1 Cautions & Warnings

- Kindly do not jump on the mats as this might damage the interior parts. Instead, walk on them normally without running or jumping.
- In the case of fire, please do not attempt to stop the fire. Instead, call the maintenance team and they will take care of it.

3 Getting started

The goal of the system was designing a heating mat, it is meant to keep a specific relatively high temperature compared to the surrounding during winter; specially snowy days. It is used to melt the snow instead of using salt for this job. Our design is a fully functioning prototype representing the required system. It consists of a black poly plastic exterior and interior layer which absorbs heat, has high heating capacity which is more efficient for a cold surrounding and can absorb heat from the sun effectively.

The design consists of a heating source attached to an electricity source (a 40,000-ampere battery in the case of the prototype) and attached to an Arduino from the other side. The Arduino is attached to heat and humidity sensor, with the aim of the coded in the Arduino that was added to it. The sensor would send the readings for the temperature and the humidity (to know if there is snow to melt or no) to the Arduino, in return the Arduino will turn the heating source on and off when not needed. All components lie inside the poly material mat, which is asymmetrical, size flexible and designed to contain the all the components.

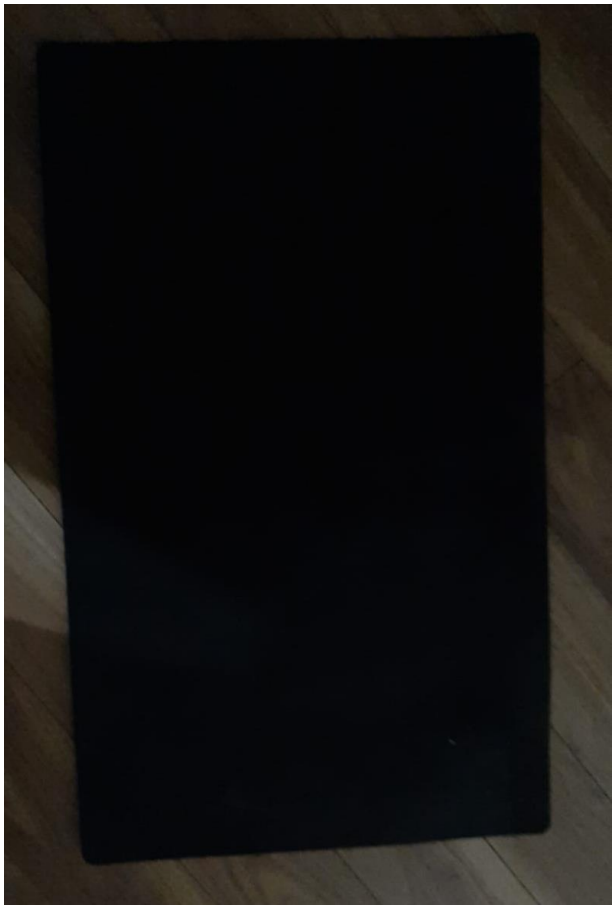
For someone to use out product they would need to just put it outside in the cold environment and make sure electricity is attached to the battery, in a real-life example the battery would be provided with a wire that can be used for continuous energy source. The costumer would only need to attach the end of the plug to a stable electricity source.

Below is a real representation of out heating mat functioning.

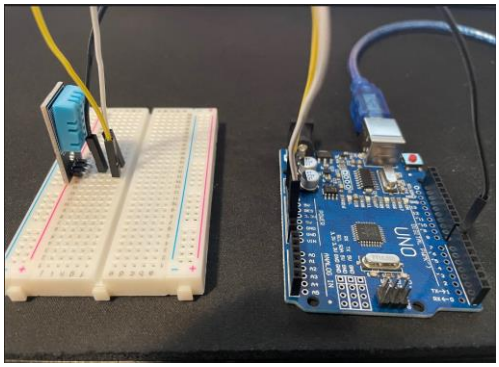
** https://www.youtube.com/watch?v=kmGkYxZEqsc **

3.1 Set-up Considerations

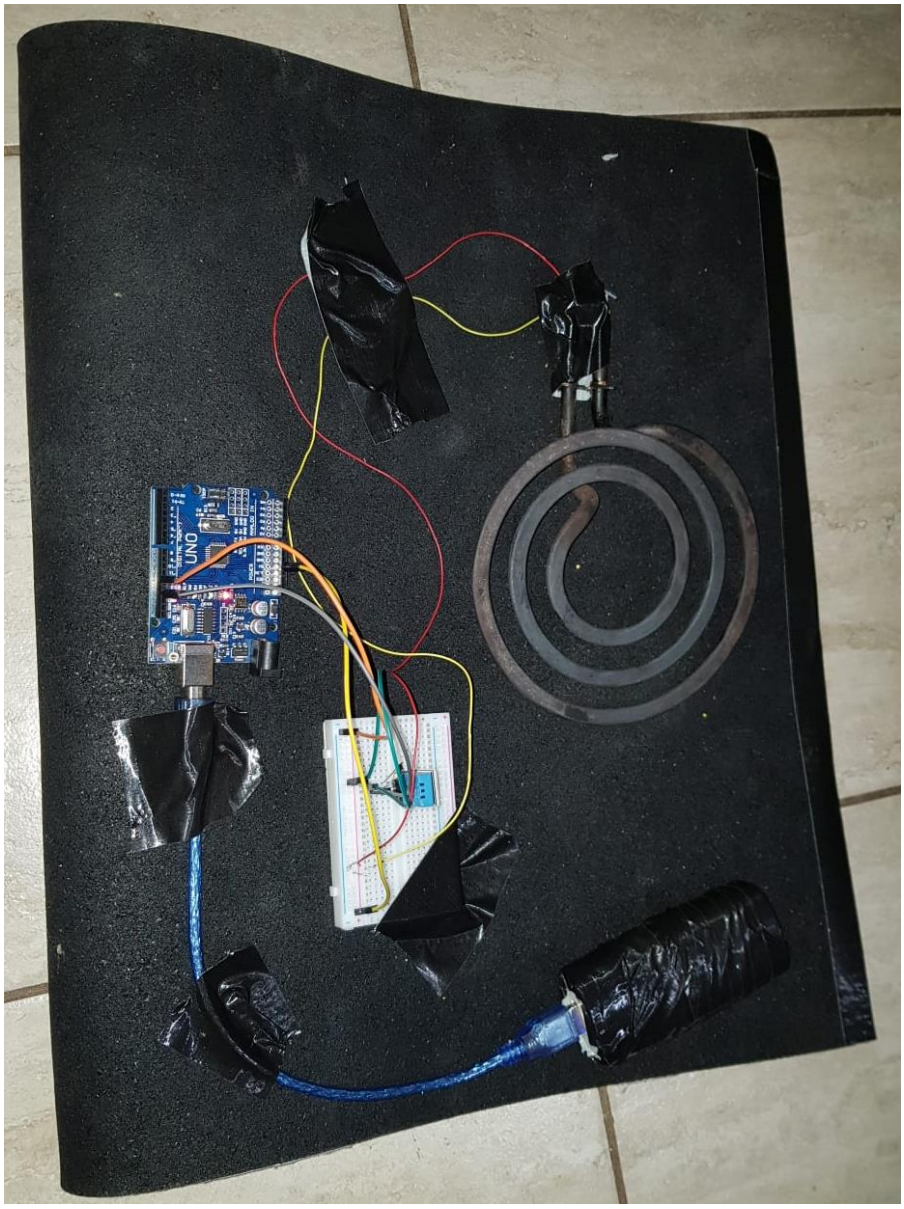
This is the Energy source in our design. In the real-life long-lasting example we would add a charger wire to the heat source that has a plug to be attached to a permanent energy source.



This is the poly plastic exterior used. The costumer will not need to deal with this. We will shape it to fit the space the costumer requires. So our products are somewhat flexible.



This part shows how the heat sensor would be attached to the Arduino. The heating cables would also be attached to the Arduino to be controlled on and off and be able to change the temperature using the code.



Here shown how the interior of the mat should lack before it's yielded and ready to be packed and sent.

3.2 User Access Considerations

The product can be used by most users and user groups, it can be purchased by individuals for their backyard or by big institutions like the university. Since the components take small area, we can edit the design to fit to different spaces as the costumers likes.

The products can be purchased by almost all levels of the community, as it has a very low cost and is very affordable, also. It can be used by everyone, since the products isn't thick, it is wheelchair friendly which is a concern many users – especially big institutions – have.

Also, since it's not hard to function this product almost anyone can buy this and use it. Its not restricted to specific place, users or user groups

3.3 Accessing the System

The only part that is private to the costumers is the code controlling panel to turn on/off or adjust the temperature of functioning. User would be giving a separate guide showing how to edit the code as needed, they would be given the code and a platform to run the code on. And also and initial passcode for the platform the is standardized and instructions on how to edit it and make it inaccessible by anyone else to prevent people missing with the temperature and settings

3.4 System Organization & Navigation

Generally, the main page should show the user if the products is working and on or off, it should also show the readings by the Arduino showing the exact outside temperature and humidity

on the mat exterior. The user should also be able to access the page where they can change the settings and values of the mat and also the page where they can change the password.

3.5 Exiting the System

Simply to turn off the system there would be 2 ways, one is the set the turn off temperature to a high value, e.g.: 30c. in such case the system will stay off.

One other way is to unplug the products from the electricity source. It will turn off as the battery finishes in a few hours.

Most important method to be added is via a specific section in the code that could turn the Arduino and heat source on and off at anytime despite the surrounding temperature and energy availability.

4 Using the System

- **Hard parts control**

  The user needs to attach the electricity plug shown to an electricity source of 110 volts preferably.

- **Code controlling**

  The user will be given a link to access the code platform where they can change one digit in the code instead of the pr4eset temperature (2 Celsius) to set any desirable temperature. It will automatically be updated if the system is attached to internet. Other wise needs to manually update it.

- **Turning system on/off**

  The user can adjust the code by changing the word on of the code to off. It would turnoff the heating mat until they undo their change.

<Given Function/Feature>

The system is user friendly, there aren't any technical complicated things to be learned. Otherwise only a technical support member will be able to run it which will make the product less user friendly. Thus only the general and basic information mentioned above need to be learned.

5 Troubleshooting & Support

If the heating mat fails to effectively heat snow or ice into water within 30 minutes to 45 minutes, consider the following steps to troubleshoot.

1. Open the mat by removing the silicon rubber and verify if the inside components are functional. If not, contact support teams and request replacements.
2. If all components are functional, make sure that heating coils are properly attached to the upper area of the silicon rubber. This will make sure proper contact is made and heat is able to be efficiently transferred.

If the temperature and humidity sensor fails to detect data, consider the following steps to troubleshoot.

1. Make sure the arduino connection to power and/or sensor is secured.
2. Make sure the arduino connection to heating coils is secured.
3. Boot up the arduino IDE application and verify the codes are identical to the ones provided in this link

5.1 Error Messages or Behaviors

In the case where the Arduino IDE provides the error message of “Serial port 'COM1' not found”. The reason for this error is that most windows users will need to install the usb driver that supports the arduino board.

1 Visit this link and install the usb driver provided. The file is less than 40 mb and easy to use.
2 After the file finish installing, extract the zip file and double click on the application within the file that says “CH34x_install_windows_v3_4”
3 After the application finishes installing the user driver onto your device, the error should be fixed.

5.2 Special Considerations

There are no special considerations that should be looked at for our product.

5.3 Maintenance

The silicon mat should be cleaned twice a week and replaced every month to ensure outside fluids do not leak into the inside components. The arduino temperature sensor should be replaced yearly to ensure the sensor does not fail during the use year (sensors are only 50 cents each). The power supply should be checked regularly to ensure it is well secured and in good condition.

5.4 Support

Visit this link to get help with problems encountered with the arduino and temperature/ humidity sensor. They will provide answers to fixing software or hardware errors. If hardware components of the heating mat fails, contact amazon using this link. Amazon will provide a full refund within 2 weeks of purchase as the failure will be on their end.

If the arduino LED does not light up, it will most likely be due to a hardware error so it is advised that users contact the hardware support department using the first link. If the LED lights up but is not reporting temperature/ humidity accordingly, it is a software error and users should contact the software support department using the first link.

To give amazon a better picture of your problem, users are advised to open the mat and check which component exactly is responsible for the failure of our product. Report the error you find to the amazon refund team and they will issue a return of your funds.

6 Product Documentation

In the designing phase of our product we contemplated between water heated tubes, heated mats with heating coils, and solar heated panels. In our conclusion, we decided that the heating coils are the suitable option as solar panels and water tubes are too difficult to assemble and are too expensive to build. Moving on to our choice of material. We've considered many different materials for our mat from plastic to glass to rubber. We decided that all other options are either not safe to use or inefficient at transferring heat, the best option we were left with was silicon mats that are durable in harsh conditions, effective at transferring heat, and most importantly cheap to use.

For the power supply of our system, we've considered the use of batteries but decided against it since the possibility of it not working the way we want to was too great. The use of batteries would bring up the problems of reusability and energy efficiency, so we decided that there was no point in testing or analyzing it as there were too many issues surrounding it. One of the major features we worked on was our system being able to automatically turn on when a certain range of temperature is detected in its environment. We thought about purchasing a temperature detector sensor that came with a controller but the price tag was beyond our budget. After the arduino lab, we discussed our ideas with the TA and decided to implement the temperature detection system with the use of an arduino and some temperature/ humidity sensors. With some programming, we were able to make the system detect temperatures in its surrounding.

6.1 <Subsystem 1 of prototype>

6.1.1 BOM (Bill of Material

Item	Cost	Link to item
Snow melting heating cables	CDN$28.99	link
Anti-slip waterproof silicone rubber sheet	CDN$16.72	link
Arduino Kit	CDN$0	
Temperature and humidity sensor for arduino	CDN$14.99	link
Grounding plug	CDN$7.77	link

6.1.2 Equipment list

- Hot glue
- Scissors
- Wire Strippers
- Volt Meter
- Safety Goggles
- Cut Resistant Gloves
- Hammer
- Tape Measure
- Insulated Screwdrivers
- Screwdriver Set
- Arduino IDE software

6.1 Testing & Validation

We put ice on our mat and recorded/ tested how long it will take our mat to melt the ice and how effective it was. The result of this test was amazing, our system was able to successfully melt the ice within 10 minute.

LINK TO YOUTUBE VIDEO DEMONSTRATING MAT

Another test we performed was with our arduino sensor. Eric personally purchased a temperature/ humidity sensor and placed it next to the sensor in our system. Then we ran the test and tested if the temperature collected with our system is accurate compared to the sensor we bought. This test also revealed how precise and accurate our system is.

LINK TO YOUTUBE VIDEO DEMONSTRATING SENSOR

The final test we ran was simply just stepping on the mat as it is intended. We concluded that our mat is durable enough to withstand the weight of a human.

7 Conclusions and Recommendations for Future Work

Overall, we were successful at melting the snow above our product and proofing its functionality.

APPENDICES

8 APPENDIX I: Design Files

The design process and details of this product are allocated in the following link :

https://makerepo.com/ChelseRoseVH/844.thunder-corp-heating-mats