HEATED SIDEWALK 2000

PRESENTED BY: TEAM 5 - MELT-O

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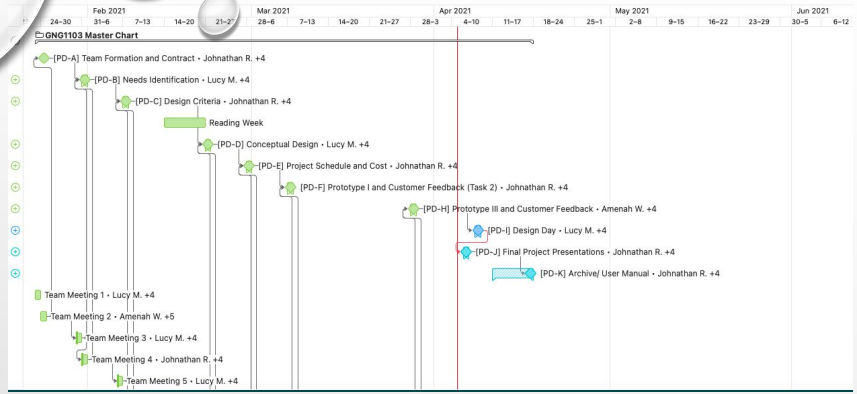
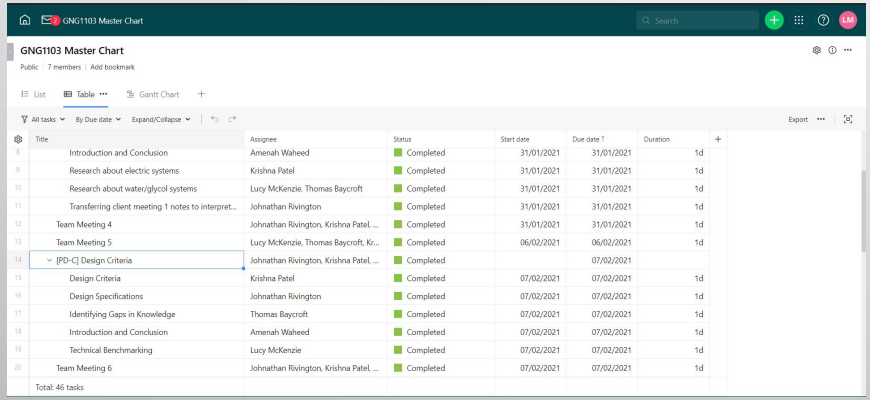
INTRODUCTION

- 1.5 Million CAD for snow removal each year
- Concerns over the impact salt has on the surrounding nature
- Looking for a new alternative

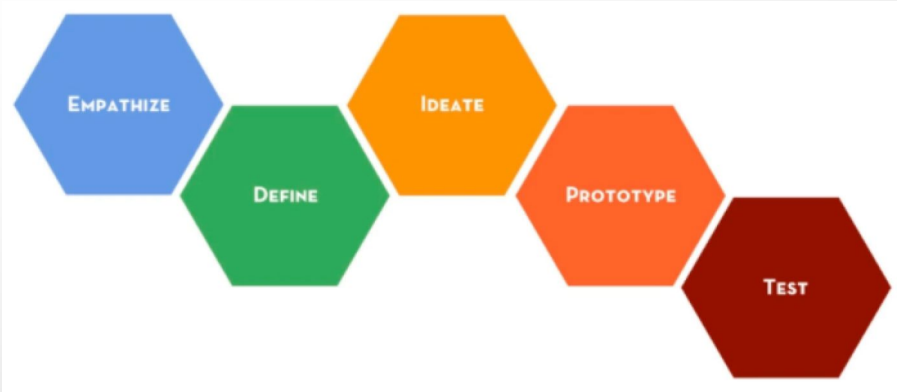




PROJECT PLAN OUTLINE

- Wrike
- Facebook Messenger
- Frequent Zoom Meetings

OUR DESIGN PROCESS

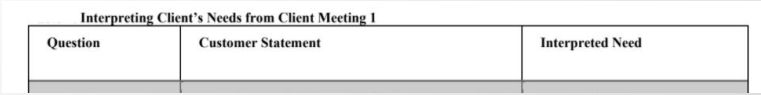


EMPATHIZE

Define user and customers:

- End user: students, staff, faculty members and pedestrians traversing the University of Ottawa campus grounds
- Customer/Client: Jonathan Rousseau from the University of Ottawa (Maintenance Sector)

Identification of Customer Needs:

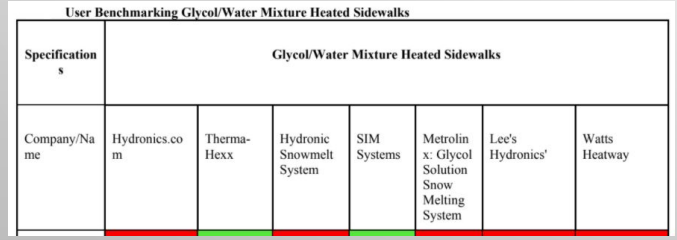


Interpreting Client's Needs from Client Meeting 1

Question	Customer Statement	Interpreted Need

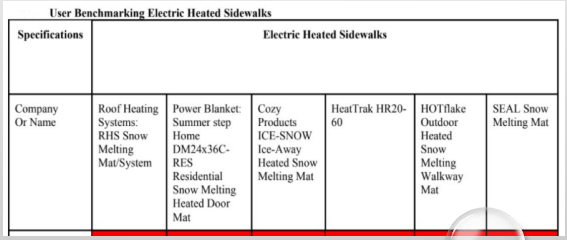
- Typical uses
- Likes
- Dislikes
- Suggested improvements

User benchmarking:



User Benchmarking Glycol/Water Mixture Heated Sidewalks

Specifications	Glycol/Water Mixture Heated Sidewalks						
Company/Name	Hydronics.com	Therma-Hexx	Hydronic Snowmelt System	SIM Systems	Metrolinx: Glycol Solution Snow Melting System	Lee's Hydronics'	Watts Heatway



User Benchmarking Electric Heated Sidewalks

Specifications	Electric Heated Sidewalks					
Company Or Name	Roof Heating Systems: RHS Snow Melting Mat/System	Power Blanket: Summer step Home DM24x36C-RES Residential Snow Melting Heated Door Mat	Cozy Products ICE-SNOW Ice-Away Heated Snow Melting Mat	HeatTrak HR20-60	HOTflake Outdoor Heated Snow Melting Walkway Mat	SEAL Snow Melting Mat

DEFINE

Problem Statement: *A solution is needed to quickly and effectively melt snow off of the sidewalks, high traffic areas and emergency exits at the University of Ottawa without compromising safety. The environment must be protected while still allowing this solution to be modular and scalable.*

Ranking the Customers Needs by Importance

Number	Need	Importance
1	Drainage system	5
2	Clear snow/ice off quickly	5
3	Ability to be deconstructed	4
4	Easy to assemble	4
5	Easy to maintain	4
6	Safe to walk on	5
7	Low cost	2
8	Safe for the environment	4
9	Ability to keep salt and sand off the surface	3
10	Energy efficient	2
11	Storable	2
12	Durable	4

Translation of client needs into applicable design criteria

Number	Need	Design Criteria

	Design Specifications	*Relation (<,>,=)*	*Value*	*Units*	*Verification method*

TECHNICAL BENCHMARKING

User Benchmarking Glycol/Water Mixture Heated Sidewalks Ranking by Importance

Specifications	Importance	Glycol/Water Mixture Heated Sidewalks						
Company or Name	N/A	Hydronics.com	Therma-Hexx	Hydronic Snowmelt System	SIM Systems	Metrolinx - Glycol Solution Snow Melting System	Lee's Hydronics'	Watts Heatway

User Benchmarking Electric Heated Sidewalks Ranking by Importance

Specifications	Importance	Electric Heated Sidewalks					
Company or Name	N/A	Roof Heating Systems: RHS Snow Melting Mat/System	Power Blanket: Summer step Home DM24x36C-RES Residential Snow Melting Heated Door Mat	Cozy Products ICE-SNOW Ice-Away Heated Snow Melting Mat	HeatTrak HR20-60	HOTflake Outdoor Heated Snow Melting Walkway Mat	SEAL Snow Melting Mat

- Results organised in a simple tricolour ranking system:

- Electric-based system is the most functionable with the requirements and constraints of this project
  - Effectictent installation/removal
  - More cost-efficient
  - Comparatively environmentally friendly

Table 6: Technical Benchmarking Glycol/Water Mixture Heated Sidewalks By Ranking

Specifications	Importance	Glycol/Water Mixture Heat Sidewalks						
Company or Name	N/A	Hydronics.com	Therma-Hexx	Hydronic Snowmelt System	SIM Systems	Metrolinx: Glycol Solution Snow Melting System	Lee's Hydronics'	Watts Heatway
Cost	3	2	1	1	1	1	2	3
Approximate Area	3	2	1	1	1	1	1	1
Weight	3	1	3	1	1	1	1	1
Tube Dimensions	2	3	3	3	3	3	1	1
Tube Material	3	3	3	3	3	2	3	3
Fluid Capacity	2	1	3	1	1	1	1	1
Panel Dimensions	4	1	3	1	1	1	1	1
Material: Panel or Concrete	4	2	3	2	2	2	2	2
Minimum Thickness	2	1	3	1	1	1	1	1
Insulation Requirements	3	3	3	1	3	3	1	1
Connecting Panels/Installation	4	2	3	2	2	1	2	2
Maximum Pressure	2	1	3	1	3	3	1	1
Minimum Temperature	2	3	3	3	3	1	1	1
Maximum Temperature	2	1	3	1	1	1	1	1
Requires Antifreeze	4	3	3	3	3	1	3	3
Coil/tubing imbedded in product	3	2	3	3	2	1	1	1
Sensors	3	1	1	1	1	2	1	1
Seal Check	3	1	1	3	1	1	1	1
Oxygen Barrier	4	3	1	1	3	3	1	1
Heating Requirement	4	2	1	3	2	1	1	3
Operating Conditions	4	1	1	1	1	2	2	1
Temporary/long term	5	2	2	2	2	2	2	2
Pump required	4	3	3	3	3	3	3	3
Total		143	166	136	141	122	115	122

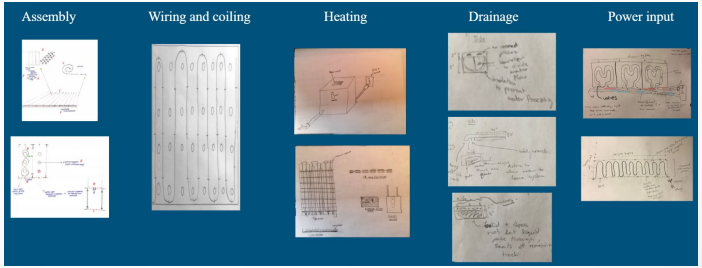
Table 4: Technical Benchmarking Electric Heated Sidewalks Ranking by Importance

Specifications	Importance	Electric Heat Sidewalks					
Company Or Name	N/A	Roof Heating Systems: RHS Snow Melting Mat/System	Power Blanket: Summer step Home DM24x36C-RES Residential Snow Melting Heated Door Mat	Cozy Products ICE-SNOW Ice-Away Heated Snow Melting Mat	HeatTrak HR20-60	HOTflake Outdoor Heated Snow Melting Walkway Mat	SEAL Snow Melting Mat
Cost	3	2	1	2	3	1	2
Dimensions	3	3	1	3	2	1	3
Durability	5	1	2	2	3	3	1
Weight (per ft)	3	1	2	2	2	3	1
Multiple sizes	3	3	1	1	1	1	1
Expandable	4	1	3	1	3	1	1
Melt rate	4	2	2	2	2	2	2
Non-slip surface	5	3	3	3	3	3	3
Voltage	3	1	3	2	3	1	2
Portability	5	3	3	3	3	3	3
Power Cord length	2	1	2	3	2	2	3
Customer ratings	3	1	2	2	3	2	2
Temperature range	3	3	3	3	2	3	3
On/Off options	4	1	3	3	3	1	3
Stair safe	3	1	3	3	2	3	1
Total		98	124	124	135	110	110

IDEATE

Brainstorm and come up with as many creative solutions as possible

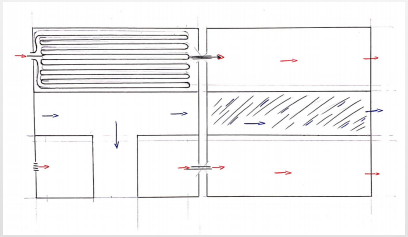
Individual Brainstorming:

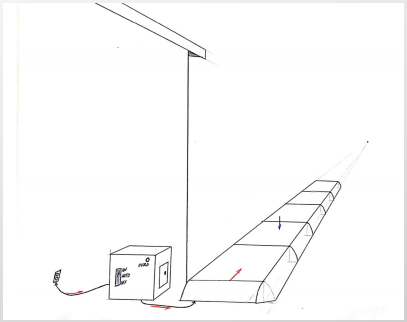


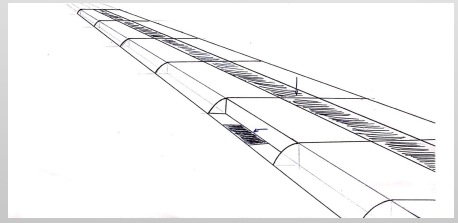
5 subsystems:

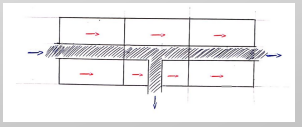
- Assembly
- Drainage
- Wire coiling
- Electric control
- Heating

Collective Brainstorming:





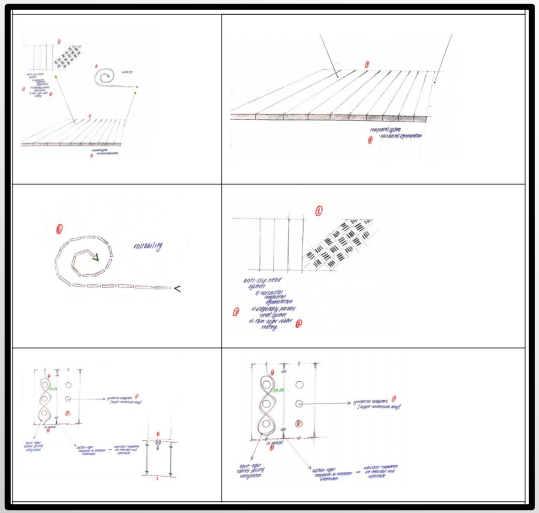


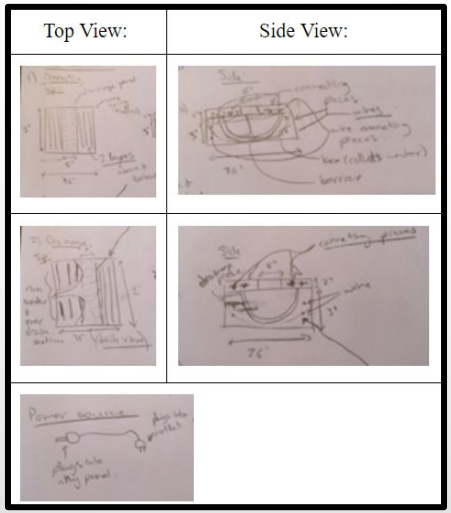


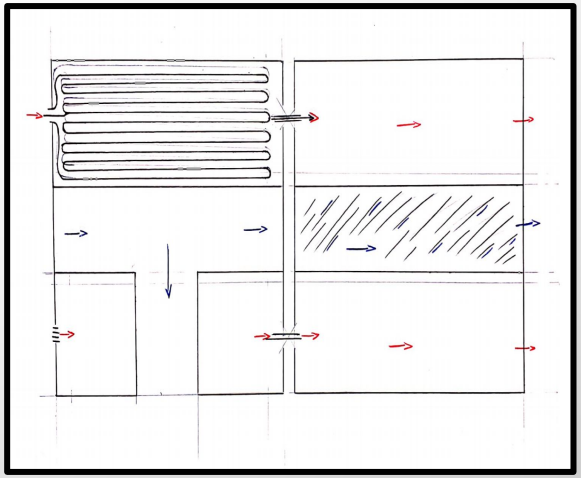
3 subsystems:

- Assembly
- Drainage
- Electrical and Heating

SKETCHING AND DATA ORGANIZATION







Subsystem Analysis

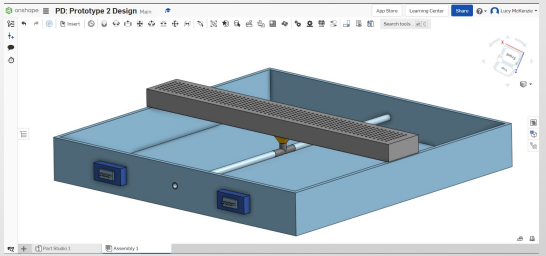
Systems	Analysis

PROTOTYPE

Build a representation of subsystems and acquire feedback in order to proceed to the final solution

Physical:

Analytical Onshape:



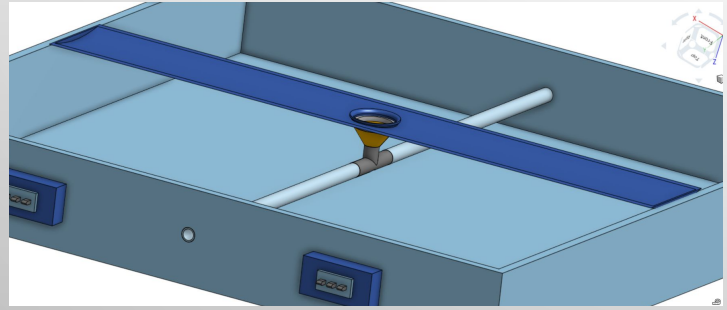
Testing Plan:

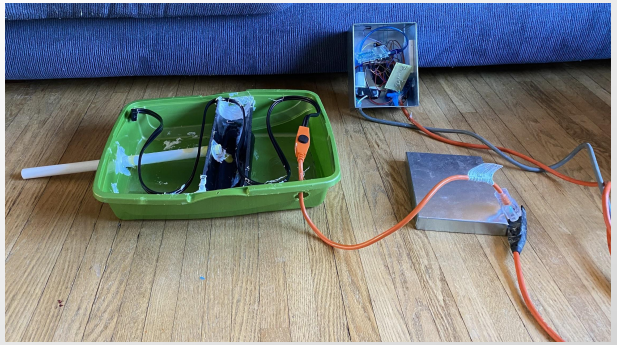
Prototyping Test Plan

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)	Estimated Test duration and planned start date (When)

TEST

Share your prototyped idea with the user and obtain feedback to improve the final design solution





Using the given feedback, we defined the final prototype of our design solution and determined to constraints, weaknesses, future goals and improvements as well as the most valuable areas.

PROJECT TEST PLAN AND SENSOR TESTING RESULTS

Raw data from testing sensors:

	A	B	C	D	E
1	Temperature (F)	Precipitation	Power State	Deg. C	
2	70	DRY	OFF	21.11111111	=(A2-32)*(5/9)
3	67	DRY	OFF	19.44444444	
4	66	DRY	OFF	18.88888889	
5	62	DRY	OFF	16.66666667	
6	62	DRY	OFF	16.66666667	
7	59	DRY	OFF	15	
8	57	DRY	OFF	13.88888889	
9	56	DRY	OFF	13.33333333	
10	53	DRY	OFF	11.66666667	
11	51	DRY	OFF	10.55555556	
12	50	DRY	OFF	10	
13	48	DRY	OFF	8.888888889	
14	45	DRY	OFF	7.222222222	
15	42	DRY	OFF	5.555555556	
16	41	DRY	OFF	5	
17	39	DRY	OFF	3.888888889	
18	35	DRY	OFF	1.666666667	
19	33	DRY	OFF	0.5555555556	
20	32	WET	ON	0	
21	31	WET	ON	-0.5555555556	
22	29	WET	ON	-1.666666667	

Example of our prototype 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)	Estimated Test duration and planned start date (When)
Prototype 1: Assembly subsystem				
1	Stability of assembly	Determine how much water pressure could the basis structure withstand without any changes to its structural integrity	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	6 hours per water type (hot and cold). 12 hours total (no supervision necessary). Date tested: 03/07/2021
2	Durability/Strength of material	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.	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.	20 minutes to add weights and record data. Date tested: 03/07/2021
Prototype 2: Drainage system				
3	Efficiency of drainage system (water in)	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	Calculation of results using averages Input (L): 1 | Out (L): 0.99 | % Eff.: 99% Observed that the water imputed flowed relatively quickly through the grate system created.	30 minutes to input liquid at the greeting system, record initial and final volumes. Date tested: 03/07/2021
		As the piping has not been shipped from the		

DRAINAGE SYSTEM TESTING RESULTS

- Tested by flowing varying volumes of water through pipes with varying slopes
  - Droplet - simulates snowmelt condition
  - 4 L - simulates heavy precipitation
- 85% - 93% flow collected from entire system
- Minimum flow velocity determined from minimum melt rate (2 in/hr): 43 mm/min

Table 1: Measured pipe properties

Pipe	Length		Diameter		Cross-sectional Area	
	(in)	(mm)	(in)	(mm)	(in2)	(mm2)
Black	12	304.8	3	76.2	7.07	2280.18
White	17	431.8	3/4	19.05	0.44	285.02

Table 4: Time taken for one droplet of water to travel through the black drainage pipe (2:1 slope)

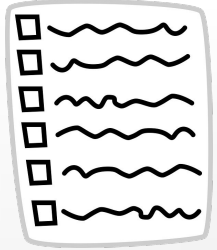
Trial #	Volume of water, V, (L)	Time taken for water to flow through the black pipe, t		Flow rate, Q, (L/min)	Flow velocity of droplet, v, (mm/min)
		(s)	(min)		
1	0.001	0.53	0.0088	0.11	49.65

Freezer was kept at -20℃

0 mins

12 mins

FINAL SPECS AND OVERALL QUALITY



Given the 100 CAD budget, our prototype is of overall good quality.

- Panel/storage dimensions (L x W x H): 18.75 in X 15.5 in X 4 in
- Panel Weight: 5 lbs
- Weight sustained by panel: 0 - 190 LBS
  - Further testing required to see weight sustained at failure (i.e. max weight)
- Typical heating temperature: 25°C at -20°C surrounding temperature
  - Heating time from 0°C - 25°C : 2 min
- Average melt rate of snow/ice: 33 g/min
- Self regulated heating system
- Range of Drainage Rate:
  - Min Tested: 0.032 L/min (Droplet)
  - Max Tested: 23.5 L/min (Heavy Flow)
- Coldest surrounding temperature without affecting function: -40°C
- Cost of one panel: $82

LIMITATIONS & SOLUTIONS

BOM & BUDGETING

Limitations:

- ❏ Budget was maximized by purchasing all the components at once
- ❏ Pricing and product availability varies between store locations

Solutions:

- ❏ Modified the design to maximize the materials purchased
- ❏ Materials purchased stayed within the budget and the design was modified to fit these materials

Part	Material	Quantity / size	Cost ($)	Picture	Name
Heating system	**Heating Wire**	**9 ft**	**$ 28.79**		Heat it HISD 9-feet Pipe Heating Cable https://www.amazon.ca/6-feet-Heating-Cable-Built-Thermostat/dp/B01GZJKOJQ?th=1
	Connectors	**1**	**$ 4.34**		Safe-D-Grid 400 Receptacle Housing https://www.andersonpower.com/shop/app_au_en/2002g2-saf-d-grid-400-receptacle-housing.html
Sensors	**Arduino Temperature Sensor (TMP36)**	**1**	**$ 2.00**		Temperature Sensor – TMP36 https://www.robotshop.com/ca/en/temperature-sensor-tmp36.html
	Arduino Rain Sensor	**1**	**$ 1.41**		Rain Weather Sensor Water Raindrops Detection Module for Ardunio https://www.ebay.com/c/2101008493
Drainage System	**Gutter**	**1**	**$ 6.89**		5 in. x 0.5 ft. Bronze Aluminum End with Round Drop https://www.homedepot.com/p/Spectra-Metals-5-in-x-0-5-ft-Bronze-Aluminum-End-with-Round-Drop-3DROPRTBZ/302471335
	PEX Drainage Tubing	**5 ft**	**$ 4.48**		SharkBite 3/4 Inch x 5 Feet WHITE PEX PIPE https://www.homedepot.ca/product/sharkbite-3-4-inch-x-5-feet-white-pex-pipe/1001013602
	PEX Drainage Tee	**1**	**$ 3.67**		SharkBite 3/4 Inch PEX TEE https://www.homedepot.ca/product/sharkbite-3-4-inch-pex-tee/1001012288
Shell	**Bus Bin**	**1**	**$ 29.78**		Rubbermaid Commercial 3349GRA Bus/Utility Tote, 20 x 15 x 5, Gray https://www.amazon.ca/Rubbermaid-Commercial-3349GRA-Utility-Tote/dp/B0003JCKCQQ
Total Cost: $81.36 + Tax					

BOM Total Cost: $81.36

Components:	Approximate Cost:
Heating Wire & Plumbing materials (piping, glue, etc.)	$60.00
Plastic Container (base)	$15.00
Electrical Components	$15.00
Top layer (lid)	N/A
Total Cost:	$90.00

PANEL HEIGHT

Limitations:

- Accessibility onto and off the panel
- Tripping Hazard
- Build up of snow and ice beneath the panel

Solution:

- A ramp was created from the excess material used for the top layer

CONTROL BOX

Limitations:

- ❏ Box must be above ground
- ❏ Risk of inaccurate temperature sensor readings
- ❏ Risk of snow and ice accumulation on the box

Solutions:

- ❏ Increasing the length of wire between the box and the first panel
- ❏ Tested the accuracy of temperature sensor reading
- ❏ Mindful placement of the box

CONCLUSION & FUTURE RECOMMENDATIONS

CONCLUSION & FUTURE RECOMMENDATIONS

WITHIN THE BUDGET:

- ❏ Updated contingency plans
- ❏ Panel height reduced
- ❏ Add connector prongs to link to another panel

OUTSIDE THE BUDGET:

- ❏ Update the BOM
- ❏ 3D print a custom panel
- ❏ Bolt the panel onto the sidewalk
- ❏ Add rough material (i.e. rubber) on the surface of the panel for increased friction and durability
- ❏ Upscaling the panel size to that of a standard sidewalk square

THANK YOU!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