Project Deliverable N
Team 3

GNG2101 Technology Entrepreneurship

Faculty of Engineering

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1.0 Abstract

For the class Introduction to Product Development and Management for Engineers (GNG2101), we had the task to use design thinking to solve one of 4 issues the University of Ottawa is currently facing. Currently the ramp at the University of Ottawa are very slippery and sometimes impracticable during the winter months. We, as a team, decided to use our skills learned in class to solve this issue. We started by interviewing Jasmine Bouchard which is in charge of accessibility at the University of Ottawa. We then did benchmarking to see what competitors were currently offering on the market. With the information from our interview and benchmarking, we define the problem with a problem statement. We then started generating ideas with various brainstorming and ideation tools. Once we had sufficient solutions, we met as a team shared our solutions and combine various ideas to come with what, we believe, is the best solution possible to the problem. Once we had chosen our solution, we builded a first prototype made of styrofoam. We showed this prototype to our customer to get her feedback and opinion on the prototype. We used this feedback to generate a second prototype in the form of a rendering. We presented the two first prototype to our classroom. We then built a final prototype made in the same material we will be using for our final product. This prototype was presented to the classroom. It was also featured at design day where the public of Ottawa could come see our designs. During the design day, Jasmine Bouchard was present and was very happy with the final prototype we had built.

In this work we discuss in further detail the process by which we designed our product. We also discuss our motivation for deciding to work on this project, the

advantages our product has and various strategies our team used during the conception of our product.

2.0 Introduction

With the rise of increasingly erratic and severe weather patterns occurring, the University of Ottawa faces a crisis as campus infrastructure ages. One notable and key issue that the University of Ottawa faces is the deterioration of usability of the accessibility ramps to key buildings such as the Morisset Library. These ramps, utilized by the most vulnerable students, are often closed during the winter seasons, due to snow and ice build up. This combined with the age of the ramps, where safety and building codes have often left these ramps obsolete, pose a challenge to all denizens of the University Of Ottawa. There are often complaints of difficulty in accessing key buildings, as well as notable reports of injuries when trying to traverse these areas affected by severe snow and ice.

The key issues faced by students and staff alike are severe build-up of snow and ice, as well as the incline of the ramps rendering them unsafe. The main cause of this issue is the lack of school funding and budgetary allocation towards winter proofing and logistical improvement of the campus infrastructure such as access points, stairs, ramps, etc. Thus, a list of design requirements were drawn up from our interview with the chief office of accessibility of the Morisset Library. The design requirements were, in addition to be able to winterproof the ramp, to be able to operate in the range of -40°C to 50°C, being able to withstand severe adverse weather such as rainstorms, windstorms, and snowstorms, and being able to be affordable for the University of Ottawa by beating out the competitors.

Our design solution is to build a modular, compact, heated mat with smart sensor integration in order to save energy over comparable competitors on the market. Our benchmarking and investigatory stage have found that the most premiere winter proofing solution provider is the HeatTrak™ series of heated mats and walkways for commercial, residential, or industrial usage. Some attributes of existing heated mats on the current market are that they are usually custom made for a specification, or requiring daisy chaining in order to maintain power over long distances, are manually operated, or require special custom sensors which are of a lower efficiency and efficacy than operating the heating manually, all the while draining large amounts of energy with 120-480 watts being required. These attributes, combined with the high prices offered by the existing market, pushes them out of the realm of affordability for the University of Ottawa. Our design uses a bi-directional interlocking design akin to that of puzzles pieces allows heating to be extended lengthwise or widthwise in order to accommodate multiple types of traffic, from wheelchairs to pedestrians. Furthermore, the smart sensor integration, which uses a combination of capacitive sensors and thermocouple, allows the heating to operate without manual interaction at all, increasing the energy efficiency of the mats by up to 50%, which is a bonus to the main ability in reducing the manpower required to deploy, operate, and maintain the operation of the mats. Furthermore, the mats uses an aluminum alloy and recycled vulcanized rubber as their main components to reduce weight. The mats themselves also have anchors built into them, as well as anti-slip traction patterns in order to increase traction to counter the effects of adverse weather and incline. These combined

with the very low cost of our design, $180 CDN vs $800 CDN for around 1 meter squared coverage, puts our design ahead of our competitors.

Name	**MaxGrip™**	**HeatTrak™ Industrial**
Price	$179.99 CAD	$757.35 CAD
Voltage	120V	120V
Energy Consumption	Up to 480W	480W
Operating Range	-40°C to 100°C	-40°C to 100°C
Connections	Bi-directional interlock	Whole Mat
Smart Sensors	Yes	No (Sold separately)
Weight	7.2Kg	11.3Kg
Coverage	1.2 Square Meters	1.4 Square Meters
Waterproof	Yes	Yes
Skidproof	Yes	Yes
Anti-fatigue	Yes	No
Material	Recycled Rubber	New Rubber
Features	MaxGrip™	HeatTrak™ Industrial
Auto Temperature Adjust	Yes	No (Sold Separately)
Detects snow and ice	Yes	No (Sold Separately)
Easy Installation	Yes	No
Custom shapes	Yes	No
Reduces Fatigue for users	Yes	No
Wheelchair suitable	Yes	Yes
Withstand heavy loads	Yes	Yes
Withstand harsh winters	Yes	Yes
Melts 2in of snow per hour	Yes	Yes
Shock proof	Yes	Yes
Anchored	Yes	No

Table 2.a - Benchmarking MAXGrip versus HeatTrak Industrial

3.0 Main Discussion

We started the project by identifying the real pain of our customer. To do so we met with Jasmine Bouchard, our customer, and we tried to empathize with her to really understand the underlying cause of the situation. To empathize we asked her questions and took a look at the current ramps at the University of Ottawa. We could of had deepen our empathy by trying the ramps ourselves during the winter but unfortunately since it is the summer we could not do so. We also did some benchmarking to know what our competitors were offering to ensure our product would have a better value proposition than our competitors. We quickly identified that our competitors offered a solution that was too expensive. We also noticed that our competitors were usually not using sensors to maximise efficiency. If they were offering sensors to their solution, they were offered for a very expensive price tag. Once we truly understood the problem and were done benchmarking, we wrote a problem statement based on that information: "Currently, the ramps at the University of Ottawa are unsafe during the winter season due to snow and ice build up. Our solution will have to be rigid, inexpensive, be compatible with all ramps, be performant, have traction in various meteorological situations, while being able to support a maximum weight that is suitable for all users." After writing a problem statement we established design criterias for our product. We then started brainstorming and generating solutions by sketching. Once we had multiple solutions we used critical thinking to access and judge the different designs and choose the best one. We also thought it was important not to restrict our design to one solution and try to integrate elements from different solutions in our design. Once we had chosen our design solution we made a first prototype

out of styrofoam. We then presented this design to our customer to get some feedback and see if she liked our design. We also presented this prototype to the classroom. Once we got a positive response from our customer we builded a second prototype in the form of a rendering taking into consideration the feedback we got from our client meeting. We then builded a final prototype with the same materials that we will implement in our final product. Once this final prototype was made we presented this prototype to the classroom. We also presented this prototype to multiple people during design day.

4.0 Interesting Design Solutions

One of our potential solution is a smart sensor controlled heated mat which will be embedded with an anti-freeze heat distribution system. This combination system which allow the usage of less electrical filaments, reduce the issue of spacing within the mat, and increase the efficiency of our system. The major drawbacks of this technique is that the bags containing the fluid will have to be able to support a weight of at least 1400 pounds. Another solution would be to put induction plates inside our mats as our heating system. The main advantage of this solution is the speed at which the induction plates could melt the snow and ice over our mats. The disadvantages, however, are the cost of induction plates. Heating the mats using chemicals was also discussed. Although chemical heating is economical in the short term, in the long term it will require labour and resources therefore adding towards the total cost. We ended up choosing to use heating filament as the heating system for our ramp. we chose this solution because it was very inexpensive, easy to assemble, required no maintenance and is very reliable.

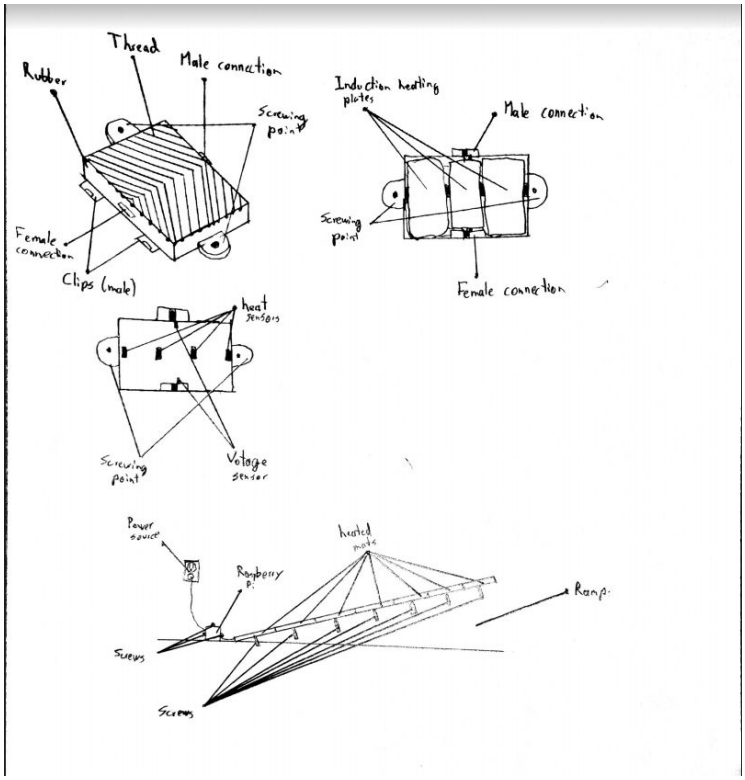

Figure 3.a - Induction Plate Heated Mat

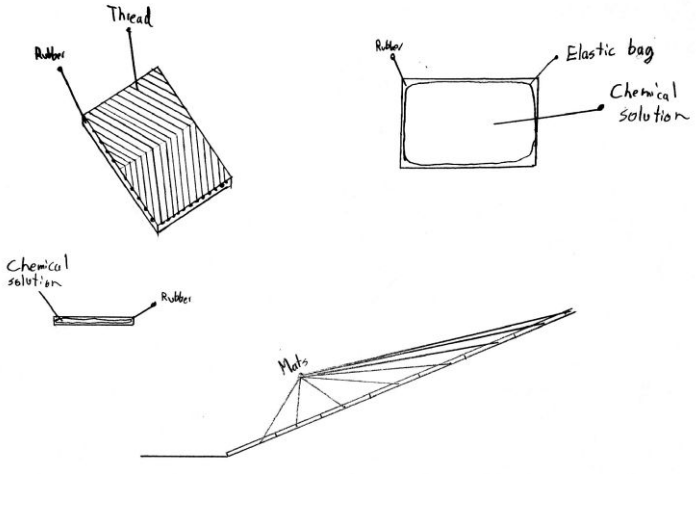

Figure 3.b - Chemical Heated Mat (non-reusable)

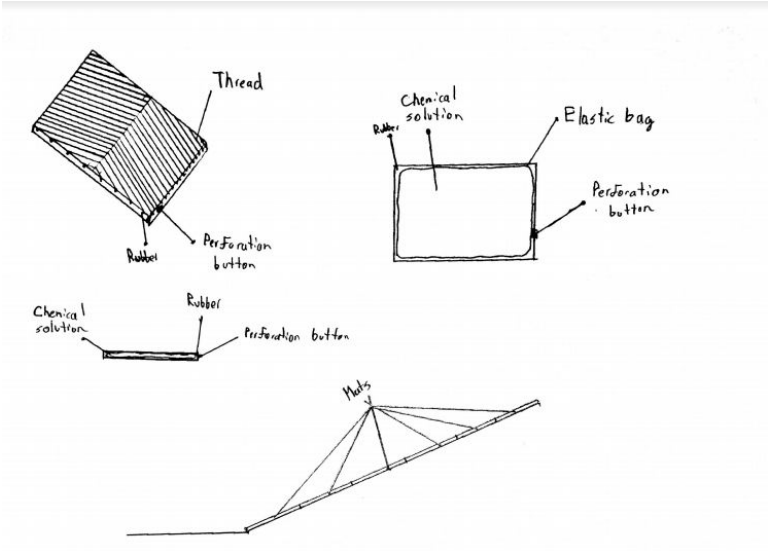

Figure 3.c - Chemical Heated Mat (refillable)

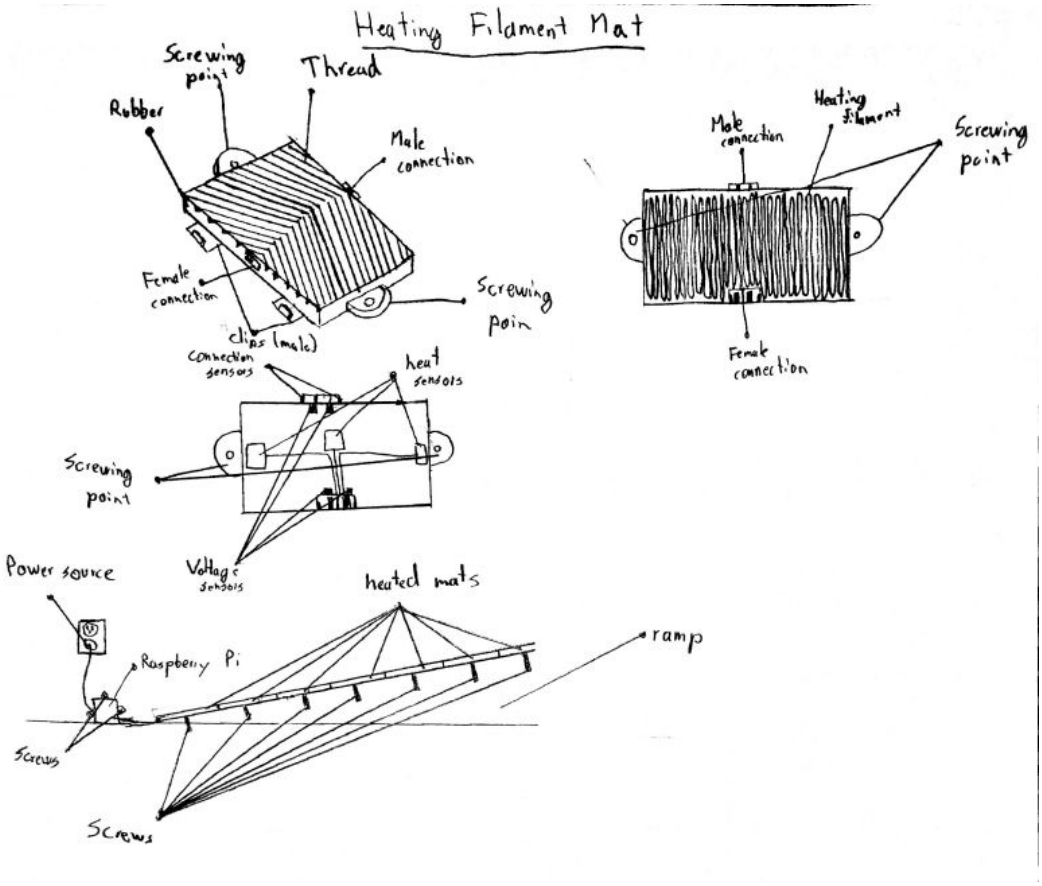

Figure 3.d - Filament Heated Mat

5.0 Design Criterias

The requirements has been specified by our client to be the following; the dimensions must be able to accommodate wheelchair traffic, the solution itself must be able to be deployed in a variety of circumstances on a variety of surfaces with a variety of dimensions and geometric configurations. Furthermore, the design needs to be able to keep up with heavy snowfall of up to two inches per hour, all the while being energy efficient and inexpensive compared to current market benchmarks. These requirements were used to form our design criterias.

6.0 Description of Design Solution

The final iteration of the design is similar to the initial conceptual designs and the second prototype render that was created. The project, now named MAXGrip, has a coverage of 1.2 square meters, and features several innovations over the traditional design of winterproof walkways. Firstly, the design is square, and features a puzzle like bi-directional interlocking system, which has been proven and tested to withstand foot and wheeled traffic. Secondly, the design features integrated smart sensors, whereas other designs utilize external add-on designs which are sold separately, and yet still the mat is recommended to be operated manually. Featuring a capacitive sensor, and a built in thermocouple, the mat operates on a purely automatic level, automatically adjusting the current, voltage, and temperature in response to moisture level, snow level, snowfall, and temperature of the surrounding environment. Furthermore, the design features circular beveled patterns which when combined with the texture of the mat offer superior grip to the regular pavement. This feature enables optically impaired users to feel the difference between the walkway mats and pavement, as well as offering superior grip in the face of adverse weather conditions.

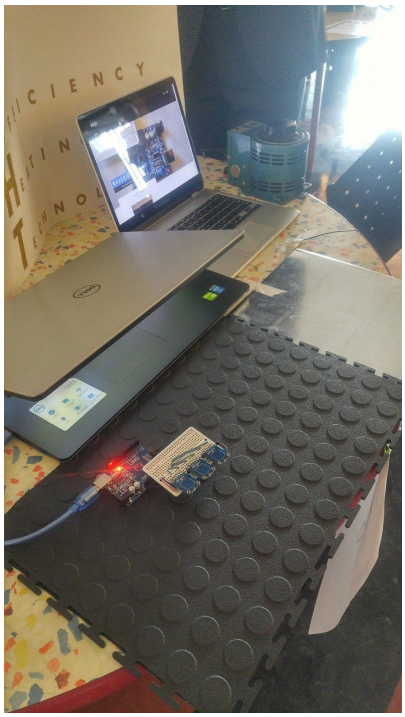

Figure 4.a - MAXGrip

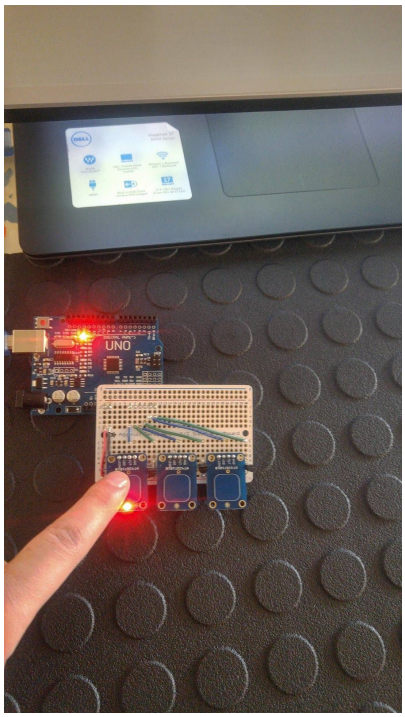

Figure 4.b - MAXGrip

7.0 Legal

When we developed our product, we did not do any research regarding patents, industrial designs, copyrights, trade-marks or creative commons license that could prohibit us from building what we had in mind. After doing some research, we have found several patents for heated mats with two of them which might of prohibit us from building our mat. We have also found out that an other incorporated company was named H.E.M.T. We will end this report by describing what our team plans to do in the future regarding our prototype and intellectual properties.

Patent CA 2606792 which might of prohibit us from building our mat, is a patent covering a product that includes a polyurethane rubber surface, a self-regulating cable

inserted inside the mat and in contact with the polyurethane surface, connection to connect the self-regulating cables to a power supply. This canadian patent was issued in 2014, therefore it is still valid today. Fortunately, the product designed in the patent has many elements that differs from our current designed product. First of all, instead of polyurethane rubber, we will be using vinyl wrapping. Instead of self-regulating cables, we will have resistance cables connected to an arduino that will control each mats. Finally, our connections will not only serve to connect the mats to the power supply as described in the patent, but it will also connect the sensors and the heating filaments to the Arduino Mini.

Patent US 5380988 might of also prohibit us from building our mats. The product described in this patent has a rigid back which has lower thermal conductivity than the top layer and which has the adhesion required to maintain the mat in position when it is being operated. The product also has a heating lamina that contains resistive metallic heating element and a strip of foil that is covering at least 1/4 of the mat. The resistive metallic heating element described in the patent is said to produce 0.15W to 1W per square inch of surface. The product described also has connectors at each ends to connect the mats together to a power source. The top layer of the product described covers all of the mat and has a lot of adherence to prevent its users from slipping under severe meteorological conditions. The resistive metallic heating element are installed in parallel and are kept at a distance from each others with vampire type connectors. The whole system is using less than 50 V. This system is similar to our design in many ways. Like the product described in the patent, our mats will be using resistive wires installed in parallel to heat up the mats, will use metal to distribute the heat throughout the mat, and will be linked to each others

with connectors. Although our two products are very similar, we will be using an aluminium sheet instead of foil to distribute the heat and will have multiple sensor and an Arduino Mini to control the mats. Also, this patent was issued in the U.S. which allows us to sell our product in Canada. Furthermore, the patent expired in 2015 since it was published the 10th of January 1995. This allows us to sell a similar product to the one described in the patent in the U.S. without risking to get sued.

As a team, we had decided to choose the name H.E.M.T. for our company. This name would stand for High Efficiency Mats Technologies. Unfortunately, after some research we have found out that another company that is already incorporated is already using the name H.E.M.T. This company uses this name to abbreviate Heavy Equipment Maintenance and Trading and as the name suggest it, their company offers maintenance and trading services for heavy equipment. Due to this Trademark conflict, our team will have to find a new name for our company that is not already incorporated.

In the past week, our team has met to discuss what we wanted to do with our product regarding intellectual properties. The best way of protecting our idea would be to patent the design. This will allow us to manufacture our product for the next 20 years with no risk of getting copied by competitors. However, since many members of our team does not plan on moving forward with this company once the class ends, we have decided we will not patent our design.

To conclude, we have made research on intellectual properties that might restrict our project. We have found 2 patents that might of prohibit us from building our mats. However these patents are either expired or differs slightly from our design. We also have

found an incorporated company with the same name than our company. We will therefore find a new name for our company to avoid causing issues. Finally, we have decided that we will not patent our design due to the lack of interest of the group to move forward with this company past the semester.

8.0 Prototyping Strategy, Testing Objectives and Results

The strategy we used for prototyping was the agile model. We started by ideating to find a solution to the problem. Once we had a solution to the problem we built a first prototype. We showed this prototype to our customer to get her opinion and feedback. We generated another solution that solved the issues mentioned in her feedback and built a second prototype in the form of a rendering. We used this prototype to make our final physical prototype. This prototype was used to do some testing. We tested our prototype with ice to see if it could melt the ice quickly. We wanted the ice cube to melt under 5 minute when the mat was at full power. Our prototype passed the test with a time of 2 minutes and 48 seconds to melt the ice cube. In the future, we plan doing more testing with our prototype to see if it is durable in the winter conditions and if it is able to maintain grip in various conditions.

9.0 Conclusion

Our project was to design a heated mat for uOttawa´s ramps for the winter. To be able to accomplish this task we followed several steps. The first steps was, empathize with our client to identify her needs. Then we defined the problem the and created metrics that we used to compare ideas. After these steps we were ready to do benchmarking and face our project. Our research and ideation brought us to the best idea that we used for the first prototype. We showed it to our customer in order to receive feedback and find ways of improving it. Fortunately for us, she was happy with the prototype, gave us good feedback, and proposed that we add warning pads for the visually impaired. Then, we build the second prototype with all the components for testing. While testing, we worked on the intellectual property and marketing aspects of the project. We didn't pursue patents since the members of the group weren't interested in carrying on the project. Concerning the marketing side, we made comparisons between our product and our competitors to see if we can have a place in the market. The last step was testing our prototype, we did before and during the Design Day. It's was successful because our software and hardware was able to work harmoniously. Our team, HEHT (High Efficiency Heating Technology), worked hard to complete our project and we got promising results that reflected that work. It was a beautiful experience and we learned a lot about engineering, design thinking, marketing, economic, and the most important thing; Team Management.

10.0 Bibliography

HeatTrak. *Industrial Snow-Melting Walkway Mats ("HTM" Series)*, [Online]. [https://heattrak.com/products/industrial-snow-melting-walkway-mats-htm-series?variant=773831883]. (Consulted the 19th of July 2017).

11.0 Appendix A : Income Statement Second Semester of 2017 - HEMT

	July	%	August	%	Septemb er	%	October	%	Novemb er	%	Decemb er	%
Net Sales (Less returns and allowances)	$499.95	100.00%	$599.99	100.00%	$719.99	100.00%	$863.98	100.00%	$1,036.78	100.00%	$1,244.14	100.00%
Cost of Goods Sold	$261.70	52.34%	$314.035	52.34%	$376.84	52.34%	$452.21	52.34%	$542.65	52.34%	$651.18	52.34%
Gross Margin	$238.25	47.66%	$285.96	47.66%	$343.15	47.66%	$411.77	47.66%	$494.13	47.66%	$592.96	47.66%
Operating Expenses	-	-	-	-	-	-	-	-	-	-	-	-
Advertising	$50.00	10.00%	$60.00	10.00%	$72.00	10.00%	$86.40	10.00%	$103.78	10.00%	$124.41	10.00%
Marketing & Promotion	$50.00	10.00%	$60.00	10.00%	$72.00	10.00%	$86.40	10.00%	$103.78	10.00%	$124.41	10.00%
Employees	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%
Shipping & Delivery	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%
Other	$75.00	15.00%	$90.00	15.00%	$108.00	15.00%	$129.60	15.00%	$155.52	15.00%	$186.62	15.00%
Total Operating Expenses	$175.00	35.00%	$180.00	35.00%	$216.00	35.00%	$259.19	35.00%	$311.03	35.00%	$373.24	35.00%
Operating Income	$63.25	12.65%	$75.90	12.65%	$91.08	12.65%	$109.29	12.65%	$131.15	12.65%	$157.38	12.65%
Interest Expense	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%
Other Income (interest, royalties)	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%	$0.00	0.00%
Income Before Taxes	$63.25	12.65%	$75.90	12.65%	$91.08	12.65%	$109.29	12.65%	$131.15	12.65%	$157.38	12.65%
Income Taxes	$6.64	1.33%	$7.98	1.33%	$9.58	1.33%	$11.49	1.33%	$13.79	1.33%	$16.55	1.33%
Net Income	$56.61	11.32%	$67.92	11.32%	$81.50	11.32%	$97.80	11.32%	$117.36	11.32%	$140.84	11.32%