STEAMPUNK THEMED WEARABLES:

GROUP #5

by

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Submitted to

Hanan Anis

for the course

Engineering Design (GNG 1103)

University of Ottawa

the 11th of April 2017

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Abstract:

This report covers the whole process taken to create our steampunk themed wearables by essentially following the design thinking process: empathize, define, ideate, prototype, and test.

The first part of this report goes over how we met with our customer, and obtained important information that led us to acquiring our problem statement, design criteria, design and target specifications, benchmarking table, and design concepts. Once all of the research and preparation was complete, we were then able to move on to constructing our three different prototypes; a physical prototype, a focused prototype, and finally a comprehensive prototype which was displayed on design day.

Conclusively, what could and will be done for the future (since our wearables were chosen to be displayed at the Canadian Aviation and Space Museum), and the topics of what was learned throughout this journey are covered.

Introduction:

Our group was hired by Sharon House and the company Avant-Garde Designs to create steampunk themed wearable technology to be exhibited in the Canadian Aviation and Space Museum that is celebrating the 150th anniversary of Canada's Confederation. The event is based around a steampunk theme that commemorates Canada's technological advances, featuring work from reputable companies, Universities, and Colleges around Canada. The steampunk theme takes inspiration from industrial steam-powered machinery and the Victorian era. Our task is to use this theme and design a wearable that integrates interactive features and modern technology while still maintaining the Victorian era style. Being that wearable is

intended to be displayed at such a special event, there is a certain degree of professionality that is expected which really motivated us to put in the extra effort to make our final product better than everyone else's.

In our first interview with Sharon, the customer, she expressed her needs and wants for the wearables we were tasked to create providing examples of the quality and level of detail that they are looking for. Sharon clearly stated that the most important aspect is that the steampunk themed wearable contains the "wow" factor that sets the design above the rest. The client emphasized that the wearable will be reflected on their behalf and therefore must be aesthetically pleasing on a level that they are used to seeing. From the start of our first team meeting, we all shared the same motivation and drive to make our design better than the rest. We all pitched ideas that at first sounded way too complex for the allotted time we were given, however, working off these ideas and turning them into feasible options for our design is what made our product better than the others. The key aspect of our design was to make it large and noticeable so that it stands out, which is where the backpack idea originated from. The backpack on its own was a great start but what made our design different was incorporating a steam machine that blows out smoke from the top of the backpack. Our design also included a button activated dc motor that spun a gear which was also unique from every other team. There were many teams working towards the same goal, therefore, there is a good chance that different groups have the same idea of a steampunk backpack or glove so we focussed on adding in features that no other group would do. Going the extra mile and adding these features to the design even after many implications is what made our design the winner of the steampunk challenge.

Client Needs:

Sharon clearly expressed that the most important aspect is that the steampunk themed wearable contains the “wow” factor that sets the design above the rest. The client emphasized that the wearable will be reflected on their behalf and therefore must be aesthetically pleasing on a level that they are used to seeing.

The main objective is to create steampunk themed wearables that will essentially make Sharon and the highly reputable company ‘“look good” while keeping in mind that the finished product will represent the University of Ottawa . This goal can be achieved by designing a unique wearable fusing the modern and Victorian Era technology together. In addition, an important aspect of the design is that the clothing has depth and ‘pops’ allowing the audience to interact with the clothing. To accomplish a 3-dimensional aspect that will display the depth of the clothing, gears, clocks, backpacks, and interactive arms can be added. The client also stated that anytime throughout the evening the lights will go out to illuminate the lighting incorporated in the displays. Therefore, Sharon would prefer the design to be equipped with a light source. The costume needs to be practical and comfortable for models to wear in order to satisfy the criteria of being a wearable technology. The garment would not impede the model's movement so that the models can better showcase the wearable technology. Since the event will take place over a duration of at least two days, the wearables features have to be able to last and function accordingly. These ideal features that meet the client needs are expected to be incorporated into the design to ensure a captivating steampunk wearable for the event that highlights Canada’s technological advancements over the years.

Client Needs Table

Needs ranked from 1 to 5 with 5 being the most important.

Number	Need	Importance
1	Attention to detail	5 - Sharon's company takes pride in their detailed work and brought in samples of wearables to show us the detail there was in even the smallest of parts.
2	Instill a sense of pride in the user end	5 - Sharon restated and emphasised the "wow" factor that she needs in the wearables throughout the entire interview.
3	Steampunk themed	5 - Must reflect the theme otherwise the wearables cannot be displayed in the event.
4	Equipped with a light source	3 - The venue may dim during certain points of the evening thus she would like the wearables to stand out.
5	Represents the quality of work from uOttawa	5 - Other universities will be participating in this event and it is important that we represent Sharon and ourselves positively.
6	3D Clothing	3 - Ideally the project can interact with the audience but it not necessary.
7	Practical and comfortable for models	3 - While it contradicts the term wearables, Sharon stated that the project we create can be put for display at booths and entrances instead of being worn.
8	Lifetime of at least 2 days	5 - If the cohesion of the parts or the technology of the suit does not last throughout the convention then our work will not be displayed.
9	Inexpensive	3 - Although having a low cost would be nice it is not essential for the success of the steampunk show.

Problem Statement:

Sharon hired us to create steampunk themed wearables that integrate interactive features and modern technology while maintaining the steampunk aesthetic. The costume will be displayed in the Canadian Aviation and Space museum where attention to detail is critical. Our final product requires us to meet their standards otherwise it will not be featured in the event.

Design Criteria:

Design Criteria Table

#	Interpreted Need	Design Criteria
1	Attention to detail	- Refined - intricate
2	Instill a sense of pride in the user end	- With the use of lights and sound, it will help the customer feel like he/she stands out
3	Steampunk Themed	- Metal accessories on the suit (gears, etc.) - Made of leather - Must encompass the aesthetic similar to that of the victorian era
4	Light Source	- A battery and a lightbulb or led will be implemented to obtain the desired luminance
5	3-Dimensional	- Incorporate features to help make the wearable “pop” and display depth (backpack)
6	Practical and comfortable for models	- Must be made in a way that makes the suit not too heavy with all the accessories put on it. - With all the electrical add-ons, the user must be

		able to move freely.
7	Lifetime of at least 2 days	- Built with a removable battery
8	Inexpensive	- Although a low cost would be nice it would not be essential for the success of the steampunk show

Impact of Client Meeting:

The client meeting had a large impact on the development of our design criteria because after seeing examples of steampunk wearables first hand we obtained a better grasp of the concept pertaining to the theme the museum is looking for. Being able to see the detail put into the wearable and unique ways of implementing 3D features helped form the design criteria. Additionally, from the meeting we learned the client expects that lights will be fused into the design in someway so that when the lights go out during the event, the wearables will be interactive to the guests. Prior to the client meeting we had no idea what the budget was for the project and whether or not we are expected to buy our own materials or if they are provided. From the client meeting we learned that we are expected to buy the materials, however it doesn't have to be expensive. The client emphasized going to thrift stores and finding old materials from junk yards to lower the cost. This enabled us to turn the interpreted need of an inexpensive project into a target specification. The client meeting put into perspective the importance of each design criteria.

Engineering Design Specifications:

Functional Requirements

- Interactive (wrist gauntlet will be used as a remote to control the following)
    - Shoot steam out of top of “spout” attached to costume
    - Gears spin (connected to servos)
    - Train noises
    - Programmable lights (flashing/blinking)
- Light source (ability to activate lights on command)

Non-Functional Requirements

- Aesthetics
- Product Life (minimum of 2 days)
- Reliability
- Reputable

Constraints

- Cost ($)
- Weight (Under 30 lbs)
- Safety (nothing impeding the model's ability to walk, no loose wires)
- Materials

Benchmarking:

Benchmarking was difficult because our task was to create an original steampunk themed wearable making it hard to take ideas from previous designs and make it our own. Therefore, the majority of our benchmarking was to compare materials for the design. The Victorian era style jacket that we used in our final project was inspired from one that we saw during the benchmarking stage. Furthermore, upon deciding on making a backpack we looked into some ideas already out there to get a feel for the general shape and size. That's when we decided on the idea of using paint cans for the base of the backpack that we could most likely get for free somewhere. On the other hand, benchmarking was difficult in terms of finding interactive steampunk technology because the interactive features are not common in most steampunk designs as it was intended to be unique for our engineering course. Therefore, finding ideas that incorporated features that relate to engineering and our project was strenuous.

Benchmarking Table 1

Scale on 1-3 (3 = green, 2 = yellow, 1 = red), the best being 3

	Importance (weight)	Costume 1	Costume 2	Costume 3
Cost ($)	5	3	2	1
Material	2	1	2	3
Steampunk Theme	5	1	2	3
Light Source	3	1	3	2
Interactive	3	1	3	2
Full Body Suit	3	3	2	1
Total		37	48	41

Benchmarking Table 2

	Costume 1	Costume 2	Costume 3
Company	PartyCity + Amazon(Forum Novelties Inc.)	Amazon(Blessume, Forum Novelties Inc., Lychee, Bristol Novelty)	Amazon(Forum), Etsy
Cost ($)	93.40	103.85	172.12
Material	Polyester, Plastic,	Polyester, Leather, Neon, Plastic	Polyester, Wood, Copper, Leather, Brass
Steampunk Theme	Yes	Yes	Yes
Light Source	No	Yes	Yes
Interactive	No	Yes	No
Full Body Suit	Yes	Upper Body	Upper Body

Target Specifications :

Ideal Values

- Light source is able to be activated (flicker/blink)
- Lightweight (comfortable)
- Full body suit
- Interactive arm, backpack, goggles

Acceptable Values

- At least has an interactive feature
- At most costs $100

- ➢ At least has a light source
- ➢ Weight is bearable for the model
- ➢ At least half of the body is a steampunk wearable

Impact of Client Meeting:

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Design Concepts:

Based on our design criteria each member of the group developed concepts for each subsystem of the wearables. Jonathan created designs for a mask, arm pieces, and a backpack. Brett developed designs for leg armor, a chest piece, a facemask, and an arm piece. Roshan sketched a chest piece, a mask, leg armor, and a backpack. Lastly, Eric drew designs

for the an arm piece, a backpack, legs pieces, and chest wearables. The concepts were divided this way in order to encourage the participation of all group members, and to develop as many idea's as possible for analyzation and evaluation.

Concept 1:

The wrist mounted device will include buttons that allow the user to interact with the technology built into the steampunk costume. The technology built into the steampunk costume will include functions that will activate lights, shoot steam out of a nozzle, make gears spin, and produce train sounds. There will be a backpack which will be rectangular will house the device that produces steam and connected to the backpack will be a nozzle where the steam is expelled. Additionally, the backpack will have lights that will be activated via the wrist mounted device. The mask will mostly serve as an aesthetic piece that will showcase the steampunk look. It would have lenses over the eyepiece, tubes attached to the mouth, and a metal mouth plate. The mask will be painted with a brass colouring to encompass the steampunk feel. However, it will have a light attached to the mask that will light up. The chest piece consists of a dress shirt, a leather hoodie which goes over the dress shirt, and a vest that goes over the leather hoodie. In addition to the steampunk themed clothing, there is a round LED light in the middle of the chest that will be attached with straps. The chest will also include smaller details such as vials and buckles. For the lower body, plain pants of either cargo, khaki or dress pants type can be worn. Plain high boots will be worn. Smaller details can be added to the paints/boots such as vials, a fake weapon, a belt or a pocket watch.

Concept 2:

The chest piece is essentially a leather vest with different steampunk themed accessories added onto it. It would have small LED lights scattered around it that would be powered either by a battery, or programmed by an arduino and activated when someone's hand was shaken. The chest piece would also have either a functional set of rotating gears or a nonfunctional set to add a better look. In addition, the vest would be wrapped with clear tubing so the audience could see the steam that would pass through it. The mask would be used to simply add a more steampunk feel to the overall suit; it would fully cover the face and have two filters on either side that would release steam through the tubes that would be installed behind it. For the legs and feet, it would consist of having knee high leather boots with different add-ons, such as: lights, gears, and a clock. Also, the thighs would have leather straps on them which would hold different types of tools. The backpack would act as a major support system for the whole suit because that is where the steam releaser and arduino would be held. The backpack would be made out of leather and have two metal cylinders on the back with a large clock between them. These materials on the backpack are to mainly to give it that steampunk aesthetic. The arm piece for concept 2 is designed more aggressively and features a spinning minigun aesthetic which can be controlled by the wearer. The entirety of the arm will be covered in either metal or leather and will progress in thicker levels as you go up the arm. Aesthetically, there are tubes running around the arm and spinning gears.

Concept 3:

The main structure for the backpack in concept 3 is paint cans. 3.79 L paint cans will be attached together using adhesive or screws. Paint cans were chosen because they can be

found easily in the case that we cannot find/create two cylinders during the prototype phase. Inside one of the upper paint cans, the will be some form of a steam maker that will be directed into a pipe that points upwards. Tubes will also be placed on the backpack that will be clear and filled with coloured water to provide movement on the backpack. The backpack also has PVC pipe, a pressure gauge, and movable gears for aesthetic purposes. The chestpiece and arm will visibly display a fusion of between the Victorian era and modern technology. The main component of the chest is composed of a long suit jacket that appeals to the Victorian era style. This is very easy to find and will balance with the modern technology quite nicely so that the entire outfit is not just trinkets, and metal. However, the arm will consist of a more modern feel with gears, syringes and tubes that will provide a more modern look. Keeping the main portion of the chest free of modern technology allows the costume to still have that old rustic look that is associated with the steampunk theme. The jacket can be found very easily at a second hand thrift store. The arm contains tubes, syringes, gears, bolts and typewriter keys that can be found at a scrap metal junkyard or can be scavenged from our homes. The arm will also incorporate a light source that is capable of turning off and on to attract people to interact with the costume.The mask foundation can be formed from an old gas mask found at thrift stores. The mask will contain tubes, gears and other objects to help instill a sense of depth and ‘pop’ aspect. The mask will only cover a portion of the face to again display the fusion between the Victorian era and modern technology. Finally, the knee-high boots are layered with thin sheets of metal (aluminum) and strapped together with leather. The boots incorporate tubing and metal tools (wrench) attached to a leather pad surrounding the entirety of the leg. The boots are easily accessible and provide the bottom half of the costume with a more Victorian era vibe which balances out the backpack and arms that contain a lot of modern technology.

Design Concept Table

Scale on 1-3 (With 3 being the best)

	Concept 1	Concept 2	Concept 3
Attention to detail	1	2	3
Instill a sense of pride in the user end	2	3	2
Steampunk Themed	2	1	3
Light source	2	3	1
3-Dimensional	1	3	2
Practical and comfortable for the models	3	2	1

Global Concept:

The mask chosen as the global concept satisfies the design criteria. The masks foundation is a an old gas mask. Trinkets, tubes and a light source will be incorporated to add detail and an interactive aspect that is listed in the design criteria. The mask will also include thick goggles that will pop and add depth to the costume essentially adding a three-dimensional aspect to the outfit.

The chestpiece is composed of a long suit jacket with a dress shirt underneath to balance the Victorian era style with the abundance of modern technology. The chestpiece will allow the modern features of the costume to stand out while showcasing the fusion between the old and the new.

The global concept for the backpack is paint cans. 3.79 L paint cans will be attached together using adhesive or screws. Paint cans were chosen because they can be found easily in the case that we cannot find/create two cylinders during the prototype phase. Inside one of the upper paint cans, the will be some form of a steam maker that will be directed into a pipe that points upwards. Tubes will also be placed on the backpack that will be clear and filled with coloured water to provide movement on the backpack. The backpack also has PVC pipe, a pressure gauge, and movable gears for aesthetic purposes.

The wrist mounted device will be made of hard plastic which will serve as the housing for the arduino that will control the desired functions and interactive capabilities. These interactive features will be controlled by buttons which are attached the wrist device and are hooked up to the arduino.

The boots are just high-knee style boots that have leather straps. The main focus of the wearable is not the boots, therefore, they are not cluttered with.

The global concept for the arm is designed more aggressively and features a spinning minigun aesthetic which can be controlled by the wearer. This will allow people to interact with the wearable and make others gain interest. The entirety of the arm will be covered in either metal or leather and will progress in thicker levels as you go up the arm. Aesthetically, there are tubes running around the arm and spinning gears.

Global Concept Table

Headpiece / Mask	- Brett (concept 3) - Jonathan (concept 1) - Roshan (concept 2)
Backpack	- Eric (concept 3) - Roshan (concept 2) - Jonathan (concept 1)
Chest Piece	- Eric (concept 1) - Roshan (concept 2) - Brett (concept 3)
Arms	- Brett (concept 3) - Jonathan (concept 1) - Eric (concept 2)
Legs / Feet	- Eric (concept 1) - Roshan (concept 2) - Brett (concept 3)

Prototype I:

For prototype I we are given two weeks since the previous deliverable to complete the task. For this prototype, the general objective is to learn and to also reduce further risk when we get to the final product.

The purpose of our first prototype is to give a physical demonstration of different body pieces, such that we can determine the dimensions that correctly fit the model and to see if the prototypes we created still fit the steampunk theme and look visually appealing. The prototype must also allow for feasible implementation of the wiring and the arduino. The making of this

prototype allows us to get a better understanding of the tasks and workload we have in front of us. The making of this prototype may also lead into problems that we may ran into later on had we not done this prototype. The prototypes function and aesthetics will also be critiqued by the customer, and their feedback will help us optimize the final design of the product.

The creation of prototypes will allow us to record measurements in which we can use later on in the final prototype. The creation of the prototype will also help us determine what materials are feasible for each part and give us a general idea of the cost of materials. With the information we gather, it will help us decide if we can continue with the design or make adjustments such that it is cost effective and satisfy the customer.

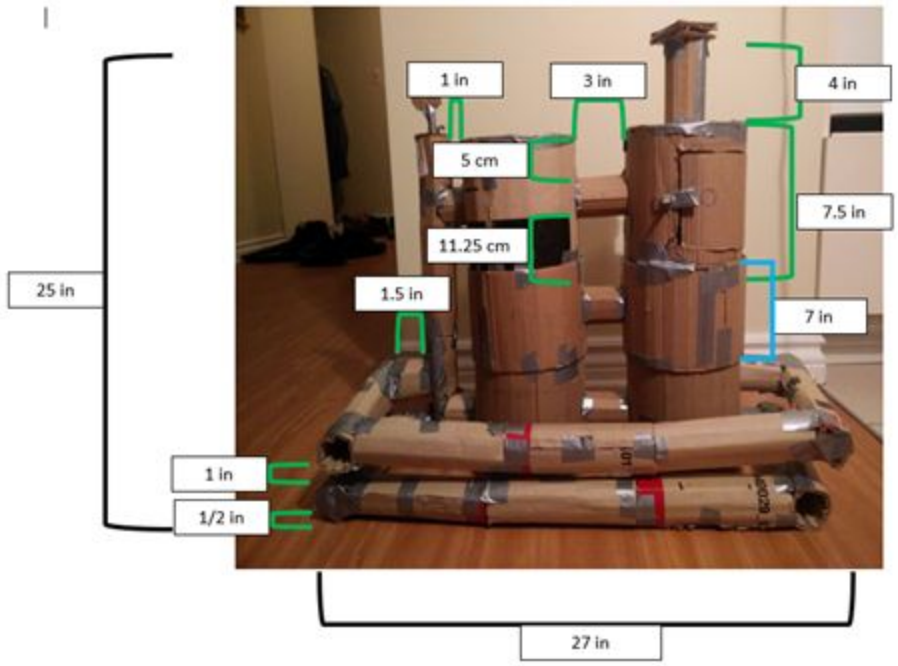
The test criteria for success and failure are whether the current dimensions fit the model without impeding their movement dramatically. The dimensions must also allow for the technology to be incorporated in the wearables. Lastly, the prototype must also retain its steampunk aesthetic.

The first prototype is a cross between focused and comprehensive. This was selected as the first prototype type because it can be made quickly that can help the team visualize and test the feasibility of the rest of the design. This type of prototype was also recommended by the professor because it requires basic tools that can be found in our households already or can be purchased at a cheap cost. Additionally, the physical comprehensive prototype will allow for feedback from the user ender as it will allow the team to communicate how the final prototype will look. We chose physical over analytical because the group felt that a tangible prototype would yield more benefits given what was being tested and what needed to be learned in the early stages of our product development.

For the first prototype we are creating physical representations of the backpack, the arduino arm, and the minigun. The prototypes will be made entirely out of cardboard, thus the

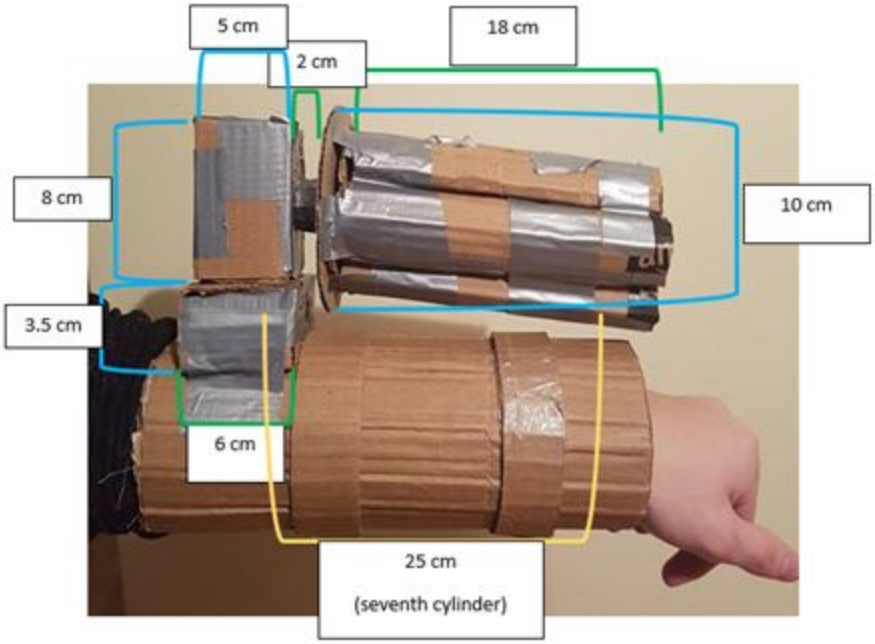
only tools needed are a knife, pair of scissors, and duct tape. All the tubes created in this prototype have the same diameter and represent PVC pipe. The tubes have a circumference of 6 inches and the length depends on each part. The cardboard can then be rolled and taped on the connecting edges. 4 cardboard paint cans are needed for the backpack and are modelled after after a 3.7 L paint can. The paint cans will have dimensions 7.5 inches in height and 20.5 inches in length. The paint lids and bottoms can be made by tracing around the paint cans. The height of stacking 2 paint cans wasn't enough so they will be extended by making cylinders that will wrapped around and between 2 paint cans. The dimensions of this are 7 inches in height and 21 inches in circumference. This piece also overlaps the paint cans by half an inch leaving space for the connecting pieces to be taped on. To connect each tower, there are 3 connecting cardboard PVC pipes that are 5 inches in length. The spacing of the connecting pipes is demonstrated in the diagram and are horizontally symmetrical. A hole is cut in the right tower at the top which will be the hole in which the steam will escape from. The pipe of this hole has a length of 6 inches. A door is cut into the side of the top right paint can so that the steam machine can be taken out and refilled. A battery hole is also cut but into the middle section of the left tower on the backside. The dimensions for the doors depend on the size of the battery and steam maker. The pipes that surround that paint cans have dimensions shown in the diagram below.

Prototype 1 Fig.1



The left arm piece, a minigun, is also made entirely from cardboard. The dimensions for piece wrapped around the arm should be custom made to the users arm. The 6 cylinders of the minigun are 18 cm in length and have a circumference of 9 cm. Another seventh cylinder should also be made but with a length of 25 cm and circumference of 9 cm as well. These cylinders will be taped onto a cardboard circular disc that has a radius of 5 cm. The longer cylinder should go through this circular disc because it will be attached to the motor. Further dimensions will be displayed in the diagram.

Prototype 1 Fig. 2

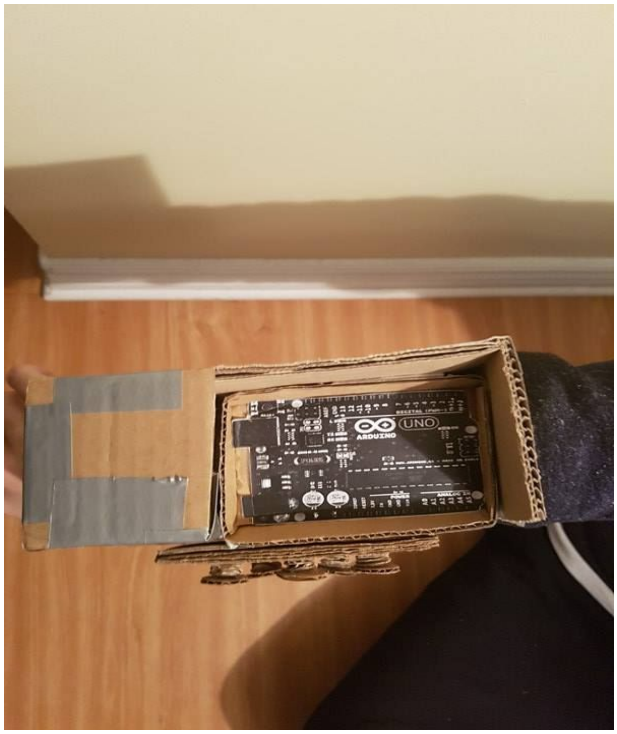


Prototype 1 Fig. 3

Finally the right arm piece that contains the arduino control panel is made entirely out of cardboard and tape. To build this piece you will need to start with a 35 cm by 18 cm cardboard cut-out. This will roll into the forearm guard but can be adjusted in size to accommodate the user's arm. Then a 11 cm by 6 cm rectangular cut-out is used as the base for the arduino system. Rectangular walls surround the arduino that are 2 cm in height. The arduino base and walls are taped in line with the end of the arm guard so that they are flush. Next, three 11.5 cm by 5.5 cm rectangles are cut which act as the base for the button panel. These three rectangles are stacked together, taped and then stuck parallel to the side of the arduino (2.5 cm) walls.

Five circles with radius 0.5 cm and another five circles with radius 1.0 cm are cut out. The smaller circles (0.5 cm) are taped on first and then the larger (1.0 cm) circles are taped on top as displayed in the diagram. Finally, a large wall encasing the arduino walls is applied to add depth and aesthetics. The wall is made up of three 7.5 cm by 6.5 cm rectangles that are stuck to the outside width of the arduino walls. Then a 18 cm by 6.5 cm rectangle is cut and adhered to the back side of the arduino wall. This rectangle spans the whole arm guard. Lastly, two 6.5 cm by 6.5 cm rectangles are cut out and taped to the side of the arduino that is not flush with the arm guard, creating a box. These rectangles are used as the front and side of the box that is seen beside the arduino system in the diagram. All that is left is to place the arduino system carefully inside the small rectangular walls that will hold the arduino in place and you have successfully made the right arm piece prototype. Diagrams are displayed below to assist in construction of the arm piece.

Prototype 1 Fig. 4



Prototype 1 Fig. 5

Prototype 2 Fig. 6

Prototype 1 Fig. 7

Prototype 1 Fig. 8

During the creation of the prototypes, the user should be recording the measurements of their cuts so that they can be used when creating the final prototype. The test criteria is being also being observed during the process: seeing if the prototype still retains the steampunk aesthetic, determining if the prototype needs to be adjusted such that it isn't cumbersome to the wearer, the volume of the backpack so that the steam machine can fit, and the ease and feasibility of implementing wires.

The total cost of the prototype may be as little as $0.00. In our case, the cardboard, tape, knife, ruler, pencil, and scissors are already available.

With the completion of the cardboard prototypes, the user can begin on determining how the technology can be incorporated into each of the wearables. Since the prototype is made from cardboard, the wearables can be adjusted fairly easily to accommodate the size and length of either the steam machine, wires, batteries, etc. The dependencies in order for testing to occur is for the physical tangible prototype to be completed. Once built, the test should take about 20 minutes or longer if there are conflicts in size.

Customer Feedback and Future Work for Prototype I:

Throughout the design process we gained a lot of great feedback, most importantly the approval of our design by Sharon. During the early stages of our design when we decided on the global concept, Sharon had the opportunity to see the idea we were going to create and had nothing negative to say. Once we completed the first prototype and presented in class, it seemed that Sharon liked the progress of our work as she took a few pictures and made no comments. However, after the presentation the professor explained to us that any form of weapon, whether it functioned or not, was not allowed. Thus, we had to scrap the minigun idea and come up with a new one.

Despite the fact that we could not make any weapon related wearables, the group still decided they wanted to make use of the motor. Another concept that was drawn quickly, involves a functional gear box which meant that the motor could still be used. So with the problem solved, the group moved onto the next prototype.

Prototype II:

Prototype II is a focused prototype to implement the technology aspects of the wearable technology. This prototype will be executed by getting a dc motor to spin a gear and making the

strip of lights run through different light sequences. This phase of the prototyping is to ensure that the desired interactive functions will work on design day. Therefore, the technology that we learn how to control will be implemented in the final prototype where every component is brought together. This prototype is also focused on ensuring the steam being emitted from the backpack is noticeable and functions well. Testing whether the steam would be visible enough in dark and light environments and to determine how long it can produce steam for before the need to refill would allow us to determine whether the humidifier is a feasible source of steam. The reason we chose to focus on these specific features of the design was to ensure the interactive features which were highly sought out by the client were met and exceed expectations. We wanted to give our steampunk wearable an intricate aspect that will separate our design from the rest. Figuring out a way to power the humidifier, and secure it inside the backpack so that it does not open up was a big part of this prototype. Also, determining how the fragile arduino and circuit boards will be attached to the left arm piece we designed was also a major obstacle that needed to be overcome and this prototype helped us to do so. The specific test objectives for this prototype is to simply figure out the code, hardware and circuitry necessary to carry out the functions that the arduino needs to execute. This prototype requires a lot more materials than the ones used in prototype one. This prototype costed about $55 which contained the arduino, lights/neopixels, buttons, dc motor and the humidifier.

The information being measured in this prototype is the height of the steam being blown out of the steam machine. Additionally, the length of the wires will also be measured in order to ensure that the person wearing the wearables is able to move freely without too much constraint. It also makes sure that the wiring will be long enough to reach both arms, connecting the dc motor on one arm to the arduino control system on the other arm.

The height of the steam can be recorded by using a ruler, hoping it reaches about 20 cm in

height. While the thickness and visibility of the steam can be observed by walking around the steam machine from different distances and with different room light settings. The visibility can be recorded with a simple yes or no, with and without the help of the flashlight.

The results from this prototype will influence the decisions that will be made because if the desired functions such as running through a sequence of light shows and spinning a dc motor do not work then new solutions must be looked into. This means that certain functions and concepts must be scrapped or altered so that the desired results can be achieved.
After the initial testing of the humidifier, we all agreed that it did meet our expectations as the smoke was very light and was hardly visible. Therefore, we had two options, either return the current humidifier or purchase a new one and prototype again to determine another solution that gives us the desired effect. However, being short for time ordering a new humidifier was not a practical solution and does not guarantee us a solution. Thus, we had to make due with what we had and figure out a way to make the smoke more visible. This prototype is what led us to the conclusion of using a flashlight to illuminate the smoke, making it more visible to viewers and giving us the effect we wanted.

We learned a lot from the testing of prototype II as we went out of our comfort zone and explored concepts that were unfamiliar to us. Lessons such as implementing the correct circuit and writing the code for the arduino to perform the requested results was learned. This was so that the arduino could control lights and run through a sequence of different light shows and spin a dc motor with inputs coming from two different buttons. This prototype is where we experienced our first obstacle, having to overcome the issue with the steam humidifier. This prototype taught us that not everything will go as planned throughout the design process and coming up with a solution when short on time is part of the learning process. Fortunate enough

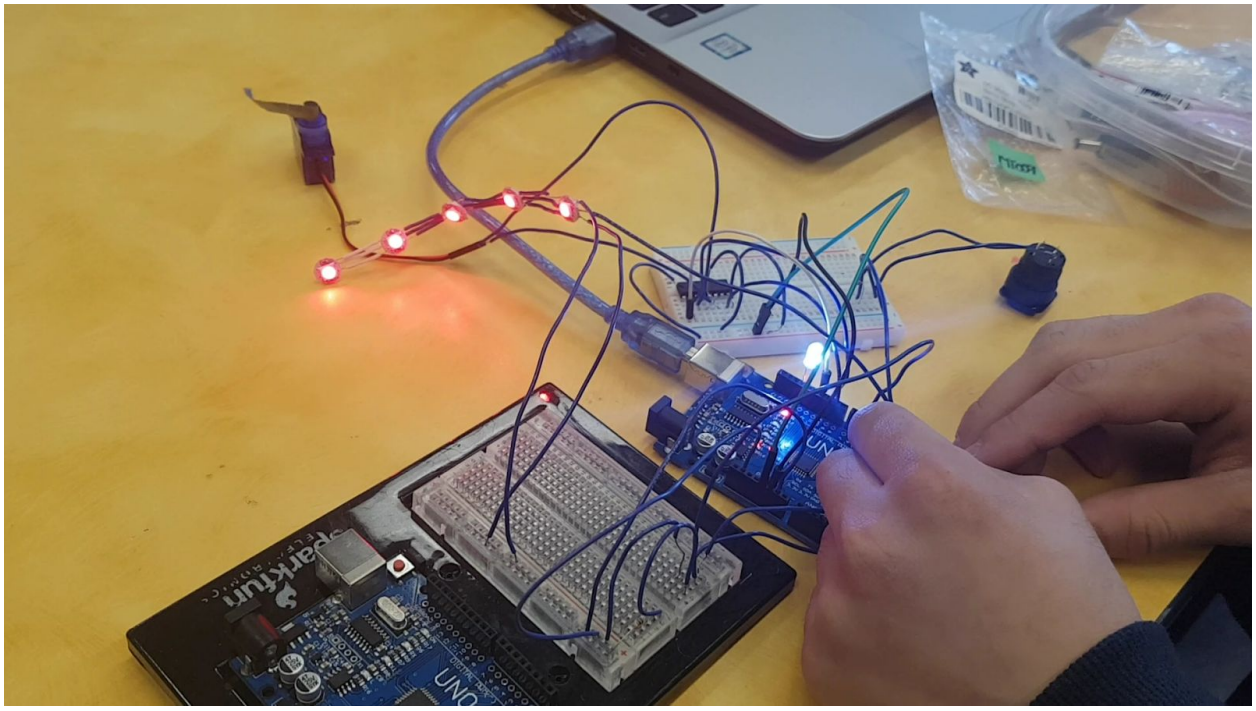
for us the solution worked exactly how we wanted and this prototype provided the wearable with the technology aspect that was required in the design.

Results and future work from prototype II:

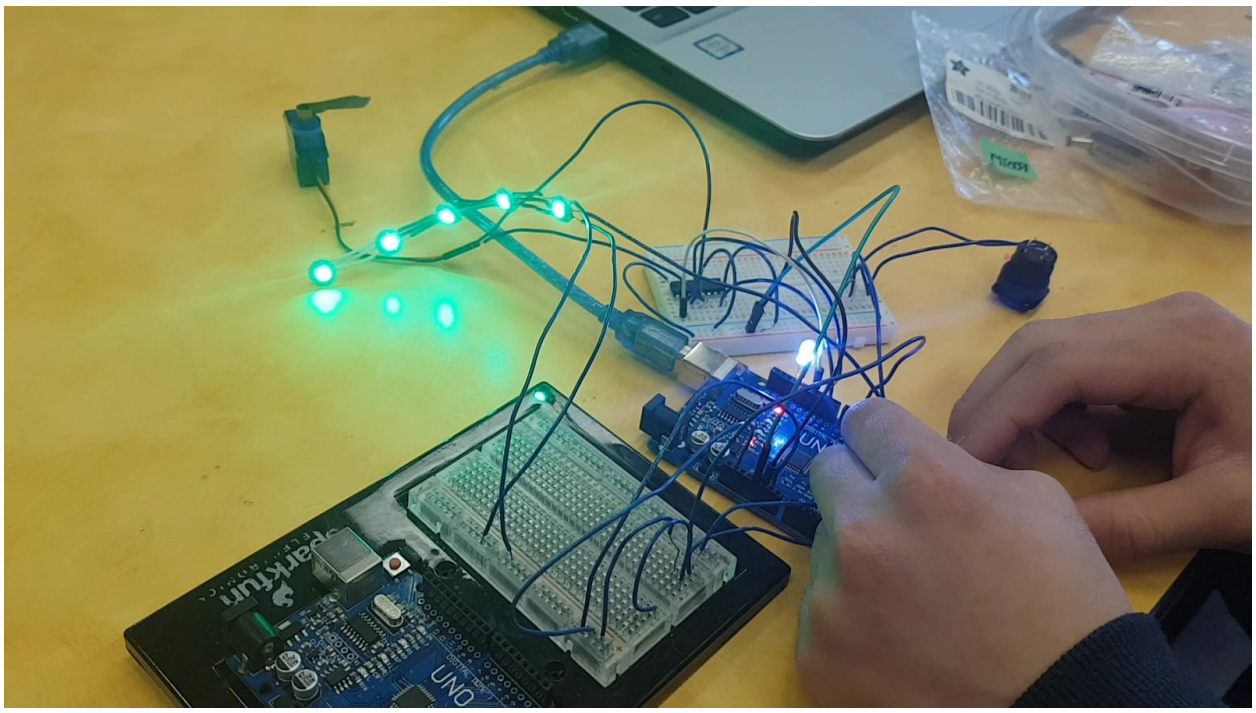
Prototype II turned out very well. We managed to get all the lights and and motor working just the way we wanted for the final project. This means that we got one button to control the lights, and another button to control the motor. The steam diffuser also worked very well as it blew a fair amount of steam and should work well within the backpack for our final prototype.

Prototype 2 Fig. 1

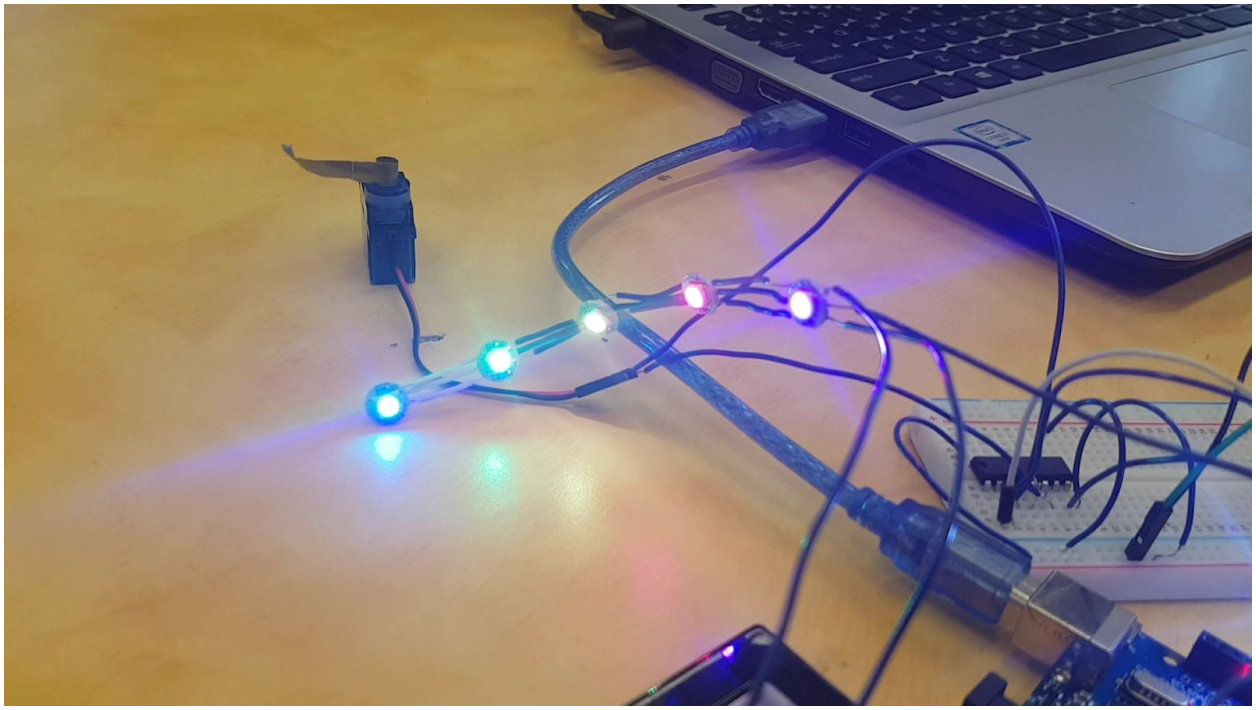
Prototype 2 Fig. 2



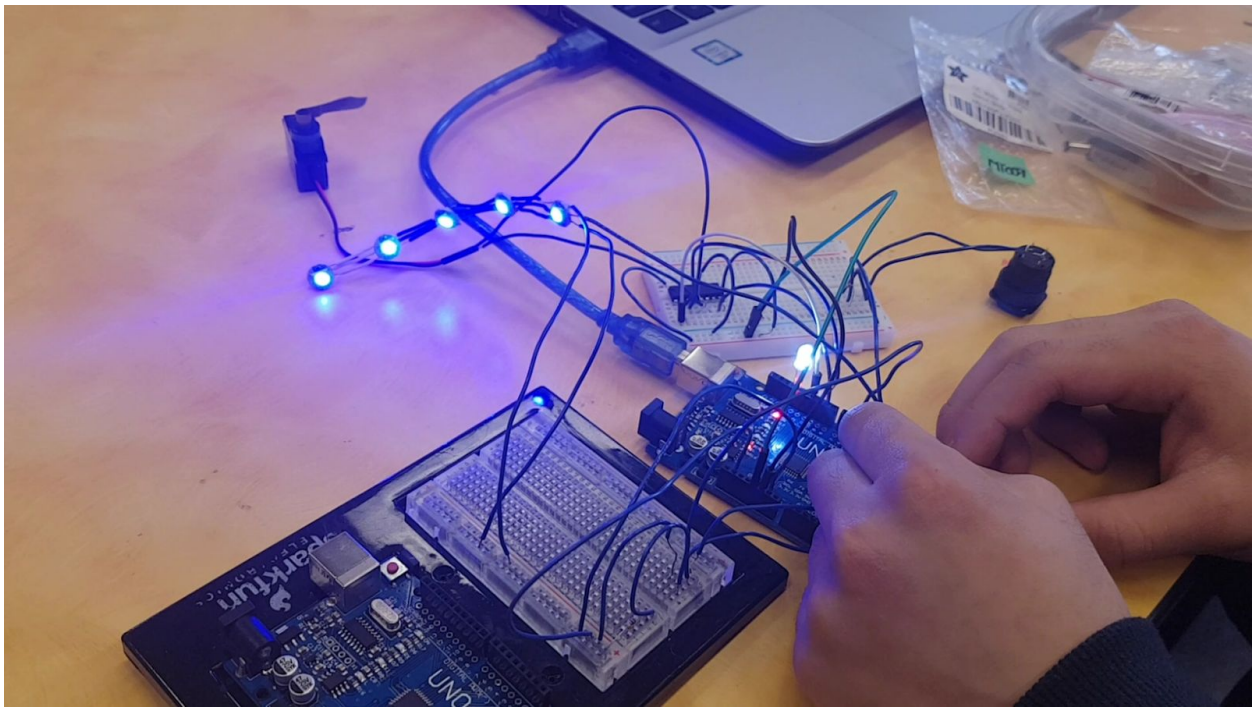
Prototype 2 Fig. 3



Prototype 2 Fig. 4



Prototype 2 Fig. 5



Prototype III:

Given two weeks to complete this prototype, we are creating a comprehensive prototype that will be judged on design day which is March 29, 2017, that will include all the lights, functionality, and looks. While this prototype does not have to be the final design, it should be fairly complete.

The main reason for this prototype is to test functionality. We need to determine whether the individual components we made throughout the prototyping stages can come together and function as intended while meeting the design criteria. Another reason for this prototype is communication, specifically with the customers. Since this is being presented on design day to judges which include Sharon House, our client we want this prototype to be the mostly complete in order to receive comments on what works well and what does not.

A specific objective would be to make sure that the arm piece that contains the motor, spins the 3D printed gears correctly. On the other arm, we are testing the technology (lights, motor) from the arduino and if they function well with the other wearable pieces. Since the wearables are as a whole we can measure the wiring path between the wearable pieces on the model. Additionally, this prototype allows us to visualize the wearables as a complete set and make any changes necessary pertaining to sizing and functionality.

From the testing we are learning how to attach a DC motor on one arm and connect it to the arduino controlling it on the other arm. We also plan to learn how to attach gears to the DC motor and incorporate this with a interactive feature. We will also discover how to attach the fragile components of the arduino and technology to the arm without breaking any connections. The results we hope to achieve is to have all the technology function by design day. Meaning that the buttons controlling the lights and motor can be activated by the model or by bystanders. We also hope to have the steam diffuser incorporated correctly into the backpack where it can be seen from a reasonable distance. With the combination of the technology and wearable pieces we also hope the prototype will look aesthetically pleasing to fit the steampunk theme. If any of these aspects fail by design day, that means we have failed to meet our design criteria. Where failing means that the technology does not function as expected or not at all or if the wearables can not be worn and become to cumbersome to have on the model.

Free materials that are required to create the backpack and arm pieces are plastic, paint cans, 3D printed gears, and cardboard. Materials that need to be purchased for this prototype are PVC piping, PVC corners, clear tubing, flexible metal, screws, hinges, paint, tape and glue, and clothing from thrift stores. Users may also wish to purchase a container of sorts instead of creating a gearbox or arduino holder.

To build the backpack, the creator would need to acquire 4 paint cans and an aluminium sheet. The user should then cut the aluminum sheet such that it is 7 inches in height and in term of length, the metal sheet should be wrapped around a paint can and be measured to be cut, two of these are needed. To join the aluminum sheets in between 2 paint cans, the user will need to drill holes and use screws and nuts to secure the structure. Next the user will need to drill holes for the PVC to stick into the paint cans. It is important for these holes to be perfectly aligned between each of the two paint can towers. There will be 5 2 inch sized holes cut into each of the paint can towers. The first three holes should be vertically aligned and spaced evenly through the towers height, these holes are to bridge the paint can towers to one another. The next two holes are for the decorative PVC piping that wraps around the towers. These two holes need to be 180 degrees from the initial 3 holes. The two holes will also be vertically aligned to each other and should only be cut into the bottom paint can of each tower and be spaced no less than 2 cm from each other. Next the user should measure how long they will like their piping to be, with at least 1 inch of the piping sticking into the paint can towers for support. With the towers, piping, and holes cut, the user can paint the towers and piping. The user should then use glue and/or tape when placing the PVC pipes into their holes. The user can also go over the tape and glue with more paint to match the colour. The next step is to retrieve one paint can lid and create a small hole for the steam to escape. Next is to attach hinges for the paint can lids for each of the towers. After screwing the hinges from the paint cans to the lids with screws and nuts, the user needs to then make a platform to hold the steam diffuser in place inside one of the top paint can towers. Optionally the user can attach a flashlight to illuminate the steam and can also create a small pipe to direct the steam in the desired direction.

The right arm consists of the motor and gearbox. The user should create an arm piece and rectangular box with no top and paint them the desired colours. Next would be to place the

motor into the gearbox and build a platform with a hole such that the the spinning function of the motor sticks out of the platform. There is also need for a hole in the back of the gearbox to allow wires to connect from the motor to the arduino arm piece. Finally the user should 3D print gears depending on the size of their gearbox and connect them to the motor.

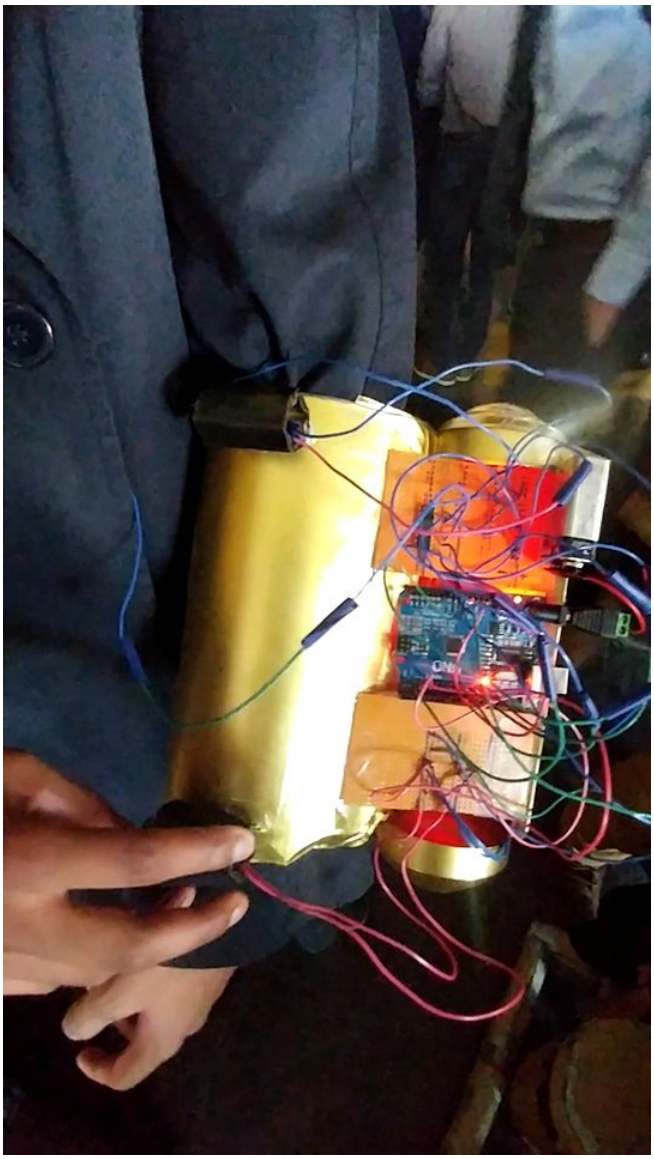
The left arm piece that contains the arduino can be made quite simply by using the already existing cardboard model from prototype one, putting a thin layer over top of the cardboard and apply the gold paint finish. Then we used the top part of a reading lamp (already gold) and glued it onto the top of the arm piece sitting horizontally across with the open area facing up. Then tape the arduino and two breadboards carefully to the open space as it fits across perfectly. Place the strip of lights connected to the arduino underneath the 3 panels (arduino, 2 breadboards) so that it lays inside the lamp. Make sure the arduino and two breadboards are secure so that no wires become loose and disable the functions.
During the construction we are measuring the weight and size of the backpack such that it does not become to cumbersome for the model. The length of wiring needed to make connections from the arduino arm to the motor arm will also be measured and cut. Lastly, the torque of the dc motor to ensure that it is capable of rotating the gears. All the other measurements were either recorded in prototype I or prototype II. The complete wearable outfit will be observed to individuals at design day. The functionality and aesthetics will be observed by judges. The combination of students, staff, and judges we hope to receive constructive feedback as to how we could improve on our prototype to include in the museum.

After the construction of all the wearables is complete, testing can begin to occur. However, this task may be difficult and time consuming. Purchasing all the materials may take many trips as the only means of transportation is the bus. Soldering and arduino is brand new to

the all the group members and may take time to learn and do correctly.

The results of all the testing should be completed before design day and fixed accordingly. Furthermore, there will be more feedback on design day so additional time afterwards may be necessary to complete the final design.

Prototype 3 Fig. 1



Prototype 3 Fig. 2

Prototype 3 Fig. 3

Customer Feedback for prototype III:

During design day, many students and faculty praised the aesthetics and technology of our design. They commented on how the steam looks very good and that the functionality of the arm pieces added to the aesthetic appeal. In terms of appearance both judges and bypassers commented that the outfit does relate fairly well to the steampunk theme. The judges did mention that there could be more interaction with the user instead of just having lights. During the final presentations, the professor mentioned that there could be cleaning up to do on the arm pieces.

Future Work for Prototype lll:

Our design was chosen to be used at the 150th anniversary of Confederation that takes place on May 17th, and so some improvements to the two arm pieces have to be made leading up to this event. Specifically, cleaning up the wires on the arduino arm and spending more time to make the gears work on the arm with the dc motor is where are focus will be to make the wearable up to standard with the backpack. The backpack needs some slight adjustments with regards to adding in new, more durable straps and touching up some rough surfaces where the hot glue is.

Conclusion:

In conclusion, a steampunk themed wearable with spinning gears, a sequence of programmed lights, and a steam machine all controlled by an arduino were chosen to solve the client's need of having steampunk themed wearables that integrate interactive features and modern technology while maintaining the steampunk aesthetic. By prototyping and testing we learned the importance of communication and engineering analysis and its importance in

creating a good product. This was evident when there was a lack of communication with the team making the arm piece and the team building the circuit and making the circuit. Due to this lack of communication the wires were much too long in some areas and much too short in others causing the wearable to not be fitted as expected. Additionally a lack of engineering analysis resulted in damaged lights causing an increase in budget and wasted time. In the future from these lessons learned the team will make sure to communicate to each other clearly using design specs and diagrams, when appropriate ,what it is that they would like to make as well as spend more time doing engineering analysis to prevent careless mistakes and wasted materials.

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http://www.thecompliancecenter.com/packaging/bottles-and-cans/metal_cans/paint.htm