UNIVERSITY OF
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Department of Mechanical and Mechatronics Engineering

Garbage Bag Closer Design Report

A Report Prepared For:
The University of Waterloo

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Summary

Due to common inconvenience caused by garbage odors in every household, a garbage sealing mechanism was constructed. This design is made to be compact and affordable for all middle class and meet the requirements of being lightweight and safe. This was further developed through concept sketches where the design with clip one hooks were chosen. The design had the highest score in the engineering design specifications and found to be the most practical for this application. The concept was to have two hooks, one extending and one stationery, attached to two clips that have a wire running through them connecting to a pedal. The clip is made to be secure by adding rubber insulation for an interference fit with the bin itself. The hooks are made to telescoping so that they could compress and extend with the spring force and reach a longer range across garbage bins. The pedal is designed to have a gear ratio that allows the cable to be winded up when force is applied. These parts are easily compact and lightweight due to their main material of high impact polystyrene. The spring itself was chosen to have a k constant that would not cause enough force to induce a pinch point. The final design utilizes pulleys and gears to run the system and is found to be less than 5 dollars in material costs. It is very compatible with different sized shape bins such as circular and rectangular bins, made from the small features that allow it to fit. The aesthetic of the whole design met the minimum requirement and is found to have no outstanding safety issues. In the end the work breakdown was evenly split amongst group members, and the general timing of the whole process didn’t deviate too far off the original planning. Going forward it was found that a less exposed design would be the biggest improvement and allow a better safety and aesthetic rating. All the initial requirements were met, and the design brings a new perspective on mechanisms that reduce odors.

1.0 Needs Analysis

The objective of this project is to reduce the odor caused by garbage (recycling and compost are included within this scope). Open garbage bins with filled garbage bags release repulsive odors creating a common problem on a large scale. The root cause of the problem is the garbage itself, however garbage and waste has been a long-lasting issue and will continue to be problem. If garbage is long-lasting so will the odors it creates. Our project also targets the middle class because it is the demographic that wants to have luxury items but may not be able to afford them, so something like this will appeal to them. Majority of people experience this problem, but those that would be interested in this is those who can't afford better or want more than their existing situation.

1.1 Need Statement

A need exists to close the garbage bag when not in use to prevent the exposure of odors while being affordable to middle class individuals by being under 5 in material costs.

1.2 Engineering Specification

Table 1 *Engineering specification table for our need to close the garbage bag*

No.	Characteristic	Relation	Value	Units	Verification Method	Comments
1	Mass	<	5	Lbs.	Analysis	Calculate the mass using density of the material and the total volume of the product.
2	Material Cost	<	5	Dollars	Analysis	Total the final product material cost by tallying up the theoretical cost to purchase the required materials for one unit of product.
3	Garbage Bin Width Range	>=	7	Inches	Analysis	Simulate the closing mechanism with garbage can sizes that have a minimum width of 7 inches.

4	Aesthetic Design	>	55	%	Test	Test 15+ subjects on what they would rate the design of the product on a scale of 1-10.
5	Meets Safety Requirements	N/A	N/A	N/A	Examination	Show there are no harmful pinching points in the design that could cause significant injury.
6	Ultimate Tensile Strength	>	30	MPa	Examination	Material does not bend or deform easily under pressure.
7	Volume (Compact)	<	0.027	m^3	Analysis	Simulate the product fitting in a 30x30x30cm (0.027 m^3) box.
8	Compatibility	>=	2	Shapes	Analysis	Simulate the product attaching to at least 2 different shapes of bins.

2.0 Conceptual Design

The process to create the idea and design for the product followed two major steps. The first step involved creating conceptual designs based on a morphological matrix. The second step focused on evaluating three of the different conceptual designs and logically picking which design was the best based on a group-decided set of criteria.

2.1 Considered Concepts

A morphological matrix needed to be created to inspire the conceptual designs. This matrix would include actions the product will perform and corresponding sub-functions that would be able to complete these actions. As a group, three actions were decided upon that the product would perform: attaching onto an already existing garbage bin, closing the bag, and sensing when it’s full. After creating the sub-functions and assembling the morphological matrix *(Figure 1)*, the matrix was used to inspire conceptual designs. The three best designs were chosen to be presented and compared.

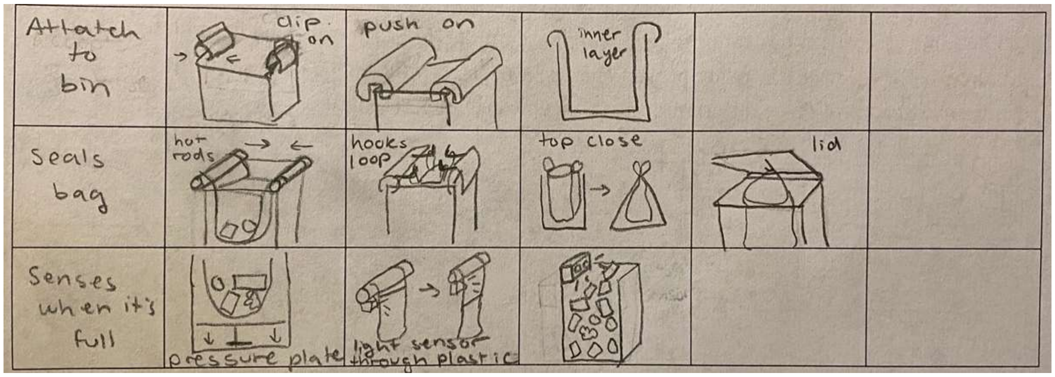

Figure 1 *Morphological chart including three actions the product will perform and corresponding sub-functions*

The first concept (*Figure 2*) revolves around curved edges, a pressure sensor and sliding rods. The curved edges performed the action of attaching to the bin, the pressure sensor would detect when the bag was full, and the rods would close the bag. The design is intended to be a lining on the inside of the bin used and closes by either end coming together to meet.

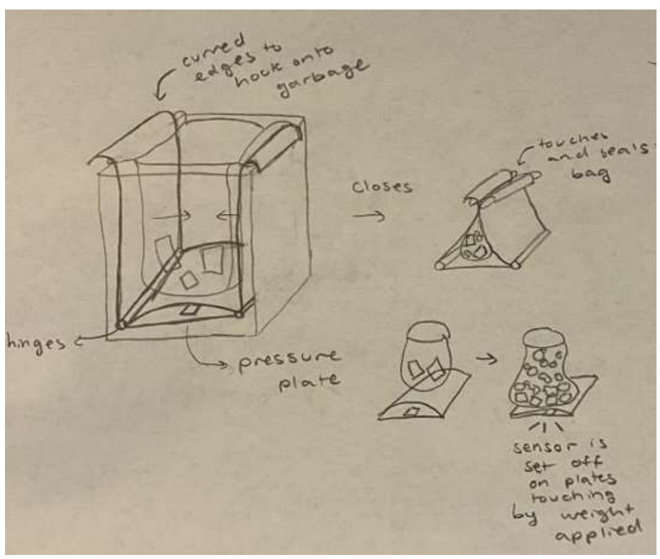

Figure 2 *Conceptual Design 1, Key Features: Curved edges, sliding rods & pressure sensor*

The second conceptual design uses the idea of magnetic hooks in order to close and open the bag. It has clips so it can attach to any garbage can and a pressure plate that rests at the bottom of the bin and detects when the garbage bag is full.

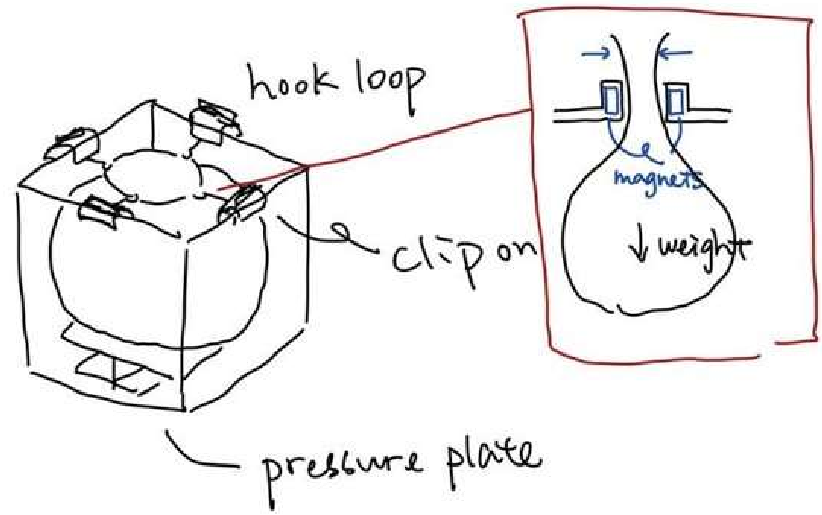

Figure 3 *Conceptual Design 2, Key Features: Clips, magnet hooks & pressure sensor*

The third concept has a bendable ring that attaches to the top of garbage cans; however, this wouldn't be too adjustable. The garbage bag is attached to hooks with built in spring scales to measure how much garbage is in the bag by weight. When the bin isn't in use, the ring has a closeable lid that functions similarly to a camera lens closing.

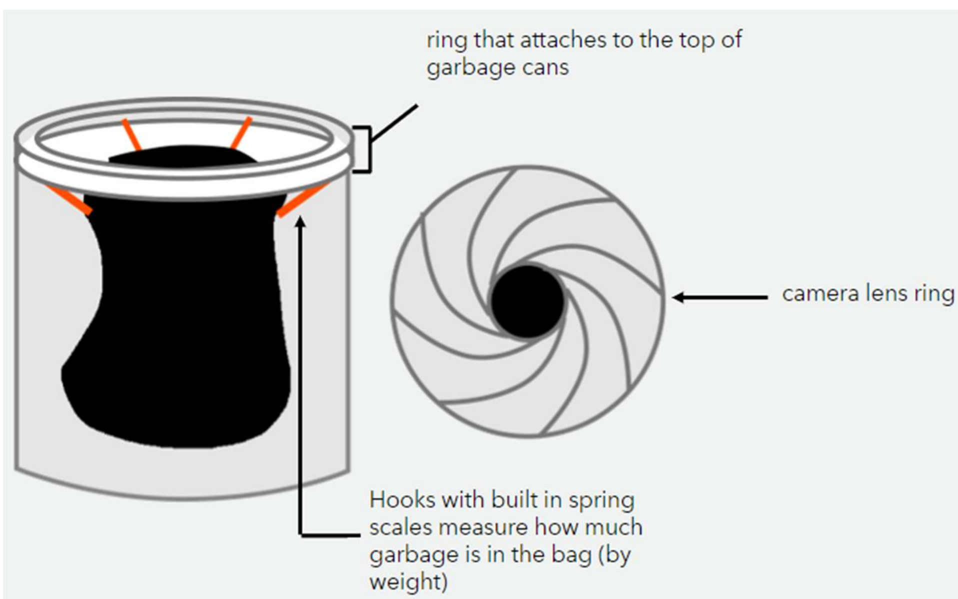

Figure 4 *Conceptual Design 3, Key Features: Bendable ring, camera lens lid & spring scale hooks*

2.2 Decision Making Matrix

In order to pick the best concept, the group created a criterion which the concepts would be judged with. With concept 1 (*Figure 2*) being the datum, concepts 2 & 3 (*Figure 3 & 4*) were judged on whether they were better or worse than the datum for that criterion point. The criterion consists of safety cost, aesthetic design, odor reduction, closing speed, adaptability and ease of production.

Table 2 *Design Making Matrix for Concepts 1, 2 & 3*

Criteria	Datum (Concept #1)	Concept #2	Concept #3
Safe for user	0	+1	0
Cost	0	+1	-1
Aesthetic	0	-1	+1
Odor Reduction	0	-1	0
Closing Speed	0	-1	+1
Adaptability	0	+1	0
Ease of production	0	+1	-1
Total	0	+1	0

Concept 3 was found to be better than concept 1 in areas such as aesthetic design and closing speed but worse in terms of cost and ease of production. Overall, they were equal in terms of design. However, concept two was slightly better than both concept 1 and 3 by being superior in safety, cost, adaptability, and ease of production but worse in odor reduction, closing speed and aesthetic design. In total, it had one better feature and was therefore the best conceptual design.

3.0 Mechanical Design

During the design of the final product, team members made several changes to conceptual design 3.

First, the pressure plate was removed because we determined that measuring the weight of the garbage would not be effective in determining whether the bag should be closed. Since the purpose of this design is to reduce odor transmission, a small amount of trash does not mean the garbage does not transmit odors, so the pressure plate was considered a redundant component.

Second, the magnet element was also removed. The main reason was that it was difficult to prove the feasibility of using magnets because the team could not actually make this finished product.

Finally, a foot pedal part was added. This is because we want the user to be able to close or open the garbage bag at any time they want. Therefore, a foot pedal was needed to allow the user to easily control this product.

The final design will be presented in the following sections.

3.1 Function

The design has three major components each with their own individual function: the clip, the hook, and the foot pedal. The hook is attached to one of the clips, and a wire will be passed through them, which will run through the whole hook and lead to the foot pedal through the pulley system inside of the clip. Garbage bags will be hung on the left clip and the head of the hook. When a person wants to throw the garbage, they just need to press on the foot pedal, the wire will contract and be shortened, so that the spring will be compressed, so the hook will open, and the garbage bag will also open with the hook. When the person is not there, the spring will automatically return to the unfolded state, the hook will then be connected to the stationary clip at the other end, and the garbage bag will also be closed.

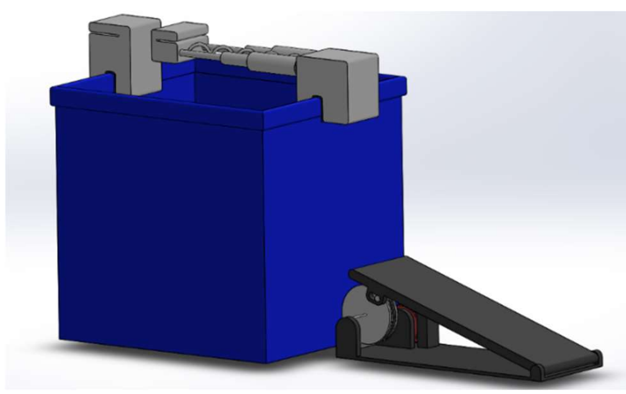

Figure 5 *General view of full design on a rectangular garbage bin*

3.1.1 Clip

The main function of the clip is to attach and anchor the device to the garbage bin. The wire goes in through the cable input that aligns with the hook and runs inside the clip and over the pulley. The pulley then feeds the cable to the output which then heads down towards the pedal. The pulley runs on an axel and is made to be tangent with the cable input and output to reduce friction on the cable (*Figure 6 A)*. The clip then has a cut out towards the bottom of the device that is made with enough allowance to even fit on bins with a lip. The cut out is lined with rubber for added grip and security for the device to stay in place and create an interreference fit with the bin. The stationery clip is made to be the same dimensions as the first one but with no inner mechanisms and something for the other end of the hook to meet and the bag to hook onto. (*Figure 6 B)*.

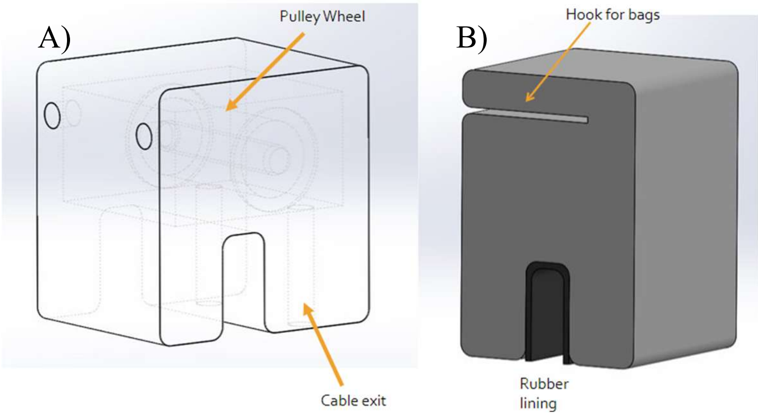

Figure 6 *A) Wireframe View of Clip Design with Input and Output, B) Solid View of Stationery Clip with a Hook for Bags*

3.1.2 Hooks

The main function of the hook is the opening and closing mechanism of the bag. A spring is in between two telescoping extensors to provide the power of closing the bag, as it supports the hook to be unfolded, so that the hook head can be connected to the other side of the bin (the stationary clip). As there are two wires going through the telescoping extensors, when the wires are shortened, the spring will be compressed, and the bag will be opened. There are two major auxiliary functions. The first one is that it holds the garbage bag by the slot on the hook head. The second auxiliary function is that it connects with the clip and pass the wires to the clip and down to the foot pedal.

3.1.3 Foot Pedal

The main function of the foot pedal is to wind up the two wires connected to the hooks and open the bag. When the foot pedal is compressed, a gear rack rotates two interlocked gears causing the spool to rotate and wind up the two wires. This causes the hooks to compress and open the bag. The main auxiliary function is to allow the user to open the bag without using their hands.

3.2 Layout

The overall design (not including the bin itself is designed to have two clips, one moving hook and a pedal. *(Figure 7)* The design was tested on a regular rectangular bin with a thickness of 0.06 inches and a lip around the edge of 0.32 inches that the clip is directly added onto. The circular bin follows the same standards, these dimensions were made based of realistic bins in households and to optimize the dimensions set for the parts. The wiring cabling of the design is made to span the whole length and height of the bin, and then some. Therefore, the total length of the cable is 2.5 feet, even though the whole bin needed about 18 inches *(see Figure 8)*.

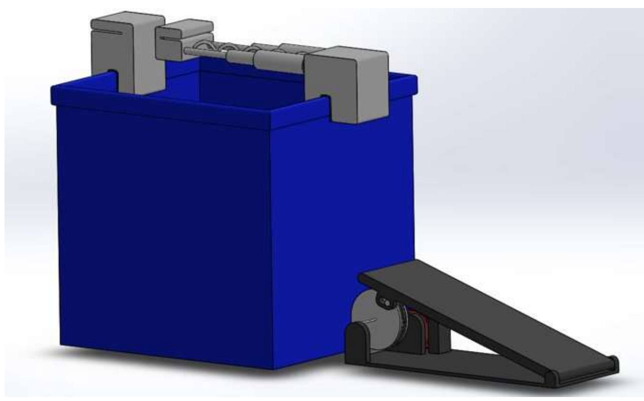

Figure 7 *Layout of full design on a rectangular garbage bin*

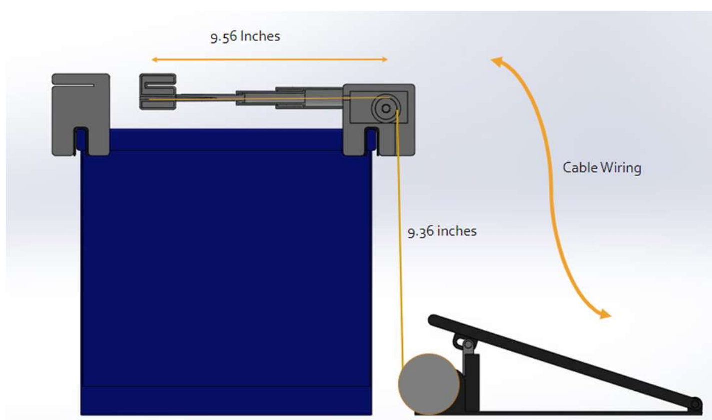

Figure 8 *Cross Section of full design on a rectangular garbage bin*

3.2.1 Hook

Figure 9 (a) shows the overall design of the hook. It consists of three main parts, the hook head, the telescoping extensors, and the spring. The spring in the middle connects the head of the hook to the clip on the right and provides the power to extend the hook. *Figure 9* (c) shows the fully contracted form, there is a small slot on the head of the clip, this is the actual hook for the bags, it is designed to prevent from slipping of the garbage bag. The inner diameter of the holes is 0.25 inch. And the largest extensor's diameter is 0.75 inch. The design is hollow inside so that the weight can be lighter. The thickness of both the extensors and the hook head are 1/16 inch.

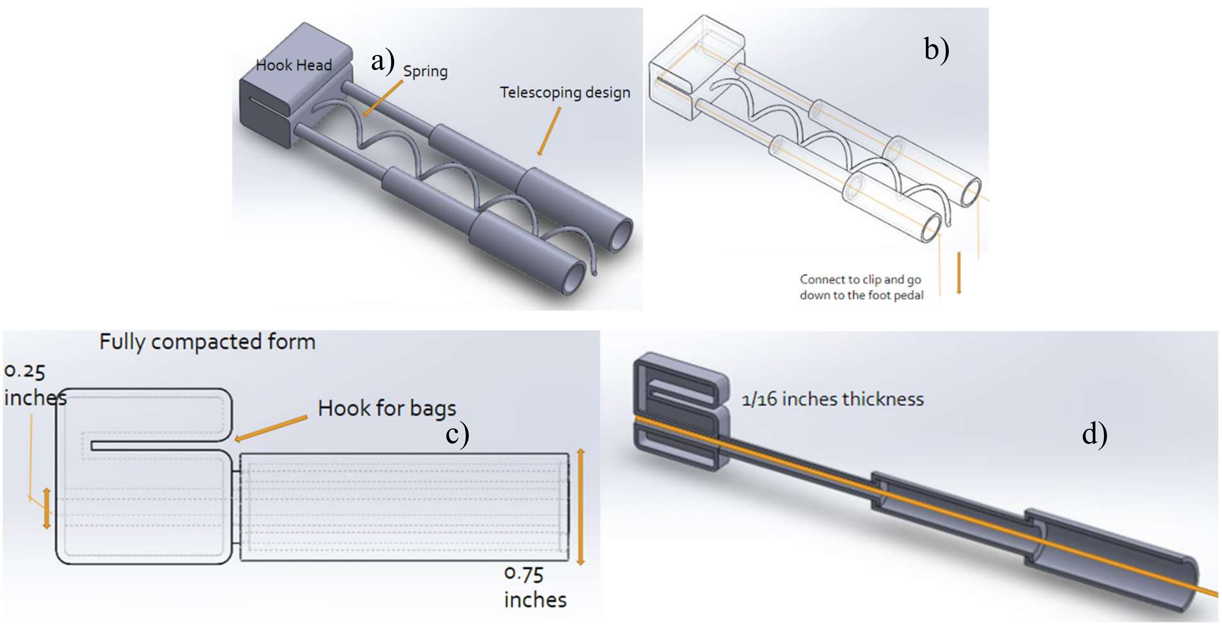

Figure 9 *a) solid view of hook design (extended), b) wireframe view of hook design (extended), c) wireframe view of hook design (compacted) with dimensions and labels, d) solid section view of hook design (extended) with the orange line representing the wire*

The design has been changed from the conceptual design. There are only two hooks with one being stationary and the other one will handle the major functionalities described in the paragraph above. The major reason is that having 4 hooks on each side would add unnecessary complexity of the opening mechanism, since it is challenged to pull springs from different sides with only one food pedal (*Figure 10*). Also, having four functional hooks will add extra materials and weight and increase the cost unnecessarily.

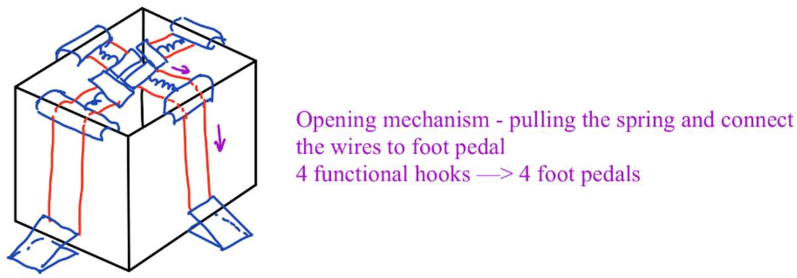

Figure 10 *Inconvenient Hook Design*

3.2.2 Clip

The clip is designed such that the dimensions can easily adjust over most and any garbage bin, regardless of their size. Average thickness of a garbage bin lip is anywhere between a quarter or half inch, thus the "clip on" portion (*see Figure 11 A)* of the design is made with the most allowance. However, to allow for a secure fit, it is intended that there must be an interference fit to secure it tight. A rubber lining runs on the inside only of 1/8 inch in thickness, the value chosen based on sheets available for purchase of the material. (cite) This makes the gap in the design be at 0.25 inches, which is to accommodate the thinner part of a garbage bin after the thicker lip around the edge. The rubber lining is malleable and is not so stiff that the clip cannot be pushed onto the lip and fit over. The cable input was made to have some allowance, and in *Figure 11 B* the 3/16 galvanized guy cable fits within and isn't forced to have friction with the sides. The design is made such that the path the cable travels is completely tangent to the pulley wheel. The pulley wheel was made so large so that the wire could be as close to the top of the whole design to keep separate from the clip portion at the bottom. It was also designed to line up the two holes with each other, and with a small axel in the center than keeps the pulley in place. The pulley has raised edges along the sides, just for extra insurance that the cables will not slide off the sides.

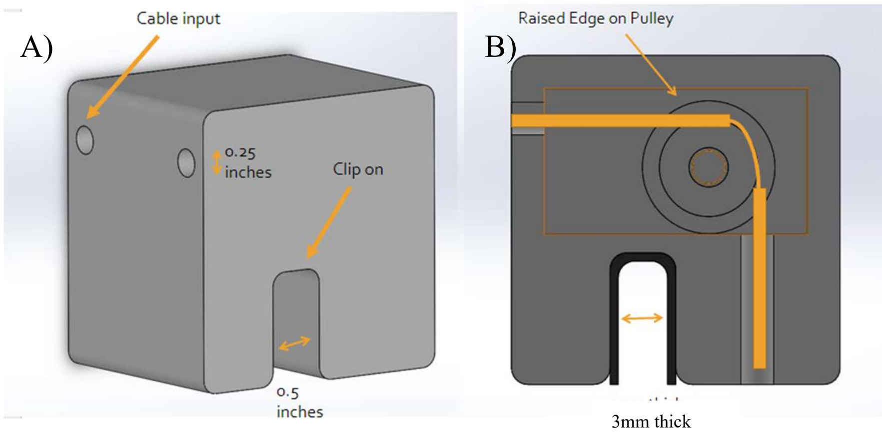

Figure 11 *A) solid view of clip design 1 with dimensions and labels B) solid view of clip design 1 showing the pulley and wire*

3.2.3 Foot Pedal

The foot pedal is designed so that any person should be able to operate it regardless of their size or strength. The length of the foot pedal is accommodating at 10 inches which is slightly below the global average for shoe size. The width is 4 inches which will allow the foot pedal to be stable and not flip side to side when being pressed. When the foot pedal is compressed, the small (blue) gear is spun approximately twice, allowing the spool to rotate the same amount. The large gear ratio (10:1) allows for the foot pedal to be compressed slightly but for the wire to be pulled significantly. The spring in the hooks opposes the force acting on the foot pedal providing some resistance while it is being compressed. This prevents the wire from being pulled in too quickly which might shake or disrupt the garbage can. Different views of the foot pedal layout can be viewed below (*Figure 12*). The slot holding the gear rack allows the top section of the foot pedal to rotate/compress while the rack keeps the same vertical orientation.

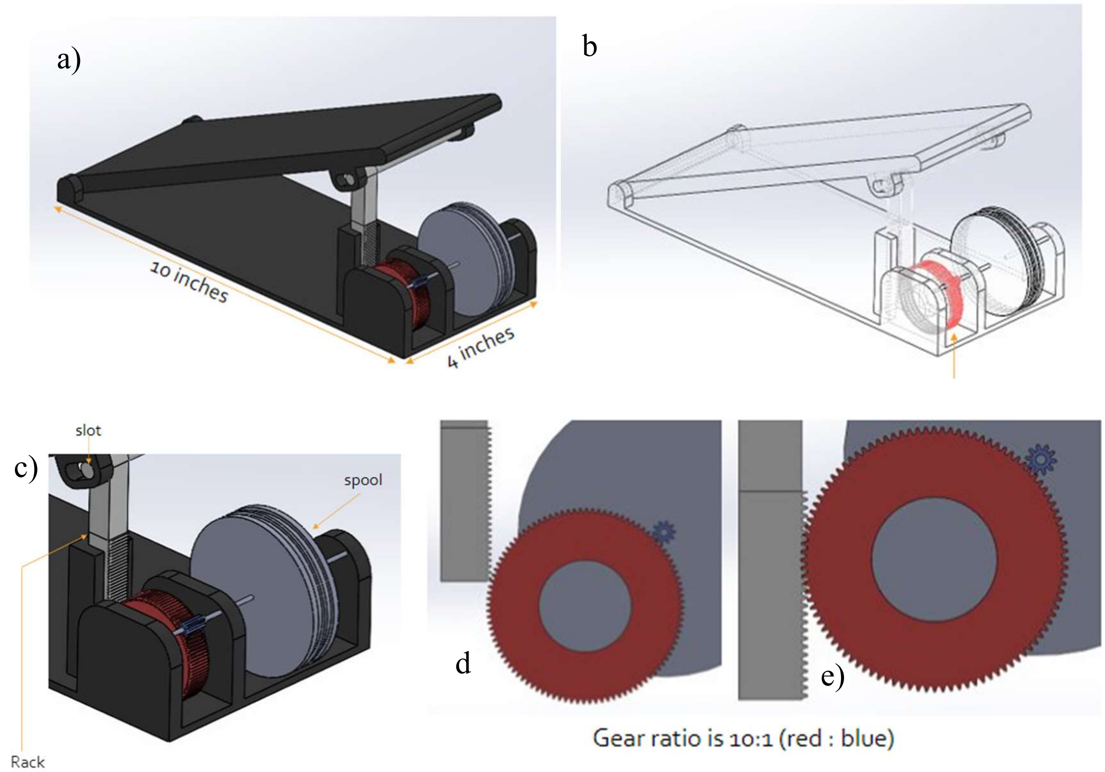

Figure 12 *a) solid view of foot pedal with dimensions, b) wireframe view of foot pedal, c) solid view of gear assembly with labels, d) side solid view of gear assembly (foot pedal released), e) side view of gear assembly (foot pedal compressed)*

3.3 Material Selection

The primary material chosen for the whole design is High Impact Polystyrene, which is a type of plastic that is known to have high impact resistance and fatigue resistance. During material selection, the main goal was to choose a stiff material with good strength and low price, thus the primary types of material to choose from was metals and plastics. Metals such as stainless steel, would've worked well, because they only cost approximately 22 dollars in material costs. The main issue was each product would weigh 13 pounds, which is far too heavy for a plastic bin to support. (Harvey, 1982) Between all the stiff plastics, this plastic was chosen because it had the best ultimate tensile strength but also because it had a cheaper price than other stiff plastics. Acetal is also a type of plastic that has great room temperature strength, but high impact polystyrene was a low-price material that was also used in lots of food grade products. (Curbell Plastics, 2020) Therefore it would be less toxic to any garbage that is accidently thrown out, so it was found to be most appropriate for this application. (Curbell Plastics, 2020) Other plastics also have higher ultimate tensile strength, and it was intended to not choose a material with too high of a value for safety reasons.

The material chosen for the insulation lining the inside of the clips to create and interference fit was rubber. Rubber was chosen because it has great grip and was malleable compared to other types of material, but not very prone to wear and tear. Between all the rubbers, EPDM (Ethylene Propylene Diene Monomer) was chosen due to its long wear before embrittlement. It is usually used in insulation products, and it was intended that the rubber chosen would secure the clip very well. It has heat and wear and tear resistance, which is important for when the clip is removed and added back. (Martins Rubber, 2020) Other rubbers like silicone have terrible wear resistance, and this rubber is typically used in these applications such as non-clip deck coatings. (Chauhan, 2019)

For the wire running through the whole design, connecting all parts, the need for a strong wire that could withstand the force of the spring was the most important. The need for a wire that wouldn't break easily and be the source of fatigue limit in the design was very vital, thus a metal cable was the best solution. It was found that galvanized cables were those of very high strength used to uphold lots of force, typically for tents. Steel itself, is a material that does not corrode easily and very high strength, so a steel galvanized guy cable is a strong wire to withstand the full force. This was a wire that was also found to be non-expensive and available in less than a quarter inch diameter, optimal for fitting in the slots made. (Worldwide Enterprises, 2021)

The material of the spring is aluminum. There are three main reasons of choosing Aluminum as the material for the spring. Firstly, it can protect against corrosion. Since the product will be used in areas or with objects that might be moist (e.g., washroom, kitchen, food), it is important that it does not corrode easily. Secondly, Aluminum is light weight. Because many garbage bins on the market is made of plastic, which is very light, so the product that will be attached to the bin needs to be light as well, so that the bin can be able to support the product. Thirdly, the shear modulus of elasticity of Aluminum is relatively low. Since the user needs to compress the spring every time when he throws the garbage, the force required needs be reasonable and lower.

In fact, during the first design stage, the material chosen for the spring is stainless steel since stainless steel is a very common material used in the spring industry. And it can also prevent from corrosion. However, the shear modulus of elasticity of stainless steel is much higher than Aluminum, which makes the force required to compress the spring very high, and the weight of stainless steel is also higher than Aluminum. Thus, it was decided to use Aluminum as the spring material.

The following equations shows the calculation for the force required to compress the Aluminum spring:

$$k = \frac{d^4 G}{8D^3 N}\ (Grassroots\ Motorsports, 2021) \tag{1}$$

$$= \frac{(0.0015875m)^4 \times (2.5 \times 10^{10} Pa)}{8 \times (0.0127m)^3 \times 5} = 1937.9\ \frac{N}{m}$$

$$F = -kx \tag{2}$$

$$= -1937.9 \frac{N}{m} \times 0.1097m = 212.6\ N$$

***Table 3** Legend of Spring Constant and Force Calculations*

Symbol	Name of Variable	Unit
k	spring constant	N/m
d	diameter of the spring wire	m
D	mean diameter of the spring coils	m
G	shear modulus of elasticity of the spring material (G of Aluminum is 25.0 GPa (MatWeb, 2021))	Pa
N	number of active coils	N/A
F	spring force	N
x	spring stretch or compression	m

4.0 Verification of Design

4.1 Mass

The total mass of the design was limited to be under 5 pounds, which we found appropriate since most trash cans are not very heavy and can be carried. The mass limit was determined by how much weight the average person easily carry, and it was found that 5-pound weights were very manageable. Thus, by using the density of each material and their volume found through SOLIDWORKS, the mass of each component was found as seen in *Table 4.*

(MatWeb, 1996) The mass of the cable was also determined, but the rate to find the total mass is found using the weight per foot. (YuanBo, 1992) Therefore the total mass of the wire is found to be 0.263 lb for 2.5 feet of cable. The total mass of the entire design was found to be 2.037 lbs, which is found to be below the limit and meets the criteria.

Table 4 *Mass Calculations for Each Material Volume in Garbage Bag Design*

Volume (cm^3)	Material	Density (g/cm^3)	Mass (lbs)
739.712	High Impact Polystyrene	1.08	1.761
0.983	EPDM	1.5	0.00324
1.638	Aluminum	2.7	0.00975

4.2 Cost

The specification for the cost was set to have a limit of 5 dollars because depending on the trash material they can be very cheap or very pricy. A garbage bin that has a pedal and closing lid can average cost 5 dollars in material cost if the material is a type of plastic. The most common plastic garbage bins are polyethylene, and because it needs a higher volume in material to encompass the bin itself too, the price is higher than the final design. (Lundell Plastics, 2020) Using the current rates of price for each material found in the current market, the high polystyrene material was found to be $1.49/lb and a total cost of 2.62 dollars. (Premier Plastic Resins, 2019) The price for the cable itself was 0.83 cents per foot and found to be a total cost of 2.08 dollars, and the spring was found to be $1.11/lb and with its low mass only $0.01 in total. (Home Depot, 2021; Indiamart, 1986) Lastly, the price of the rubber was found to be less than a cent, with its rate being only $1.52/lb. (IndiaMART, 2004) Therefore the rubber would be most practical to purchase in bulk, but the total price only comes to $4.71. This meets the requirement of being below 5 dollars in material cost.

4.3 Garbage Bin Width Range

According to the Engineering Specification, the garbage bin width range needs to be greater or equal to 7 inches, so that users can use the product for any bins with a diameter of 7 inches or smaller. To show the design can meet the requirement, under the SOLIDWORKS simulation, the product is attached to a rectangular bin of 10 inches width (*Figure 13 A*) and a circular bin with a diameter of 10 inches (*Figure 13 B*). As the hook head can touch the stationary clip on the other side of the bin, the requirement is met.

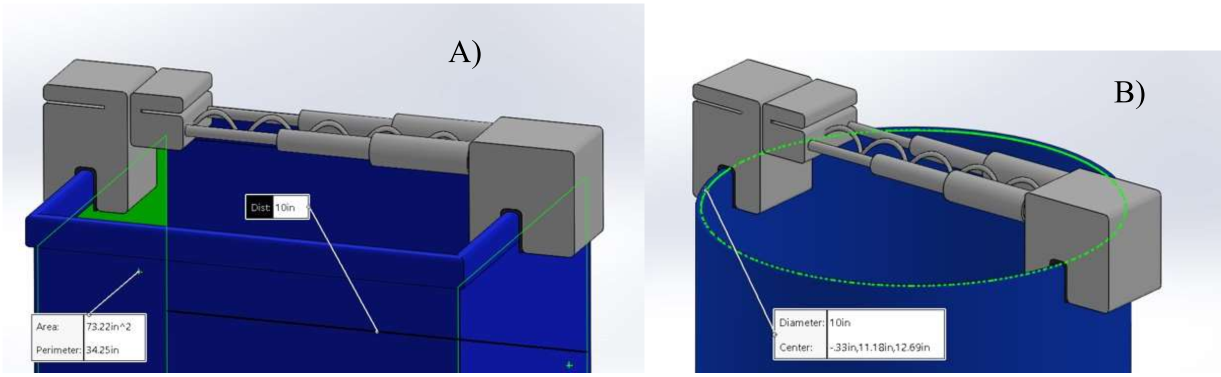

Figure 13 *A) Rectangular Garbage Bin with 10 inches Width B) Circular Garbage Bin with A Diameter of 10 inches*

4.4 Aesthetic Design

The aesthetic design characteristic was to be greater than 55% and verified by a test. An online survey was created with google forms (Figure 14 a)) which contained an image of the overall design and an option to rate the design on a scale from 1-10. 20 survey results were collected and the average for aesthetic design was calculated to be 6.2 which is valid.

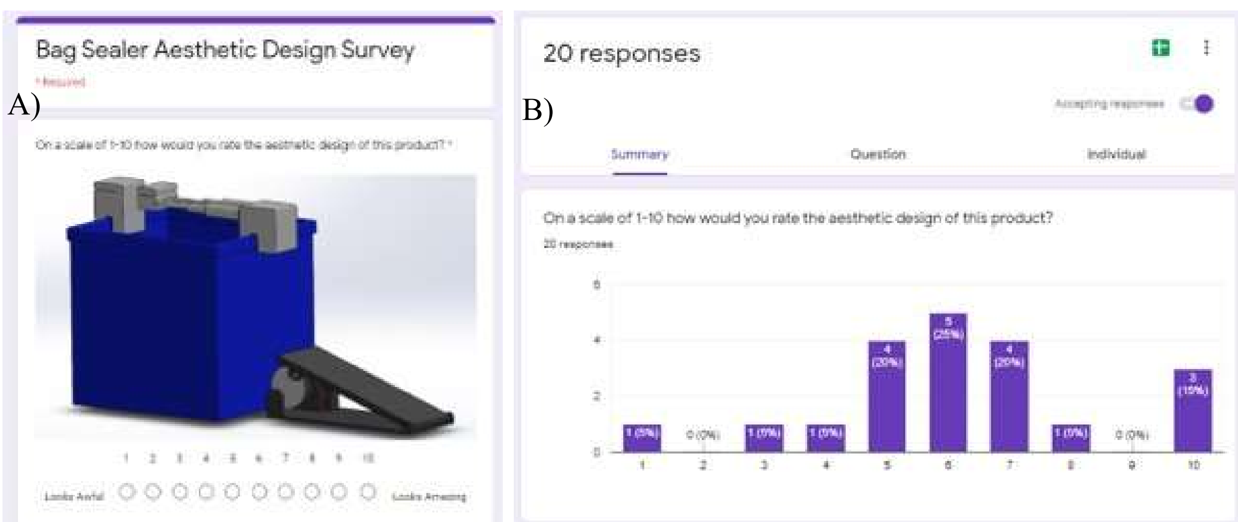

Figure 14 *A) Online survey question B) Online survey results*

4.5 Safety Requirements

The main areas that pose a safety risk are between the hook and clip (Figure 15 [1]) and the spring (Figure 15 [2]). Both areas area a risk to safety because a person's finger or hand may get caught or pinched. This risk is reduced by using a spring that can not exert enough force to cause significant damage. They are still pinch points but won't cause any damage. A pinch would only be capable of happening in these areas if someone was pushing or releasing the pedal when a finger or hand is in the way. A pinch would not happen without the interaction of the user.

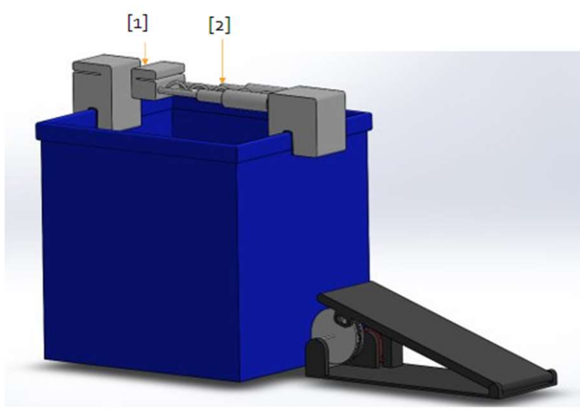

Figure 15 *Safety Concern Areas*

4.6 Ultimate Tensile Strength

The ultimate tensile strength of the main material used to compose most of this design is 42 MPa (AZoM, 2013). This meets the requirement of being greater than 30 MPa, which is stiff enough to hold itself upright yet so not so strong that it can't break and has no give to it. For safety reasons, the design it made that under dire circumstances it could break to allow a person to remove themselves from pinch points. The minimum limit was based on another material, ABS filament, which is typically used in 3D printing, and is the material the design was based off in terms of strength. The filament allows for structures to hold themselves upright and is not too strong that one couldn't break it if need be. The ultimate tensile strength for this material was around 27.6 - 55.2 MPa, and so the lower limit was rounded off to give a nicer value. (Manufacturing, 2021)

4.7 Compactness

The entire design is intended to be compact, easy for storage and carrying on the go for outdoor use. To show that this design is small and easy to travel with, under a SOLIDWORKS simulation (*Figure 16*), the parts were mated to be flush to the bottom of a 30 cm x 30 cm x 30 cm box (0.027 m^3). This size was chosen for the limit because it is the size of approximately 2 shoe boxes, which is feasible for shipping and packing. Through examination, it can be seen that all parts do fit inside the cube and is indeed very compact.

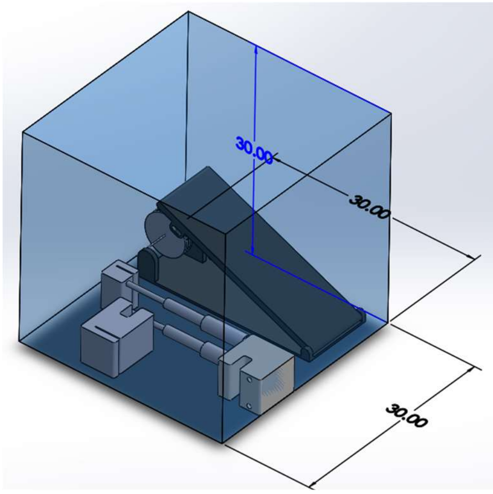

Figure 16 *0.027 m3 With All the Parts of The Design Inside (Units in Image Are in Centimeters)*

4.8 Compatibility

Since there are various shapes of trash cans in the market, this product needs to be able to be installed on different shapes of trash cans. Nowadays the main garbage bin shapes are rectangular or circular, so to prove that the product is compatible with these two different bin

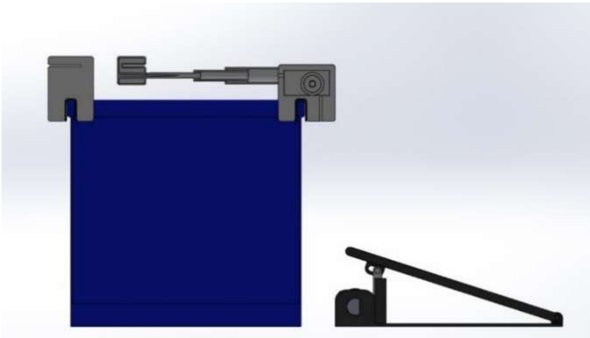

Figure 17 *Side Sectional View of Product Attached to A Rectangular Bin*

shapes, the following SOLIDWORKS simulation was performed. *Figure 17* shows the product is attached to a rectangular bin.

Figure 18 shows the product is attached to a circular bin. From the side sectional view of the circular bin, one can see that the clips are attached to the edge of the bin perfectly, which proves that the product is compatible with at least 2 different shapes of garbage bins and meets the Engineering Specification.

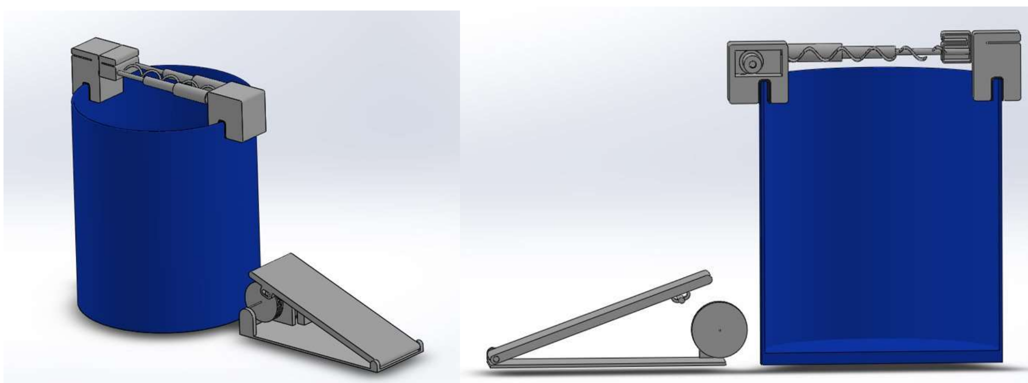

Figure 18 18 *A) Isometric View of Product on A Circular Bin B) Side Sectional View of Product Attached to A Circular Bin*

5.0 Project Management

5.1 Work Breakdown Structure

In the work breakdown structure seen in *Table 5*, each main task was divided evenly between all the members. Under the first phase of choosing and deciding the concept, each member was tasked with sketching and designing at least one idea. Together the group evaluated the designs in a decision matrix and chose a final design to present at the review meeting. In the next phase, constructing the individual components of the concept chosen, it was decided that Emma would work on the extending hook design, Ashley on the clip design, and Nathan on the Pedal design. Everyone worked on the presentation and took detailed images of their parts to present at the design review meeting. Using the feedback everyone discussed how going forward the design will be adjusted and then primarily Ashley and Emma collaborated to see how their parts will combine. The final assembly was then done on the simulation of the garbage bin, where everyone was helping one another to try and make the simulation as realistic as possible. The verification of design was split so that everyone looked for the niche material their part needed and reached a consensus for the general material. Ashley found the mass and cost of each part, where Nathan worked on safety analysis and Emma focused in on the auxiliary function of the spring.

***Table 5** Garbage Bag Sealer Project Work Breakdown Structure*

Garbage Bag Sealer Project WBS				
Main Tasks	Subtasks	Time estimate (hr)	Contingency (40%)	Total (h)
*Garbage Bag Sealer **Project***		28.5	11.4	39.9
1.0 - Choose Concept Design		5.5	2.2	7.7
1.1	Gantt Chart	1	0.4	1.4
1.2	Prepare for Presentation	1.5	0.6	2.1
1.3	Present current progress	1	0.4	1.4
1.4	Revise Project Plan	2	0.8	2.8
2.0 - Construct Individual Components		10	4	14
2.1	Clip Design	2	0.8	2.8
2.2	Hook Design	2	0.8	2.8
2.3	Pedal design	2	0.8	2.8
2.4	Make Presentation and include feedback	2	0.8	2.8
2.5	Present current progress	1	0.4	1.4
2.6	Revise Project Plan	1	0.4	1.4
3.0 - Final Assembly		6	2.4	8.4
3.1	Start final report	0.5	0.2	0.7
3.2	Prepare final presentation (make PowerPoints)	1	0.4	1.4
3.3	Final Design of all components	2	0.8	2.8
3.4	Assemble components	2	0.8	2.8
3.5	Present final design	0.5	0.2	0.7
4.0 - Verification of Design		7	2.8	9.8
4.1	Finish up final report	3	1.2	4.2
4.2	Finish SOLIDWORKS sketches	2	0.8	2.8
4.3	Teamwork Assessment	2	0.8	2.8

5.2 Schedule

In the first iteration of the schedule, the timing was based on when deliverables were due, and then spaced out the timing accordingly. It can be seen in *Figure 19* that using the work breakdown schedule as well, the timing was placed accordingly. Gaps were placed in the second stage where all the components were supposed to be constructed for midterms. In *Figure 20*, for the second version, the design structure was changed, and the time required for midterms was extended. Thus, the third component of the design was pushed to be completed in the third phase and everything else remained the same. In the final schedule (*Figure 21*), the group ended up following the schedule the same, the only change being that third component being redesigned completely for a more attainable result.

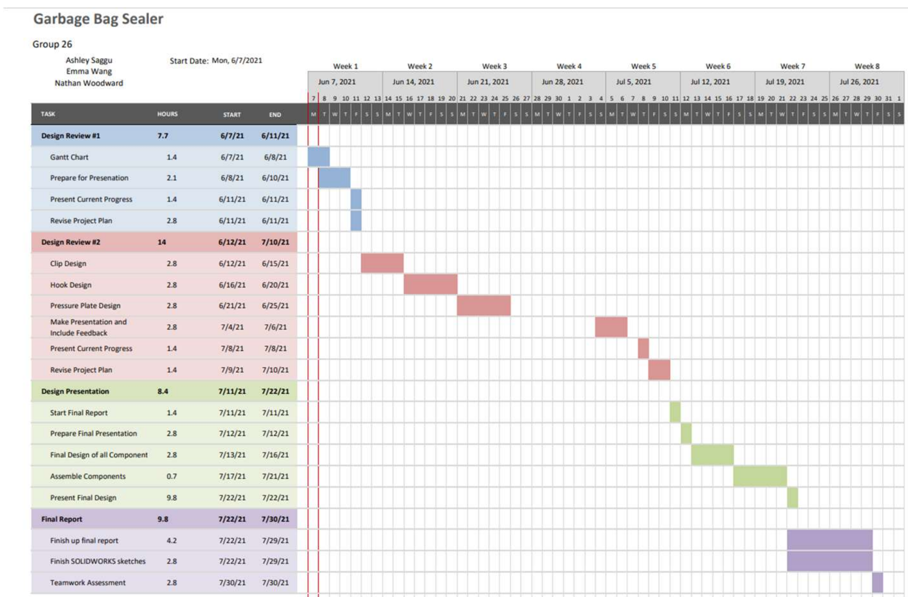

Figure 19 *Version One of Design Schedule in Gantt Chart*

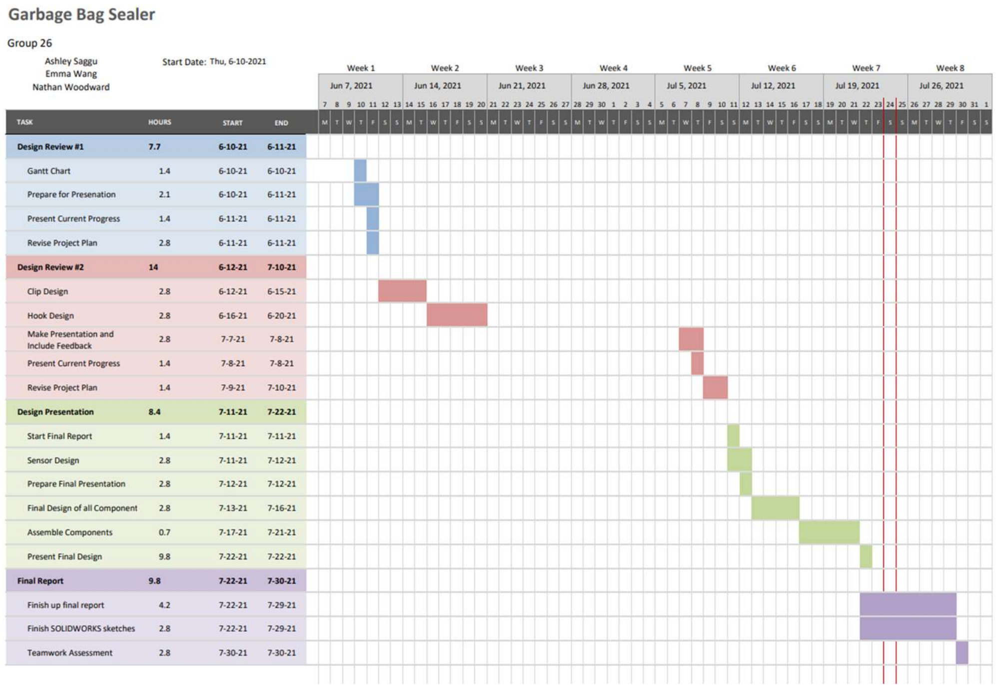

Figure 20 *Version Two of Design Schedule in Gantt Chart*

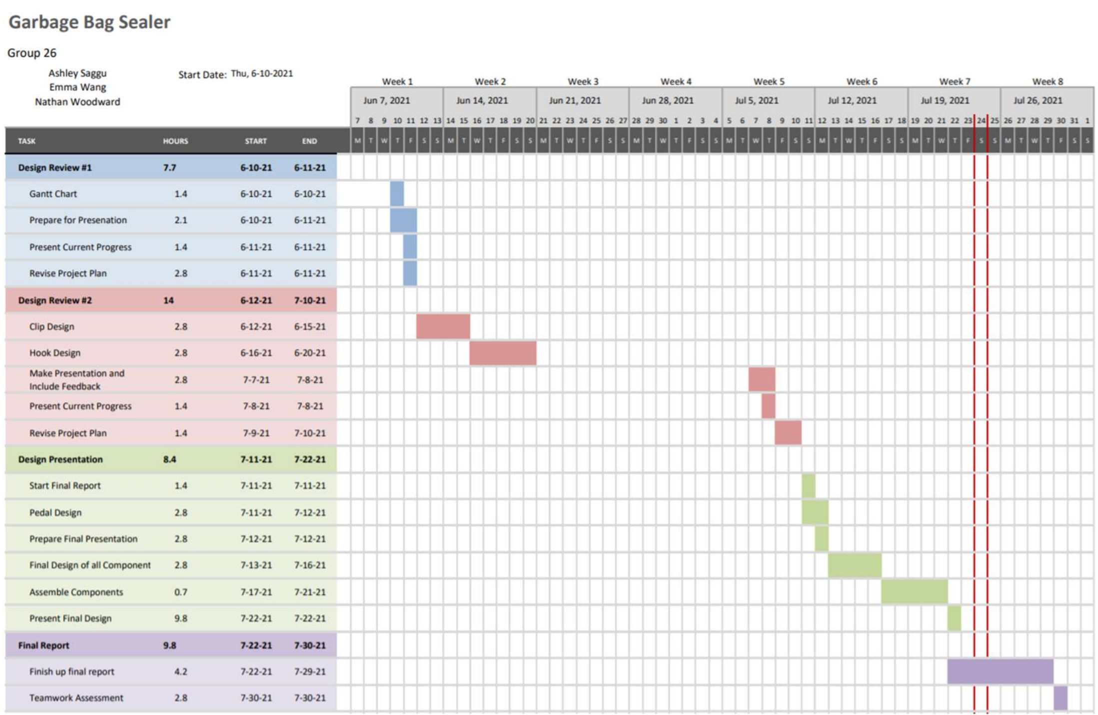

Figure 2121 *Version Three of Design Schedule in Gantt Chart*

6.0 Conclusions

In conclusion, the objective of this design was to prevent odor emitted from garbage bins while meeting the engineering design specification. Proven in section 4, the product created meets the outlined engineering design specification and prevents odor. Each section of the design performs an important sub-function that allows the product to perform. The clip is compatible to clip onto multiple shapes and provides a stable base for the product to operate. The hooks assist in the opening and the closing of garbage bag. The foot pedal contracts and releases the hooks. Overall, these three sections combine to offer a durable, competitive solution for dealing with odor at a low price.

7.0 Recommendations

Aesthetic design

As one can tell that although the current design meets the Engineering Specification of 55% likeness, the aesthetic rate is only about 6.2. There are many ways to make the design look better in terms of aesthetics. For example, now that the wires are exposed, which may look cumbersome compared to the original garbage bin. A plastic shell can be applied to pack the wire part where the wires connected from the clip to the foot pedal.

Safety Requirements

There are 2 major safety concerns described in 4.5. In fact, the second safety concern around the spring can be eliminated by applying / combining the telescoping design. We can have another telescoping extensor to pack the spring so that there is less chance when the user accidently placed their hands in the spring area and get hurt.

Garbage Bin Width Range

When the hook is fully compacted, the entire length of the hook is 3.65 inches, which will take about 1/3 of a bin with a width (or diameter) of 10 inches. Thus, although the design meets the Engineering Specification, it can be improved because the space left for users to throw garbage is smaller compared to the original bin, which might cause some inconvenience to users. In the future, in order to improve the design, there can be more than 3 sections of telescoping extensors on each side, so that when the hook is fully compacted, it will have a shorter length, which will provide more space for users to throw the garbage

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