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LAZY SUSAN REINVENTED
ENGINEERING DESIGN

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Abstract:

After given the task of creating a product for a real client, the group was required to apply the concepts taught to effectively solve the problem and produce a competitive design. The simplistic idea of a Lazy Susan was chosen and implemented into an automated steam punk themed rotating catering tray. All components were assigned materials to be constructed from, as well as a method of assembly. The top base was created first and included the metal dowels, that were placed in a spiral arrangement, with wooden plates accompanying the dowels. The base also supported the middle rod which held up the roof. The plates were made out of plywood and were traced and cut using a jigsaw. The plates sat on top of the metal dowels and were covered in aluminum foil in order to place food on them. The roof was based on a hexagonal pyramid to resemble the features of a bolt. It was wrapped in copper wire to enhance aesthetics. The bottom base was where the motor was stored and in order to cover that, sheet metal was wrapped around the edges of the bottom base. For the motorized functional aspect of the design, a rotisserie motor was used due to it's built in rotating features. Firm constraints had to be imposed to ensure satisfaction of the client's requirements. The most important included the time period and budget. The group's skill set, prototype size and available machinery took a lower precedent due to the ability to work around these restrictions. The pitfalls experienced included functionality and construction. The challenges manifested as having to assemble distinctly crafted pieces of the structure (plates, base, dowels, motor, and roof) to form the innovated motorized lazy Susan as well as fixing a motor that made the motorized aspect successful. Having the design successfully implemented does not prohibit further work to be done to improve it. Consequently, a smooth and consistent rotation, should be considered, hence, the rotisserie motor should be replaced with a stepper motor. Also, the dowels will be affixed firmly. Safety with the current structure will also be addressed by making sharp metal edges smoother . Further on, aesthetics will be implemented by having vapour escape from the plates and redesigning the structure of the roof.

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1. Introduction:

The simple idea of a Lazy Susan was reinvented to form a "steampunk" themed structure which serves as a large catering tray. This report discusses how the implementation of the design thinking process was used to come up with a solution to the design problem. The following paragraphs will describe the design process, the construction of the structure and improvements that can be made. The report will also consider the firm constraints and challenges encountered during construction and the steps to be implemented prior to participation in "*Canada's 150th anniversary celebrations showcase*".

2. Discussion:

2.1. Background

A lazy Susan is a turntable (rotating tray) placed on a table or countertop to aid in distributing food. Lazy Susans may be made from a variety of materials such as glass, wood or plastic. They are usually circular table to share dishes easily among diners. The idea is very simple and can easily be made into an automated rotating device. Due to its simplicity, the Lazy Susan was chosen to be the technical automated aspect of the design.

2.2. Implementation

2.2.1. Base

One of the first elements of the project that was worked on was the base. A foundation was needed to begin imagining and implementing the previously formulated design. The base was made out of plywood that was bought as a 3x3 rectangular piece. Since cutting the base into a 3ft diameter circle was the first task done at the lab, the team was unfamiliar with the tools offered and the way things were made. After discussing with a lab coordinator at Brunsfield, the team was presented with an idea to cut the wooden piece with a jigsaw. This will ensure precision and so a circle was accurately measured out and traced on the rectangular piece. The wood was clamped and the jigsaw was used to cut out the 3ft diameter circle. To enhance aesthetics, keeping in mind the steampunk theme, the base was spray painted in a brownish, copper color.

2.2.2. Plates

Since getting more familiar with the tools, the team felt confident that using a jigsaw would also be beneficial when cutting out the wooden “plates” where the food will be placed. Scrap pieces from the wood that was used for the main base was used and measured into 4 inch diameter circles. The wood was clamped in order to ensure stability when using the jigsaw. After the plates were cut little rectangular wooden pieces were cut to be nailed onto the bottom of the wooden plates in order to be placed into the hollow metal dowels. It was agreed that no wood would be shown in order to allow for an aesthetically pleasing model therefore the plates were covered with aluminum foil. Aluminum foil was used to make sure that food can be placed on a sanitary surface and the silver color fit the steampunk theme.

2.2.3. Dowels

The dowels were found in the disposable corner at the Brunsfield center. Their purpose is to hold the wooden plates and would be placed in a spiral arrangement. Initially it had been planned that circular dowels would be used in order to be more aesthetically pleasing. However, since there was a fixed budget, sacrifices had to be made. In order to start cutting the dowels all measurements had to be present and calculated. The exact height of the top where the roof will be placed had to be calculated in order to begin measuring and cutting the metal dowels. The proportions were found according to the desired height and width of the client. The client had wanted a 4ft in height product and at least a 3ft in width so with that in mind it was decided that the roof would be almost half of the diameter of the base of about 1.5 ft in diameter. Figuring out the angles of the roof the height was found and this was essential information because an exact length was needed to see how far the longest dowel would be from the roof and from the base. A good amount of space was wanted between the tallest dowel and roof to allow for reaching space for the food provided on the plate. Therefore the longest one would be about 31 inches leaving half a foot between it and the roof. Then they decreased in height by 1.25 inches creating 25 dowels, making the last one 1.25 inches long. When the plates were cut they were placed on the base and were traced in order to make sure the dowels will be placed strategically. In order to place the hollow dowels on the base and to place the plates on the dowels, little rectangular wooden pieces were measured and cut to perfectly fit into the hollow metal dowel in order to be screwed on to the base. The dowels were already a matte black color so no enhancement to the features were made.

2.2.4. Middle Rod

The middle rod was what was holding the roof up and was placed in the center of the base. The same metal hollow dowels were used to create this middle rod. After cutting the individual dowels, 3 4ft tall metal dowels were left to use. It was decided all 3 would be used in order to enhance the aesthetics portion and stability. Since the metal dowels were hollow and really thin, it was not possible to weld them together so electrical tape was wrapped around the top and bottom of the pieces. They created a triangular shape that was very aesthetically appealing. They were placed on the base the same way the other dowels were, small rectangular wooden pieces were screwed into the base and went inside the metal dowels. These wooden pieces had to fit exactly in the metal dowel allowing no room for movement or else the dowels would be very unstable.

2.2.5. Roof

The roof was very difficult to execute. Initially it was planned that there would be a frame made out of wood in a cone like shape then the frame would be covered by metal. It was noticed that the middle rod was quite heavy so the roof had to be very light in order to ensure stability and that the motor will function properly. In order to make the roof light in weight it was decided to just create the frame of the roof out of wood but in an aesthetically pleasing shape. Recalling the steampunk theme, it was decided to create the roof in the shape of a bolt, which has a hexagonal bottom. The roof is based on a hexagonal pyramid as seen in figure 1. The desired diameter of the roof was used to determine the length of the hexagon from one corner to the other corner. The desired height of the roof was used to determine the length of pyramid sides. With these two measurements, the measurement for the smaller hexagon was determined. We calculated the lengths of each side of the hexagon taking into account the 120 degrees internal angle and the desire length of 1.5 ft. diameter. After measuring and cutting the pieces using a bandsaw a smaller hexagon was also made to go on the top. To attach the top and bottom hexagons together wooden pieces were cut at an angle that allowed for the desired height. When placing all the wooden pieces together wood kept splitting and there was no time to measure and cut out replacement pieces so screws were placed across the split of wood in order to keep the split from expanding. Also when placing everything together the wooden shifted and so some on the pieces weren't attached. To enhance the aesthetics of the roof, copper wire was used to wrap around randomly on the roof.

2.2.6. Bottom Base

The bottom base was done last since it did not require as much time or effort. The bottom base was cut the same way the top of the base was cut. It was created to be a bit bigger in diameter than the top of the base to allow room for rotation. The bottom base was measured and traced on the rectangular plywood piece as a 3 ft. 4'' diameter circle. In order to hide the motor and to cover everything underneath the top of the base, sheets of metal were cut to the desired height. Enforcements were made from wooden sticks to be placed on the edge of the bottom base in order to keep the sheets of metal stable, standing and in a circular shape. The sheets of metal were meant to wrap around the edge of the base to give it height and depth. On top of the bottom base the motor sat in a wooden box. Also, wooden dowels with wheels screwed onto them were screwed to the bottom of the base with the wheels facing upwards. This allowed for the top of the base to be supported not just from the center where the motor was attached. This helped additional weight to be taken off the motor in order for it to function properly.

2.2.7. Motor

Since no real weight was approximated, a reasonable motor was never bought to support the weight of the structure created. After creating the structure there was only two days left till Design Day the motor was not figured out. This caused some panic die to the fact that the motor is the main functional requirement on the product. At this point it was too late to buy a reliable motor online because it would have taken too long to ship and it would not have been shipped on time. Thinking of a quick replacement and some improvisation a rotisserie motor was bought. The motor was ensured that it is capable of holding about 20-30 lbs. This raised a problem since the weight that was going on top of the motor was most definitely more than 20-30 lbs. To eliminate as much weight off the motor a piece of metal was milled into a square shape that fit the key of the rotisserie motor perfectly. A wooden box was created that went inside the base in order to surround the motor. The bottom of the motor was unscrewed in order to attach it to the top of the wooden box. This allowed for the motor to be hung upside down for the turning part to be faced upwards towards the top of the structure and the part that is supposed to spin. To eliminate more weight off the motor and to place the top base onto the motor, a wooden piece was cut and made that perfectly hugged the milled piece of metal. A bearing was used and placed around the milled piece of metal under the wooden piece to ensure that the bearing is supporting the weight of the base. To ensure the bearing was not rotating a wooden bridge like structure was created and placed around the beating to keep it place. The motor had to be plugged into a power supply to work so a hole in the sheet of the metal on the side of the base was cut to pass the cord of the motor through.

2.3. Constraints

Due to the specific nature of the project's requirements, strict constraints were imposed to ensure our client was satisfied. The most significant of which were the budget and time. The funds donated to the project had to be distributed with great care and concern. Our group was given a total 200 dollars to cover all expenses. The materials had to be carefully considered and conserved to ensure the budget was not exceeded and that they could be used to the fullest extent. Our group strived to waste as little as possible, in addition to scavenging waste material.

The other major constraint proved to be allotted time for the assembly of the final product. While in theory construction could have begun at the beginning of the semester or shortly after, the group needed to keep pace with the course material. The group needed Sharon's input and the lecture material to move the project in the right direction. Between the customer meetings and lecture content, the project developed at a moderate and constant pace. Construction of the final product could only start after input was received for the first prototype. As a result, only three weeks was designated to the construction of the final product. Another constraint was the team's skill set. Only two members had advanced experience with machinery such as the drill press, jigsaw and hydraulic press. This meant that time had to be allotted to teaching the other three members how to safely and effectively use the machinery. Furthermore, none of the group members had welding experience, which forced them to find other ways to support and fasten some of the many metal parts. Initially, welding was going to be used to achieve the steampunk aesthetics with the scrap parts found, but this was unable to be implemented.

The size of the final product proved to be a burden as it pushed the budget and construction time beyond the initial estimates. At Sharon's request, the product was to have a three-foot diameter and be above five feet tall. This proved difficult to implement with a 200-dollar budget as it allowed for very limited materials. In addition, the group experienced great difficulty constructing the large model, as the larger parts required more support and reinforcement than anticipated. The size also demanded a more powerful motor to provide motion. Yet another impact of the size made transporting the product extremely difficult; it was unable to be moved without damage or deconstruction. On two occasions, group members were injured during transportation, one of which had to be hospitalized as a result. The last significant constraint was the equipment available. The Brunsfield machinery proved sufficient for the project needs, but a higher degree of quality could have been reached with tools to cut large circles in metal and wood. A machine to plane the wood would have also saved a significant amount of time. Despite the extensive constraints, the group was able to overcome them to produce a prototype that satisfied the customer. This was only achieved through planning, problem solving and teamwork.

2.4. Challenges

The objective of this design project was to create a sizable “Steampunk” fair attraction piece which is engaging and automated. With the construction of “The Lazy Susan Reinvented”, there were various challenges faced with functionality, construction and the general design.

2.4.1. Functionality

The major functionality challenge that was encountered while designing was to determine what and how the whole structure would actually rotate. In order to solve this problem, the first design suggested that a $150 motor be purchased which would allow us to control the speed of the rotation. However, due to time and budget constraints, the NEMA 23 Stepper Motor could not be purchased. With no other options left, the rotisserie motor was purchased four days before Design Day. The motor also had to be disassembled from its original assembly of being a rotisserie motor. The design of how to attach the motor to the base and also result in the rotation of the whole base was all completed in under a day. Even with terrible time management with the motor functionality, the design was complete and the structure did rotate at a satisfying speed.

2.4.2. Construction

Another challenge presented was the lack of carpentry skills within the group. Only one member of the group had some experience in building, constructing and use of tools. Even with the Brunsfield training given during the lab, it did not measure up to the level of training with tools and machinery needed to build the lazy Susan. While constructing the separate parts, progress was significantly slowed due to the continuous asking for help from the workers at Brunsfield. The construction of the 3ft wide base should not have taken a whole day as it did, however it took one hour to figure out how to draw a circular shape on wood. The construction of the roof was extremely difficult as the wood began to split due to making holes in the wrong places and using power tools incorrectly. Even with the challenges presented with carpentry, the design was still implemented professionally as intended. The carpentry skills learned in this course will only benefit for future designs and projects.

2.4.3. The General Design

The last challenge presented which is directly related to the design of the lazy Susan was the general design. The basic general design was implemented in the final product; however, the initial project plan was not put forth as many of the ideas had to be cut. Due to weight, cost, and functionality constraints, the lazy Susan was not as “steampunk” as intended. The initial plan was to cover the base, the small plates and the roof with sheet metal. Sheet metal is too expensive and hard to construct with. It was adding too much extra weight to the whole structure and was interfering with the rotating of the base. Therefore, the base and the roof had to be spray painted in order to have the steam punk effect. The small plates were then covered with tin foil. Lastly, due to budget

and time constraints, the idea of having the dowels release steam when the food is lifted was discarded. Many ideas relating to the lazy Susan had to be discharged due to cost, weight, time and experience constraints. Refer to the "Next Steps" sections to view what can be done in time for the gala competition.

2.5. Next steps

There are many new tasks required to implement to our current design to improve functionality, the safety of the design as well as proper steampunk esthetic.

2.5.1. Improving Functionality

Improving the functionality of the final design would have to ensure smooth and consistent rotation, at a constant speed with the option of changing the velocity if need be. Another functionality improvement needed in the current design is to stabilize the dowels.

The original stepper motor that was sized for the final product has an output of 125 ounce inches of torque which an estimated 20% surplus to ensure functionality. The current rotisserie motor is to be replaced with this stepper motor. In order to set up our new motor, an Arduino, driver and potentiometer must be purchased to set the time intervals for which we will step our motor (varying the speed of rotation). The potentiometer would be needed vary the current applied to the Arduino. The amount of current being measured by the Arduino would be used to vary the interval between steps to our driver, which is needed to drive the motor.

The screws supporting the dowels must remain sunk into the wood and then covered with a hard glue or silicone to ensure a smooth surface for the wheels that ease the rotation. A hard surface as opposed to a surface that has less density will reduce the amount of friction and thus require less current to be drawn to the motor. Although our new motor is sized to handle the weight capability, it's important to keep in mind the overall efficiency of our final product.

In order to support the existing dowels, sheet metal will be bent acting as a sleeve for the dowels. A sufficient height will be taken into consideration to ensure stability. This is to be determined by trial and error as the dowels are different heights and thus have different weights and stability requirements. Adding this feature will also compliment the steampunk esthetics.

2.5.2. Overall Safety

The overall safety of our final project could be improved in a couple areas of our current design. The components of our design that need to be improved revolve around the base of the project. Currently, there is a 1inch gap between the fixed portion of the base and the rotating component of the base. This gap should be covered in order to eliminate any foreign objects from entering the space. This issue could be solved by including a smaller gauge of sheet metal (if funding permits) that will be installed on the upper edge of the fixed portion of the base protruding towards the center and overlapping the rotating portion. Another safety issue encountered were sharp edges in various parts of the project due to the use of the sheet metal. A small amount of clear silicone or glue around the edges of the metal should significantly reduce this problem.

2.5.3. Overall Aesthetics

The overall esthetics of our project could be enhanced with some modifications of the roof, improving the plates holding the food and adding a few electrical components such as pushbutton switches and a vape machine.

Improving the current design of the roof would be the most efficient way to greatly implement the steampunk theme to our project. Improving the symmetry of the wood and removing the copper wire would allow us to install symmetrical triangles on the exterior, using hex-headed shaped sheet metal screws. This would allow for more steampunk accessories to fit on the roof and in turn making a dramatic difference to the overall appearance of our project.

The new design of the plates would include small holes allowing for vapor to escape upon the removal of the food item on the plate. This will be implemented by installing small, light actioned, normally-closed pushbutton switches beneath the surface of the plates. Adding food on the plates will depress the pushbutton opening the circuit. Upon removal of the food item, the switch will return to its normally-closed position sending a signal to the Arduino, which will control sporadic and moderately rhythmic pulses to the vaporizer greatly enhancing the esthetics as well as interacting with the user. Longer duration intervals of slightly less rhythmic pulses will be occurring while users aren’t interacting with the project. Including this into the design will entail some additional programming to the Arduino.

3. Conclusion

The objective of this report was to showcase a new and reinvented design of the simple lazy Susan idea. Having a budget of $200 and adhering to a steampunk theme had made the design implementation challenging. In addition, keeping pace with course material while also constructing design and learning how to use new and advanced machinery to construct added to the team's challenges. Although there were challenges and further design implementations to improve its quality, the team was able to qualify for the steampunk showcase for Canada's 150th celebration.

Figure 1. Roof created using a hexagonal pyramid structure. The roof is wrapped in copper wire to enhance aesthetics.

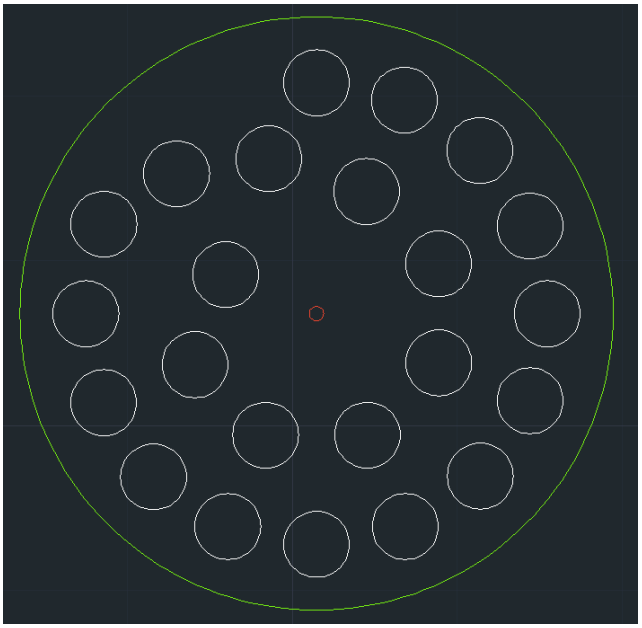

Figure 2. AutoCad sketch of the the 4'' diameter plates.

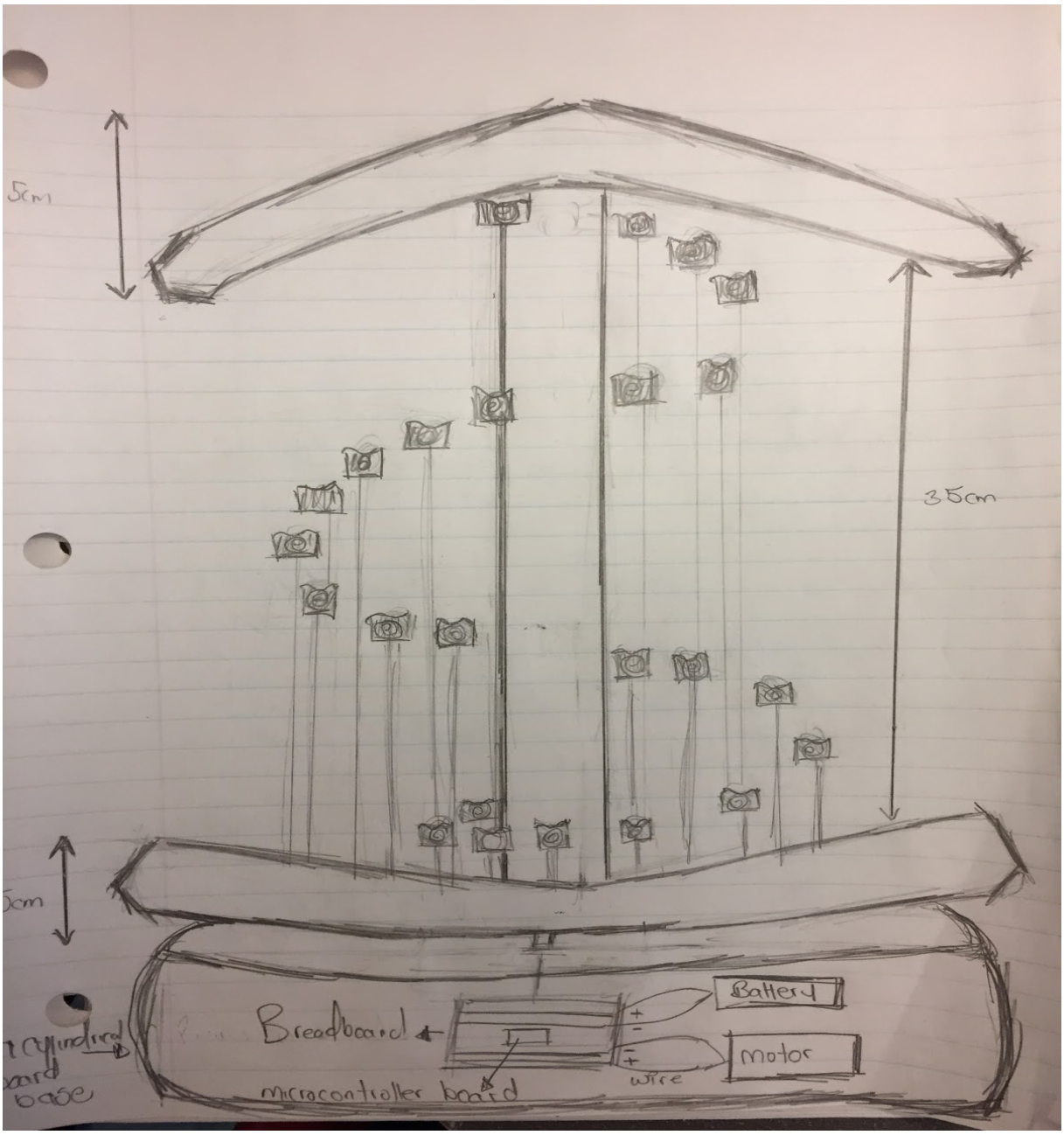

Figure 3. Initial conceptual design with target specification that were later changed

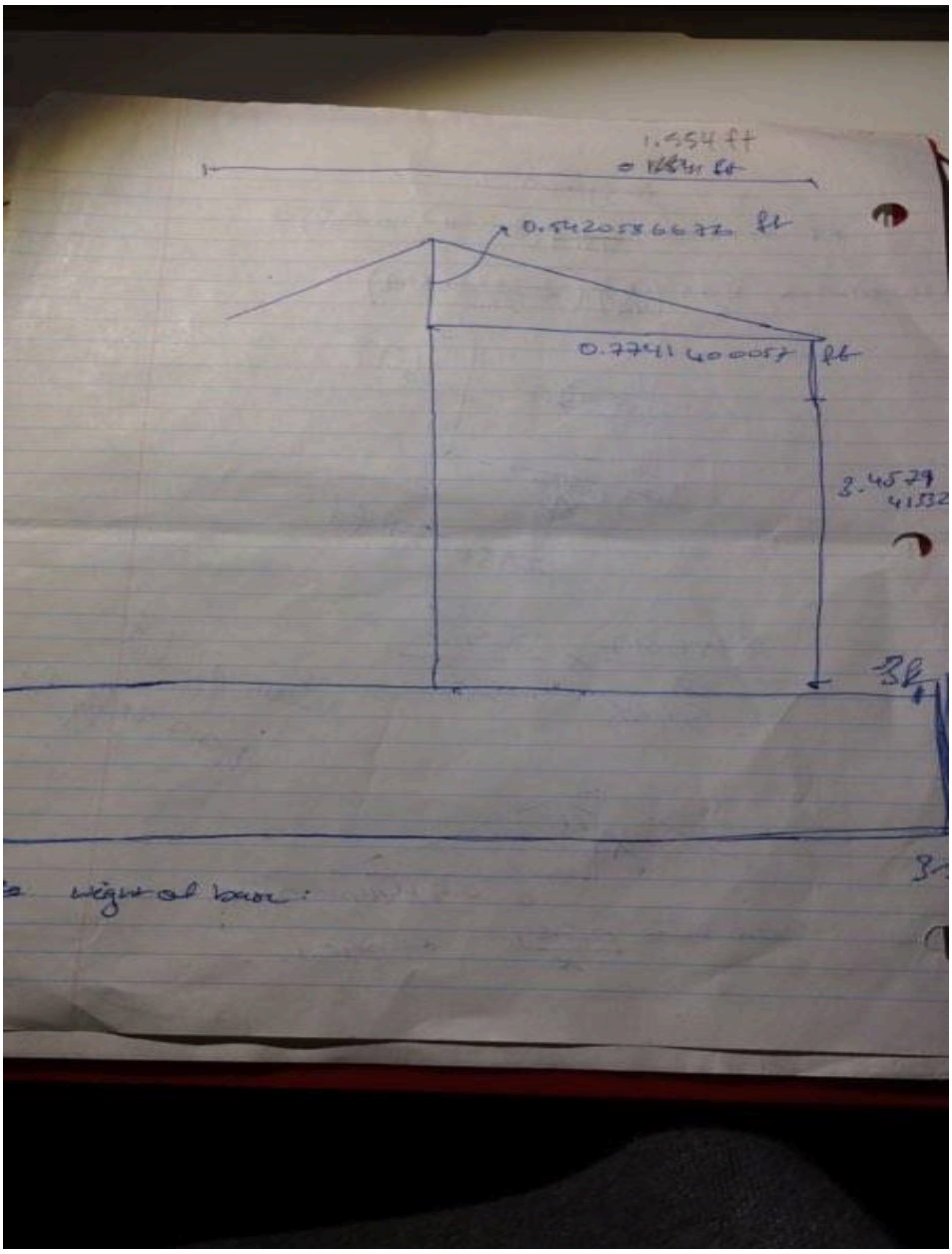

Figure 4. Refined and recalculated dimensions to fit user's needs.