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Improved Greens Harvester

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FL19 MEMS 411 Mechanical Engineering Design Project

IMPROVED GREENS HARVESTER

Our project is improving an existing greens harvester. EarthDance Organic Farm School currently has some inconvenience and problems with their greens harvester. It does not cut greens at a constant length, greens get clogged in between the brush and the basket, and the basket has to be emptied a lot of times. Our improved greens harvester has a higher greens harvester with wheels that makes using the harvester less troublesome. Band saw is stuck at front in between the wheels for cutting greens at a consistent length. Conveyor belt was used to aim for less clogging. The basic frame of the device is made up of wood. The PVC pipes were used to make the conveyor belt. Rope was used for the brush and connected in various directions to minimize the rotating torque The basket was made much bigger with cloth so that it does not have to be emptied often. A bike brake attached to the handle would trigger the driver, the motor, which is connected to the conveyor belt. The pulley on the other side of the conveyor belt rotates as well, and the pulley connected to it cross-linked rotates the brush in the other direction.

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1 Introduction

Our design project is improving an existing greens harvester for EarthDance Organic Farm School. A greens harvester is used to efficiently cut greens when there are too many to do by hand. We interviewed the customer and found some problems with the greens harvester. These problems include: the Quick Cut harvester does not deliver a consistent cut length, the mechanism that shovels the greens into the collection bin gets clogged, the collection bin must be emptied several times, and the band that drives the blade does not work well in wet conditions. In addition to these problems, we saw features of the harvester that could be improved upon, for example, we noted that the harvester could provide a consistent cut if it was mounted on wheels and its height could be adjustable. Over the upcoming semester, we will set out to design a greens harvester that better suits our customer's needs.

2 Problem Understanding

2.1 Existing Devices

2.1.1 Existing Device #1: Quick Cut Harvester

Figure 1: Quick Cut Harvester (Source: farmersfriendllc.com)

Link: https://farmersfriendllc.com/products/harvest/quick-cut-greens-harvester
Description: The Quick Cut Harvester consists of a drill-powered saw that moves back and forth along a track. When the harvester is pulled along a patch of greens the greens are cut to a length depending on the height the user holds the harvester over the patch. Strings rotate at the front of the harvester to push the freshly cut greens into the attached collection bag. This is also powered by the rotation of the drill. The harvester is emptied simply by turning the device sideways and dumping the greens through the open end of the collection bag.

2.1.2 Existing Device #2: Johnny's Selected Seeds Green Harvester

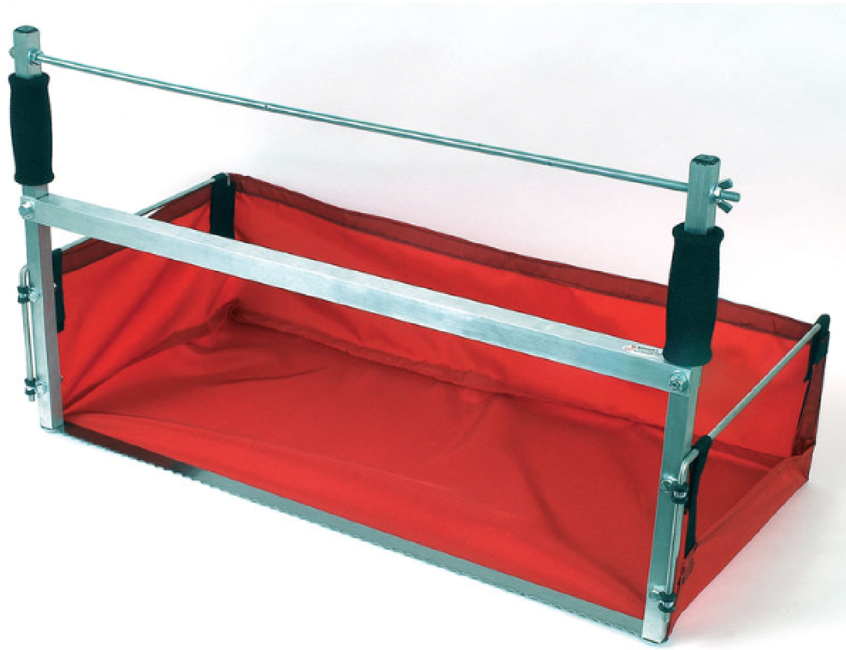


Figure 2: Johnny's Selected Seeds Greens Harvester (Source: johnnyseeds.com)

Link: https://www.johnnyseeds.com/tools-supplies/harvesting-tools/greens-harvester/
Description: This greens harvester is manual and consists of a scalloped blade attached to a collection bin made of cloth. This harvester is lightweight and spans the entire width of a typical market farm row. The user holds the harvester over the produce and must create the back and forth motion as they move along the row, however, the plants must be dense so that they can support each other while being cut. After the produce is cut it falls into the collection bin behind the blade. When the bin is full, the user turns the device on its side and pours the produce out of the open end of the collection bin.

2.1.3 Existing Device #3: Sutton Ag's HarvestStar

Figure 3: HarvestStar (Source: suttonag.com)

Link: http://www.suttonag.com/harvest_star.html
Description: Sutton Ag's HarvestStar is a greens harvester that is operated by pushing it over the area of greens that you want to harvest. There is a blade along the front of the harvester that is moved back and forth by a 12 V motor. After being cut the greens are transported along a belt, operated by another 12 V motor, and deposited into a bin up to 11 x 29 inches. Each motor is operated by a rechargeable battery. The length of the greens is determined by turning a knob that adjusts the blade height between 0 and 2 inches.

2.2 Patents

2.2.1 Patent 1: Position data-powered control system for camera and stage equipment for automated alignment to defined mobile objects (DE202010013678U1)

This patent combines the use of known components in the Spidercam with a data processing program to automatically align, position, and move camera and lighting units versus manually. The unit is fitted with a device that allows for position data determination, which is sent to a digital interface for processing. The same device allows for coordinates to be sent to the carrier unit to orient the camera to the desired position. Though the system as a whole can be oriented autonomously with remote-control, this may be enabled or disabled as desired.

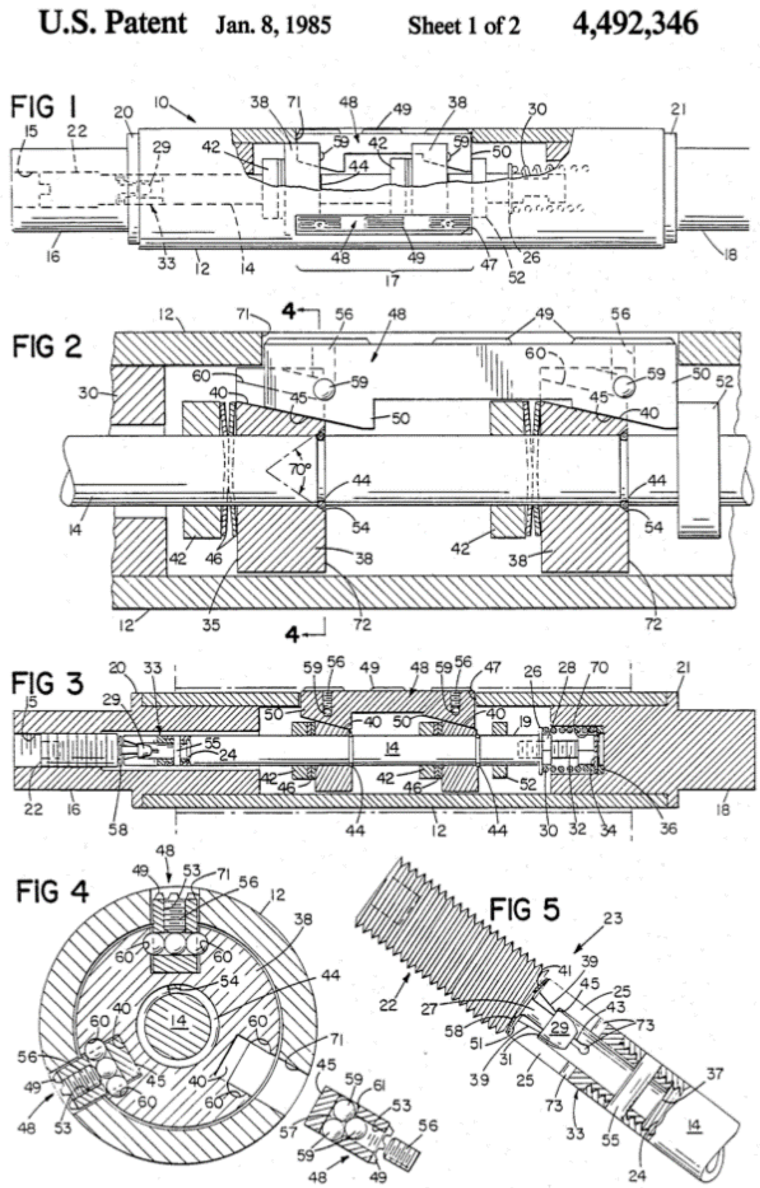


Figure 4: Patent Images for expansible shaft

2.2.2 Patent 2: US3420312A

This patent describes an invention of a cutting mechanism designed to improve an existing harvester that cuts crops irregularly due to irregular ground surface. This cutting mechanism includes two cutting discs that rotate in opposite directions to cut crops, especially cucumbers, and a regulator located at leading peripheral edges of the discs that senses the height of dirt. The disc mounting mechanism and sensing mechanism allow adjusting the height of discs according to the height of the deposited dirt to be possible.

Jan. 7, 1969 E. F. GREEDY **3,420,312**

HARVESTER CUTTING MECHANISM

Filed July 18, 1966 Sheet 3 of 4

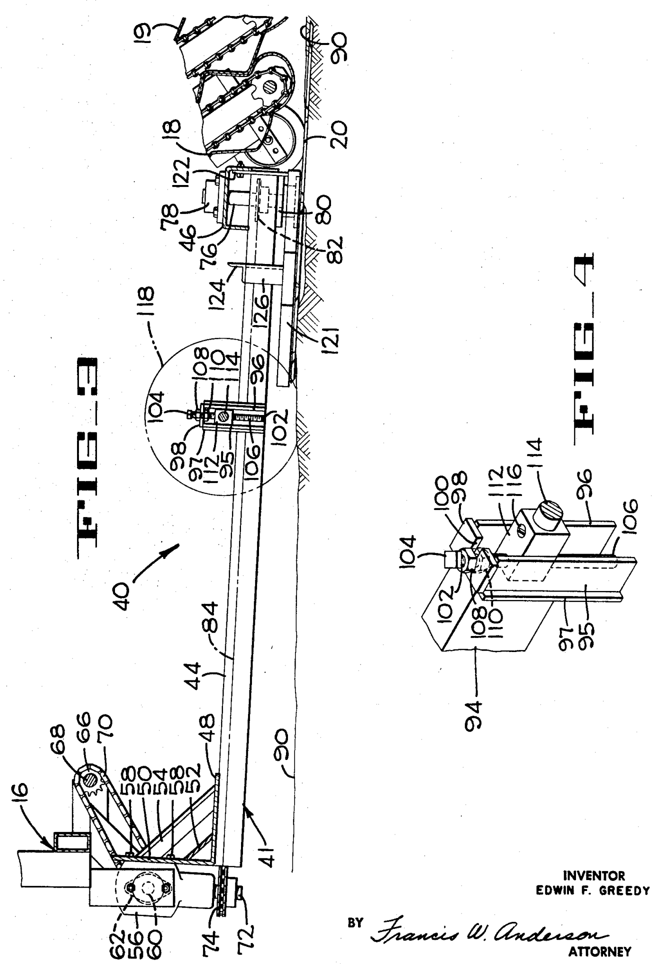


Figure 5: Vertical Image for the Invention

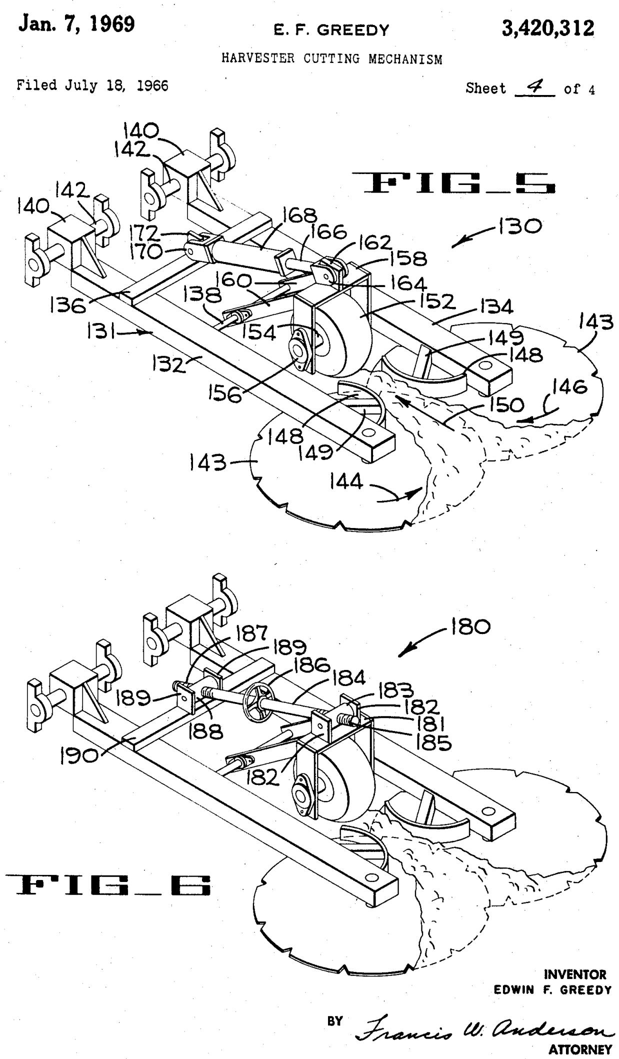


Figure 6: Enlarged Image for the Invention

2.3 Codes & Standards

2.3.1 ISO/TC 23 Tractors and machinery for agriculture and forestry

ISO/TC 23 is a standard tractors, machines, systems, implements and their equipment that are used in areas such as agriculture, forestry, gardening, landscaping, irrigation, electronic/electrical aspects, and electronic identification. We would have to follow this standard when designing our greens harvester because the device is a machine used in areas listed above.

2.3.2 ISO 4254-1:2013 Agricultural machinery - Safety - Part 1: General requirements

ISO 4254-1:2013 states the general safety requirements and procedures to verify the design of machines used in agriculture to handle the dangers that are usually found in most machines. Moreover, this standard describes safe working practices including some residual dangers that the manufacturer should give. We need to take these general safety standards into account when designing our machine so that our machine is not dangerous when using. Also, as a manufacturer, we need to consider what other risks there are that we need to provide.

2.4 User Needs

2.4.1 Customer Interview

Interviewee:
Location: EarthDance Organic Farm School
Date: September 6^{th}, 2019
Setting: The farmers at EarthDance showed us the quick-cut greens harvester they are currently using. They explained to us how it works and some of its problems. They also showed us the beds where the crops were growing. We held it to feel the weight and asked any questions we had. The whole interview was conducted in his office, and took ∼40 min.

Interview Notes:
What are the typical uses of the device?

– It cuts crops and collects them in a basket.

What are the current likes and dislikes of the product?

– I like the drill as the motor because most of our machines are operated with the drill. We are more familiar and have more tools to fix it when it needs maintenance. Some things I don't like about it is sometimes big crops stick to the roller and do not go in the basket, we have to bend over to make the machine reach the crops, it gets heavy during continuous usage, the height of cutting crops is irregular because the machine height is established by the user.

Are there any other things we need to take into consideration when improving the device?

– Machine should be improved so that the machine and farmers won't step on the beds while cutting all crops.

How many times do you have to empty out the basket?

– I have to empty out the basket about 10 times for one row of crops.

2.4.2 Interpreted User Needs

The following is a table providing what changes we think our customer would benefit from. The importance of each aspect is ranked.

Table 1: Interpreted Customer Needs

Need Number	Need	Importance
1	The GH cuts evenly and neatly	5
2	The GH has the drill as the motor	4
3	The GH has a roller that does not jam large crops	3
4	The GH is tall enough for user to operate standing up	5
5	The GH is lightweight and easy to move	5
6	The height of the blade is adjustable	4
7	The GH covers the span of one whole row and will not affect the other rows of crops	4
8	The GH basket is large	4

2.5 Design Metrics

Table 2: Target Specifications

Metric Number	Associated Needs	Metric	Units	Acceptable	Ideal
1	5	Total weight	lb	< 15	< 10
2	1	Total width	in	< 30	< 30
5	8	Amount of times the GH must be emptied	integer	< 10	< 5
6	6	General Safety Requirements ISO 4254-1:2013	binary	Pass	Pass

2.6 Project Management

The Gantt chart in Figure 7 gives an overview of the project schedule.

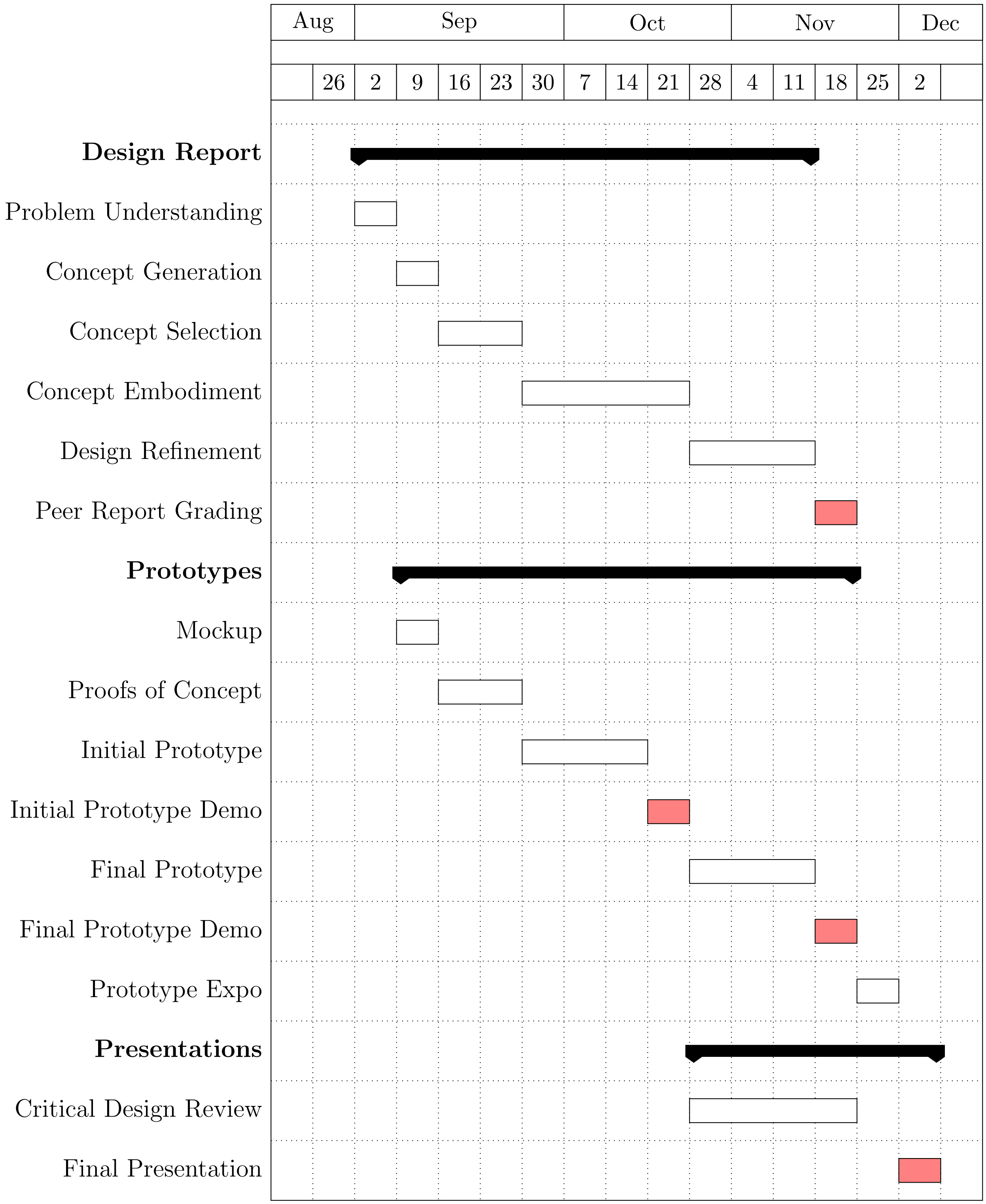


Figure 7: Gantt chart for design project

3 Concept Generation

3.1 Mockup Prototype

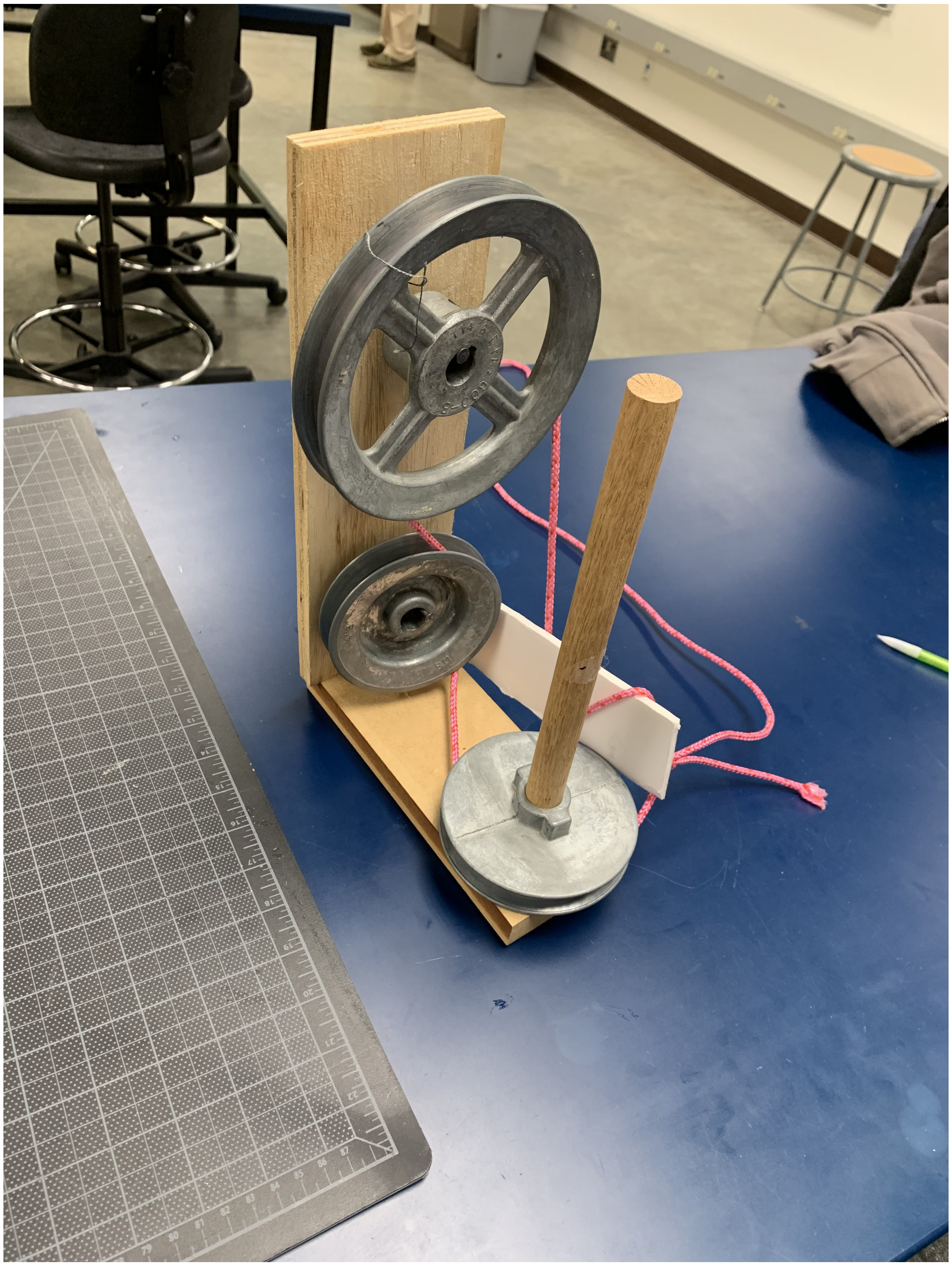


Figure 8: First prototype mockup

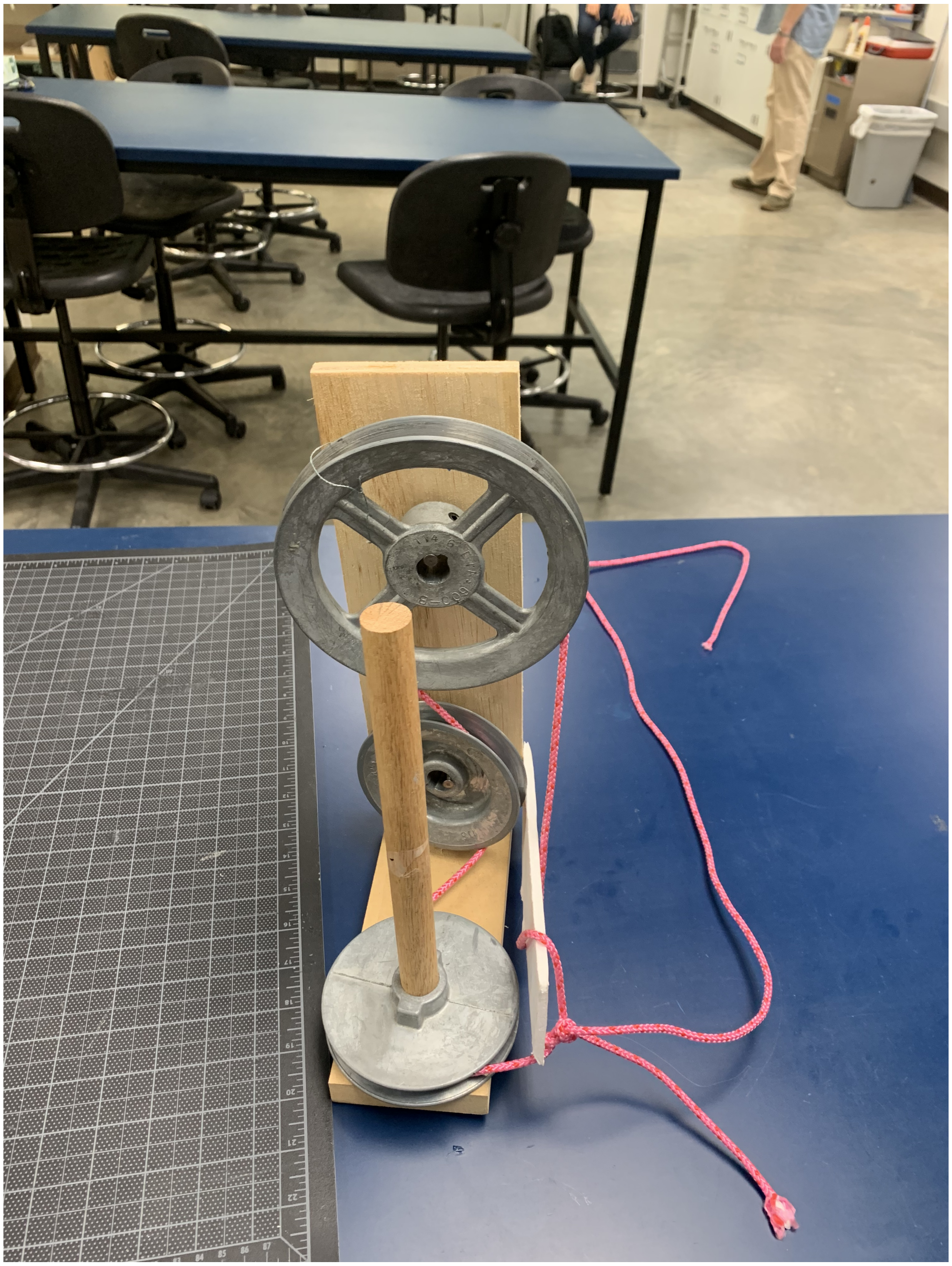


Figure 9: Mockup prototype

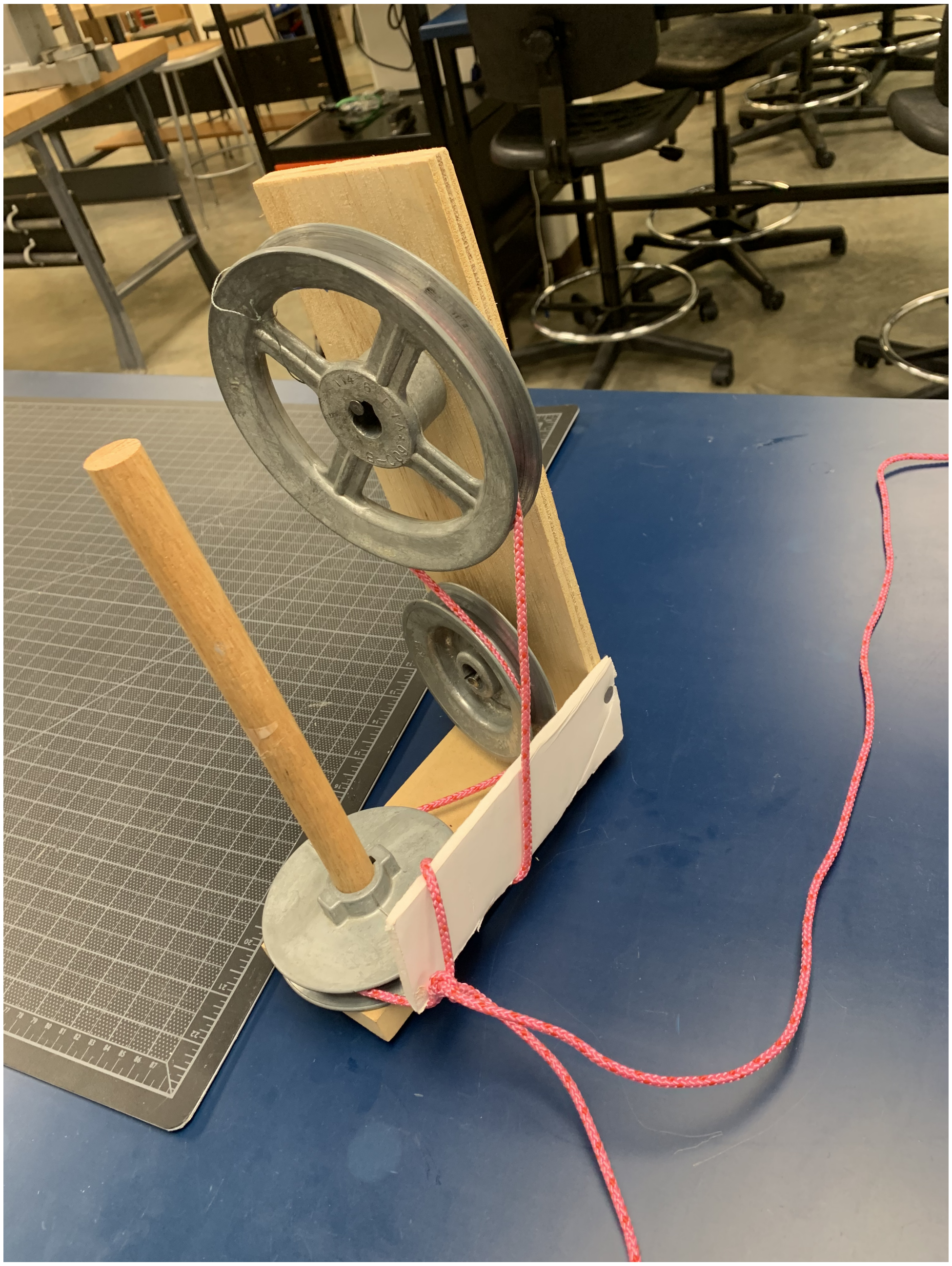


Figure 10: Mockup prototype

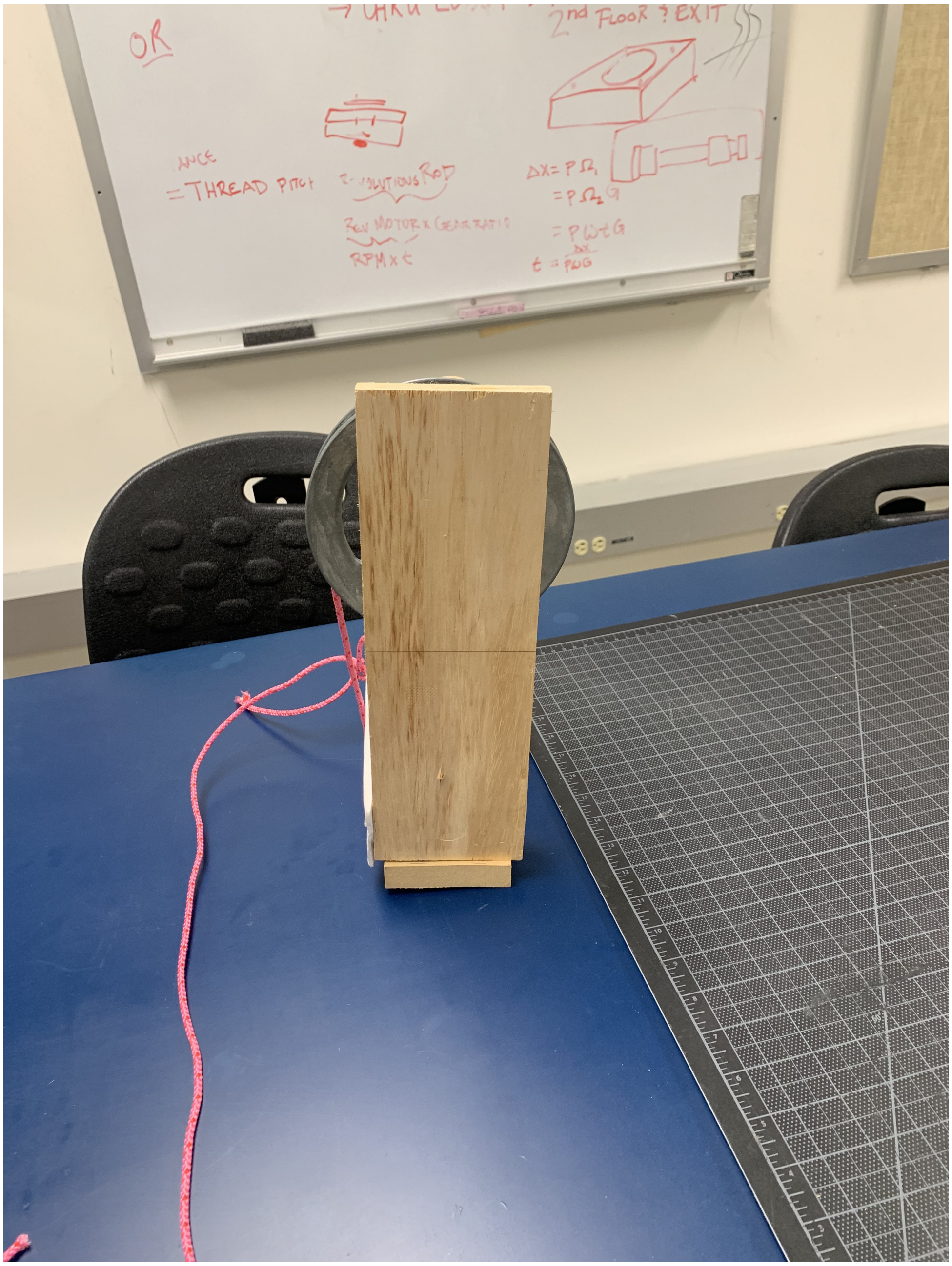


Figure 11: Back view of mockup prototype

In studio, we created a prototype of the belt and wheel mechanism that will drive our greens harvester. We based our design on the mechanism from the already existing greens harvester that we studied at EarthDance Farm. Given that the mechanism was not functional when we studied it, we had to perform outside research and innovate to create our new design. Creating this prototype made us explore the ways that we could connect all of our components and make them operate based on a single drill. Specifically how the horizontal rotation of the drill could translate into the vertical rotation of the conveyor belt and brush.

3.2 Functional Decomposition

Using a function tree and morphological chart we broke down our necessary functions of our greens harvester.

Figure 12: Function tree for Greens Harvester, hand-drawn and scanned

3.3 Morphological Chart

Our morphological chart shows possible solutions to our necessary functions on our function tree.

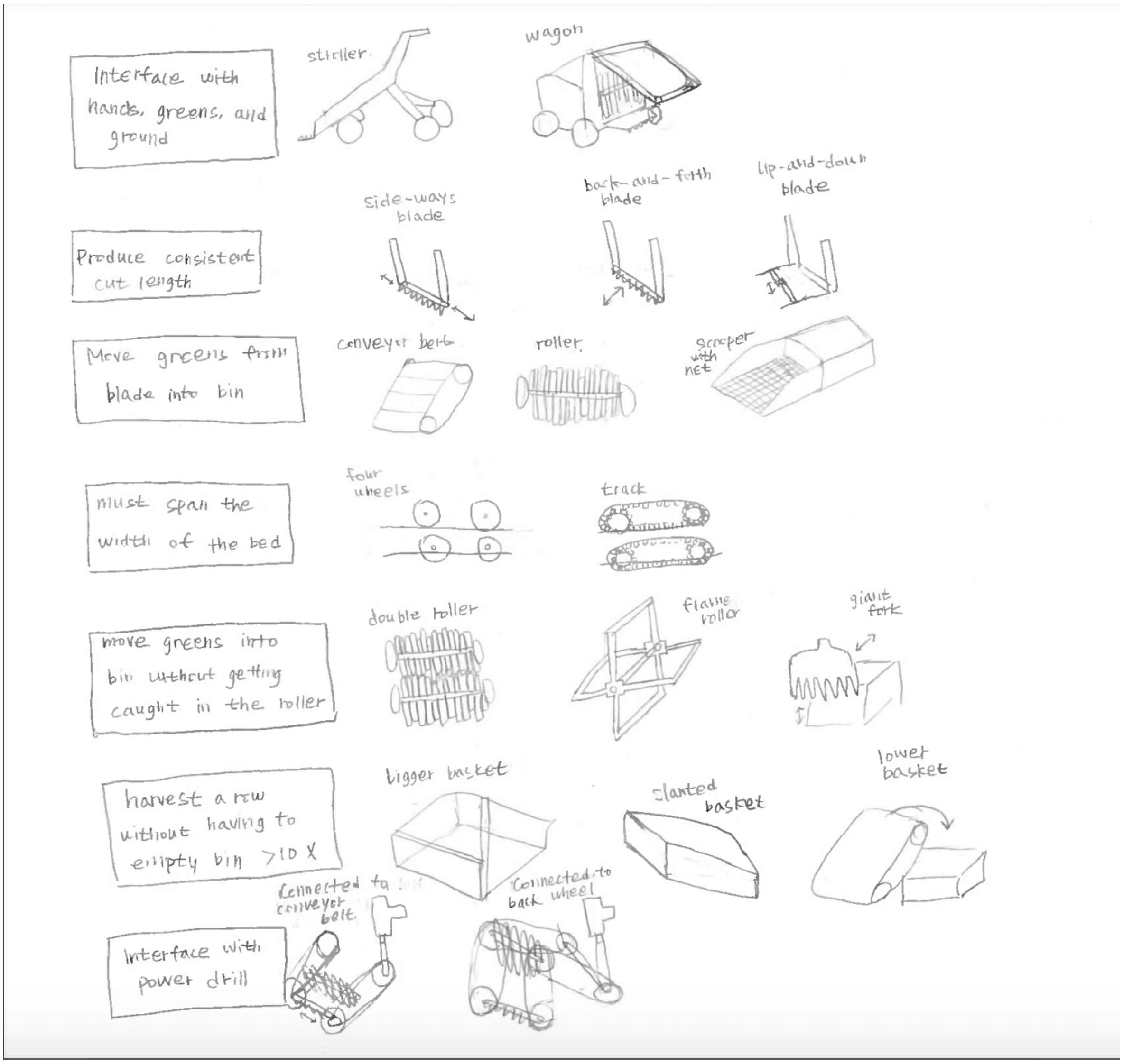


Figure 13: Morphological Chart for Greens Harvester

3.4 Alternative Design Concepts

3.4.1 Greens Harvester

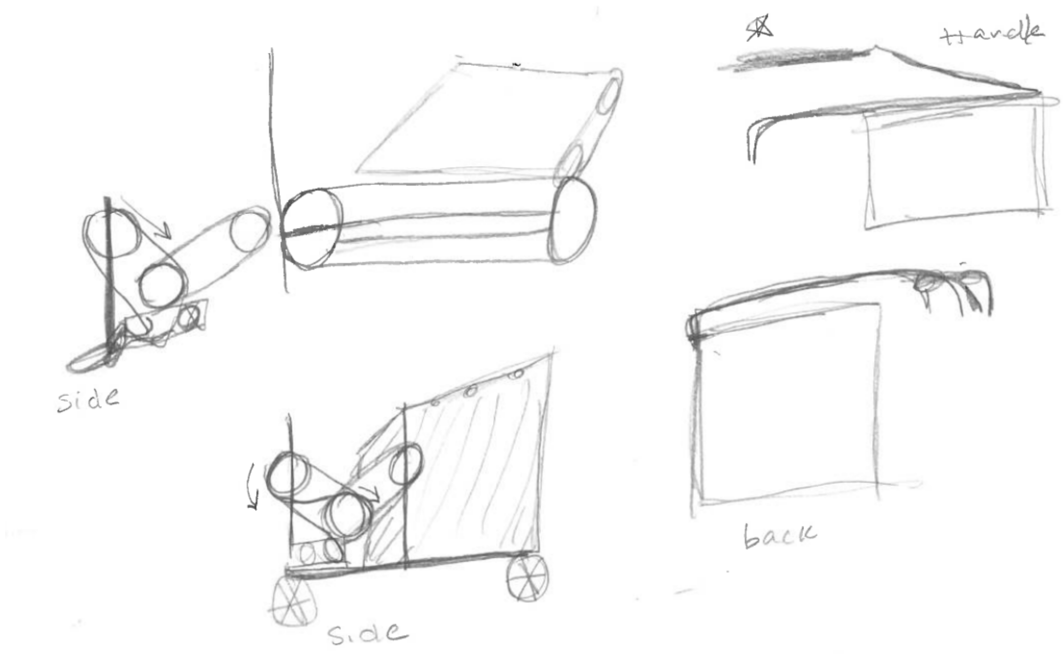


Figure 14: Preliminary sketches of Greens Harvester concept

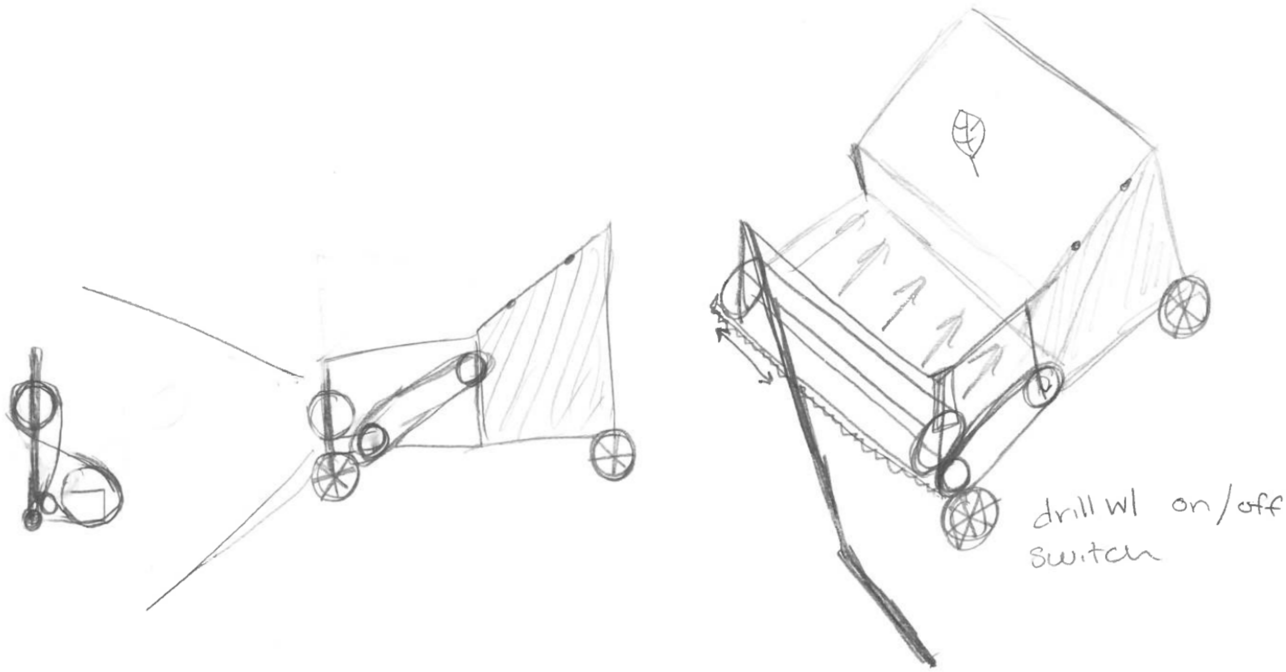


Figure 15: Final sketches of Greens Harvester concept

Solutions from morph chart:

1. Wheels and blade at set height keep greens cut at a consistent height
2. Conveyor belt helps move greens from blade into the bin
3. Larger bin allows longer use before having to stop and empy
4. Frame roller decreases amount of greens getting clogged in the roller

Description: A greens harvester is operated by a drill that has a push button switch. The harvester is pushed from the side of the bed with the handle. When the drill is turned on the blade will move back and forth and the brush will spin. The band connected to the drill also goes around a conveyor belt that helps the greens get into the bin. The bin is made of a water resistant fabric and one side has snaps at the top so, when the bin is full the door can be lowered to empty the bin.

3.4.2 Rolling Basket

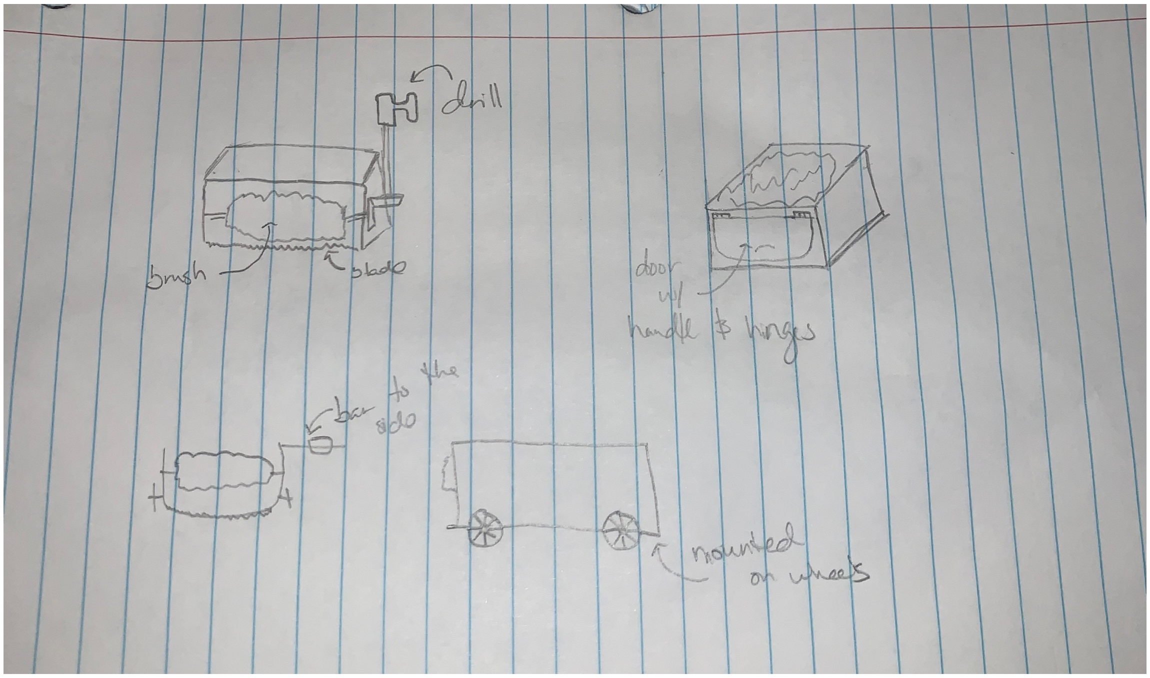


Figure 16: Preliminary sketches of Greens Harvester concept

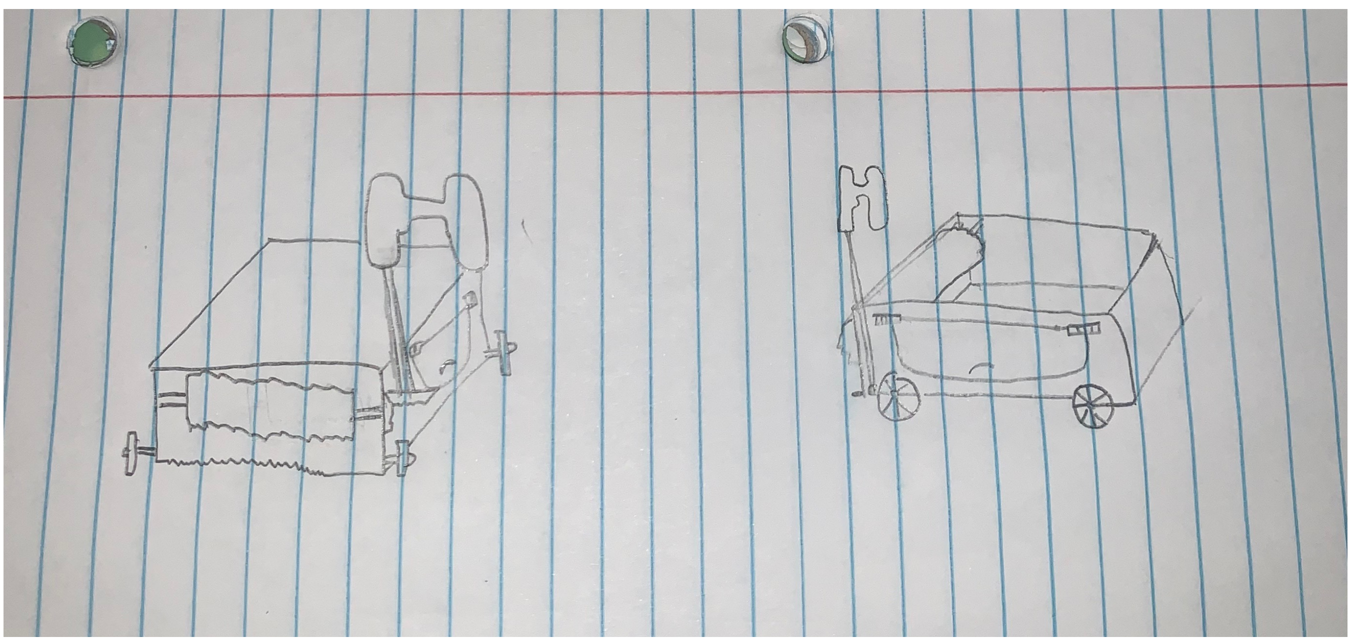


Figure 17: Final sketches of Greens Harvester concept

Solutions from morph chart:

1. Wheels keep harvester at a consistent height and allow for rolling without without strain on the back

2. Door allows more to be held in the storage bin without overflowing, allowing the harvester to be emptied less
3. Uses a drill which compliments the many 9V batteries that they already own

Description: A greens harvester is operated by a hand drill. When the drill is pressed, a blade at the front of the harvester will move back and forth and a brush above the blade will spin. The spinning of the rush pushes the greens into the blade which cuts them. When the collection basket is full the greens can be emptied through a door on the side of the harvester.

3.4.3 Lawnmower

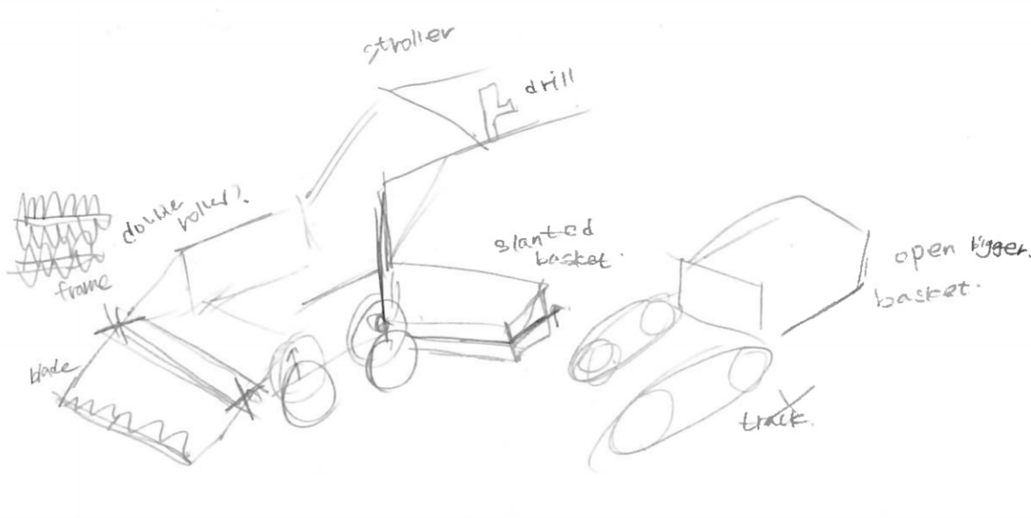


Figure 18: Preliminary sketches of Greens Harvester concept

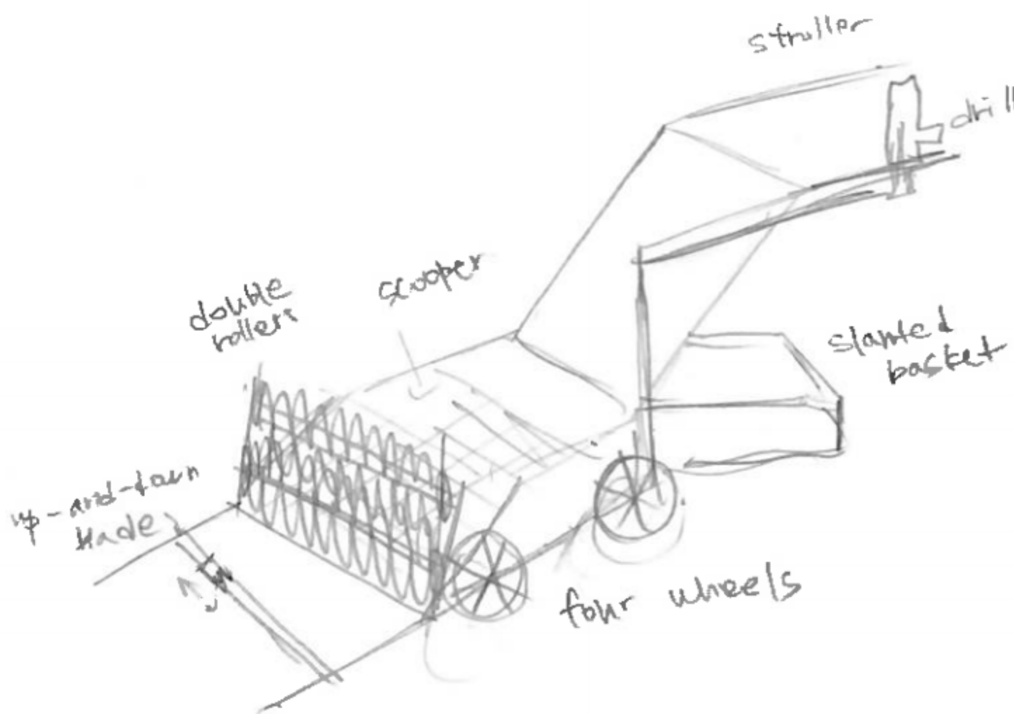


Figure 19: Final sketches of Greens Harvester concept

Solutions from morph chart:

1. Four wheels make it possible to span the width of the bed
2. Double roller prevents greens from getting caught in the roller
3. Slanted basket allows basket to contain more greens
4. Up-and-down blade cuts the greens at a consistent length
5. Uses a drill connected to back wheel

Description: A greens harvester is operated by a drill that is connected to the back wheel. Blade that moves up and down cuts the greens at a consistent length. Basket is slanted so that more greens could be collected before emptying them out. Double rollers take out greens that are caught in each others' rollers. Four wheels make it possible to not step on the beds. The harvester is stroller type so it is easier to make it move.

4 Concept Selection

4.1 Selection Criteria

In selecting a design for our greens harvester, we prioritized consistency, carrying capacity and ease of use. Our Analytic Hierarchy Process is included below.

	Consistent Cut Height	Doesn't Put Strain on Back	Emptied <10x Per Row	Minimal Clogging	Operated by Drill	Adjuastable	Row Total	Weight Value	Weight (%)
Consistent Cut Height	**1.00**	3.00	5.00	3.00	1.00	9.00	22.00	0.28	28.16%
Doesn't Put Strain on Back	0.33	**1.00**	1.00	3.00	0.33	9.00	14.67	0.19	18.77%
Emptied <10x Per Row	0.20	1.00	**1.00**	0.33	0.20	5.00	7.73	0.10	9.90%
Minimal Clogging	0.33	0.33	3.00	**1.00**	0.33	5.00	10.00	0.13	12.80%
Operated by Drill	1.00	3.00	5.00	3.00	**1.00**	9.00	22.00	0.28	28.16%
Adjustable	0.11	0.11	0.20	0.20	0.11	**1.00**	1.73	0.02	2.22%
						Column Total:	**78.13**	**1.00**	**100%**

Figure 20: Analytic Hierarchy Process (AHP) to determine scoring matrix weights

4.2 Concept Evaluation

For each criterion, we compared each design concept to the Quick-cut Greens Harvester, 1 being much worse than the reference and 5 being much better than the reference. Our Weighted Scoring Matrix to rank the designs is included below.

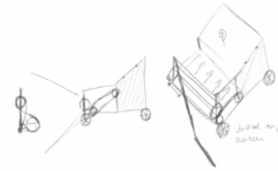
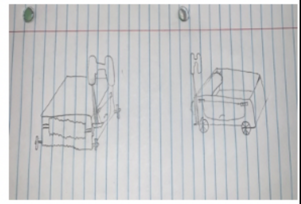
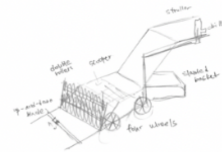
Alternative Design Concepts		Handle-in-front Greens Harvester 		Original-modified Greens Harvester 		Double-roller Greens Harvester 	
Selection Criterion	**Weight (%)**	**Rating**	**Weighted**	**Rating**	**Weighted**	**Rating**	**Weighted**
Consistent Cut Height	28.16	3	0.84	3	0.84	2	0.56
Doesn't Put Strain on Back	18.77	5	0.94	4	0.75	5	0.94
Emptied <10x Per Row	9.90	4	0.40	3	0.30	2	0.20
Minimal Clogging	12.80	4	0.51	3	0.38	4	0.51
Operated by Drill	28.16	5	1.41	5	1.41	5	1.41
Adjustable	2.22	1	0.022	1	0.022	1	0.022
	Total score	**4.12**		**3.70**		**3.64**	
	Rank	**1**		**2**		**3**	

Figure 21: Weighted Scoring Matrix (WSM) for choosing between alternative concepts

4.3 Evaluation Results

Double-roller Greens Harvester has a blade that goes up and down, which would make it more difficult to cut at a consistent height than the blade that goes side to side. Handle makes it possible to not bend down when using the machine. Double-roller would lead the clogging to happen less. However, the basket is not enlarged, which would make storing greens inefficient.

Original-modified Greens Harvester preserves most of the designs from the existing harvester, except the wheels and a slightly larger basket. These design parts help to put less strain on back and decrease the number of times the user has to empty out the basket.

Handle-in-front Greens Harvester was the winning concept. This design had the best rating for not putting strain on back because it has a handle that goes around and in front the machine, making it possible move the harvester by merely pushing it forward. The basket was designed bigger than the existing greens harvester so that user would have to empty it out less than ten times per row. This design changed the type of roller from cloth to plastic (rod-type), preventing the greens from getting clogged. All of the alternative design concepts were operated by drill and were not capable of height adjustments.

4.4 Engineering Models/Relationships

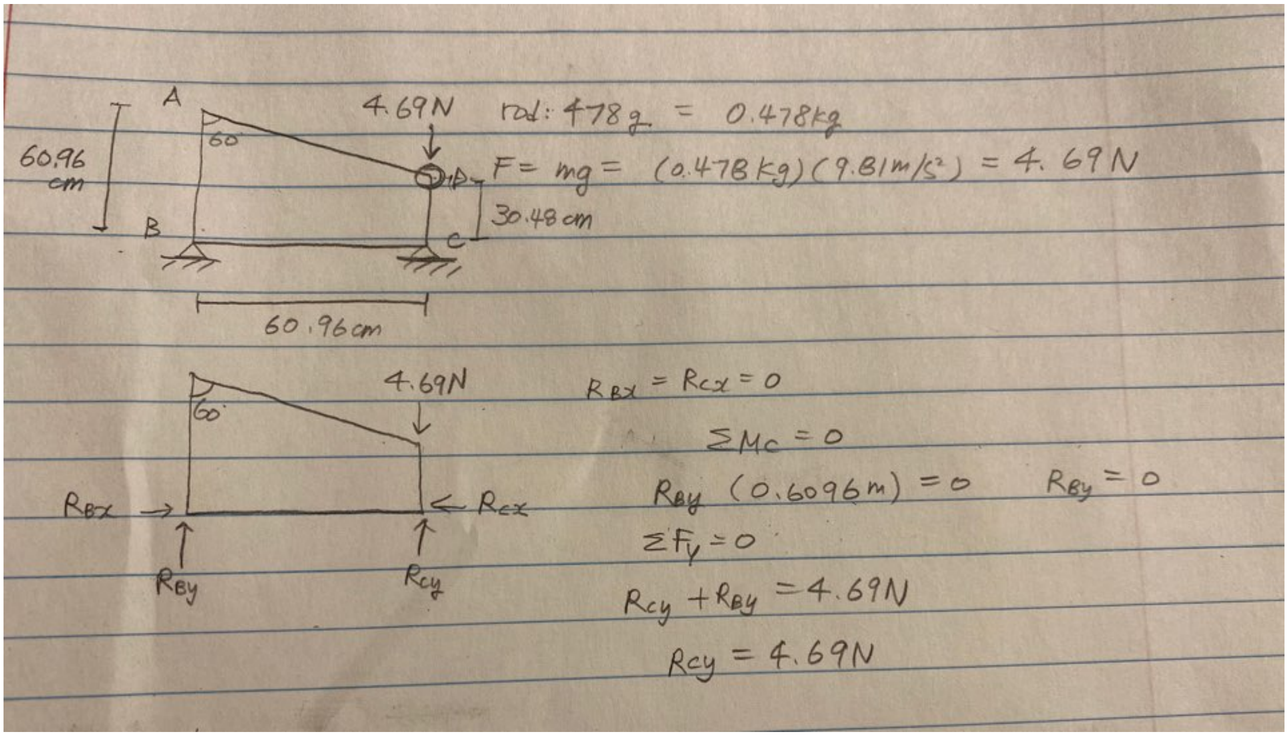


Figure 22: Forces on the Frames

This physical engineering model was analyzed to see if stress on the frames caused by the mass of the rod of the roller would lead the frames to break. The mass of the roller was about 478 g. Since it is the only external force acting on the system, there would be 4.69 N of compression on the frame CD. This analysis was used to decide that the compression force was small enough that it would not cause any frames to break. The internal forces were calculated using moment equation.

$$\sum M = \sum F * d \tag{1}$$

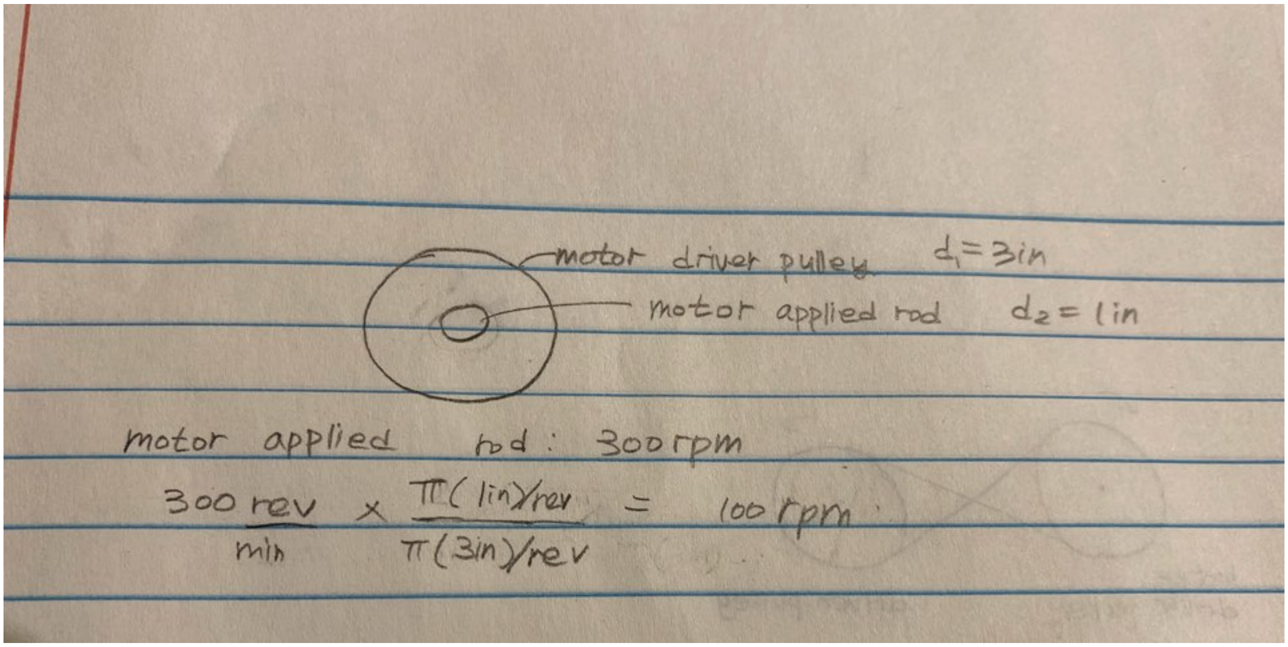


Figure 23: Speed of the Motor Driver Pulley

Assuming a user uses the motor at about 300 rpm, the velocity of the motor driver pulley was calculated relative to the motor speed. Since the diameter ratio was 1 to 3, the velocity ratio would be 3 to 1. This systems model was used to predict the speed of the pulley. It helped us decide that 3 to 1 seemed like a reasonable ratio because we did not want the pulley to turn as fast as the motor.

$$1\,rev = circumference = \pi * diameter \tag{2}$$

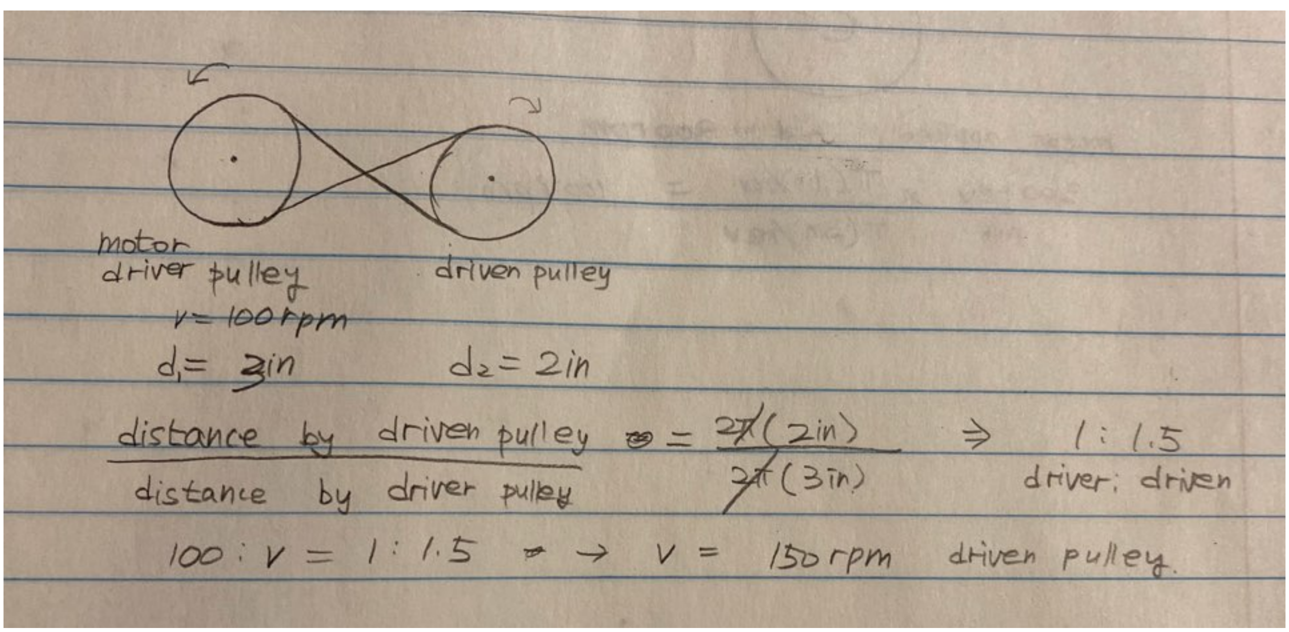


Figure 24: Speed of the Motor Driven Pulley

After we calculated the hypothetical speed of the motor driver pulley, we used the model to decide the speed of the motor driven pulley. We wanted the motor driven pulley, which is connected to the conveyor belt, to be a little faster than the motor driver pulley, which is connected to the roller because we wanted to prevent greens from getting clogged between the roller and the conveyor belt. If we decided the diameters to be 3 in and 2 in, the speed of the motor driven pulley turned out to be 150 rpm. The ratio was calculated using the equation below. D is the diameter and v is the velocity.

$$d\,by\,driven\,pulley\ /\ d\,by\,driver\,pulley\ =\ v\,by\,driver\,pulley\ /\ v\,by\,driven\,pulley \tag{3}$$

5 Concept Embodiment

5.1 Initial Embodiment

One of the Initial Prototype components is the blade. It was designed so that it moves side to side to cut the greens. This design of the blade could efficiently cut a whole column of greens at once because the length of the blade is similar to that of the bed.

Another Initial Prototype component is the pulleys. The pulleys were used to connect the conveyor belt, blade, and the brush so that they would all rotate with one power source, the drill. Conveyor belt and the brush were linked by the pulleys so that they would go in the opposite direction. The pulley connected to the blade would move the blade side to side as it rotates.

Last Initial Prototype is the conveyor belt. Conveyor belt was used so that the basket could contain more greens and the greens would not get stuck while being transferred to the basket. Because the collected greens are moved up the conveyor belt and dropped in the basket, the chances of greens getting stuck in the brush and basket are eliminated.

Performance Goals

1. have to empty the greens harvester less than 5 times over a row of crops
2. Cutting height has greater or equal to 4” of adjust-ability
3. Requires maintenance/debugging fewer than 5 times over a row of crops

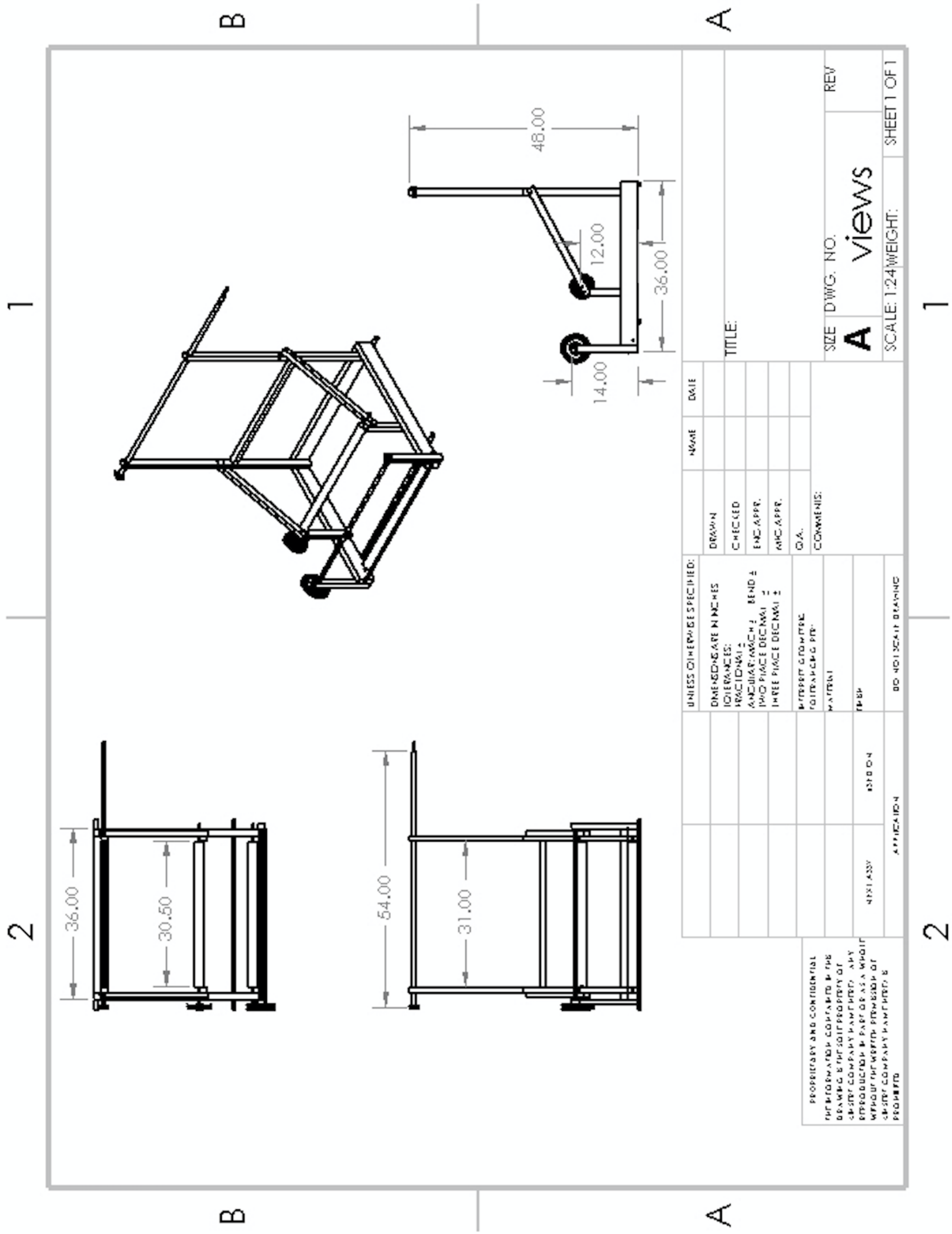
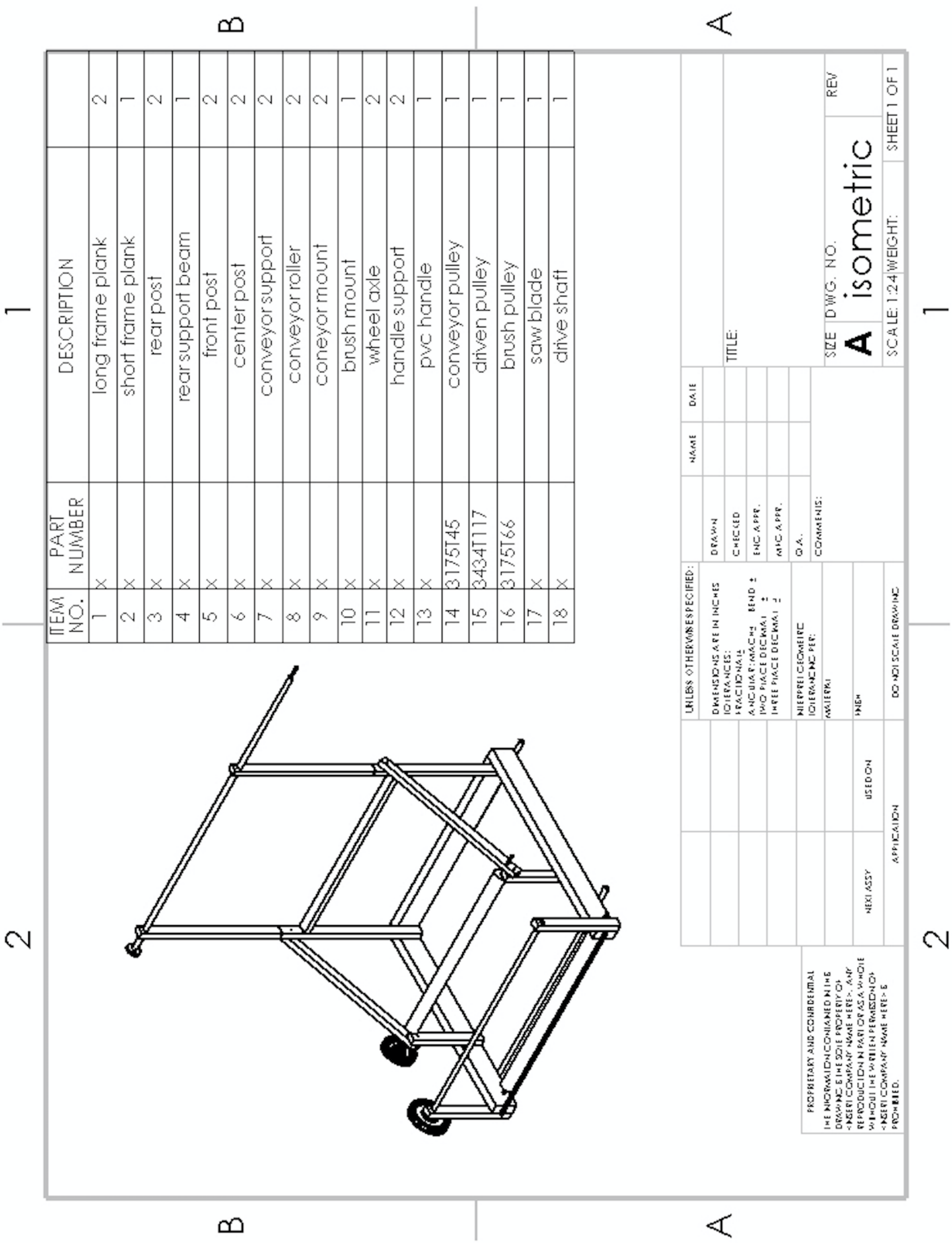


Figure 25: Assembled projected views with overall dimensions



ITEM NO.	PART NUMBER	DESCRIPTION	
1	X	long frame plank	2
2	X	short frame plank	1
3	X	rear post	2
4	X	rear support beam	1
5	X	front post	2
6	X	center post	2
7	X	conveyor support	2
8	X	conveyor roller	2
9	X	coneyor mount	2
10	X	brush mount	1
11	X	wheel axle	2
12	X	handle support	2
13	X	pvc handle	1
14	3175T45	conveyor pulley	1
15	3434T117	driven pulley	1
16	3175T66	brush pulley	1
17	X	saw blade	1
18	X	drive shaft	1

Figure 26: Assembled isometric view with bill of materials (BOM)

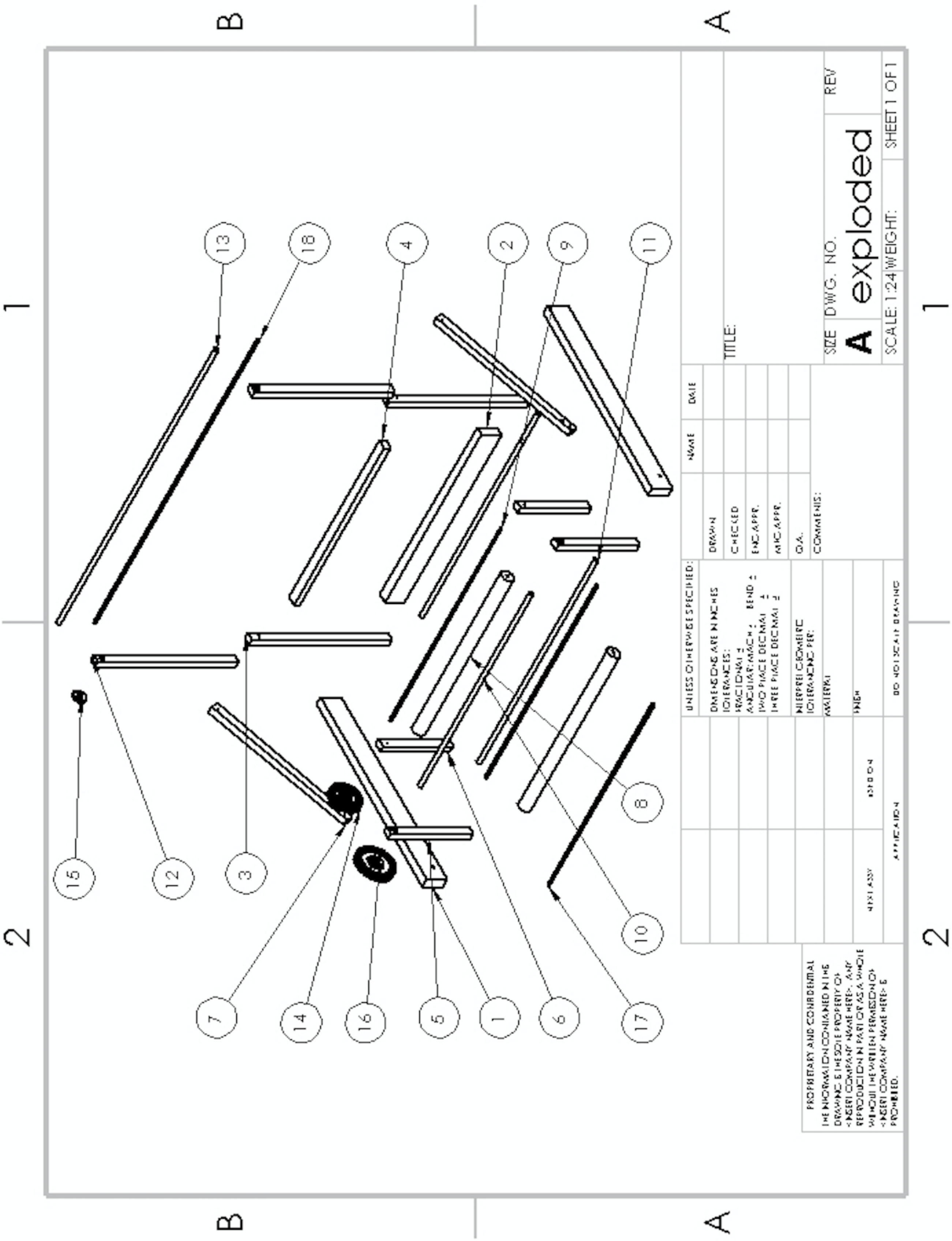


Figure 27: Exploded view with callout to BOM

5.2 Proofs-of-Concept

During our construction of our Proof-of-Concept prototype we were able to determine how we want our final prototype to look and function.

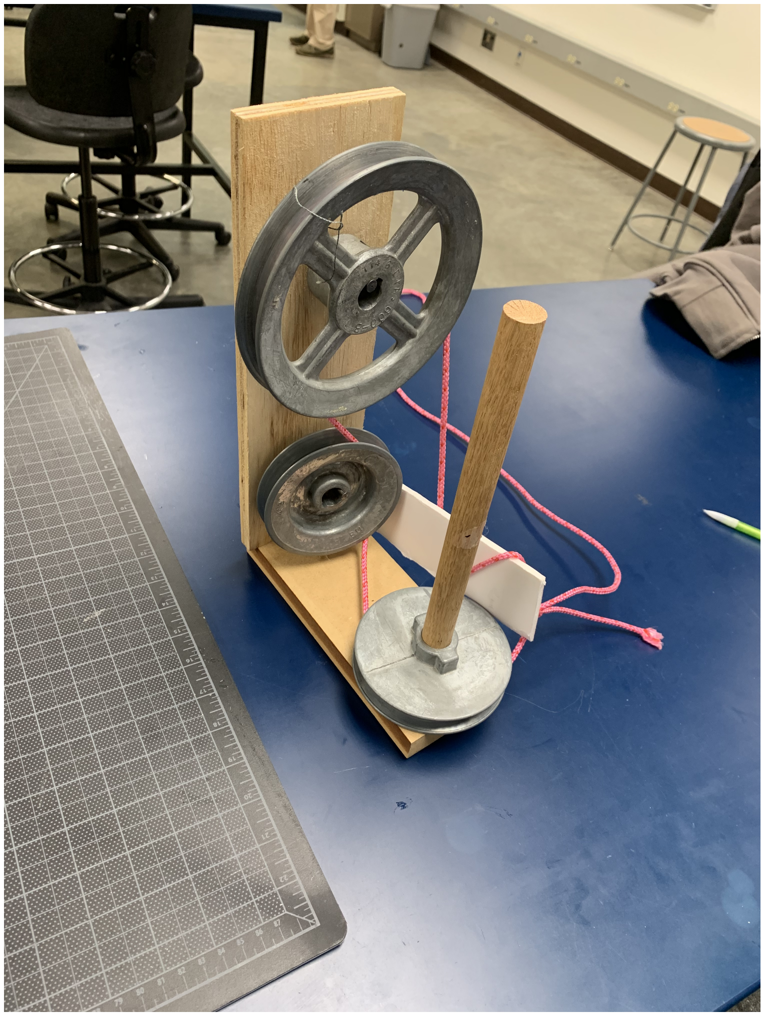


Figure 28: First Proof-of-Concept in an attempt to model pulley system

Figure 29: Close view of mechanisms that move our Greens Harvester's brush and conveyor belt

Figure 30: Full initial prototype of Greens Harvester

The Proof-of-Concept prototypes helped us realize what would and would not be possible for our design in our time constraint. When we first tried to model the pulley system we had extreme difficulty; we still attempted to include it in our initial prototype but determined it would not be used in our final design. Having the physical design also makes it easier to see if certain aspects of our design would work, such as the handle placement.

Since we found difficulty in getting the pulley system to function properly in our final prototype, we plan to simplify the pulley system by keeping the blade fixed while having the brush and conveyor belt rotate to gather the greens into the collection bag. Additionally, the handle will be in the back of the design instead of connected in the front; this will make it easier to attach the drill to power the moving parts of the design. Other than the two major changes, the initial prototype follows the selected concept very closely.

6 Working Prototypes

6.1 Overview

A handle comes out to side of the greens harvester so that the user would not step on the greens bed. Also, the greens harvester is taller and has four wheels, so the user does not have to bend down. The basket is bigger than the existing greens harvester for bigger storage. The brush is placed at the front with conveyor belt right behind so that when the brush sweeps the greens, the conveyor belt would move them up and into the basket for less clogging.

6.2 Initial Prototype

The initial prototype had four wheels that helped roll the greens harvester straightly and easily. The basket was bigger and removable, making it easy to empty out. However, the rotation of the brush and the conveyor belt was tight for them to rotate with a driver motor. we still had to figure out the pulley system, how we are going to make the band saw go side to side, and the brush rotate one way and the conveyor belt the other with one motor. We had to make a handle and make the harvester taller. The driver still had to be connected.

Figure 31: Initial prototype of Greens Harvester

6.3 Final Prototype

Our final prototype has a stronger and thicker brush that are attached in different directions to minimize the rotating torque. The greens harvester is taller than the initial prototype. The handle is added to the side with a brake, that is connected to the driver trigger. The triggered driver connected to the conveyor belt would rotate the conveyor belt backwards. The pulley on the other side is connected to the pulley of the brush cross-linked so the brush rotates together in the other way. Band saw is just fixed at the front so that hypothetically, if the user pushed the harvester hard enough, it would cut the greens.

Figure 32: Final prototype of Greens Harvester

Figure 33: Final prototype of Greens Harvester Other Side

7 Design Refinement

7.1 FEM Stress/Deflection Analysis

From machine elements we know that mesh the accuracy of a Finite Element Analysis is based on the mesh used. We used the finest mesh to make the study as realistic as possible. To simulate the pushing of the Greens Harvester we created a load of 50 N (about 11 pounds) and made it act at the end of the rod. In reality the force would be distributed as opposed to acting at a single point, so this approximation probably led to greater deflection and stress values in our study. We made the other end of the bar fixed to simulate the bar being fixed at the support posts. In a more accurate model, there would be a fixed point for each support, or the entire length of the bar between the two supports would be fixed. This assumption probably also led to greater deflection and stress values in our study.

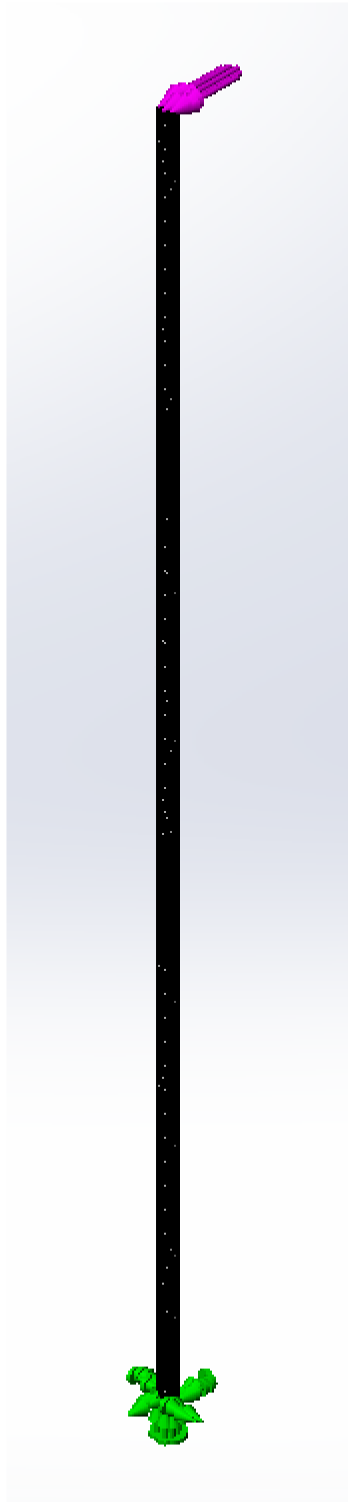


Figure 34: Unloaded model with loads and boundary conditions shown

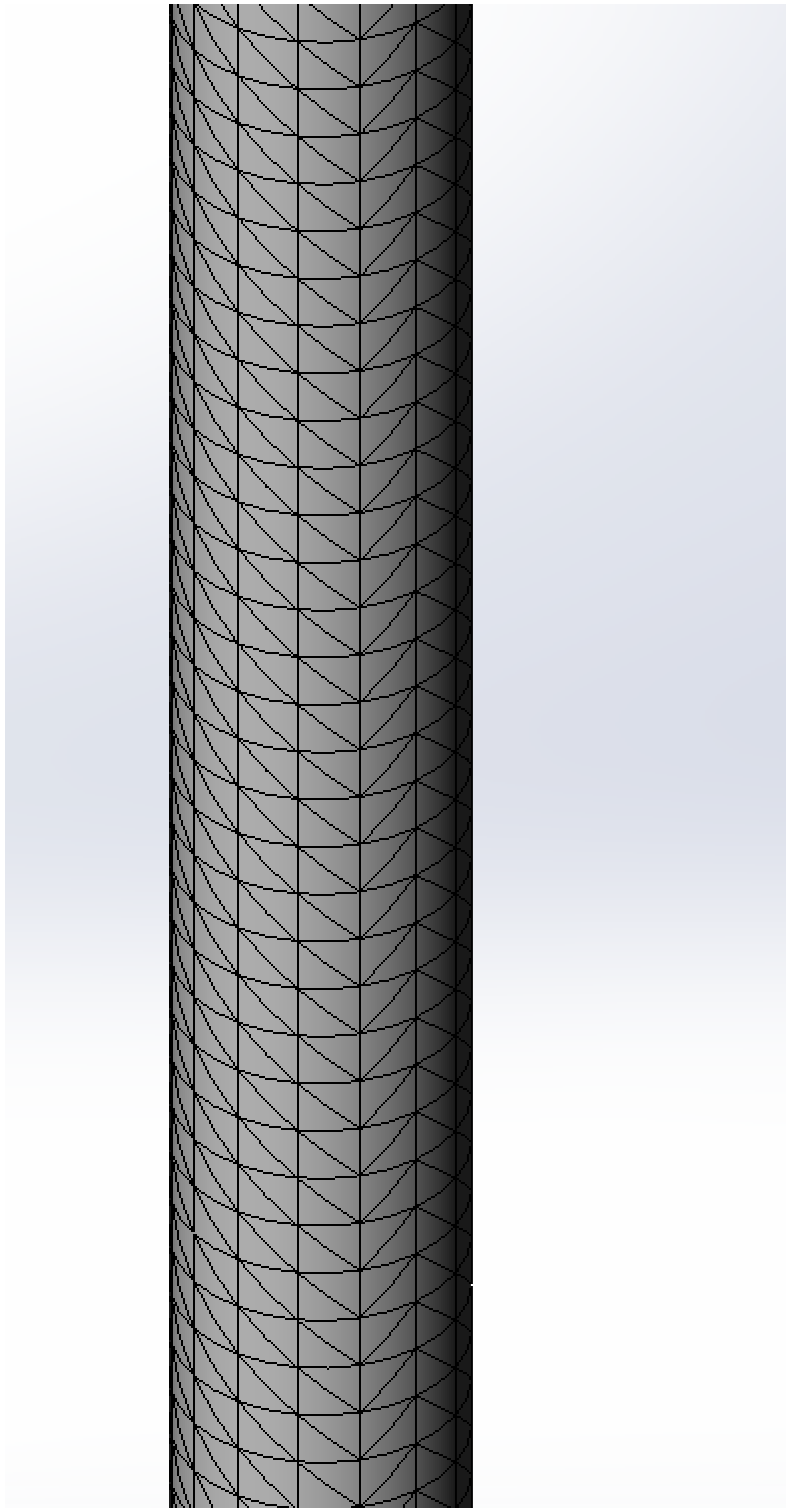


Figure 35: Mesh of the unloaded model

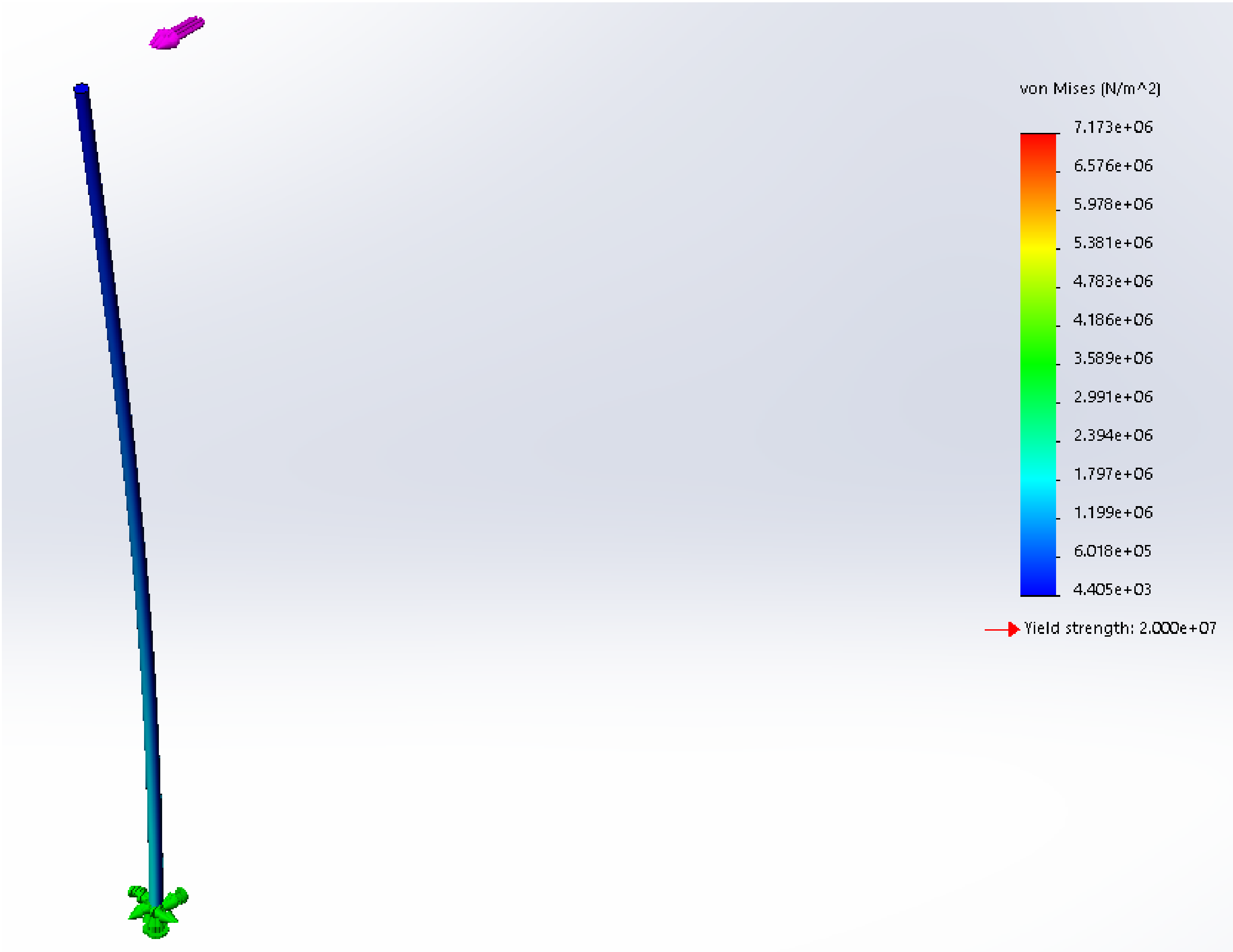


Figure 36: Loaded model with color-coded stress and legend

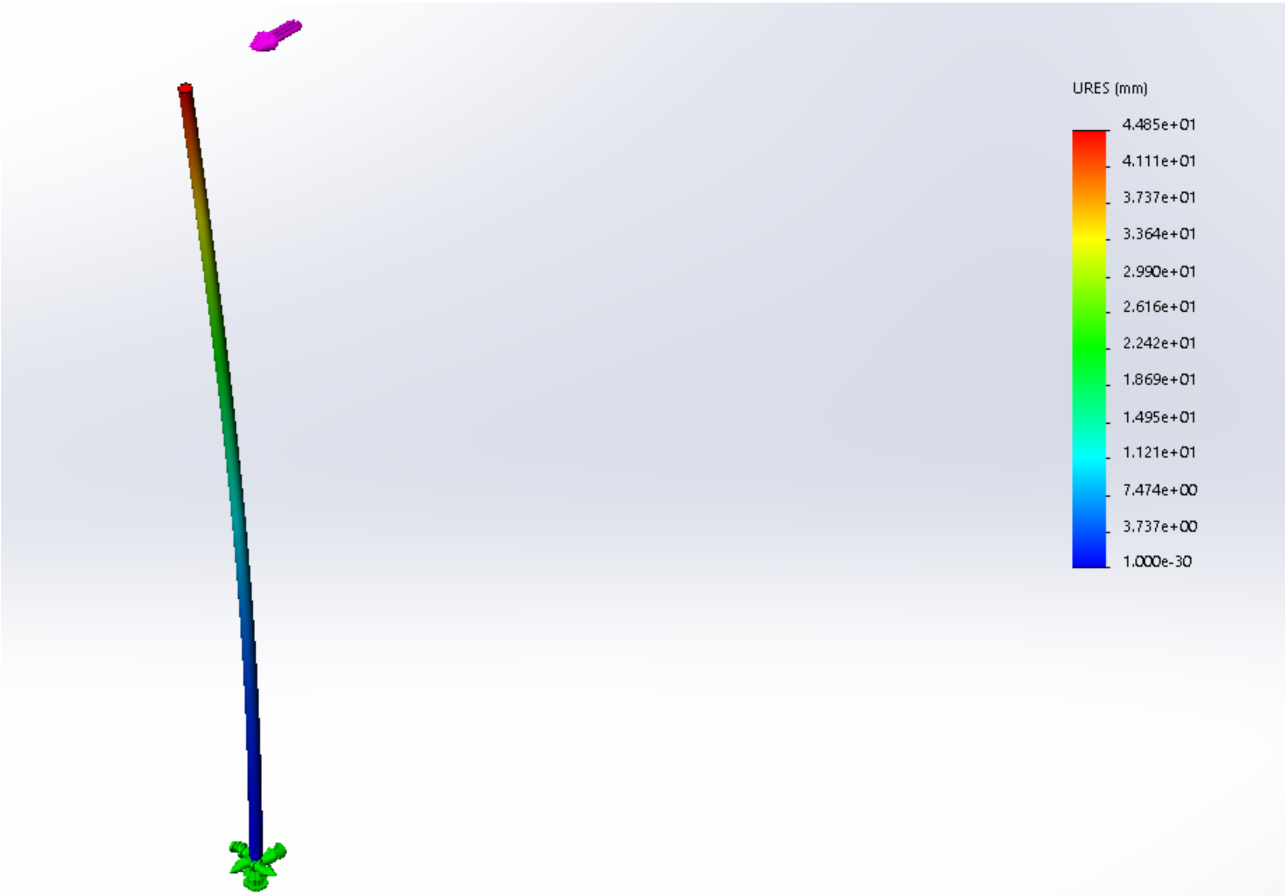


Figure 37: Loaded model with color-coded displacement and legend

Based on the maximum normal stress theory, the factor of safety is the yield stress divided by the maximum working stress. According to our Solidworks study, our yield stress is $2x10^7 N/m^2$ and our working stress is $7.173x10^6 N/m^2$. Based on this information we found our factor of safety to be 2.7882.

According to Solidworks, the maximum deflection of our handle is 4.485 mm. Due to our applied loads and boundary conditions, we can assume that this is probably an overestimate. Also assuming that the wood would have to bend more than a few millimeters to fail, our predicted deflection seems tolerable.

7.2 Design for Safety

As a precaution, we decided that not having an oscillating blade would be a safer option. This is why our blade is fixed.

7.3 Design for Manufacturing

Figure 38: Conveyor belt roller before modification

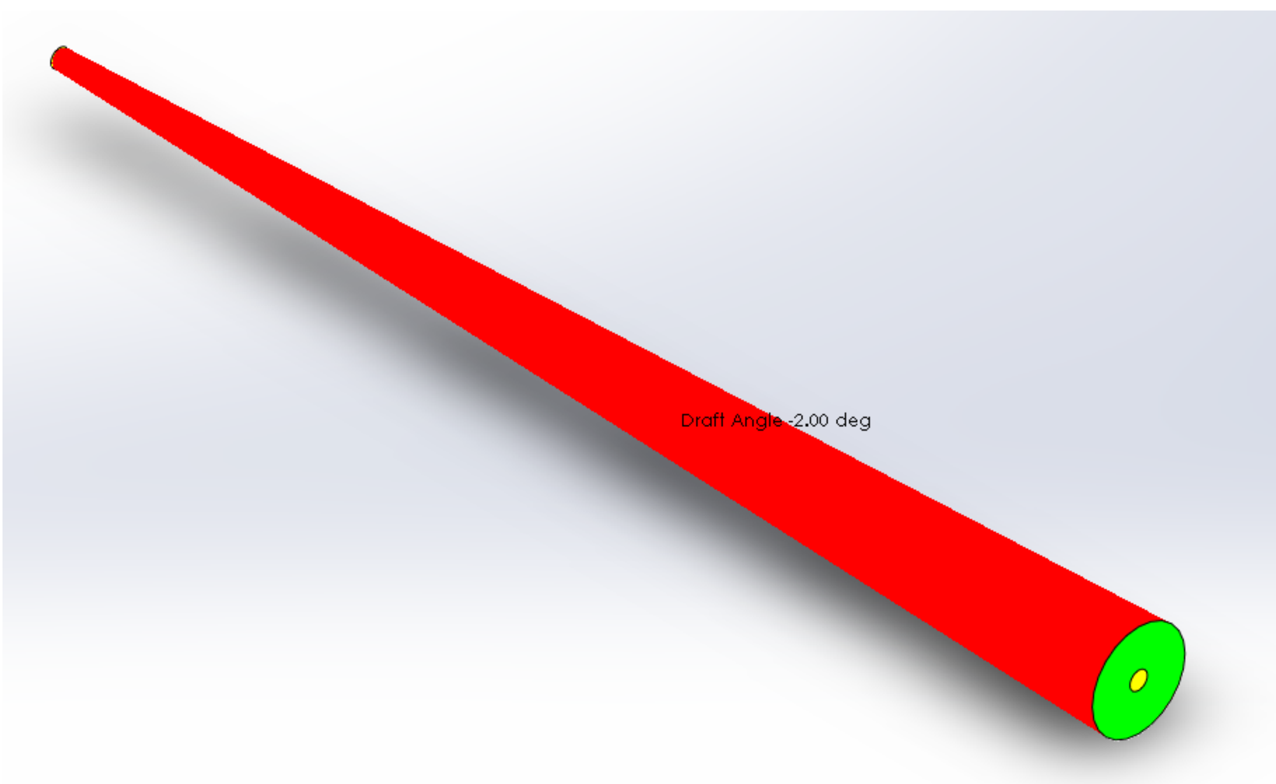


Figure 39: Conveyor belt roller after modification

Figure 40: Legend for draft analysis

After running a draft analysis on our conveyor rollers, our part only displayed yellow on the outer surface of the tube. To modify the design and remove all of the yellow from the draft analysis we edited the feature to include a draft of 2 degrees in compliance with the parameters of the analysis.

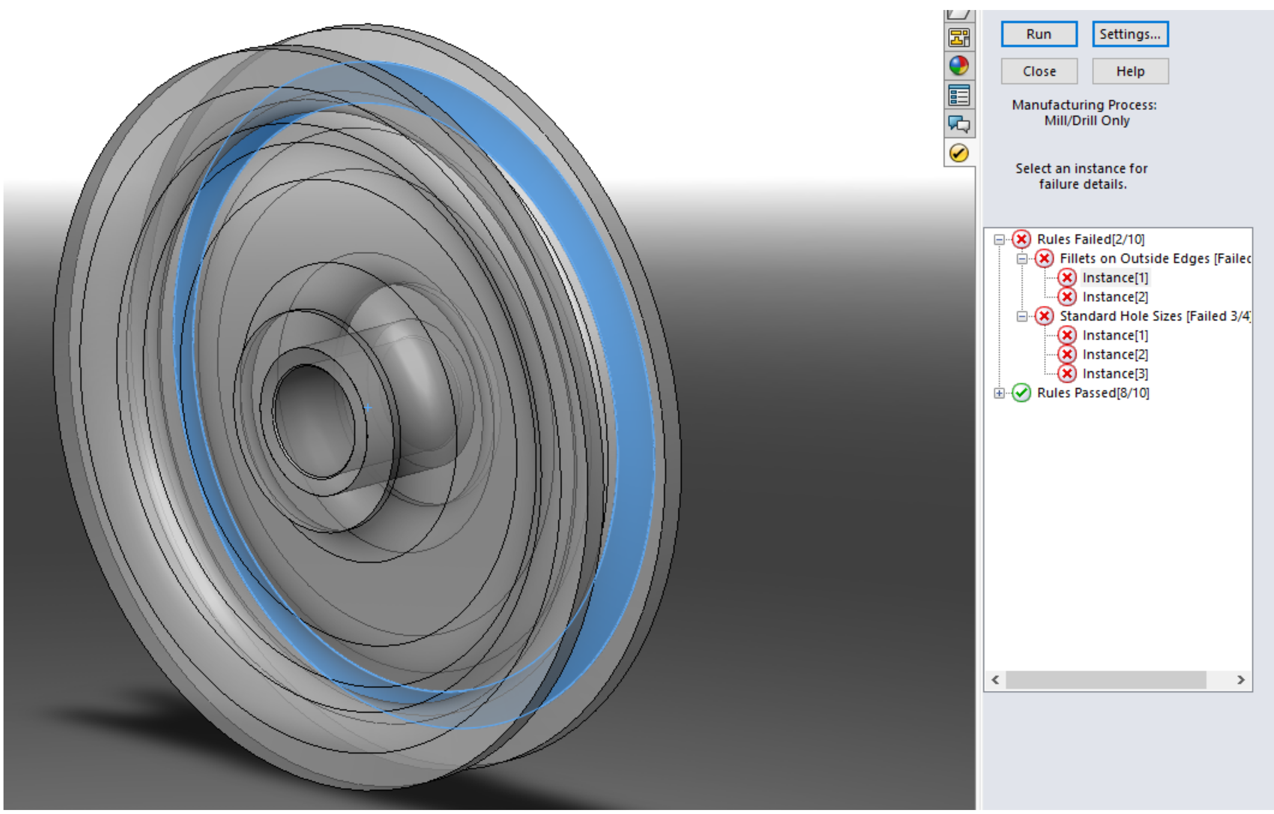


Figure 41: Failed rules instances for Mill/Drill Only

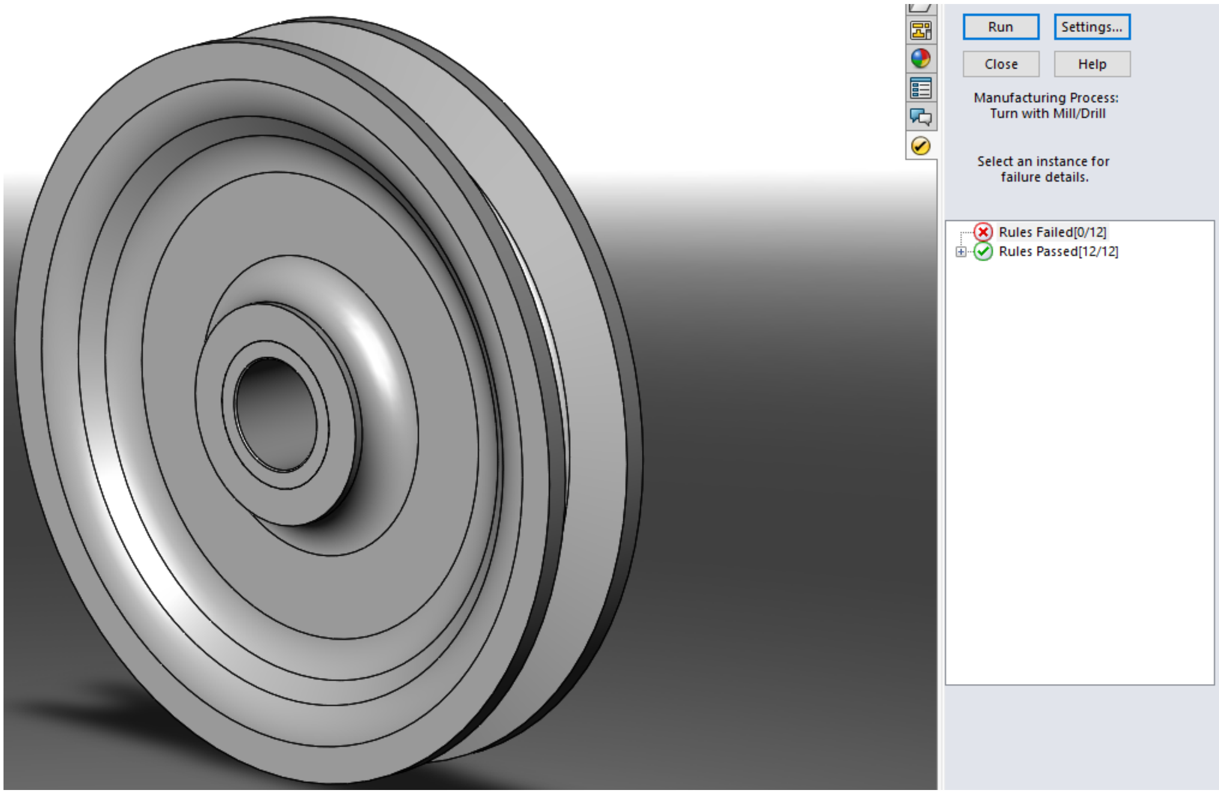


Figure 42: Failed rules instances for Turn with Mill/Drill

Running a DFM analysis on one of our pulleys showed just how hard it could be to manufacture. When running the analysis for mill and drill only, many rules were failed, especially pertaining to the flange and holes of the pulley. When running the analysis for "Turn with Mill/Drill" no rules were broken meaning that it would be easy to make the part using this method.

7.4 Design for Usability

An important factor of our design was ergonomics. One of our customer's main complaint was having to bend over the crops for extended periods of time, which caused discomfort. With our four wheeled push design, the user can easily and comfortably walk along and push the harvester without straining their body. Another feature we included for usability is the collection bag which can be removed and attached easily via velcro straps and handles to carry the produce to another location simply.

8 Discussion

8.1 Project Development and Evolution

Does the final project result align with its initial project description?

- Our final project results partially aligned with our initial project description. Our project had all of the components to theoretically work but our final prototype had some technical difficulties.

Was the project more or less difficult than expected?

– The project was more difficult than expected. Many of the obstacles that came in our path we did not foresee and sometimes we had difficulty overcoming them.

On which part(s) of the design process should your group have spent more time? Which parts required less time?

– We should have spent more time on the more advanced parts of our prototype. For instance, although our design was structurally sound, many of our moving components did not work.

Was there a component of the prototype that was significantly easier or harder to make/assemble than expected?

– The pulley system was significantly harder than we had anticipated due to the fact that no one in our group had ever constructed anything like this system before.

In hindsight, was there another design concept that might have been more successful than the chosen concept?

– We still believe that this was the best possible design.

8.2 Design Resources

How did your group decide which codes and standards were most relevant? Did they influence your design concepts?

– Codes and standards related to agriculture and farms were the most relevant. We tried to influence our design concepts by considering the safety standards for agricultural machines.

Given more time and money, what upgrades could be made to the working prototype?

– Given more time and money, we would make the connections between the woods stronger, getting screws of more appropriate length and making sure they are drilled in straight.

8.3 Team Organization

Were team members' skills complementary? Are there additional skills that would have benefited this project?

– Team members' skills were complementary. We had different entrusted tasks.