SPARTAN ROBOTICS INC.

651

Porter High School

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I. Introduction - Spartan Robotics Inc.

Spartan Robotics Incorporated is an organization that has been on the forefront of robotics technologies in recent years, working to design and develop robotic solutions to a variety of everyday problems. Over the past decade, advances in robotic technologies have allowed for jobs that once could only be performed by humans to be completed by sophisticated machinery, allowing for low-cost solutions to a wide range of business practices. Through the utilization of advanced technologies, well-organized engineering process, and a team of educated and hard-working engineers, Spartan Robotics Inc. has successfully developed numerous robotic solutions for various clients over the last several years. Our most recent solution includes the Tartarus, a robot capable of braving the difficult dangerous conditions of underground mines, in order to efficiently mine and collect various ores and material, and safely return them to the surface. After our great success with the development of this solution, our team sought out another problem that required an engineering touch. This year, our team of engineers were freshly equipped with not only the latest materials and technology, but with innovative and novel concepts, and an unprecedented motivation towards achieving engineering success to create a solution to an everyday issue.

This year's client consists of the BLT Farms, run by Mr. Riley Bread and Family. For over 155 years, this family has run the farm using traditional, old-fashioned methods, while slowing adopting newer technologies, such as tractors and combines. Despite the use of seemingly new equipment, the farm continues to display characteristics of older technologies and is in need of an update. The Bread's four children have since obtained a post-secondary education, and have returned armed with the latest information and technical skills. To help improve the efficiency and productivity of the farm, the children have proposed many ideas that utilize the latest agricultural technologies, including hydroponics and robotic solutions. While the original owners of the farm are resistive to the adoption of these new technologies, the children continue to push the idea of implementing such solutions, arguing that these methods will help achieve greater success. To determine what technological improvements should be implemented on the farm, the family has reached out to Spartan Robotics Inc., seeking input on the best and most efficient methods of agricultural production.

Presented with a new challenge, the engineers of Spartan Robotics Inc. have been given a new opportunity to implement the latest in robotics technologies to design and develop a modern and advanced robotic solution for the BLT Farms. In addition, the employees of Spartan Robotics Inc. are presented with the challenge of marketing their design and creating business practices that would ultimately benefit the company. Building off of knowledge and designs from previous years, Spartan Robotic Inc. aims to create an efficient robot capable of performing the necessary tasks to aid in the agricultural productivity of the farm and to persuade the farm owners towards adopting emerging technologies.

II. Research Paper

Throughout history, farming has been one of the earliest forms of cultivation**.** Our earliest ancestors started out as hunter-gatherers and then moved on towards farming once they realized the vast potential that it had. Until the 1700's, farming techniques were relatively the same[1], but this all changed with the agricultural revolution which set forth a new age in farming. In our current society, robotics is now beginning to be incorporated into farming techniques to make it even more effective.

From the beginning of time, farming has been an integral part of major civilizations such as the Egyptians, Mayans, Sumerians, and Romans. These civilizations had the difficult task of producing enough food for their civilizations to prosper. The Mayans had to make terraces on the hillsides and create steps that would reduce erosion and water runoff[2]. With only simple tools to work with, this task would take a long time and it required hard labor. The Romans, on the other hand, used aqueducts to carry water to their crops[3], and they used a variety of tools such as hoes, spades, and rakes in order to farm, and the Egyptians used wooden plows and sickles to cultivate and harvest their crops. [4] All these ancient civilizations had limited farm technology, but they were successful in farming because of their techniques which ranged from using animals such

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1 Rymer, Eric. "The Story of Farming - Historylink101.com." Historylink101. Accessed September 21, 2016. http://historylink101.com/lessons/farm-city/story-of-farming.htm.

2"Maya Agricultural Methods | HistoryOnTheNet." History on the Net. September 18, 2015. Accessed October 21, 2016. http://www.historyonthenet.com/mayans/maya-agricultural-methods.

3 "Roman Agriculture: Facts About Roman Farms | Primary Facts." N.p., n.d. Web. 21 Oct. 2016.

4 "The Farmer and His Tools - Reshafim." N.p., n.d. Web. 21 Oct. 2016.

as oxen to pull the farm equipment or using a variation of an irrigation system for the crops.

From the moment mankind started farming, we have steadily been making our agricultural techniques and tools more efficient. Advancements in farming have certainly come a long way from when our ancestors first started farming. From the humble ox plow to the mighty tractor, advancements in agriculture have allowed for food to become more widely available for people all over the world. Inventions such as the thresher made farming more efficient since farmers could accomplish more. The threshing machine allowed them to separate the grains from the wheat in a timely manner instead of having to do it by hand. While advancements in farming have yielded positive results, incorporating robotics into agriculture will help maximize the number of crops that can be grown and harvested.

The game this year, Bet the Farm, is all about performing the difficult task of farm work with a robot in order to improve the number of crops that can be harvested. The game field is setup to simulate a small field on a farm with silos, crops, and pig pens. Another interesting thing about the game is that it tries to make things realistic by having real world problems such as growing and harvesting produce or taking care of the livestock that is “roaming” the farm. The game is able to create a competitive atmosphere between the harvesting robots by having them perform a variety of tasks. Each task that is completed by a team’s robot will receive points, and whoever has the most points wins the competition. The tasks that the robot will have to perform include harvesting certain crops such as corn, tomatoes, and lettuce. Not only that, but the robot will need to perform other tasks such as collecting the seeds from a silo, and spreading them in certain areas of the farm. While this game is much more simple than the real world market, it still manages to teach competitors about the real world applications that it could be used for.

The world population is increasing every day and it estimated that the population will reach 9.7 billion people by the year 2050 [5]. This means that food production must rise if we are going to continue to produce enough food to sustain the entire world population. While farmers have been able to do this task for centuries, the demand is now bigger than ever and we need to ease the burden of them having to produce enough food. Especially since two percent of the United States population consist of farmers, and other farmers around the world still use primitive technology to aid them in farming. [6] For this very reason, it is very important for robotics to be incorporated into agriculture. The benefits of having robotics in agriculture will result in a higher production of food which will be very valuable since our population is rapidly increasing.

5"World Population Projected to Reach 9.7 Billion by 2050 ..." N.p., n.d. Web. 21 Oct. 2016

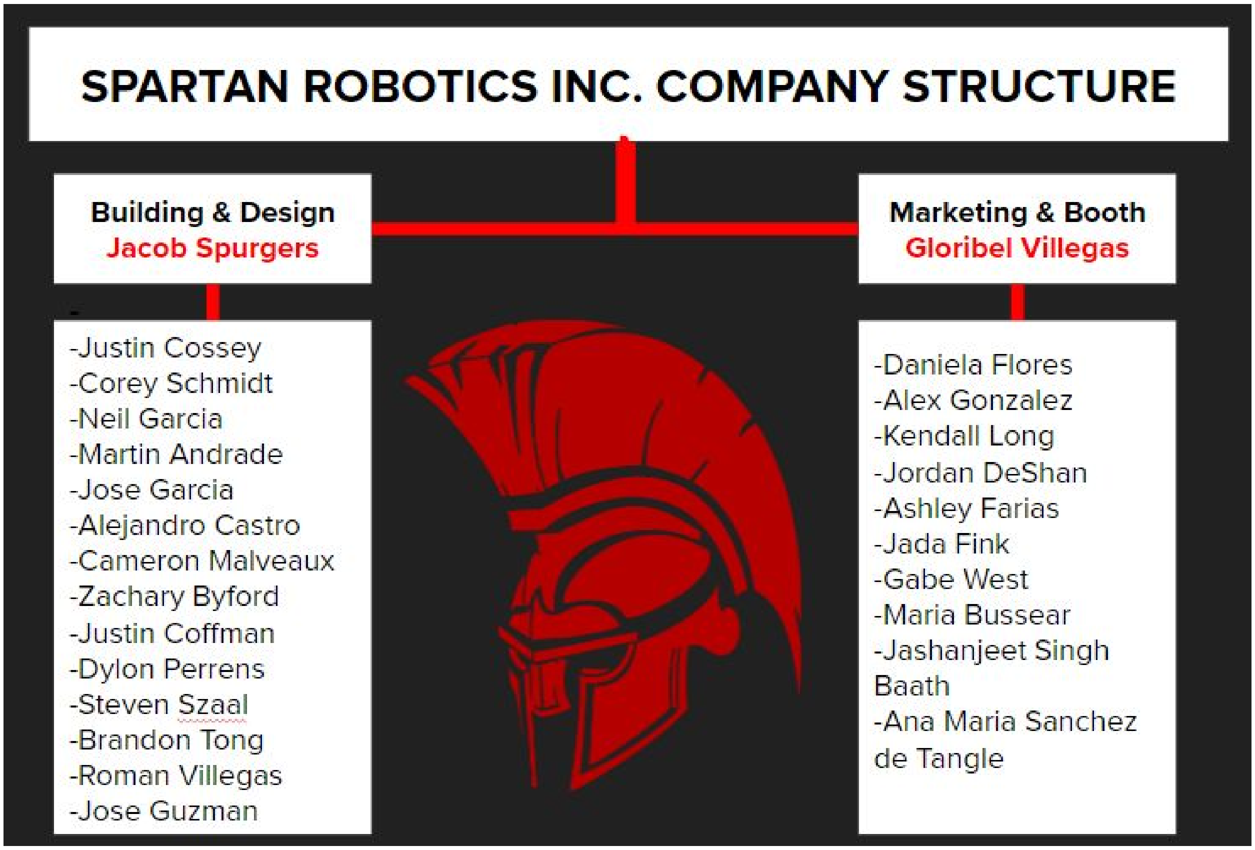
6 "Fast Facts About Agriculture - The Voice of Agriculture ..." N.p., n.d. Web. 21 Oct. 2016.

III. Business Model - Engineering and Marketing

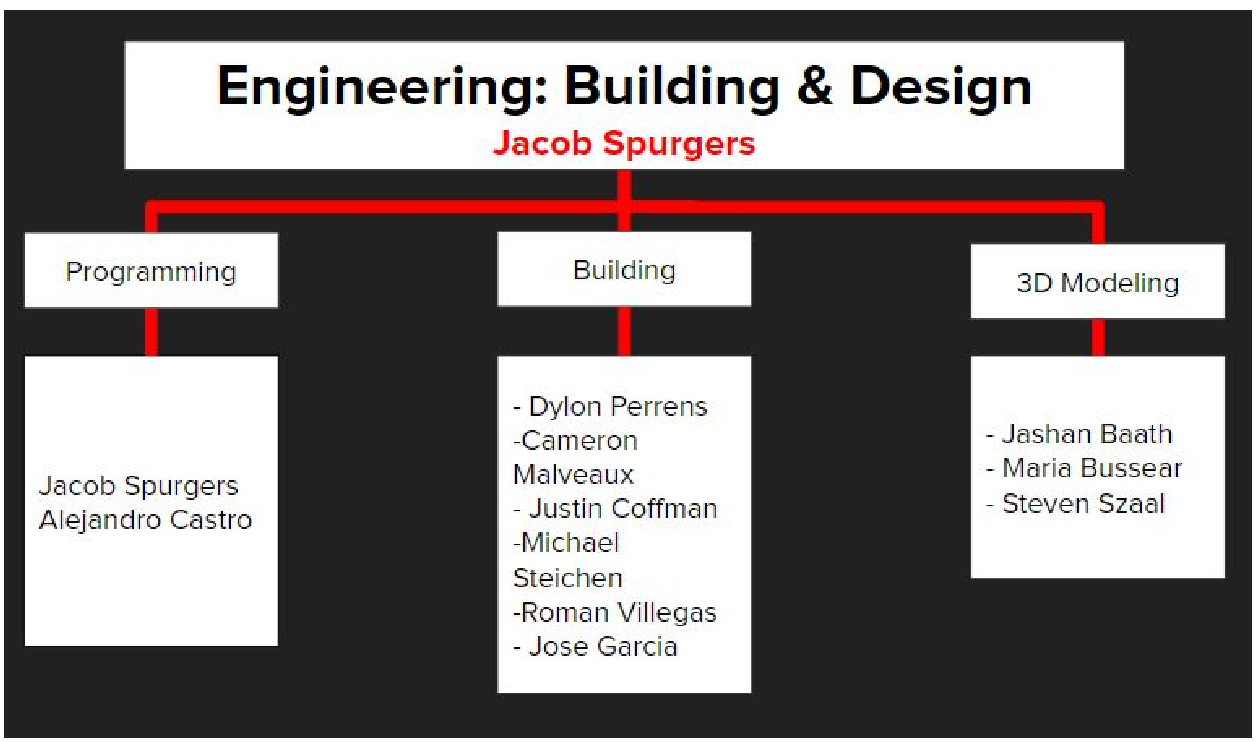
Spartan Robotics Inc. employs a wide and diverse range of employees, in order to achieve maximum success and unity in the field of engineering. Among our employees include many individuals who specialize in specific areas of design, construction, and engineering. In addition, Spartan Robotics Inc. possesses a team of highly experienced businessmen and women, in order to devise marketing strategies to advertise our various products. Both the engineering and marketing teams work in unison and communicate effectively on a regular basis, in order to create a company that is reliable and stable, and capable of creating impressive robotic solutions, all while marketing the importance of the utilization of advanced technologies and engineering strategies.

Overall, Spartan Robotics Inc.'s business model consisted of two primary parts, **Engineering** and **Marketing**:

- **Engineering**: The members of the engineering team were responsible for all aspects of the products created by Spartan Robotics Inc. These team members are responsible for implementing the latest technologies and creating robotic solutions for a variety of issues and proposals presented to them.
- **Marketing:** The members of the marketing team were given the responsibility of marketing and advertising the robot, and building company reputation, in order to influence potential clients to purchase Spartan Robotics Inc. products.



Engineering:



Marketing:

Both the Engineering and Marketing teams were given a variety of responsibilities, in order to ensure the success of both the final robot and the marketing campaign that would help to advertise the benefits and functions of the company's robotic solution. With both teams working in unison, the engineers and businessmen and women at Spartan Robotics Inc. are able to produce reliable and efficient robot solutions, and reach out to a variety of businesses in order to meet their needs.

BEST

BEST Team Demographics – 2016

Submittal of this form is ***required*** as part of the **Robot Compliance Check** conducted at the local hub. **Please complete prior to this check.** Alternate format (e.g., electronic) is acceptable if approved by your local hub.

School Name: Porter High School **City/State:** Porter, Texas

Most correctly describes school location: ☐ Rural ☐ Urban/City ✔Sub-urban

Type of school (check the box): ✔Public ☐ Private ☐ Home school ☐ Other:

Type of school (check the box):
☐ Middle/Jr. High ✔High School ☐ K-12 ☐ Other: ____________________

Which most appropriately describes the total student population at your school:
☐ 1 to 399 ☐ 400 to 799 ☐ 800 to 1199 ✔1200 to 2000 ☐ greater than 2000

Number of students on the BEST team by grade:
K - 5th: 6th: 7th: 8th: 9th: 2 10th: 5 11th: 10 12th: 7

Number of students on the BEST team by race (optional):
African-American: 2 Asian American: 4 Hispanic: 10 Native American: 0
White: 8 Other:____

Total number of students on the BEST team:
Number of males: 16 Number of females: 8 Total: 24 (males + females)

Total number of students who worked on the robot:
Number of males: 14 Number of females: 3 Total: 17 (males + females)

Total number of students who worked on the BEST Award:
Number of males: 2 Number of females: 5 Total: 7 (males + females)

Total number of ADULT MENTORS assisting your BEST team (NOT including teachers): 0

How is the BEST program implemented at your school?
✔ Extracurricular activity ☐ Classroom integration ☐ Other____________________

Approximate number of students on your BEST team that are	Male	Female	Total
• intending to pursue higher education (tech school, college, university)	16	8	24
• likely to take STEM courses in higher education	16	8	24
• likely to pursue STEM-related degrees in higher education	16	8	24

Approximate number of students on your BEST team likely to pursue careers in engineering, science, math, or technology:

Number of males: 16 Number of females: 8 Total: 24 (males + females)

Our team/school used the following software provided by BEST Robotics (check all that apply):
☐ MathWorks Simulink ✔easyCv4 ✔RobotC
☐ SolidWorks ☐ HSM Works ☐ Siemens SolidEdge ☐ AutoDesk Fusion360
☐ Mathematica ☐ Solidwize (SolidWorks Training)

IV. Client Needs and Considerations

This year's client is the BLT Farm, run by Mr. Riley Bread and Family. For over 155 years, the farm has been run using traditional methods, and outdated technologies. While the adoption of innovative solutions to agricultural challenges has taken place, progress towards a modern and efficient farm has been slow. The children of the Bread Family have returned from college and brought with them many ideas that they believe would help to improve the efficiency of the farm, including the use of hydroponics, and automated robots. To decide with technological implementations would work best on the farm, the family has reached out to Spartan Robotics Inc., requesting the creation of various designs and solutions that would help the family achieve greater success on the farm.

The engineers at Spartan Robotics Inc. are presented with a major challenge concerning the needs of the farm. In order to efficiently operate on the farm, the proposed robotic solution must be capable of achieving a variety of agricultural tasks. Among these tasks include:

- Planting and Cultivating Corn Seeds
- Harvesting and Delivering Ripened Corn
- Harvesting and Delivering Hydroponic Tomatoes
- Harvesting and Delivering Hydroponic Lettuce
- Securing loose pigs, and delivering them to their proper holding areas
- Operating Water Valves present on the Farm.
- Managing the rough and difficult terrain of the farm itself.

The collection of these ideas means that the engineers at Spartan Robotics Inc. are presented with a major challenge. However, through the use of new technologies, innovative solutions, and a sophisticated design process, the engineers will be able to design and develop a robotic solution capable of performing all the necessary tasks efficiently.

To test the success and potential of various design prototypes, the BLT Farm company has organized a region-wide competition designed to simulate the conditions of the family farm. The competition will consist of a game-type simulation, that will allow Spartan Robotics Inc. to test and prototype a variety of embodiment designs and engineering solutions, that can then be utilized within the final product. By competing in this competition, Spartan Robotics Inc. will have the opportunity to design a scaled prototype of our final robotic solution and make necessary changes and improvements based on the performance of the robot.

To perform within the competition itself, the engineers of Spartan Robotics Inc. will design multiple designs, each capable of performing a variety of different tasks. One of these solutions will be selected, and modified in order to function according to the rules and guidelines of the simulation. In addition, the company will be challenged with marketing the various robotic solutions, persuading potential buyers to select the creations of Spartan Robotics Inc. Such marketing practices must accomplish a variety of tasks, including:

- Informing potential buyers of the various solutions offered by Spartan Robotics Inc.
- Highlighting the features of the robotic solutions presented by Spartan Robotics Inc., as well as their primary functions and uses in agriculture.
- Persuading potential clients of the benefits of selecting Spartan Robotics Inc. products, and informing them of the immense Return on Investment (ROI) that can be attained when using such technologies.
- Establishing relationships with current and future clients, and obtaining further proposals and opportunities for the engineers of Spartan Robotics Inc. to apply their knowledge of engineering and technology.

V. Brainstorming and Creating Game Strategy

This year's competition has been given the name "Bet the Farm." In this competition, teams are challenged to design and create a robot capable of performing a variety of agricultural tasks on the farm. The game takes place on a 24' x 24' field, centered around a windmill. Within the field itself, there are four corn plots located for harvesting corn, and planting seeds. In addition, there are two hydroponic growing stands, located in opposite corners of the game field. In the opposing corners are grain silos with chutes that seeds can be funneled into. Each team is located near an area where they are given the opportunity to harvest corn and plant seeds. In addition, robots are allowed to traverse the field, in order to collect hydroponic plants present on their respective growing regions. The game field remains open, meaning that teams are free to plant and harvest in whatever regions of the field they desire, however, area's that are restricted to specific teams include their water valves, located at the base of the center windmill.

Robots taking part in the game are challenged to collect the various crops located around the field, as well as perform various tasks, such as controlling a water valve and collecting stray pigs located around the field. In order to score points, robots can perform a variety of tasks, including:

- Planting corn seeds
- Harvest and deliver ripe corn
- Harvest and deliver hydroponic tomatoes
- Harvest and deliver hydroponic lettuce
- Corral and secure loose pigs and feed them
- Turn on the water valve

Each game piece is capable of scoring each team a certain number of points. In addition, many bonuses can be earned for completing specific tasks.

Scoring Details for "Bet the Farm"

Game Piece	Scoring Details	Value	# of Pieces on the Field

Water Valve - Under or Over Water	Valve handle moved from Off to underwater or overwater zone	50	
Water Valve - In Optimum Position	Valve handle moved to Optimal Water zone	100	
Pigs secured in pen	Each pig touching the floor within the pig pen, and gate closed magnetically	10	20
Heads of Lettuce	Lettuce in lettuce section of produce stand, and touching floor of produce stand	15	16
Tomatoes	Tomatoes in tomato section of produce stand and touching floor of produce stand	20	64
Harvested Corn in Community Bin	Each corn supported by the floor of the center section of the bin (worth 5 points per team).	5	96
Harvest Corn in Team Bin	Each corn supported by the section of the bin color coded for each team.	20	96
Corn Seeds Planted	Each seed within a planting hole and touching the bottom of the hole.	10	24 Per team
BONUS - Feed Pigs	Bonus for each corn ear touching the floor within the pig pen and closed magnetically. Maximum of one Corn Ear per pig.	10	24 Per team
BONUS - Plant and Harvest Corn	Bonus for every pair of corn (one seed planted and one ear harvested and placed in team bin).	20	
BONUS - Harvest Diversity	Bonus if a team has scored at least 1 of each harvested crop (Corn, Tomato, and Lettuce). Only corn scored in the individual's team account for a bonus, can be repeated 4 times for a maximum of	50	

	200 points per match.		

Game Rules:

To allow for a safe and fair game, the game has been created with a set of rules and guidelines, which every team must follow. Prior to the beginning of each round, teams are located near areas from which they can harvest corn and plant seeds. The overall game field is open, meaning teams can plant and harvest crops in whichever area of the field they choose. However, teams must use a specific water valve and are restricted from using those of other teams. Both robots drivers and spotters will be located outside of the field, in their respective areas.

Driver and Spotter Allowed Activities:

- Spotters are allowed to touch the seed tray, and seeds that have not been through the chute at any point during the match. Spotters are allowed to touch the inlet to the seed chute, and load seeds into their team's chute above the silo during the match.
- Drivers and Spotters must abide by the BEST Generic Rules

Driver and Spotter Non-Allowed Activities:

- The Driver and Spotter are not allowed to leave their respective areas during the match.
- The Driver and Spotter are not allowed to touch game pieces, the game field, or their robots during their match.
- The Driver is not allowed to touch any pieces other than the silo chute, seeds that have not been through the chute, and the seed tray.
- The Spotters and Drivers are not allowed to throw anything.

Any violations of the BEST rules during a match will result in a 20-second penalty, while the continued action may result in disqualification.

Game Strategies:

Before designing our robot, our team of engineers had to create a game strategy beforehand, in order to determine the functions that were necessary when designing the robot itself. To conceptualize a variety of game strategies, our team of engineers split off into numerous groups, each creating their own unique game strategy. Through this activity, a variety of game strategies, that utilized different functions and designs, were introduced, allowing our team to improve upon the many ideas, and ultimately select a single strategy to use. Overall, our engineers assembled a list of possible functions that the final robotic solutions would have to accomplish. Among these included:

- Obtaining Corn Seeds, and properly placing them in their specific locations.
- Collecting and delivering corn to the proper scoring bins.
- Harvesting hydroponic tomatoes from hydroponic stands, and delivering them to the produce stand.
- Harvesting heads of lettuce from hydroponic stands, and delivering them to the produce stand.
- Controlling the water valve, and positioning the valve to the proper configuration.
- Collecting loose pigs, and returning them to their proper locations.

These operations constitute the various ways in which points could be scored in the game. Team members split off into sections and began brainstorming various strategies that took advantage of the methods of scoring points. The ideas presented by our teams were extremely diverse. Each was unique, and utilized the parts of the game field in different ways, in order to score the most amount of points in the given time.

Proposed Game Strategies:

- **BLT - Bacon Lettuce Tomato:**
    - This game strategy aimed towards collecting the most amounts of lettuce and tomatoes, as well as collecting the stray pigs located around the field.

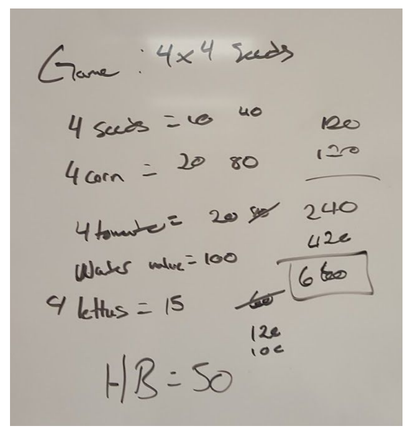
        - Each head of lettuce is valued at 15 points, with a total of 16 pieces located throughout the field.
        - Each tomato is valued at 20 points, with a total of 64 pieces throughout the entire field.
        - The pigs located around the field must be returned to the starting box. If returned, each pig is worth 10 points.
    - Overall, given that all possible points were scored, using this strategy would allow for a maximum of 1570 points. However, because the locations of each game component were located around the field, our team determined that collecting every single game piece would be too difficult, and would not be completed in time. Instead, collecting only the pieces present on the robots specified region, this strategy totaled 810, given that every potential piece is successfully collected and scored.
        - The probability of achieving a perfect game was determined highly unlikely by our team of engineers. In addition, collecting every piece, and returning multiple times to each stand would be time consuming, and thus, each piece would likely not be collected resulting in a lower score. Taking these factors into account, our engineers hypothesized that using this strategy could score around 300-500 per round.
- **BLC - Bacon Lettuce Corn:**
    - The BLC strategy was similar to the BLT, however, instead of collecting tomatoes, the robot would be tasked with collecting corn. Using this strategy, drivers would be required to collect all stray pigs and return them to their appropriate location. Then, the robot would grab all the lettuce located at a single hydroponic stand, and score them in the produce stand, for a total of 120 points. Afterward, the robot would be tasked with collecting as much corn as possible, until the allotted time runs out. Our

engineers estimate that the robot would be able to collect a total of between 5 and 8 pieces of corn, for a score of between 100 and 160.

        - In addition, the pigs scored into the pig pen would yield an additional 50 points towards the total score per round.

    - While this strategy could potentially score a large number of points, none of the bonuses are taken advantage of, leading many of the engineers at Spartan Robotics Inc. to dismiss the game strategy. Still, some believe this strategy could serve as a backup strategy, in the event of robot failure during the game.

- **4 x 4 - Lettuce, Tomato, Corn, and Water Valve**
    - This strategy took advantage of four components of the game field: the lettuce and tomatoes located on the hydroponic stands, the collectible corn located on corn stalks, and the water valve. Particularly, the game strategy relies on the harvest diversity bonus, which rewards 50 points for every 1 lettuce, corn, and tomato successfully scored. This bonus could then be applied a total of 4 times, totaling a bonus of 200 points per round. In addition, turning the water valve into the “on” position would score 100 points.

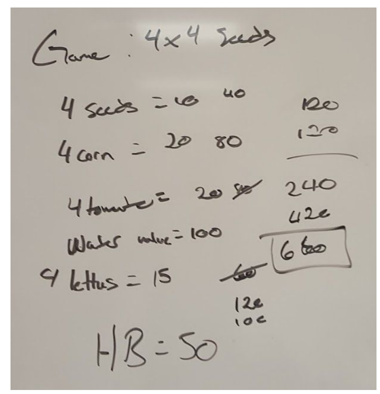


    - The goal of this strategy would be to collect four pieces of lettuce, corn, and tomatoes, in order to obtain the harvest diversity bonus a total of four times. In addition, the water valve would be positioned in the “on” configuration, allocating 100 additional points. If time remains, the robot could return to collect even more pieces, scoring additional points.

- Scoring Details:

Game Piece:	Points:	Number of Pieces:	Total Score:
Lettuce	15	4	60
Tomato	20	4	80
Corn	20	4	80
Water Valve	100	1	100
Total Points Possible per Round:			520

- **4 x 4 Plus - Lettuce, Tomato, Corn, Water Valve, and Seeds**
  - The 4 x 4 Plus game strategy is essentially identical to the 4 x 4 strategy, expect an additional task, collecting and planting corn seeds will be performed. The strategy, like the original 4 x 4 strategy, takes advantage of the harvest diversity bonus, collecting four of each of the required pieces in order to score a total of 200 bonus points per round. In addition, by scoring the corn seeds, our team can earn additional points, through the plant and harvest corn bonus, which awards 20 points for every pair of corn collected and seed planted. By planting only 4 seeds, and harvesting the 4 corn needed for the original strategy, the team could earn a total of 80 bonus points per round, through the Corn and Seed bonus.



  - This strategy would prove to be more difficult than the original 4 x 4 strategy, and would also require additional time, and greater skill from both the drivers and the spotters. Thus, this strategy has been considered a more in-depth strategy, given that enough time remains within each round to perform the additional activities.

Game Piece:	Points:	Number of Pieces:	Total Score:
Lettuce	15	4	60
Tomato	20	4	80
Corn	20	4	80
Water Valve	100	1	100
Total Points Possible per Round:			520
With Corn and Seed Bonus:			600

VI. Selecting Our Game Strategy - Evaluation of Design Alternatives

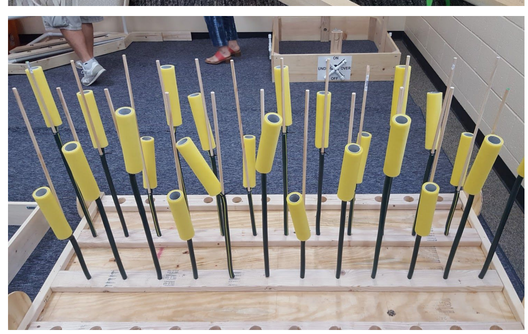
Now presented with a wide variety of potential game strategies, the engineers of Spartan Robotics inc. were tasked with selecting the most favorable strategy, that would produce the greatest amount of points in the lowest amount of time. Our engineers met frequently to discuss the positive and negative aspects of each strategy, in order to determine which concept to implement. To decide which game strategy to use, our team voted on the most ideal strategies, and then created a decision matrix, weighing the benefits of the various concepts, and scoring them based on their potential. Factors that were taken into account within the decision matrix included ease of design and construction, efficiency, and total points scorable.

**Values range from 1-4, four being the highest and most favorable.*

Strategy:	Ease of Construction	Efficiency	Total Points Scored	Total:
BLT - Bacon Lettuce Tomato	4	2	1	7

BLC - Bacon Lettuce Corn	3	1	1	5
4 x 4 - Lettuce, Tomato, Corn, and Water Valve	2	3	3	8
4 x 4 Plus - Lettuce, Tomato, Corn, Water Valve, and Seeds	1	3	4	8

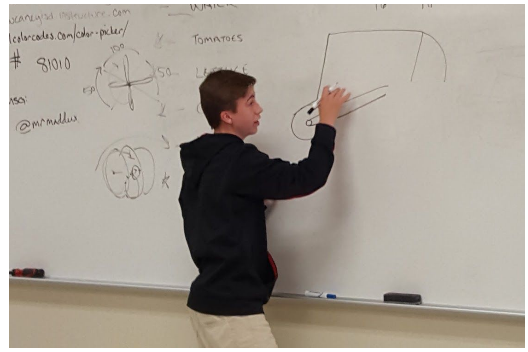
Based on the following decision matrix, our team ultimately decided that the most ideal strategies to implement were the 4 x 4 and 4 x 4 Plus strategies. Because our robot would be limited on time, our team decided that our primary tasks included those dictated by the 4 x 4 strategy, while secondary tasks would include the additional functions present in the 4 x 4 Plus strategy. Ultimately, based on these strategies, our robot now had a list of functions that were necessary, in order to score points based on our strategy. Among these functions include:

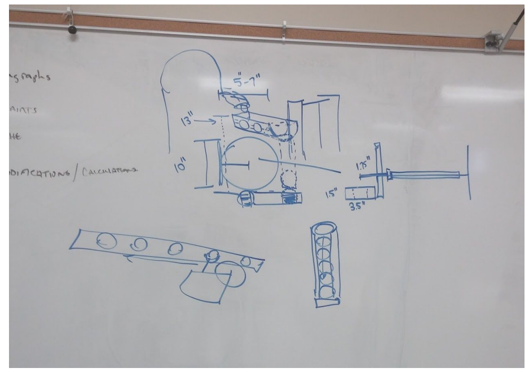


- Controlling the Water Valve
- Collecting Corn and placing it in the scoring bin
- Collecting Tomatoes and Lettuce, and placing them in the Produce stand
- Collecting the Corn Seeds, and properly placing them in their scoring areas.
- Maneuvering quickly and efficiently around the field, giving the driver the most optimal control and handling.

Given this list of tasks, our engineers were able to begin working on potential embodiment designs for the robot itself, creating various prototypes that would allow our team to test the functionality of each proposed part.

VII. Embodiment Design - Offensive and Defensive Evaluation





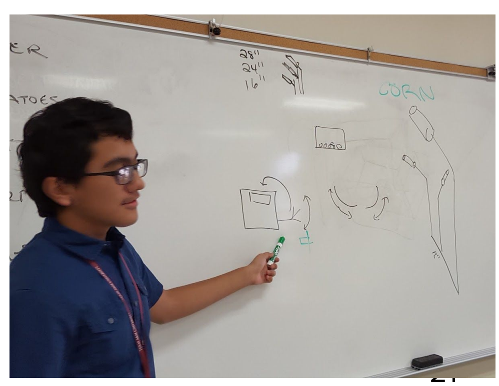
Now given a set of tasks that the robot must accomplish, the engineers of Spartan Robotics Inc. were able to begin designing and prototyping various embodiment designs that would be capable of performing the necessary functions. Similar to selecting our game strategy, our team of engineers split off into groups, each focusing on a certain aspect of the robot. Each group was tasked with creating multiple potential designs that would allow the robot to perform the various tasks. Designs were then analyzed and examined but the whole engineering team, in order to improve, and ultimately decide on the final embodiment designs to implement.

Each individual group focused on one of the following functions, creating embodiment designs and prototypes to test their functionality:

- Drive Train/Chassis
- Methods for Collecting Corn, Lettuce, and Tomatoes
- Methods for Collecting and Storing Seeds, and Dispersing them into Scoring Sections
- Systems of Dumping Collected Crops into Proper Scoring Bins

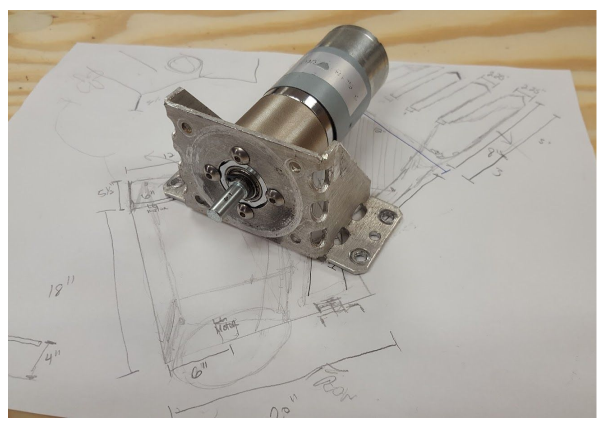
As teams brainstormed various ideas for potential embodiment designs, our engineers came together to share and discuss their ideas, in order to determine which concepts would prove most effective for the robot.

Drive Train/Chassis:

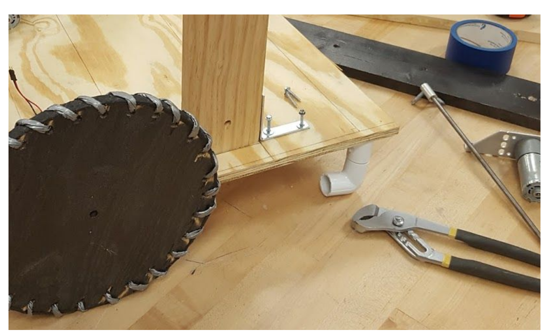


The drivetrain and chassis are certainly one of the most important components of any robotic solution. The chassis provides a fundamental structure from which all other components of the robots can be attached. The importance of the chassis means that the structure must be rigid and stable, providing the optimal efficiency for the final robotic design. In addition, in order to obtain maneuverability across the field, the robot required some method of transportation. This came through the design of the drive train, which utilized motors to drive two large wheels, providing the primary means of movement for the robot. Similar to last years design, our wheels possessed small holes around the rim, to allow for duct-tape threads to be weave through the wood. Using this thread, the wheels would gain better traction, increasing the maneuverability of the robot. In addition, PVC skids were created to allow the rest of the robot to easily move across the game field.

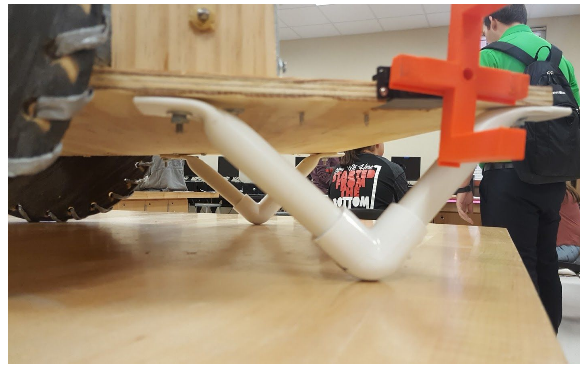
- The chassis consisted of a single sheet of ½" plywood, dimensioned at approximately 18 x 24 inches. Towards the back-end of the sheet of plywood, metal large motor mounts were screwed into the outer edges, allowing our engineers to attach motors perpendicular to the direction of the plywood sheet. Doing so allows us to position two 10" diameter wheels on either side, providing our primary method of movement. This sheet of plywood was fairly light, but strong enough to allow all our robot's components to rest securely on the chassis.

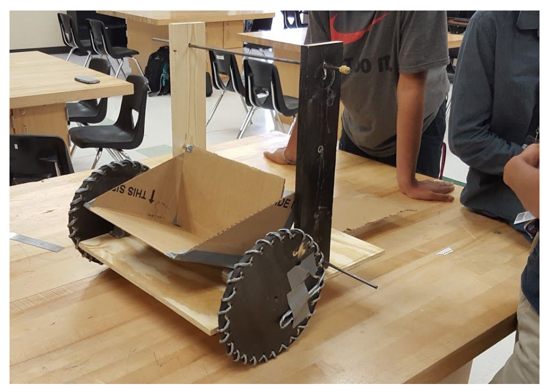
- To drive the two wheels, two large motors were attached to the base chassis. These motors directly drove the two wheels, providing a large amount of torque, giving our robot the ability to maneuver effectively around the field. To help keep the remaining



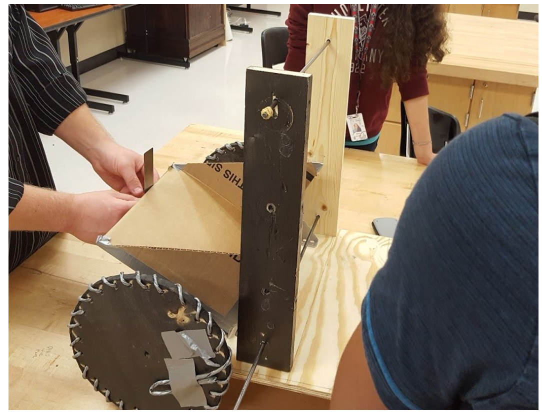
plywood level with the wheels, PVC skids were created, heating the PVC piping, and bending it to the proper position. These skids would help the robot further maneuver around the field, without limiting its ability to move. Our first skid designs consisted of an elbow piece that rested below the plywood sheet. A t-shaped PVC connector was cut in half and then secured into the chassis using screws. Then, using small PVC pipe pieces and PVC glue, the elbow connector was connected to the T piece, creating a skid that allows for easy movement for the robot. After prototyping this design on various material (tile, carpet, etc.) our team decided that this design required improvement. To create better maneuverability for the final robotic solution, our engineers created a new design of skids, then worked through two bent PVC pipes connect with a single 90 elbow connector. These designs proved to be much more efficient, allowing for greater control of the robot across the field.



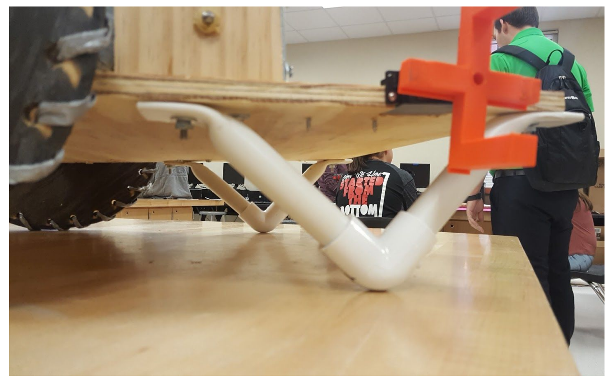
- Towards the middle of the base sheet, two large wooden towards were installed vertically. These towers would serve as the basis for an elevating claw, whose function included collecting corn, lettuce, and tomatoes. The towers were secured by screwing into the base, and fastening L-brackets to hold them in their proper location. From here, our team was able to mount the various electronics and motors necessary for robotic functionality. On the left tower, the VEX cortex was mounted, along with both of the large motors used to drive the two metal shafts. On the right tower, holes were drilled to secure the metal shafts, and cardboard bumpers were fastened onto the outer side of the tower.

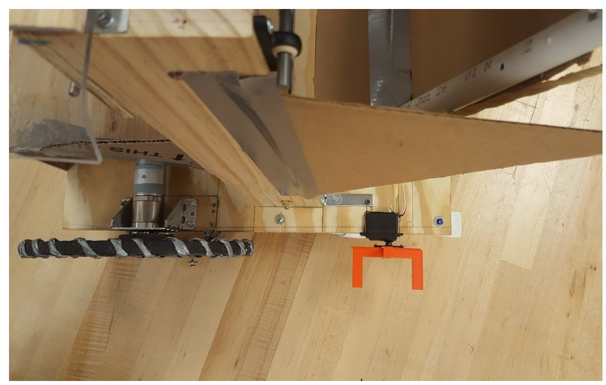


- Holes were drilled towards the top and bottoms of each wooden tower, at symmetrical locations, to create slots for long metal shafts, and pivot points for our forklift mechanism. Motors would drive these metal shafts, allowing us to elevate the forklift using a pulley system. The string would be fastened to each metal shaft, and then fastened onto the forklift arms, causing the arms to rise and fall with the rotation of the shaft.

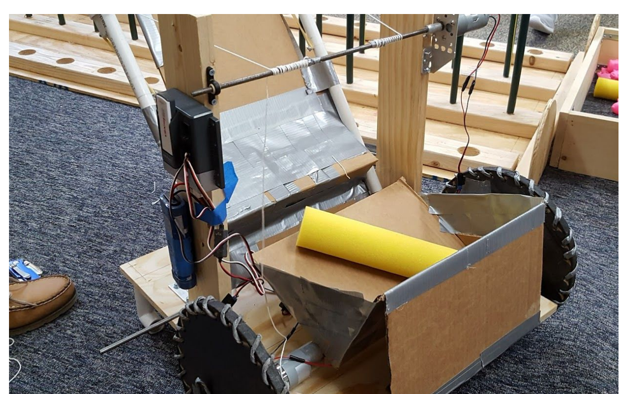


- To operate the water valve, our team of engineers decided to create a 3d printed claw, that would be attached to a servo. This claw would attach to the water valve located on the field, and rotate in order to position the water valve onto the on position. Using the 3d printed part, we were able to dimension the component exactly to fit the dimensions of the PVC water valve, allowing for easy operation and increased driver control. The claw was then mounted along with the servo on the base chassis of the robot, in a position that would allow the driver to easily maneuver to the pipe, and operate the servo.

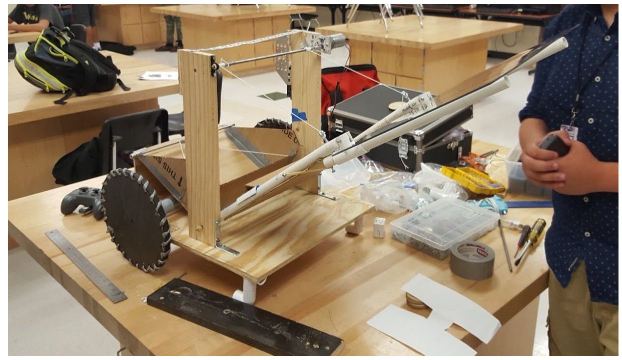




- In order to dump the collected game pieces from the robot, our team of engineers created a bucket that would elevate with the use of a rotating shaft. The initial designs were created with cardboard and were

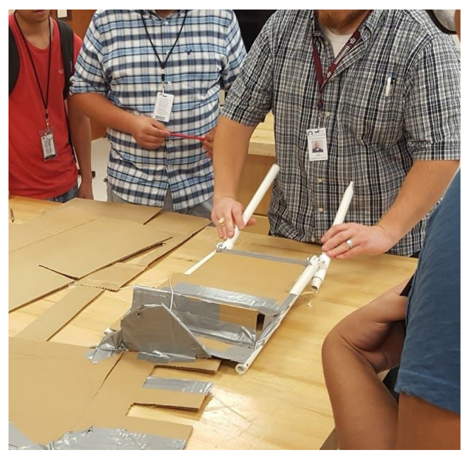


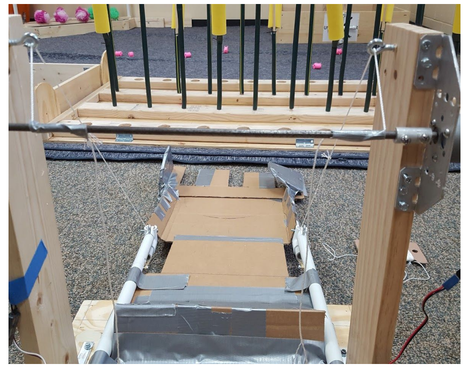
fastened to a rotating shaft, creating a pulley-like mechanism that pulls on one side of the bucket, causing the contents to fall out the other side. After prototyping our initial designs, our team created the official bucket using thin plywood in combination with cardboard. Using these materials would create a heavier design, aiding traction on the rear wheels, and creating a more rigid and stable component. Strings were then attached through I-bolts on the bottom left and right sides of the bucket, closest to the center of the robot. The string was strung through these bolts and then fastened onto the rotating shaft, allowing the driver to operate the bucket controls more easily.



Fork-lift Mechanism:

- The primary component of our robot was our lifting mechanism, which served as our method of collecting corn, lettuce, and tomatoes. Two long PVC pipes were used to create the initial structure of the lifting mechanism. The two PVC pipes had a pivot point towards the middle, allowing the outer PVC tubing to fold inwards, creating a more compact design. Using the elasticity of multiple rubber bands, these inward tubes could be sprung outwards, into their proper positions. This mechanism was used so that the starting size of the robot would fit within the dimensions required by the game rules. Upon starting each round, these arms would be sprung into their proper positions, allowing for the collection of game pieces. To help create more rigidity between the two PVC pipes, a PVC T-connector was cut in half and glued onto both sides of the arm. Then, a single

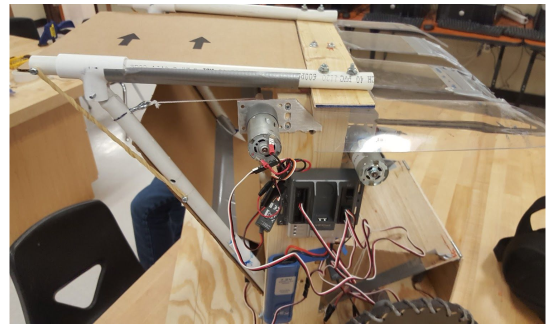




12” tube of PVC cut in half was glued between the two sides, creating structural support for the entire arm. In addition, cardboard cutouts were added in between the PVC pipes, to create a platform for the collected game pieces to travel on, into the bucket.

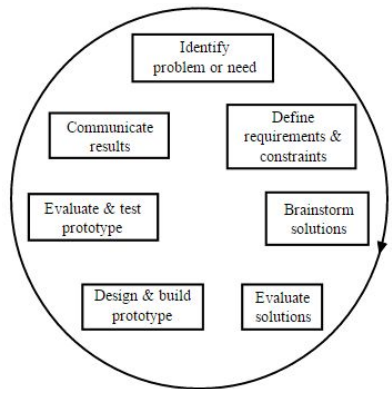
- At the ends of the PVC piping, our engineers fashioned a claw-like mechanism, that possessed slots that would allow the robot to move onto the tubes holding up the corn pieces. From here, the driving could elevate the arms back towards the robot, causing the pieces of corn to be pulled up, into the claw, and down into the bucket. From here, the robot would travel to the scoring bin, where its contents would be dumped to be scored. In addition to collecting corn, this claw design would allow the robot to collect the tomatoes located on the hydroponic stands. By placing the string holding the tomatoes between the gaps on the claw teeth, the driver could raise the claw, and pull the individual tomatoes of their velcro fasteners, and into the bucket. Prototypes of these designs were created by our engineers, initially using cardboard, and tested using the actual game pieces as the Sam Houston State University. After the functionality of the designs was agreed upon, our engineers created more rigid components, utilizing different materials, such as acrylic and plywood. These new parts would replace their identical parts, creating a more stable and efficient robot, that offers easier driver control.

- In order to collect the lettuce, our engineers created metal hooks, using the provided piano wire, and then fastened them onto the edge of the claws. Using these hooks, the driver could position the robot right in front of the lettuce heads and then hook onto them with the piano wire, allowing the driver to move the collected pieces into the produce stand. In total, 4 hooks were created using the piano wire, and fastened onto the two middle claws, using epoxy and duct tape.



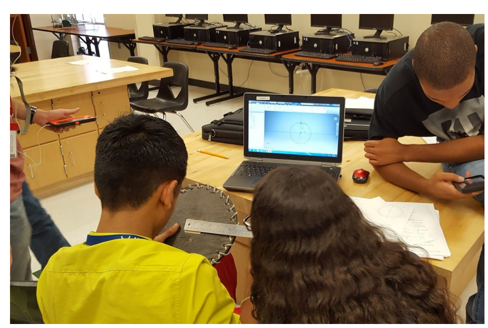
Engineering Design Process:

- In creating each component of the robot, our team of engineers utilized an extensive engineering design process, allowing all members of the team to properly analyze and evaluate the designs presented. Using these steps helped to ensure accuracy between the many stages of engineering that occurred while creating our robotic solution. Overall, the use of a specific engineering process allowed our team to create an effective and efficient design.

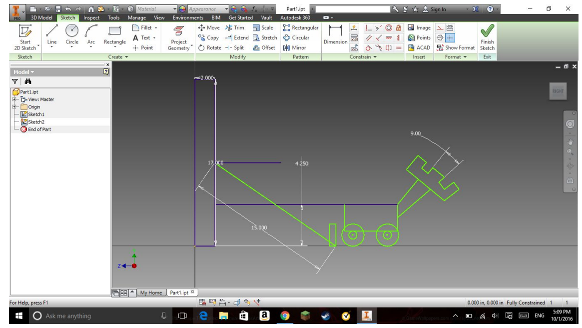


Using Autodesk Inventor and CAD:

To ensure accuracy within our designs and concepts, our engineers focused on sketching the components of the robot within Autodesk Inventor, allowing our team to agree on specific dimensions and designs for embodiment concepts. The use of Autodesk Inventor is an important skill among engineering, and by utilizing the program, our engineers gained experience with the software, increasing their abilities to take advantage of the software.



The many drawings created by the 3D modeling team allowed both the design and build teams to accurately model and create the components of the final robot. Using the CAD drawings, accuracy between the design and build teams could be better ensured, creating a more stable and efficient robot. In addition, CAD was used to model and create the 3D printed claw, which serves as the robot's primary means of operating the water valve.



IX. Safety

The safety of our team members was a primary concern during the construction of the robot. All engineers were required to take a safety assessment test, evaluating an individual's ability to perform safely in the workplace, and use power tools properly. In order to continue with the remainder of the engineering process, all our engineers were required to complete the safety test, and score a 100. Doing so would ensure that all engineers were educated on proper workplace procedures, and would act properly when working on our robotic solutions.

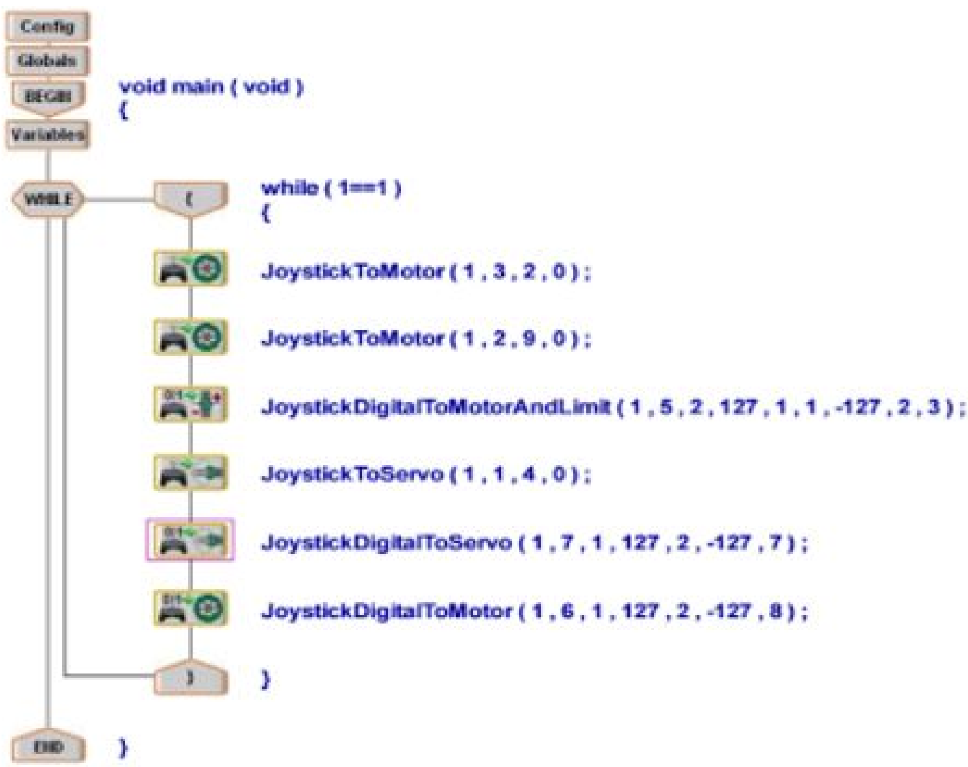
Regular safety precautions were utilized during the construction of the robot. All engineers were required to abide by these rules and guidelines, in order to ensure the safety of all team members. Among these rules and guidelines included:

- Wearing safety glasses at all times
- Always having adult supervision while working with power tools
- Never entering the shop without permission, and without a partner
- Keeping all tools in proper locations, and returning them after their use

X. Programming Code

The code that would allow the robot to function was created using the EasyC software program. This program serves as a medium to create functions for the robot, allowing the user to control the various components using a wireless remote. By using EasyC, our engineers were able to take advantage of the drag-and-drop system of programming, allowing for greater ease and driver control.

EasyC Programming Flowchart:



EasyC Raw Code:

```
Main 1
#include "Main.h"
void main ( void ) {
while ( 1==1 )
{
JoystickToMotor ( 1 , 3 , 2 , 0 ) ;
JoystickToMotor ( 1 , 2 , 9 , 0 ) ;
JoystickDigitalToMotorAndLimit ( 1 , 5 , 2 , 127 , 1 , 1 , -127 , 2 , 3 ) ;
JoystickToServo ( 1 , 1 , 4 , 0 ) ;
JoystickDigitalToServo ( 1 , 7 , 1 , 127 , 2 , -127 , 7 ) ;
JoystickDigitalToMotor ( 1 , 6 , 1 , 127 , 2 , -127 , 8 ) ;
} }
```

The following code allows for user control of the two large motors, using the analog joysticks on the remote control. In addition, the various triggers and buttons have been programmed to operate various components, including the water valve servo, the bucket, and the claw arms.