The IceBreakers

Team 1176: Project "Off the Grid" Notebook

Little Rock BEST Robotics 2019

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Ice Breakers

The Ice Breakers is a school club at Columbia Christian School competing for the third time in the BEST Robotics competition. The club consists of students from grades 9-12, teachers covering various subjects, mentors with different professional backgrounds, and various supporters. Columbia Christian School is led by the administrator, Ted Waller, to improve academically in all subjects and to provide a firm education for students.

Objective

Each team faces the task of designing and constructing a robot that is capable of reconnecting fallen power lines and replacing damaged underground wires during high-risk situations, among other tasks. Each robot will be required to be contained within a 24-square-inch box and can only weigh 24 pounds. Robots that exceed these limits will be disqualified. To earn points at the competition, the students' robot will be required to reattach power lines that have been downed due to the natural disaster. There will also be garbage on the roads that the robot may remove in order to earn points. There will also be an autonomous round in which students will program the robot to move along a track that will be read with infrared sensors. Each round will last 3 minutes and be played with four teams, one at each game station.

Summary

The Columbia Christian School Ice Breakers began the process of designing and fabricating the "Icebreaker" by using the engineering process, available technology, including web-site design, and the development of a robotics notebook for the Little Rock Hub competition *Off The Grid* held on November 2, 2019.

The competition is an intense six-week robotics competition for high school students. Students are given materials and a theme and are then asked to build a robot within the given time. At the end of six weeks, the students take the creations to Little Rock to compete. This competition is designed to promote math and science and to encourage the participating students to pursue technology-based careers. For this year's game, the objective is to design a robot that can take the place of linemen during high-risk situations, and get the power back on in the event of a natural disaster.

The Icebreaker will continue to progress and evolve throughout the competition. Students will use and analyze the design and engineering process to further productivity. The students will effectively use the trial and error process as well as efficiently discuss and analyze the proper strategies for designing and building a robot.

Research Paper

Help from Machines

There are several benefits of machines being used in place of members of a workforce at the sight of a disaster. From clearing rubble, repairing power lines, or simply gathering an overall view of an area, the use of machines can replace workers or volunteers in several high-risk situations. Just like how there are firefighters and electricians each step of the process of regenerating a civilization requires a uniquely designed machine.

Ice Storm of 2000

One of the most well known natural disasters in recent Arkansas history is the ice storm of 2000. This storm had an incredible impact on as many as fifteen counties in the southern area of Arkansas, from roads being littered with electrical wires to tree branches up to six inches in diameter having fallen. Power was initially lost on December 15. Depending on the area, citizens had no electricity from anywhere from two days up to two weeks. Two witnesses from Columbia County were interviewed about their experience. One witness stated that he couldn’t even see his lawn through the tree branches on the ground. He also said that if drones had been used during the cleanup, the process would have been much faster and simpler. One of the major issues that were created by the storm was the lack of food. Grocery stores such as Walmart and Brookshire’s could not restock their food supply since the roads were blocked after a few days. A large number of citizens went without receiving their weekly amount of food, in addition to frozen foods having thawed in refrigerators due to the lack of electricity. After the storm passed, the grueling process of cleaning miles of land from fallen tree branches, fallen wires, and ice began. The process of rebuilding southern Arkansas and eastern Texas lasted for almost six months due to the disadvantage of the ground being covered in over an inch of solid ice and the massive amount of debris. There was also a massive risk of more branches falling, or a fallen wire still being active.

Linemen

Linemen are most often workers that repair fallen electrical wires. Unfortunately, taking the position of a lineman includes many risks, such as falling to one’s death, being crushed by rotten poles, and being electrocuted by a live wire. A lineman from the 2000 ice storm was interviewed about his experience. He explained that one of the main materials that the linemen were required to remove were fallen tree branches. The majority of the trees that inhabit Arkansas are pine trees, which become very brittle during cold weather, and with ice forming constantly on them, a tree branch snapping was extremely likely. This would commonly cause a wire to snap. Fortunately, with the proper tools, this position can be completely operated. If a machine was manufactured that was able to scan fallen wires for electric charges, replace rotten poles with sturdy ones accurately, and reconnect fallen wires, then many deaths could be prevented. One possible solution is for a machine that could scan wires for electrical charges, outstretch an extendable arm that could reconnect wires to the standoffs, and conduct the proper tests to check the strength of the pole and confirm that the pole has not rotted. Another issue is replacing damaged underground wires. A plausible solution to this matter is to construct a machine that could scan the ground where the wire is located to determine the exact depth of the wire. The machine should also be able to uncover the wire and scan the wire for electrical charges to ensure that the wire is absolutely safe for the crew to manage the wire. Another machine that could be of great use is a drone. Drones could reduce the time taken to search for victims trapped under debris.

Food Shortage

The main worry during any natural disaster is a food shortage. The average human can go about three weeks without food, and three days without water. If all the roads to a town are blocked by fallen debris and grocery stores cannot receive shipments of food, then there is only a matter of time before food shortage becomes a life-threatening situation. If there was a proper machine that could traverse several miles of troublesome terrain, then this issue would be much more manageable. Perhaps a machine that was operated similarly to a military drone that was comprised of metals that would not rust, but was also incredibly durable. For the machine to be able to carry any kind of package, there would most likely need to be a length of five feet at a minimum. The machine would need to be able to overcome obstacles in an extremely small amount of time since a machine the size of a small human cannot carry enough supplies for more than six to eight people.

Overall, machines provide a safer and more reliable way to complete life-threatening tasks after a disaster. From delivering food to isolated towns and discovering trapped victims to replacing or repairing power lines, machines are far more efficient and secure for recovering after a natural or man-made disaster.

If further advancements to robotics are made generations to come would live a completely different lifestyle. Linemen and rescuers would no longer have to risk their lives to do their job. Robots that are controlled from afar can take over. This would prevent casualties and make repairing power lines a lot more efficient. These robots would be specifically made to do their job. Robots could definitely change the world and force humans to adapt, but according to the current research, the benefits would outweigh the deficits.

History

Electricity was first discovered by inventor Benjamin Franklin in 1752. He did this by flying a kite during a thunderstorm. A metal key was tied to the kite to conduct the electricity. Thomas Edison took this electricity and made the first successful long-lasting light bulb in 1879. Then, the problem was transferring this electricity. A direct current system was made, but this was very inefficient. This caused friction which resulted in the loss of electricity. A more efficient system was needed. The first alternating current transmission system was designed by Nikola Tesla. This was much more efficient and took over direct current. In 1893, the Westinghouse Electric Company used an alternating current system to light the Chicago World's Fair. This was a huge milestone in the world of electricity. The same year a 22 mile AC power line was made, sending electricity from Folsom Powerhouse in California to Sacramento, the longest line to date. In 1900, transmission lines reached an all-time high of sixty kilovolts. Finally, in 1957, the first nuclear power plant to provide electricity in the United States was made in Pennsylvania, called the Shippingport Reactor (The Historical Archive, 2007). Even to this day, we are still using alternating current systems for the transmission of electricity. Direct currents are only used for laptops and cellular devices. Also, nuclear power plants have proved to be a very efficient and clean source of energy.

Current Scientific Research

Efforts have been made in China to develop a robot that can replace human jobs during the event of a power grid disaster. Dream-I is a reconfigurable live-working robot targeted towards replacing and repairing of power transmission lines. Dream-I is fully autonomous or self-operating. Dream-I is designed to accurately walk on lines without fail. The robot has two ends: an insulator replacement end and a drainage plate bolt fastening end. This allows the robot to replace and repair lines. The robot has also gone through various tests of high voltage to ensure the robot will be appropriate for all situations (Yan, 2017).

References

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Members and Teams

Construction	Date Applied
• Jordan Perritt	10/15/19
• Missy Gunnels	10/15/19
• Jessie Gunnels	10/15/19
• Victoria Allison	10/15/19
• Brayden Voss	10/15/19
• Jared Massey	10/15/19

- Jake Williams 10/15/19
- Jonathan Stevens 10/15/19
- Austin Plafcan 10/16/19

Notebook

- Aaron Chen 10/16/19
- Brandon Johnson 10/16/19
- Jessie Gunnels 10/15/19
- Missy Gunnels 10/15/19
- Elizebeth Attebery 10/15/19
- Jake Williams 10/15/19
- Miranda Madden 10/15/19

Spirit

- Katie Norman 10/15/19
- Gwen Gunnels 10/16/19
- Maggie Gunnels 10/16/19
- Chloe Rowe 10/17/19

Programming

- Jake Williams 10/15/19
- Brayden Voss 10/15/19
- Victoria Allison 10/15/19

Drivers

- Jonathan Stevens 10/15/19

- Brayden Voss 10/15/19
- Jake Williams 10/15/19
- Victoria Allison 10/15/19

Research Paper

- Missy Gunnels 10/15/19
- Elizabeth Attebery 10/15/19
- Aaron Chen 10/16/19
- Brandon Johnson 10/16/19

Website

- Jake Williams 10/15/19
- Gentry Needham 10/18/19

Social Media

- Victoria Allison 10/15/19
- Jake Williams 10/15/19

Teachers

- Mrs. Pearson – Creator and leader of the club, Ice Breakers, and provided machines and permitted materials
- Mrs. Allison – Sponsor of the club, provided machines, and permitted supplies

Sponsors:

Southern Arkansas University Engineering Department- Doctor Rashad Islam

SAU engineering workshop- Mr. Jeff Sumner (see figure 12)

Entergy Electric Company-Mr. Doug Fields (see figure 19-21)

Magnolia Fire Department- Mr. Daniel Fields

Magnolia Police Department-

Albemarle-Mr. Steve Card

1. Design Process

1.1 Problem Statement

Best robotics gave us the challenge of making a robot that is able to clean up debris after a storm and restore power to a city. The robot has to be able to increase human productivity and decrease the danger that is involved in a Lineman's job. The robot needs to be able to be placed into a 24 inch squared box at the beginning of the competition. The robot can not weigh more than 24 pounds. The robot needs to be able to remove “power lines” off of houses, rehang power lines that have been taken out in a storm, and lay underground electrical power lines. The participants will also have the option to program the robot to compete in an autonomous round. The autonomous portion will require the robot to run along the set track and deliver the supplies to the different sights around the playing field. All teams are required to build a robot out of BEST provided or approved parts.

1.2 Design Elements

There were several issues with the robot’s design. One of the major issues was constructing an arm that was capable of reaching obstacles without exceeding the dimension limits. To resolve the issue, the construction team measured the range of motion of the original arm and decided how much extra range of motion that is needed. Then, the team discussed what kind of arm would be able to increase the range of motion while still using the same servos.

2. Brainstorming and Building the Robot

2.1 Brainstorming Session

During the brainstorming sessions, students presented several ideas. Some of these were used in the final designs and some were not. Ideas for strategy were also presented during these sessions. The idea for a “cowcatcher” on the front of the chassis was presented in the first session. This is still included in the final design. The students had already decided to mainly focus on scoring points. The students decided not to attempt to transport skid supplies in an attempt to focus on scoring in other ways. Another idea presented was to do a closing fork-type hand to use instead of what is now the gripper. Another of the student’s less feasible ideas was to have strategic infrared sensor placement. This was rendered unusable due to a lack of skill with soldering on circuit boards. Students briefly considered using a rail slide arm instead of a straight angle arm. The students attempted to focus on autonomous delivery of supplies, but that was also unable to be used due to the misuse of circuit boards. The students also considered a one-wheeled chassis, but that idea was rejected because this would cause inefficient turns

2.2 Brainstorming Robot Chassis

The design team briefly considered reusing the previous year's chassis. This team ultimately decided against using this due not only to the chassis' width but also had a great deal of wear and tear from the previous competition.The construction team eventually decided on 1 cm thick plywood for the body (see figure 1). The decision was made to use a chassis design with two wheels and one PVC slider hub (see figure 3). The two wheels would be located on the backside of the robot, with a PVC slider in the front. The next time the team met, the decision was made that the body should be 16 in long and 9 in wide. This was so that the battery pack could be placed in a more discreet location, allowing for a more clean and fluid design. Another benefit to this design was that, if needed, the students could downsize the chassis itself to save weight for other portions of the robot. (see figure 1)

2.3 Brainstorming Arm

The students began to consider possibilities for the arm after coming up with the original design for the chassis. Two scale models were drawn of front-end loader upper and lower arms, to begin with. The students decided that a gripper should be added to this design. This was decided on as the original design and students cut this out at home that day. The students eventually reconsidered this design due to problems with properly utilizing a range of motion. The new arm was a simulated 10-inch human forearm with a gripper claw controlled by a servo. The arm will be controlled by a pulley system to keep in compliance with height restrictions at the start of the game.

3. Strategy

3.1 Offensive Strategy

The team's original offensive strategy was to focus on the autonomous obstacles since this would provide the most points. This plan failed because of sensor damage. The new offensive strategy is to focus on low hanging objects and the debris on the ground. The low hanging objects will be obtained by the scissor arm and the debris will be obtained by the "cow-pusher".

3.2 Defensive Strategy

The students decided not to waste time on a defensive playstyle, instead of focusing more on offensive methods. The nature of the robot's design itself prohibited the students from having many defensive opportunities in general. Due to the methods the students used to design the chassis and the scissor lift, the students would not have many opportunities to prevent other teams from scoring. The driver's only defense is to hang the second-highest wire on the public towers to prevent other teams from using those towers.

3.3 Strategies Effects on Design Elements

3.3A Offensive Design Elements

The students designed the robot mainly with the offense in mind. The original focus was on the autonomous round because this held such high scoring capabilities, but later in the process, the students focused more on being able to reach up to the lower hanging wires, having a claw to grab the wires, and being able to push debris into the designated point area. For the autonomous round, students began programming and working with the circuit boards in an attempt to finish those quickly. The students also designed a straight arm that was mounted onto a lift table in order to be able to reach the wires for hanging on the powerlines. Another feature the students spent time on was a “cattle pusher”. The students designed an attachment to the robot chassis that was shaped like the tip of a triangle that would move debris, not only out of the way but into the scoring area.

3.3B Defensive Design Elements

The students did not focus on defense and therefore defensive strategies did not shape the design of the robot. The only defensive elements that were added to the design were the arm and the claw since the only defensive strategy involved claiming the towers.

4. Basic Design

4.1 Original Arm Design

The original design for the robot’s arm was a front end loader arm model. This model would be made of plywood and would have been mounted on top of a scissor lift table that would have extended the arm enough to reach some of the lower power lines. The students focused on this specific iteration of the arm for the majority of the building time, adapting this version to different lift heights. The arm ended up being too tall, however, there was no way to lessen the height after the added height of the scissor lift and the lift table.

4.2 Arm Design Alternatives

The students briefly discussed the method of having both a rigid forearm and a pivoting upper arm model. Students came to the realization that the pivoting portion would not allow for enough upward movement to justify using it.

4.3 Final Arm Design

The final arm design was a rigid forearm simulated off of a human forearm. The forearm of the robot was ten inches long. The students decided that the new forearm needed to be controlled by a servo that would move up and down. This design was chosen as the final design because the robot needed a rigid forearm that was attached to the base of the chassis. At the end of this arm, a claw was placed to grab wires and place the wires on the hooks. The forearm's purpose was to be a steady base for the claw so that the claw was able to extend and grab the power line. The students wanted a forearm that had the most control so that the claw was able to grab the power lines most efficiently. (figure 13)

4.4 Scissor Table

The students eventually realized that a scissor table was the most logical way to solve the design problems. This was not being able to have enough height on the arm to reach the bottom wire on the tower. The students first modeled the table out of cardboard and realized that this would not be strong enough (see figure 10). Polypropylene was chosen for the final version. (see figure 14) Students discovered a balance between the table, the chassis, and the arm could be obtained by using two tables: One as the base and the other on top as the table for the arm. Many problems were encountered with the scissor table. Braces were needed to keep the arm from bowing. There was a lot of tension in the arm requiring bolts to be loosened to relieve tension. If the braces were not implemented, the scissor table would have broken apart under the weight of the arm. (Refer to figure 8)

4.5 Alternate Materials for the Scissor Table

4.5A Extension arm

There were several materials that could have been used as alternatives for the robot's scissor table. The students thought about using an extension arm instead of the scissor table. The problem with the extension arm was that the arm was over the twenty-four-inch height limit. The robot had too much height and there was no way that the extension arm could be used, be able to be placed in the twenty-four-inch box, and still be able to reach the power lines. (Refer to figure 4 and 5)

4.5B IGUS slides

Originally the team was going to use the IGUS slides as the material that allowed the scissor table to lift up and down. Due to a lack of experience and time crunches to meet the team's personal goals, the team had the idea to just use the IGUS slides. The students decided to use the IGUS rods but wheels were implemented that fit in and slid along the IGUS rods.

4.5C Telescoping tubes

After the extension arm idea was thrown out we decided we wanted to focus on telescoping tubes that would slide in and out of each other. The students had to throw out the idea because the only thing that there was to build the Telescoping tubes was ¾ inch PVC pipe and a 1 inch PVC pipe and the Telescoping tubes would not slide in and out of each other.

4.6 Final Scissor Table

The final design for the scissor table was a variation of the IGUS slides. A motor was attached at the opposite side of the scissor table and attached to a thread-all rod, which was mounted onto the end bearings. A motor, with a string attached. was connected to the cardboard base under the scissor arm. A second cardboard base with the arm attached was mounted at the top of the scissor arm at the same side as the first base. The string from the second motor traveled up to the claw. The scissor lift was attached to the robot and wired. (Refer to figure 2)

5. Claw

5.1 Claw Design

The original claw design was to use two separate gripper pieces attached to gears that are hooked up to the servo. The gears attached to the separate claw pieces are against each other so that when one gear turns and moves the piece, the opposite gear does the same. (see figure 6)

5.2 Claw Alternatives

In the alternative design, the gears were replaced with long, thin rectangle pieces that were hooked up on a star-shaped piece on the servo. The rectangle pieces are attached to each other on a pivot so that, when the star piece turns and pulls the rectangles back, the two arm pieces are pulled shut. When the servo turns the other way, the claw pieces are pushed outward.

5.3 Claw's Final Design

The alternative claw design was used in place of the original. The gears were going to be too difficult to make, and the gears were not already provided. Gears have too many tiny details to make with the team's equipment. Also, the rectangle pieces were found to make sufficient use of the incredibly limited turning radius of the servo. The students decided that instead of focusing on how and what to make the final claw out of, this could be one of the 3-D printed pieces.

6. Programming

Programming was an essential part of the construction of the robot. Without programming, the robot would not have been able to operate. The first decision the students had to make was what programming language to use. The students chose RobotC because the program is a dependable language that was more widely used than the other options such as using Simulink or Python. Wide use meant that if problems were encountered, the students could solve the issue by referring to previous cases where others had the same problem. There was more documentation of how the program worked. In addition, C, the language that RobotC is based on, is a popular, widely used programming language as well. Since RobotC is based on this language, the students had a chance to become familiar with the syntax of a popular and important language. When the students started programming, the team considered how the robot should move and what buttons/joysticks would control those movements. The students decided on a 2 joystick movement system in which the left joystick controls forward movement, while the right controls leftward and rightward movement. The other motors and servos (arm, claw, scissor lift) are controlled by buttons and triggers. A code snippet has been marked up to explain the process and the variables and why the variables (see figure 7.)

7. Drivers

The students waited until the robot was almost done to decide who would drive. Students asked who was interested in driving the robot and had each one test drive the robot in a mock competition. This was to see who would be able to achieve the most points within a certain time limit. The results of this test were recorded and made into two data tables to determine who would be the drivers. The charts are listed below.

Name Trial 1	Time (min)	Debris	PVC cable	Low Power Line	High Power Line #1	High Power Line #2	Power Line Homes	Points
Jake	3 min	2	0	2	1	0	0	190
Jordan	3 min	3	0	2	0	0	0	260
Jared	3 min	1	1	1	0	0	1	130
Brayden	3 min	2	1	2	1	0	1	300
Ryan	3 min	1	0	2	1	1	0	320

Jessie	3 min	1	0	1	1	0	1	210
Victoria	3 min	3	0	1	1	1	1	350
Missy	3 min	1	1	0	1	0	1	180
Elizabeth	3 min	3	0	1	0	0	1	150

8. Robot Testing

During the first testing the scissor lift was rising with the gripper on top the metal brace bowed which made the tread pop out the motor shaft the robot worked with the small motor. Complications arose when students added the gripper base to the scissor lift. (see figure 11) With the robot's gripper attached the scissor table was weighed down and dragged on the wooden plank in the base.The students discovered that if the metal support on the bracket was turned, the bracket no longer dragged. A table grinder was used to even up the metal bracket.

The table weight was tested on the scissor arm lift. The table caused the drive shaft brace to bend. The team determined that taller wheels on the arm might prevent the bracket from bending. The students also tested the scissor lift's capabilities to lift the gripper/claw arm. The arm was too heavy for the scissor table to lift. Students attempted to loosen the nuts and bolts to cutdown on the friction so that the scissor lift could handle the arm. When the scissor lift was laid down in the scissor lift table, the motor could not lift it. Moving the motor to the base would help support the scissor arm and relieve some of the tension and excess weight on the table. The team determined that another support at the same height as the motor would be needed on the other side of the scissor lift. The next problem was that the wheels on the scissor lift table kept getting off track. Students made slides from the IGUS linear guides for the wheels. Students used flanged bearings to help guide the threaded rod. Students observed that the scissor lift began to bow and lift unevenly with the arm attached directly by a bracket. The students discussed how to fix the bowing problem, and tested the scissor lift with the DryLin Linear Bearing Carriages. One of the scissor lift blades was found to be wider than the others, causing it to lean to one side. Students stabilized the lift. The arm was found to be too heavy, so the students made holes in it to make it lighter. The threaded rod began to become unattached if the lift was lifted too high, students decided that it should not be lifted past a certain point.

9. Team Meetings and Organization

A team meeting was held on the 23rd of September to discuss the robot. Students were assigned to one to three teams based on skill. All students were informed about the requirements of the notebook, research paper, programming, and construction of the robot. For the notebook, the team created a document on Google Docs so that everyone could all work on the document at the same time without the need for copying and pasting. Students were informed about the task at hand, including the requirements, at least a week before their tasks were due. All drawings of the robot's design were kept in the sponsor's classroom.

September

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25 First Team Meeting: 1:45 - 2:38pm	26	27 Meeting: 1:45 - 2:38pm	28
29	30					

October

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	2 Meeting: 9:40 - 11am	3	4	5 Meeting 9:30 - 12:30 pm
6 Meeting: 2-4:30pm	7	8	9 Meeting: 9:40 - 11:25am	10	11	12
13	14	15	16 Meeting: 12:52 - 1:45pm	17	18	19 Practice Day
20 Meeting 2-3:30pm	21	22	23 Meeting: 9:40 - 11:25am	24	25	26
27	28	29	30 Meeting: 1:45 - 2:38pm	31		

10. Safety

Students strived to fulfill all appropriate safety regulations throughout the six week building period. The students even invited a local small business owner, Rob Gunnels, from Gunnels Mill Incorporated, to teach safe and proper usage of machinery on September 27, 2019. Mr. Gunnels demonstrated how to use all relevant equipment and explained exactly what safety procedures needed to be followed. Following that meeting, the students had a much better working knowledge of this equipment and how to safely and properly go forward with the construction.

Materials Used

Cortex Microcontroller-1

Vexnet Joystick-1

Vexnet Key 2.0-2

Motor Controller 7.2V 4A-4

Large Motor-2

Small Motor-2

7.2 V 3000 mAhr NiMH battery-2

Charger Adapter--1

Screw Terminal Sensor Interface Cable 3-wire-4

Servo Power Adapter Cable-1

Smart Battery Charger and power cord-1

8-bay AAA Smart Battery Charger and Power Cord-1

AAA NiMH Rechargeable Batteries (installed in joystick)-1

USB A-A Cable-1

Futaba 3003/3004 or HiTec HS-425BB Servos-1

Servo horn screw-2

Servo horn-1

24” servo extension cable-2

40” servo extension-2

Servo mounting screw-4¼” bore,24 tooth, (small) drive pulley-1

BEST IR Sensor Kit-1

1/4” shaft coupler, with set screws-1

DryLin N Linear Guide system-2

Iglide G300 Flanged Bushing-2

Igubal ¼ Rod End Bearing-1

3/16” thick polypropylene sheet, 12x24-all

⅛” thick PVC Type 1 sheet 12”x24”-2x12=24”

0.063” thick x2” wide 6061-T6 aluminum flat 24” long-2(2x2)=8”

0.063” thick 5052-H32 aluminum sheet, 12x24-all

1⁄2” thick 2’x4’ plywood, any grade-144”

1”x4” (nominal) #2 whitewood, 2 ft. long-1”x4”x2”

¾” schedule 40 PVC pipe, 5 ft. long-14”

¾” PVC 90 degree elbow (slip)-1

¾” PVC tee (slip)-4

2.5”x5/8” steel ZN, corner angle bracket-2

All-purpose duct tape, 2” (1.88”) wide, 50-60 yard.

Painter’s tape, 1” wide, 30-60 yd.

Carpenter’s wood glue, 4oz.

¼” 20 threaded rods, 3 ft. long, steel-all

¼”-20 hex nut, steel-1

#10-32 x 1” socket head screw, high strength (150 KSI min) steel**

#10-32 x 1- ½” machine screws, steel, round head, phillips**

#10-32 machine screw nuts, steel

#10 flat washer, steel

#8-32 x 1- ¼” machine screw nuts, steel (20)

#8 medium split lock washer, steel (28)

#8 flat washer, steel

#2-56 x 1” machine screws, pan head, Phillips, stainless** (4)

#2 flat washer, steel (4)

Wood screw eye bolts, 0.192 wire dia x .97 shank x.97 shank x75 thread x.27 id, steel (1)

#6 x 1” wood screws steel, flathead (12)

#4 x ¾” wood screw, steel, slotted drive, round head (20)

¾” nylon sticky back hook and loop fastener (12”)

#18 twisted nylon or polypropylene seine twine, 225 to 250 ft long (4’)

.VEX motor mounting kit (4 mounts + servos)

Corrugated cardboard ¼” maximum thickness 2(12” 25”) 600m^2

Team Custom Part 3 (gripper)

Appendix

Figure 1

Early chassis sketch

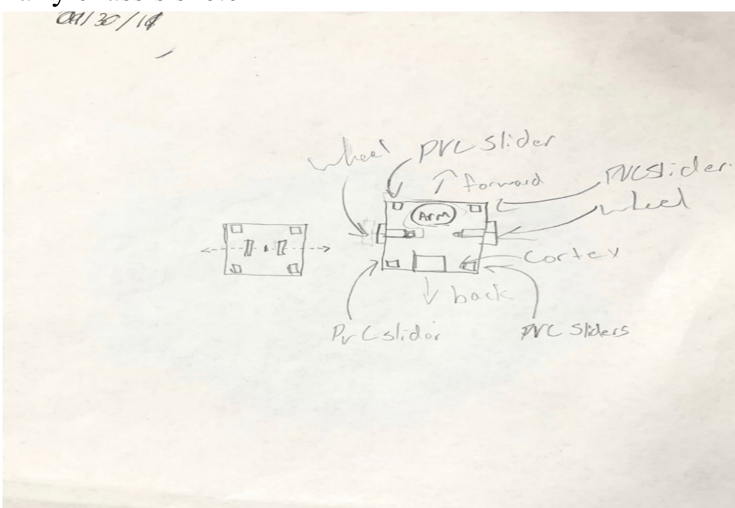

Figure 2

Current scissor table design

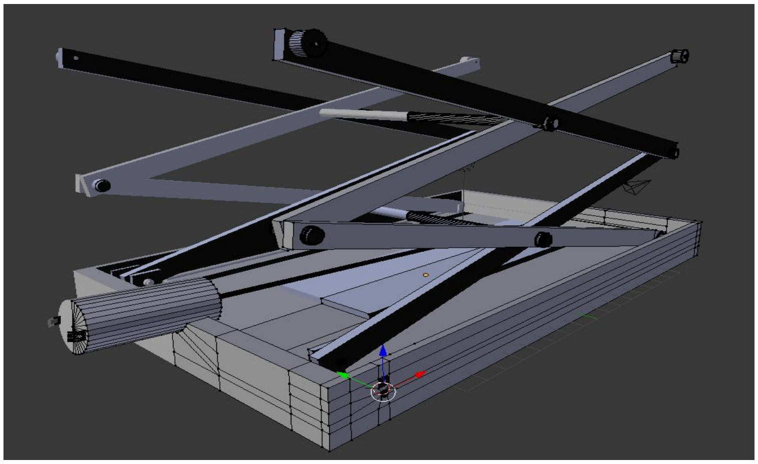

Figure 3

The current robot chassis design

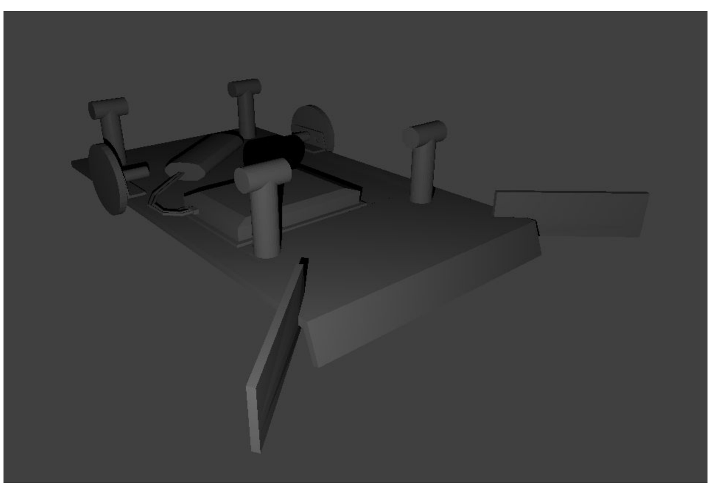

Figure 4

Scissor table and rack and pinion

Figure 5

Extended scissor table

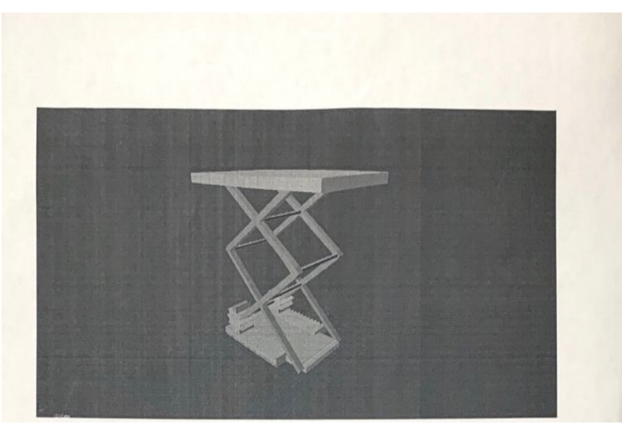

Figure 6

Initial drawing of the arm with gripper design

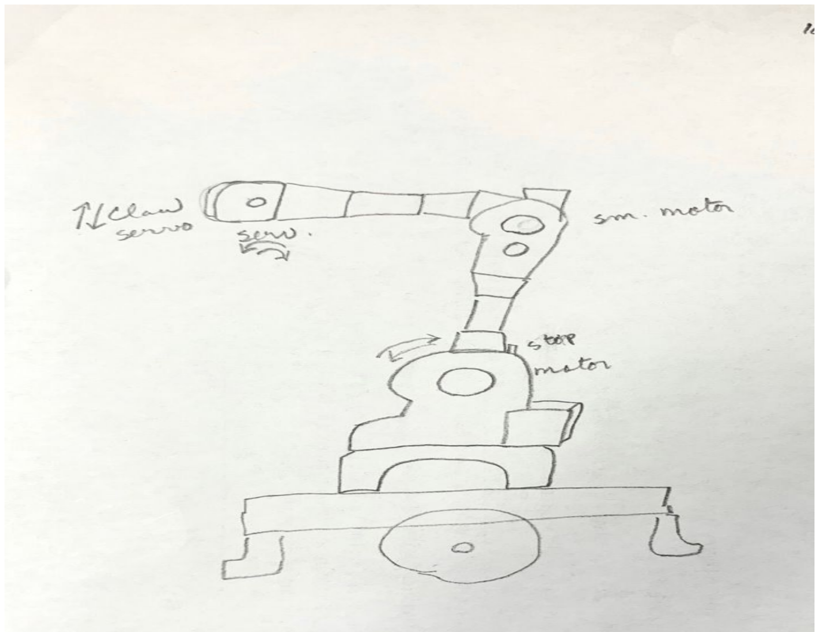

Figure 7

This is the 5th full revision of the program that controls the robot

```
#pragma config(Motor,  port2,           leftWheel,     tmotorVex269_MC29, openLoop)
#pragma config(Motor,  port4,           rightWheel,    tmotorVex269_MC29, openLoop)
#pragma config(Motor,  port6,           scissorLift,   tmotorVex269_MC29, openLoop)
#pragma config(Motor,  port7,           arm,           tmotorVex269_MC29, openLoop)
#pragma config(Motor,  port9,           claw_servo,    tmotorServoStandard, openLoop)
//*!!Code automatically generated by 'ROBOTC' configuration wizard  !!*//
//The above is autogenerated by the 'Motor and Sensor Setup' menu.

#define sensitivity 0.0001 //Increase this value to make the claw move slower, but be more fine controls. This value stays constant throughout the operation of the program

task main()
{
	/*
	Initialization of variables
	---------------------------
	claw - controls and stores the degree at which the claw servo is turned. Value can be between -120 and 120
```

```
	modifier - This stores a value between -50 and 50.  -50 is the sharpest left, 50 is the sharpest right.
		This value is set and determined further on in the program.
	lSpeed - This is the speed of the left wheel motor.  The value is stored between -127 and 127.  The students
use
		Two different speeds to perform turns
	rSpeed - This is the speed of the right wheel motor, which stores a value between -127 and 127.
	*/
	int claw = -120;
	int modifier = 0;
	int lSpeed = 0;
	int rSpeed = 0;

	//Infinite while loop evaluates to true forever to keep the robot running until the loop is interrupted.
	while(true)
	{
		if(vexRT[Btn5U] && claw < 120) //If the 5UP button is being pressed(evaluates to true) and the
claw degree value is less than 120, then the value of the claw decreases by 5
		{
			claw += 5;
			wait(sensitivity); //This wait prevents the claw from opening too fast so the driver can
have more refined
					//control of the claw
		}
		else if(vexRT[Btn5D] && claw > -120) //If the 5DOWN button is being pressed(evaluates to true)
and the claw degree value is more than -120, then the value of the claw will decrease by five
		{
			claw -= 5;
			wait(sensitivity); //This wait prevents the claw from closing too fast so the driver can have
more refined control of the claw
		}
		motor[claw_servo] = claw; //Sets the claws servo position to the value stored in the claw variable
that has been manipulated in the preceding statements

		if(vexRT[Btn6U]) //Turns the arm in a clockwise direction if the 6UP button is pressed(evaluates
to true)
		{
				motor[arm] = 127;
		}
		else if(vexRT[Btn6D]) //Turns the arm in a counterclockwise direction if the 6DOWN Button is
pressed(evaluates to true)
		{
				motor[arm] = -127;
		} else { //If nothing is being done, the arm motor will be turned off
				motor[arm] = 0;
		}

		if(vexRT[Btn8U]) //If the 8UP button is pressed(evaluates to true), the scissor lift will be lifted by
spinning the motor in the clockwise direction
		{
			motor[scissorLift] = 127;
		}
```

```
			else if(vexRT[Btn8D]) //If the 8DOWN button is pressed(evaluates to true) the scissor lift will be released by spinning the motor in the counterclockwise direction
			{
				motor[scissorLift] = -127;
			}
			else //If neither of the 8DIRECTION buttons are being pressed the motor is turned off
			{
				motor[scissorLift] = 0;
			}

			/*The modifier is set to the value of the Ch1 joystick direction.  The division by 2 makes the value max out at -50 and 50
			  So that when the value is added to the forward direction, 100 will not be exceeded;
			  The reason for this added is so that the robot can turn while still making progress in a forward direction*/
			modifier = vexRT[Ch1] / 2;

			if (modifier < 0 && vexRT[Ch3] == 0) //If the 3rd joystick axis is not doing anything and the other one is to the left, the robot turns left with no forward movement at a faster turning speed
			{
				lSpeed = -100;
				rSpeed = 100;
			}
			else if (modifier > 0 && vexRT[Ch3] == 0) //If the 3rd joystick axis is not doing anything and the other one is to the right, the robot turns right with no forward movement at a faster turning speed
			{
				lSpeed = 100;
				rSpeed = -100;
			}
			//If the right joystick is turned to the left( < 0 ) and the left joystick is forward ( > 0 ), the robot uses the following formulas to determine speed
			//The formulas were chosen as a way to continue forward progress while still retaining the ability to turn
			//the left wheel is the value of the left joysticks forward value divided by 2.  The other is the same, except the modifier is subtracted(a negative value, which causes addition)
			//The same principle applies to the other formulas. The students are just slightly modified for different directional movement
			else if(modifier < 0 && vexRT[Ch3] > 0)
			{
				//Left Turn
				lSpeed = vexRT[Ch3] / 2;
				rSpeed = (vexRT[Ch3] / 2) - modifier;
			}
			else if (modifier > 0 && vexRT[Ch3] > 0)
			{
				//Right Turn
				lSpeed = (vexRT[Ch3] / 2) + modifier;
				rSpeed = vexRT[Ch3] / 2;
			}
			else if(modifier < 0 && vexRT[Ch3] < 0)
			{
```

```
                //Back Left Turn
                lSpeed = vexRT[Ch3] / 2;
                rSpeed = (vexRT[Ch3] / 2) + modifier;
        }               else if (modifier > 0 && vexRT[Ch3] < 0)
        {
                //Back right turn
                lSpeed = (vexRT[Ch3] / 2) - modifier;
                rSpeed = vexRT[Ch3] / 2;
        }
        else
        {
                //Straight
                //if the only joystick in movement is the left one, then the only movement is forward or
backward tspeed
                lSpeed = vexRT[Ch3];
                rSpeed = vexRT[Ch3];
        }
        //Sets the motors to the values that were set in the preceding statements
        setMotor(rightWheel, rSpeed);
        setMotor(leftWheel, lSpeed);
    }
}
```

Figure 8

Mrs. Pearson and Missy Gunnels working on scissor table

Figure 9

Jonathan Stevens working on rack and pinion

Figure 10

Miranda Madden cutting cardboard for original scissor lift

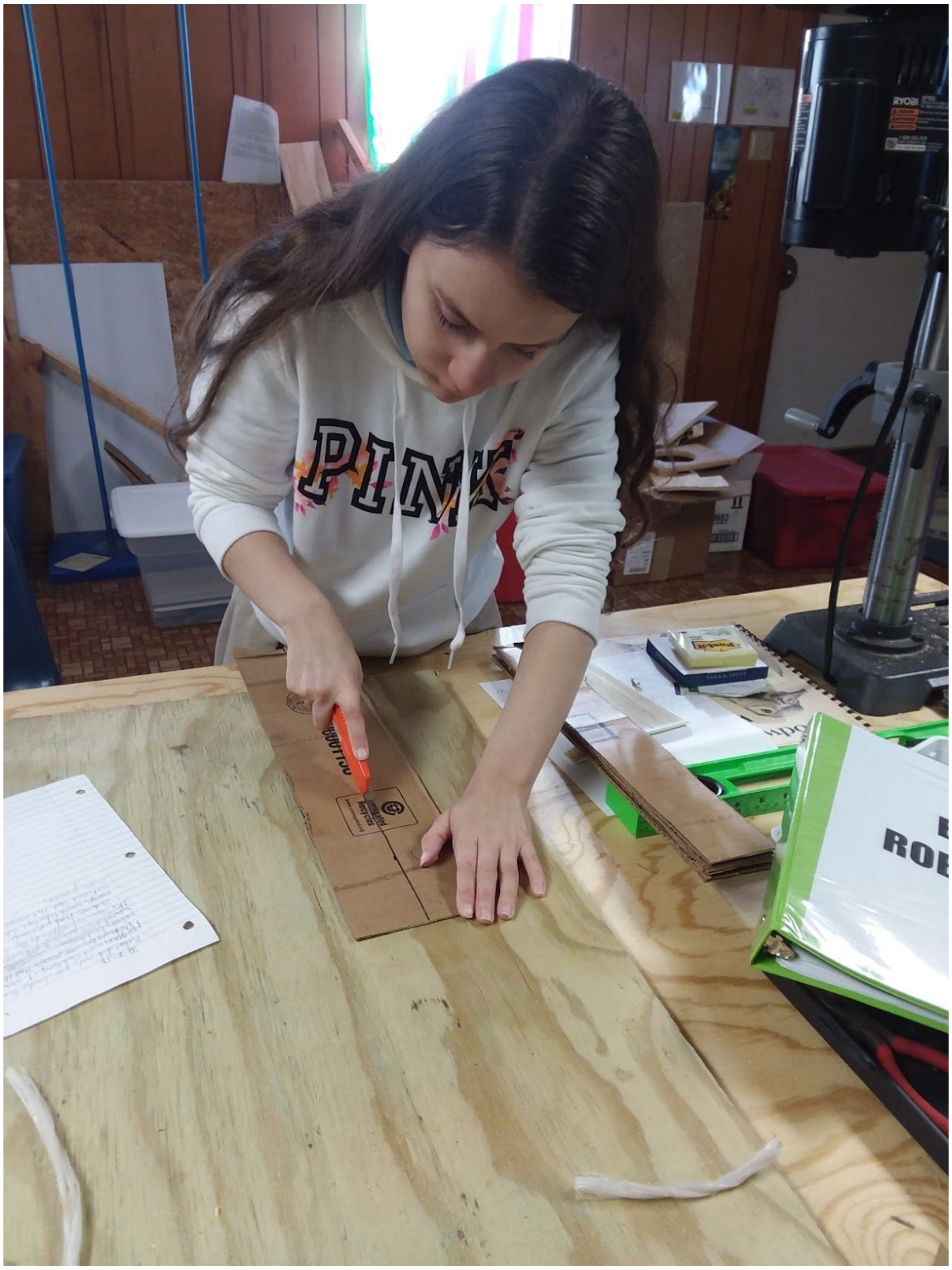

Figure 11

Jordan Perritt working on aligning the drive shaft on the scissor table.

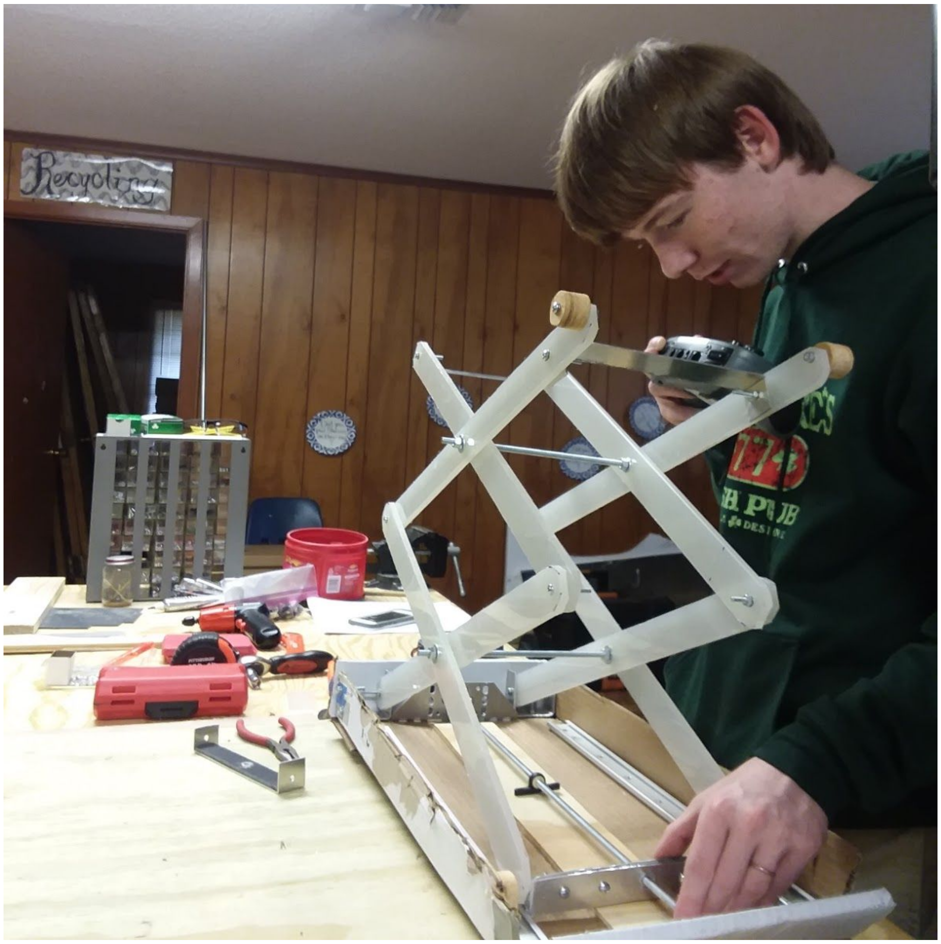

Figure 12

Jonathan Stevens cutting metal for arm

Figure 13

Jake Williams working on the robot arm

Figure 14

Victoria Allison working on the scissor table

Figure 15

Miranda Madden logging daily notes for the notebook team

Figure 16

Jordan Perritt and Jonathan Stevens discussing arm designs

Figure 17

Jonathan Stevens at the SAU engineering workshop

Figure 18

Brandon Johnson using a bandsaw to form pieces of the arm

Figure 19

Missy interviewing Doug Fields

Figure 20

Doug Fields from Entergy standing in front of his truck

Figure 21

Missy Gunnels and Doug Fields after the interview