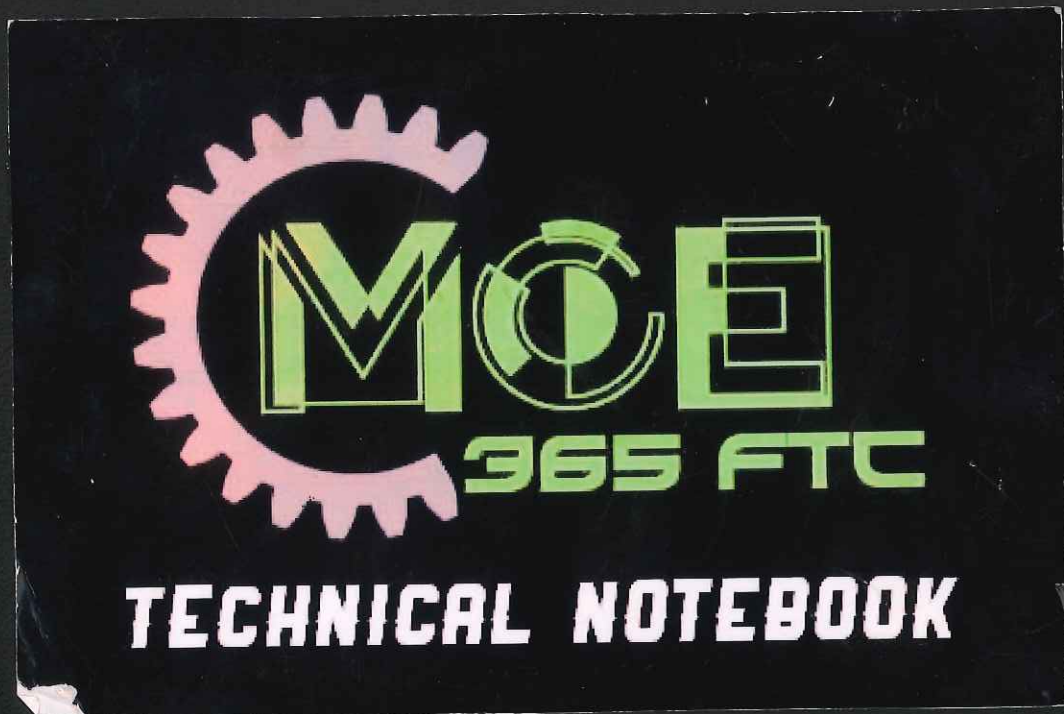


ENGINEERING NOTEBOOK





MOE 365 Technical Notebook Summary Page

Our Non-Technical is used to show the progress of our connect, communications, social media and fundraising programs. This notebook contains our business plan and team bios.

We took a lot of time developing goals and a new team organization (Pages 9-11). This became our Business Plan.

Some of our favorite Outreach events include the Blue Rocks Science Day (Page 123) where we taught little kids about our robot and let them use demo bots. We really are trying to improve Delaware FIRST. We've done this by hosting a Brainstorming Event (Page 129) where we helped new teams see a brainstorming process/got ideas for the new game. We've also hosted multiple scrimmages like the Delaware one on Page 138.

MOE has taken a lot of time to try and gain new sponsors along with sustain the ones we have. Our brainstorming for sponsors is on page 21. Some sponsors we gained are: Burriss Logistics (Page 126), Boeing (Page 132-133), and Be Barre Fit (Page 134). We have tried to sustain our sponsors by trying to keeping them updated on what we are doing and doing demonstrations for them. This can be seen on page 124 where we demonstrated our robot for the company Axalta and presented them with a 3D Printed version of our robot. MOE also received a grant for a 3D Printer from Ekocycle. In addition, Axalta sponsored a scholarship for Delaware FTC student. The application can be found on Page 26 and the acceptance email/plan for the printer can be found on Page 135. For fundraising we have also sold Horsey Youth Raffle Tickets for a sports car.

MOE 365 Technical Notebook Summary Page

Our design process began after we learned what challenges we would be facing in Cascade Effect. We started by designing a chassis using 80-20 (p. 19) to figure out a design which would best accommodate our needs. We had brainstorming sessions in small groups for ideas in strategy and robot design, and hosted a brainstorming session for rookie teams to help our decision making for the season (p. 20).

CAD is a major part of our design because it allows us to design and test ideas more quickly than if we had to physically build it (p. 19). This is our second year using CAD and we are continuing to use Autodesk Inventor because it remains a software that several of our team members are familiar with. One of our objectives was to have a robot design based on industrial design, mobility, and simplicity. CAD greatly assisted in this, allowing us to easily fabricate custom parts (p.).

At the beginning of the season the Technical team made a timeline (p. 2). This helped with time management and gave us goals to reach by certain dates.

Programming for the Mecanum wheels were completed on a prototype robot. The challenge was to make the robot go in any direction and orient robot direction (Pg. 80). Programmer did lots of work on testing various sensors including Ultrasonic and Accelerometer (pg 82). These will be used later in season. Another challenge was to calibrate the encoders on the new AndyMark Never Rest 40 motors (pg 83). Our future autonomous strategies are on pg 84. We are using very simple "off the ramp" and aim to dispense in the small rolling goal strategy for this tournament, since we do not have time to program any more.

NOTEBOOK GUIDELINES†

NOTEBOOK INTRODUCTION

Using a Notebook to record ideas, inventions, experimentation records, observations and all work details is a vital part of any engineering process. Careful attention to how you keep your Notebook can have a positive impact on the patent outcome of a pending discovery or invention.

Following are some overall recommendations to help you keep more efficient and accurate Notebook entries. Remember, however, that these are simply a suggested set of guidelines. Only your attorney can supply the exact guidelines she would like you to follow to satisfy specific legal requirements. That is why we recommend that you consult your legal counsel.

RECORDING DATA

Your Notebook is a vital record of your work whether it is for patent purposes, legal records or documenting drug research under FDA guidelines. The Notebook can help you prove:

- a. Exact details and dates of conception
- b. Details and dates of reduction to practice
- c. Diligence in reducing your invention to practice
- d. Details regarding the structure and operation of your invention
- e. Experimentation observations and results
- f. A chronological record of your work
- g. Other work details

Follow a few simple rules of thumb

1. Always record entries legibly, neatly and in permanent ink.
2. Immediately enter into your notebook and date all original concepts, data and observations, using separate headings to differentiate each.
3. Record all concepts, results, references and other information in a systematic and orderly manner. (Language, charts and numbering systems should be maintained consistently throughout.)
4. It is acceptable to make your entries brief. Always, however, include enough details for someone else to successfully duplicate the work you have recorded.
5. Label all figures and calculations.
6. Never, under any circumstances, remove pages from your notebook.

Remember to treat your Notebook as a legal document: It records the chronological history of your activities. The following guidelines should help you maintain the consistent and accurate entries needed for future legal purposes.

1. Start entries at the top of the first page, and always make successive, dated entries, working your way to the bottom of the last page.
2. After completing a page, sign it before continuing to the next page.
3. Make sure that you record the date of each entry clearly and unambiguously.
4. Never let anyone other than yourself write in your Notebook (excluding witness signatures, discussed later).

5. Never leave blank spaces, and never erase or remove material you have added. Simply draw lines through any blank spaces at the same time you are making your entries.
6. Do not erase errors. Just draw a single line through any erroneous entry, then add your initials. Enter the correct entry nearby.
7. You can supplement your entries with supporting material (e.g., test-result printouts and other documentation). But you must permanently affix the material onto a page in its proper chronological location.
8. Never rely solely on any supplemental attachment. Always include your own entry describing the attachment and add any conclusions that you might draw from its substance.
9. Occasionally, secondary sources might be too large or inappropriate to attach directly to your notebook. In this case, you can add all secondary sources to an ancillary record maintained precisely for this purpose. However, always remember to write a description of these secondary sources, clearly and unambiguously, in your notebook.

DOCUMENTING PATENT ACTIVITIES

A primary purpose of your Notebook is the support of documenting work that may be patentable. To support patent activities, it is necessary to provide clear, concise, chronological entries with specific dates. To rely on these dates, you must have at least one non-inventor corroborate that the events actually happened and that he or she understood your invention by signing and dating the "Disclosed to and Understood by" signature blocks.

Your Notebook should help you document and prove:

1. *Conception Date*—The date that you knew your invention would solve the problem.
2. *Date of reduction to practice*—The moment that you made a working embodiment of your invention.
3. *Diligence in reducing your invention to practice*—Diligence refers to your intent and conscious effort to make a working embodiment. You are not required to rush, or even to take the most efficient development strategy. But your Notebook must include details relating to your diligent activities. These are dates and facts that show what activities you have conducted to reduce the invention to practice, and when such activities were conducted. Since you may still be diligent despite periods of not working on reducing your invention to practice, always remember to provide reasonable excuses for these periods of inactivity by supplying facts relating to why there was no activity during the period in question. (e.g., unavailability of test conditions or equipment).
4. *How to make and use your invention*—provide documentation details sufficient to teach a colleague how to make and use your invention.
5. *The best mode of practicing your invention*—document the best way to practice your invention.

A non-inventor colleague should corroborate each of these events/facts by signing the "Disclosed to and Understood by" on the relevant pages.

† BookFactory provides these sample guidelines "AS IS" without any warranty.

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16	Meeting (Lift Decision Matrix)	10/7/14
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18	Meeting (Lift and Chassis CAD Modeling)	10/11/14
19	Meeting (Lift and Chassis CAD Modeling)	10/11/14
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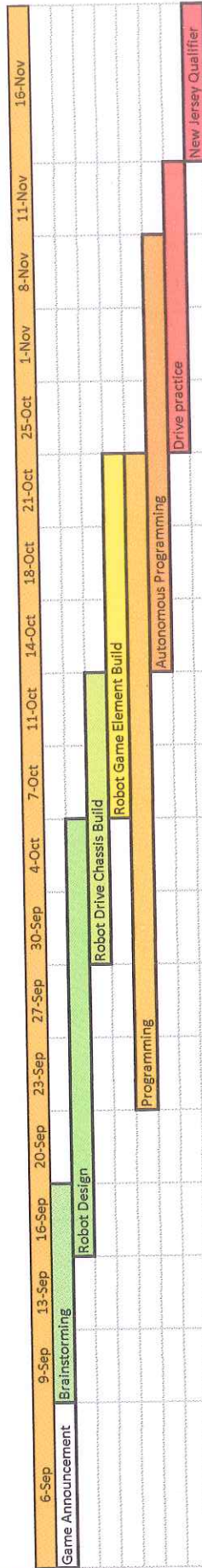
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Timeline



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SIGNATURE

Mike Powell

DATE

11/21/14

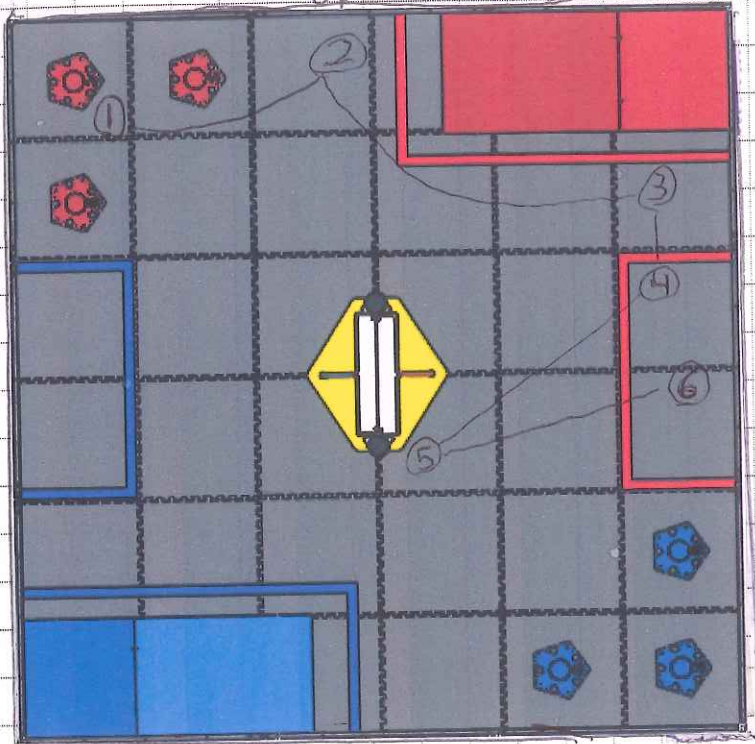
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PROPRIETARY INFORMATION

Game Strategy

Tele-op Routine



- 1) We start tele-op off in the corner, holding the 90cm goal.
- 2) We then focus on collecting balls in the area in front of our ramp.
- 3) After, we focus on the corner next to the ramp. This location sets us up for endgame.
- 4) We drop off the 90cm goal and prepare for endgame.
- 5) We score in the center goal.
- 6) We return to our parking zone.

Overview

Our game strategy is dependent on our partners & opponents, and varies slightly given on those factors. Our typical strategy is to keep the 90cm goal with us, scoring on our side of the field, while our partners work on the other side. This has proven to be effective because it gives us unrestrained access to the balls on our side, while crowding our opponents and slowing them down. Our endgame routine is consistent. Just before endgame, we leave the 90cm goal in our parking zone and grab enough whiffel balls to fill the center goal. We then score in the center goal, and return to our parking zone. If enough time remains, we score more balls in any unfilled rolling goals that are accessible to us. We have found this method to be the most efficient and allows us to maximize our scoring potential.

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SIGNATURE

Matthew Warner

DATE

3/14/15

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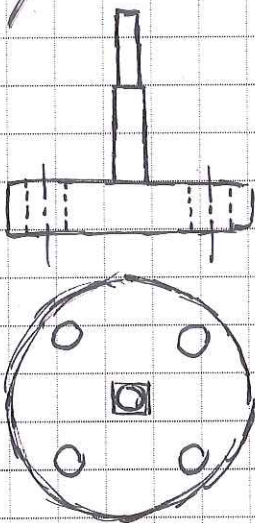
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PROPRIETARY INFORMATION

Mechanum Chasis Development

Part 1

A number of our team members went to a development session for a mechanum chasis with the Flaming Phoenixs and a rookie team started by a former member of our team. At this session we discussed things such as how to use the chasis, and adapter for using the wheels, a CAD model of a chasis, and programming needed for the chasis. We printed out some prototypes for an adapter and tested them on the wheels. We left with the goals of finishing a chasis, designing a better adapter, and finalizing a programs for it.



Our initial design
for an adapter

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Elham Dike

DATE

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DATE

6-19-14

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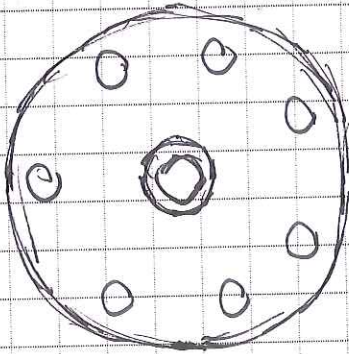
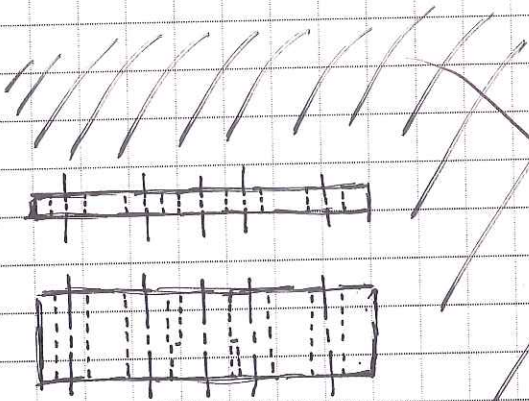
Meeting

Tasks

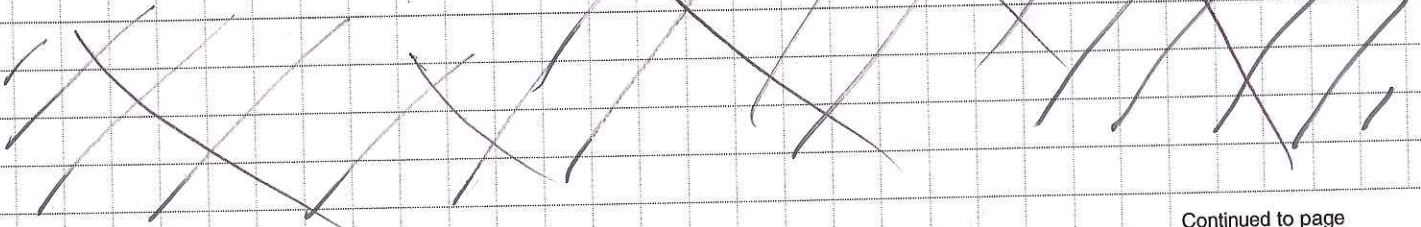
• Finish adapters for mechanism chassis

Reflections

• Make holes bigger than they need to be when 3D printing



Our second attempt at an adapter



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Ethan Price

DATE

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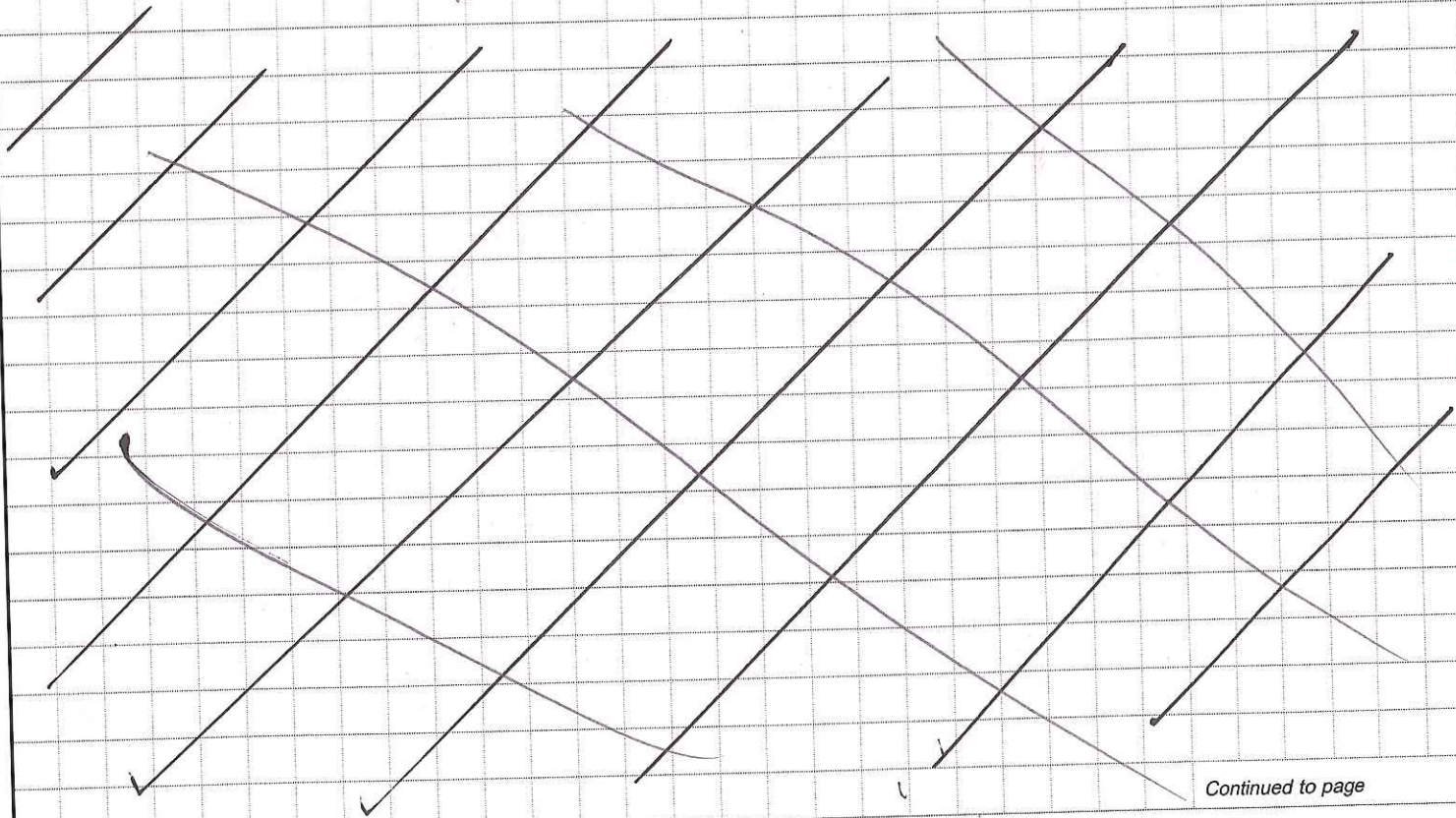
6-24-14

PROPRIETARY INFORMATION

Mechanism Ideas (Also Meeting)

- Ideas (Scoring) -

- Spring Loaded Ball Launcher - Dispensing balls
- Pitcher ^{machine} Launcher - Dispensing balls
- Linear Slide - Reach higher goals
- Rolling Goal Grabber - Manipulating rolling goals
- Belt Feeder - Collecting balls



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SIGNATURE

Wm Price

DATE

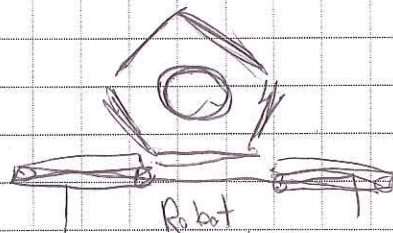
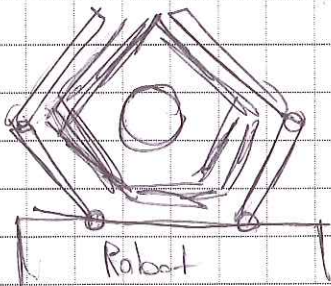
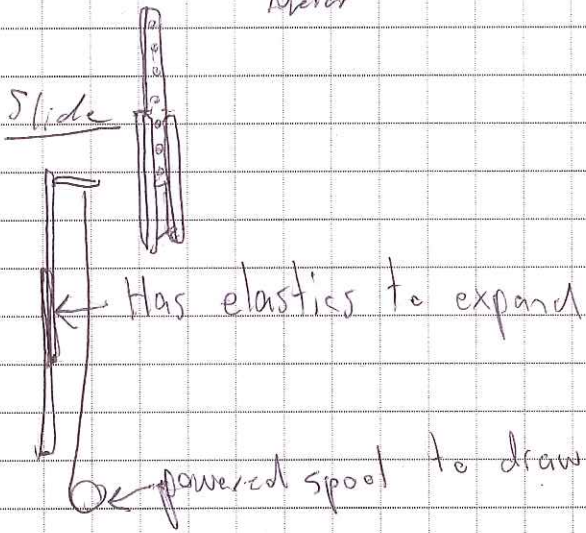
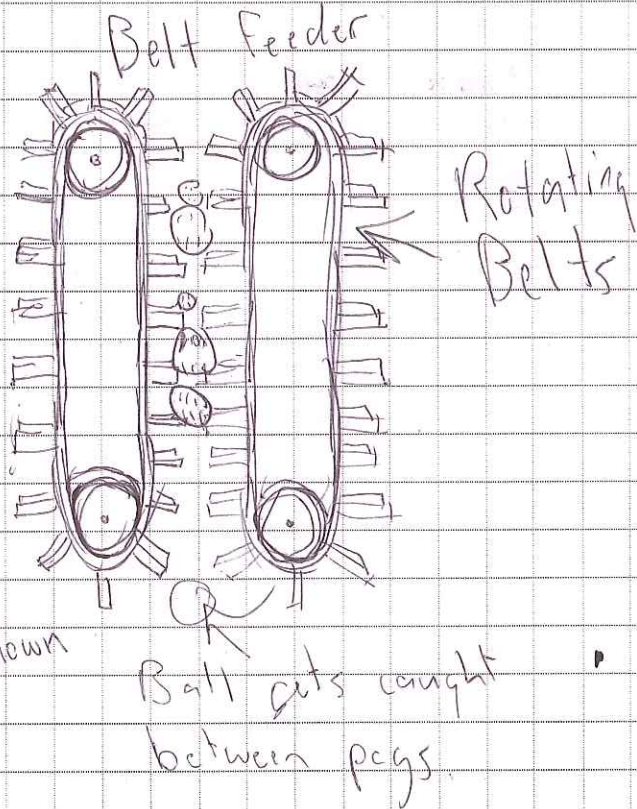
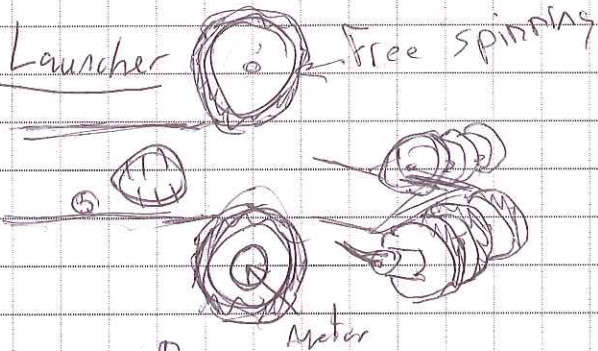
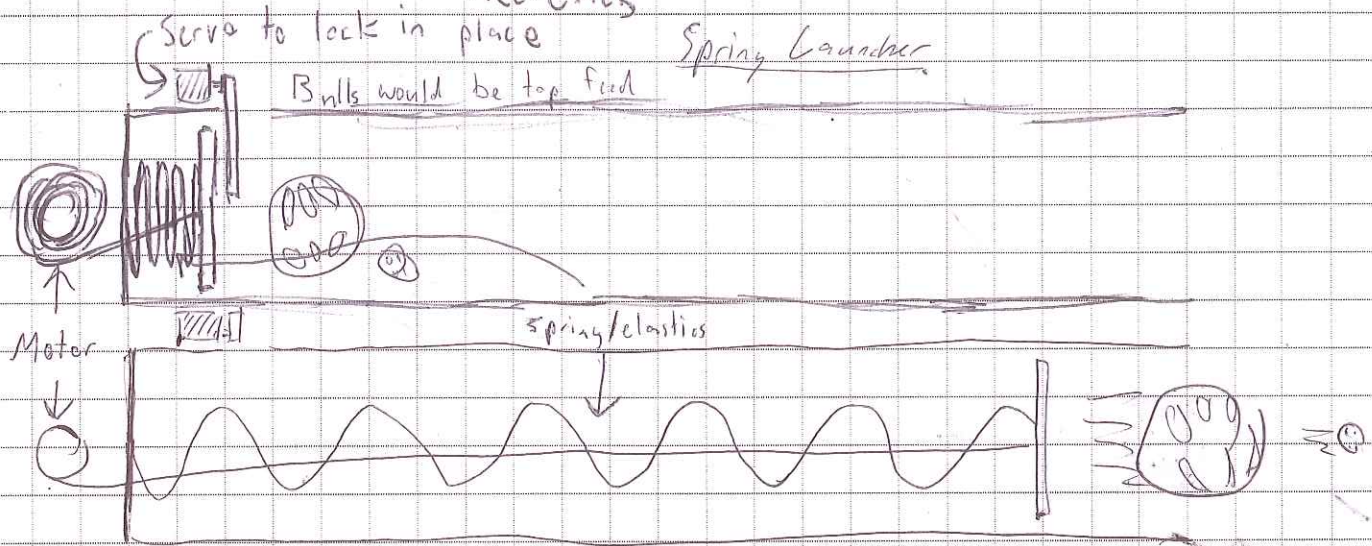
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PROPRIETARY INFORMATION

Sketches



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SIGNATURE *Ethan Price*

DATE 9-14-14

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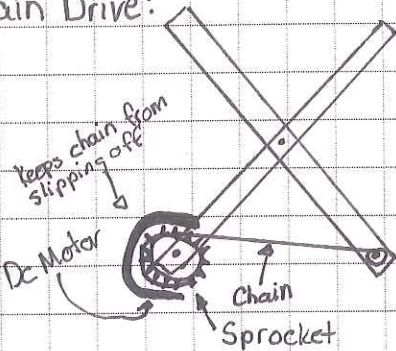
PROPRIETARY INFORMATION

Lift Design Ideas/Sketches

How to drive a scissor lift?

Thoughts on Scissor Lift:

Chain Drive:

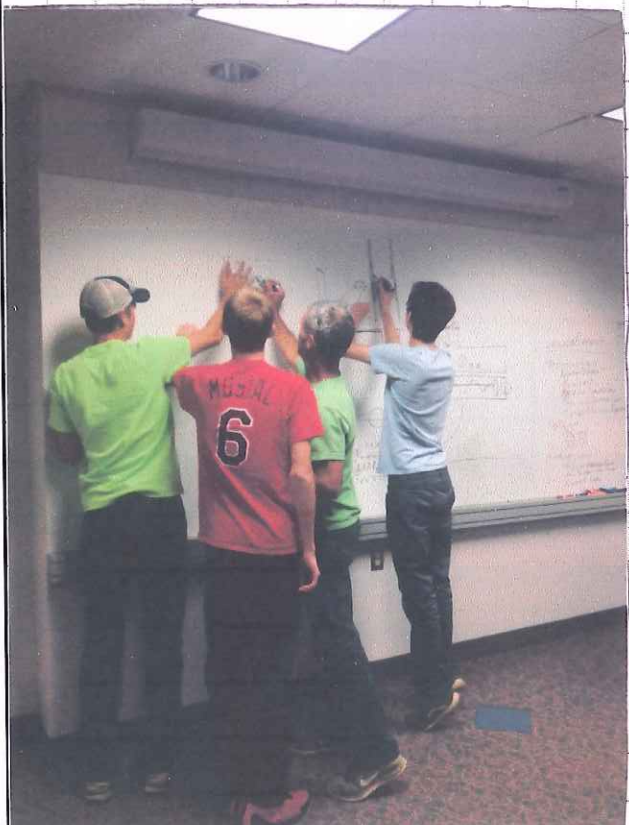
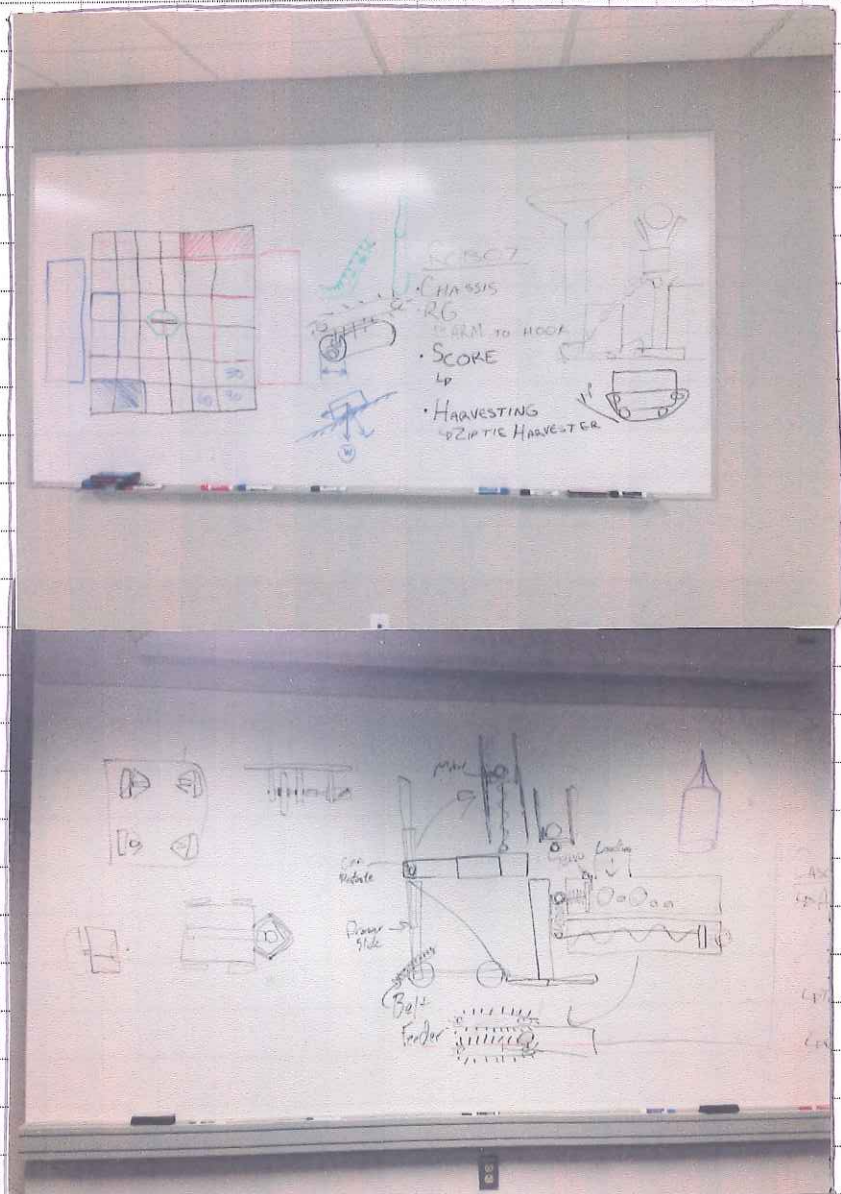
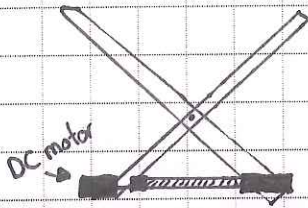


- How to increase speed but keep precision the same if not greater

- Most easiest efficient way to raise the scissor lift needs to be investigated

- ~~Other~~ Ways to make it lighter/different material other than aluminum?

Screw Drive:



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SIGNATURE

Jack Hoopman

DATE

9/20/14

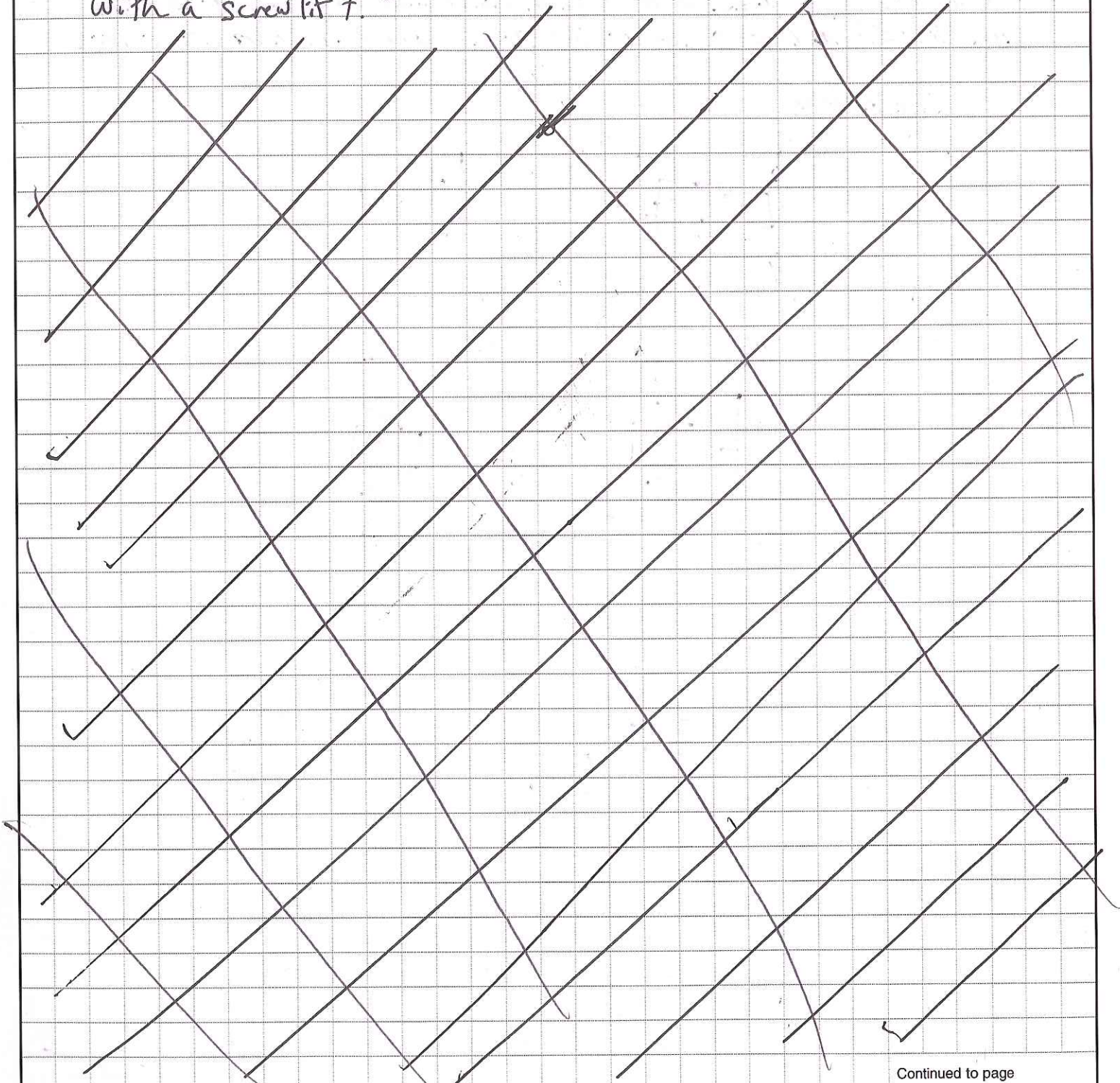
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PROPRIETARY INFORMATION

Scissor lift design

Today in the workshop, we worked on the scissor lift design. we started prototyping the lift and dispenser with PVC, and a crude scissor lift. Our goals for next time will be lengthening the PVC tubing and planning a way to power the scissor lift with a screw lift.



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SIGNATURE

Shane Olym

DATE

9/23/14

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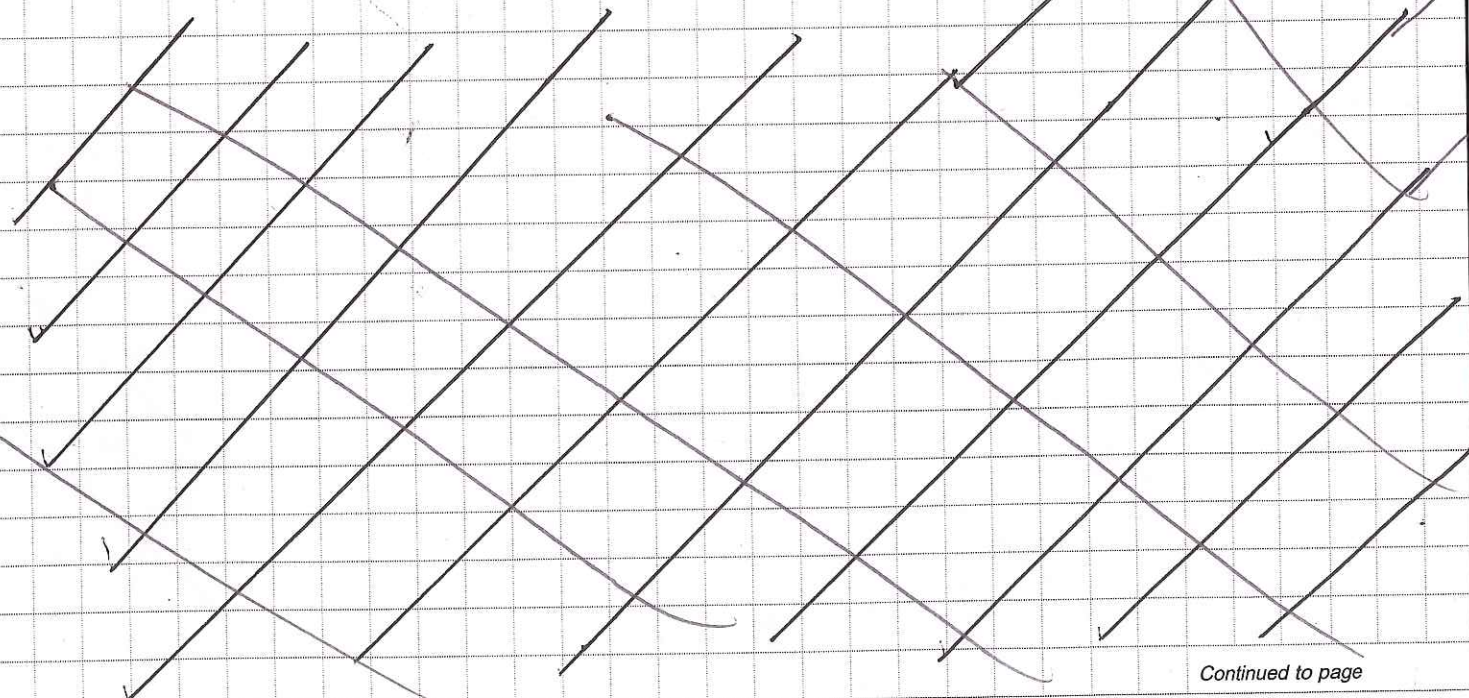
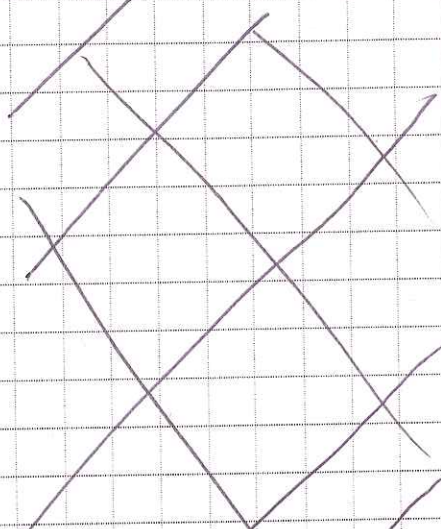
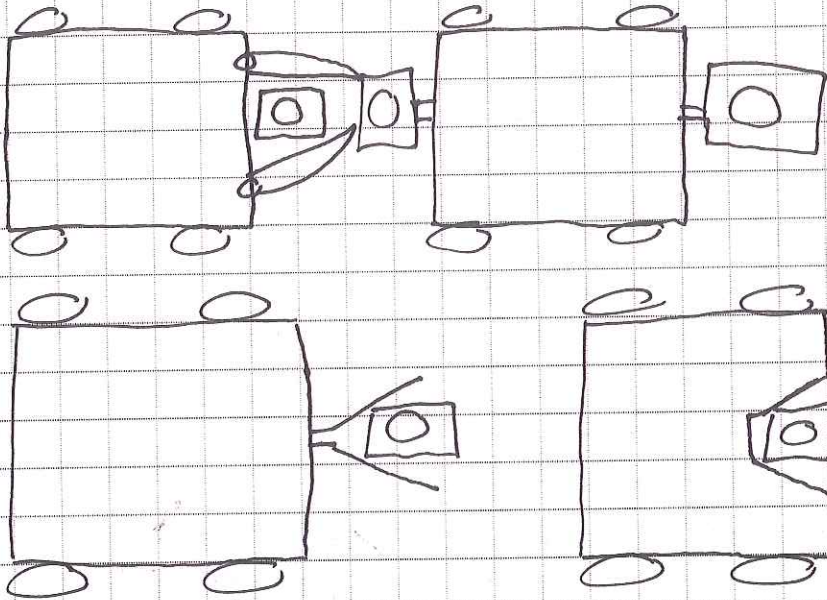
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PROPRIETARY INFORMATION

Goal Manipulation Brainstorming Ideas

Today we discussed goal manipulation and how to control and move the rolling goals. Some ideas we discussed were controlling multiple goals, being able to score while maintaining possession of the rolling goal/goals. We decided that controlling the rolling goals with pegs into the ~~un~~ holes of the rolling goals would be hard to control.

Sketch Ideas



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SIGNATURE

Jack Keenan

DATE

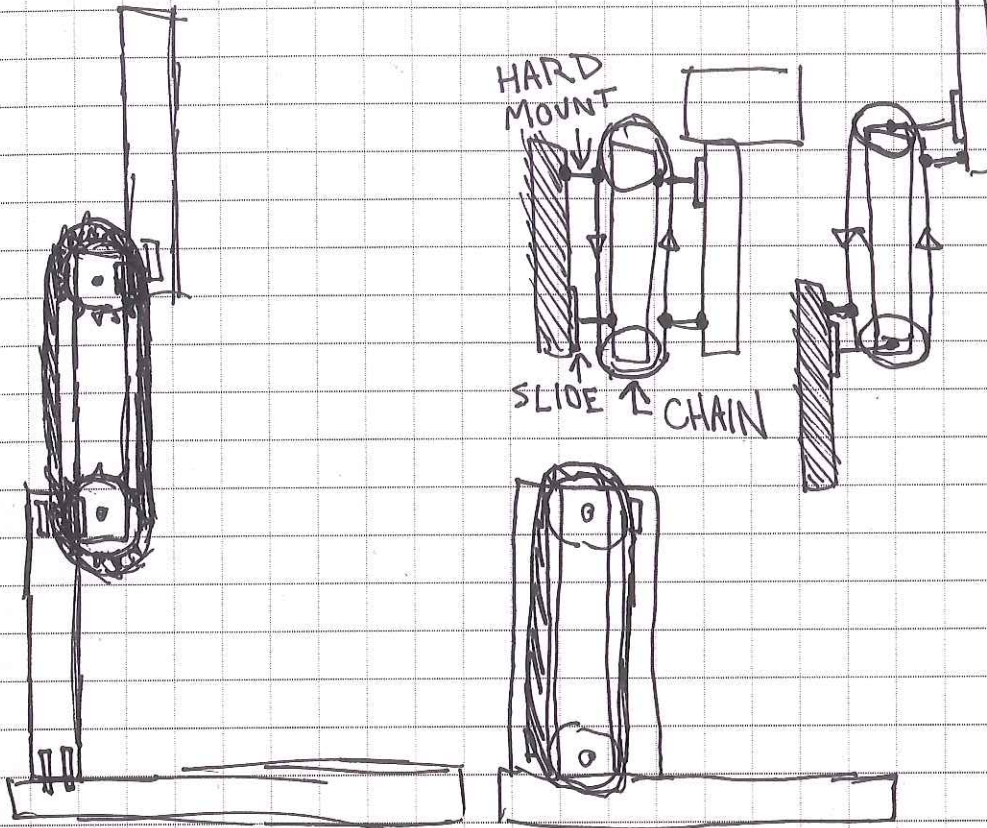
9/27/14

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PROPRIETARY INFORMATION

Linear Slide Ideas



THIS IS OUR IDEA FOR A THREE STAGE LINEAR SLIDE WITH THE DRIVING CHAIN MOUNTED IN THE MIDDLE. WE ALSO MADE A WORKING PROTOTYPE OF THIS DESIGN TODAY.



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Thomas Paves

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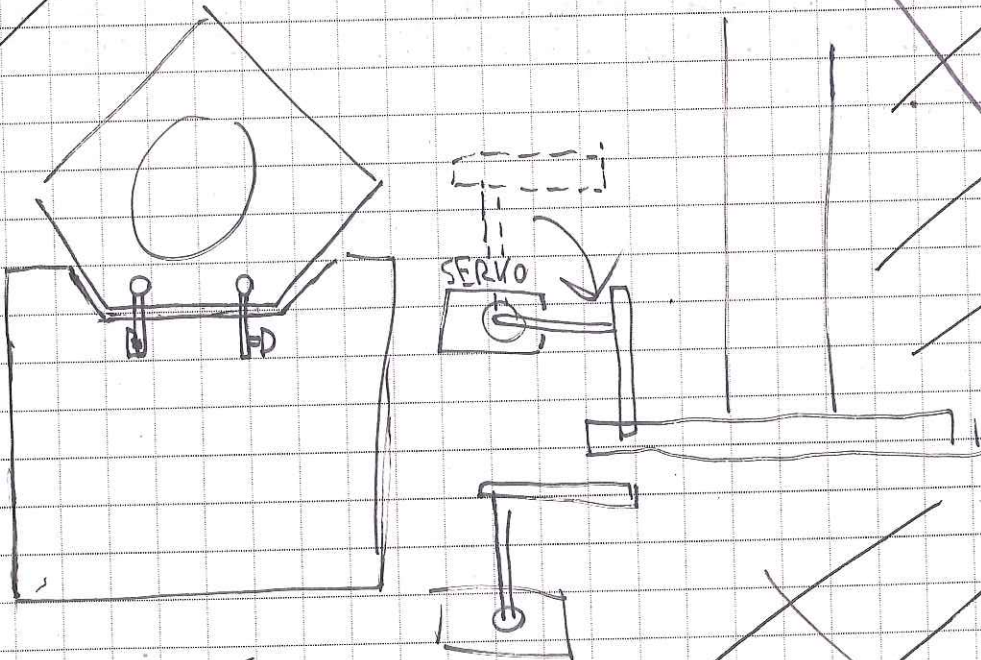
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9-27-14

DATE

PROPRIETARY INFORMATION

Goal Manipulation



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SIGNATURE

Mare Chopko

DATE

11/21/14

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DATE

PROPRIETARY INFORMATION

Meeting

TASKS

- Working robot by November 15th
- Decide on chassis option
- General chassis (ping and play)
- Decide on criteria for lift choice - Scissor vs. 45° scissor vs. elevator lift

REFLECTIONS

- We have figured out how we will be deciding on a lift (Decision matrix)
- Almost ready to test harvester
- Attempted to make elevator more stable (need more parts)
- Overextended prototyping time
- ~~45°~~ Scissor lift goes up but doesn't stay in position (need to make a mechanism for it to fall down)

Lift Decision Matrix:

	Elevator	Vertical Scissor Lift	45° Scissor
Speed			
Stability			
Extend Height			
Footprint			
Reliability			
Maintainable			
Feasibility			
Lowest Motor #			
Lowest Servo #			
Motor (or Link) Strain (or these or)			
Rank 1, 2, 3 → Lowest sum will win			

• This is the Decision Matrix we will use to evaluate our lift mechanism once the prototype is done.

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SIGNATURE

Alexhek Subramaniam

DATE

10/7/14

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DATE

PROPRIETARY INFORMATION

Pictures of lifts:



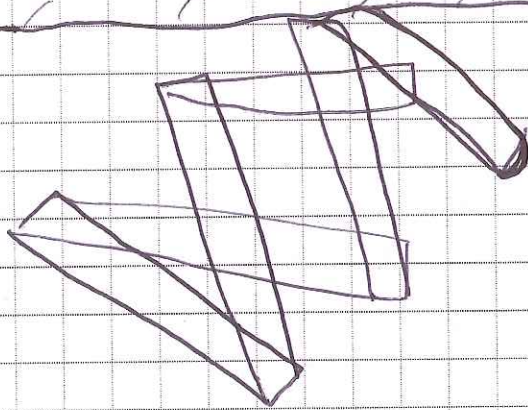
Direct Drive
LIFT uses
RACK & pinion
CHAIN to lift
tube for
dispensing balls

Elevator lift



VERTICAL SCISSOR
LIFT to lift dispenser
to high goal was
option

Vertical Scissor lift



45° SCISSOR
WOULD HAVE A
TUBE FOR DISPENSING
BALLS

45° Scissor lift

Continued to page

SIGNATURE

alsheda

Sulwamamiam

DATE

10/7/14

DISCLOSED TO AND UNDERSTOOD BY

DATE

PROPRIETARY INFORMATION

Meeting

Tasks

- Decide on which lift to use
- Review chassis design and begin construction
- Prepare mecaenum bot for programming work

Reflections

- We decided to use an elevator lift based on our matrix
- We cut all the pieces for the chassis, now we need to paint and assemble them
- Fitted mecaenum bot with new motors and encoders
- We need to make a CAD model of our lift and harvester
- We need more 80-20 L-brackets

We started off by discussing the chassis that was finalized in CAD. Two important things came into account.

- The new hardmounted bearings we ordered could fit into the 80-20
- The screw holes on the bearings were too small for our screws

We had two options:

- Drill holes through the 80-20 and directly attach the bearings to it
- Fabricate baseplates which we would attach the bearings to, and then attach those to the 80-20

We decided to use the baseplates as they would allow more customizability as well as a more rigid and flat mount surface.

After that, we started to assemble the chassis based on the CAD design. We began with cutting all of the 80-20 to length, with 4 17.5" pieces, 4 2.7" ones, and 2 9" ones. We made a jig to use with the bandsaw so we were sure we were making 90° cuts. We also found we need more L-brackets for the 80-20.

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SIGNATURE

Matt Warner

Ethan Price

DATE

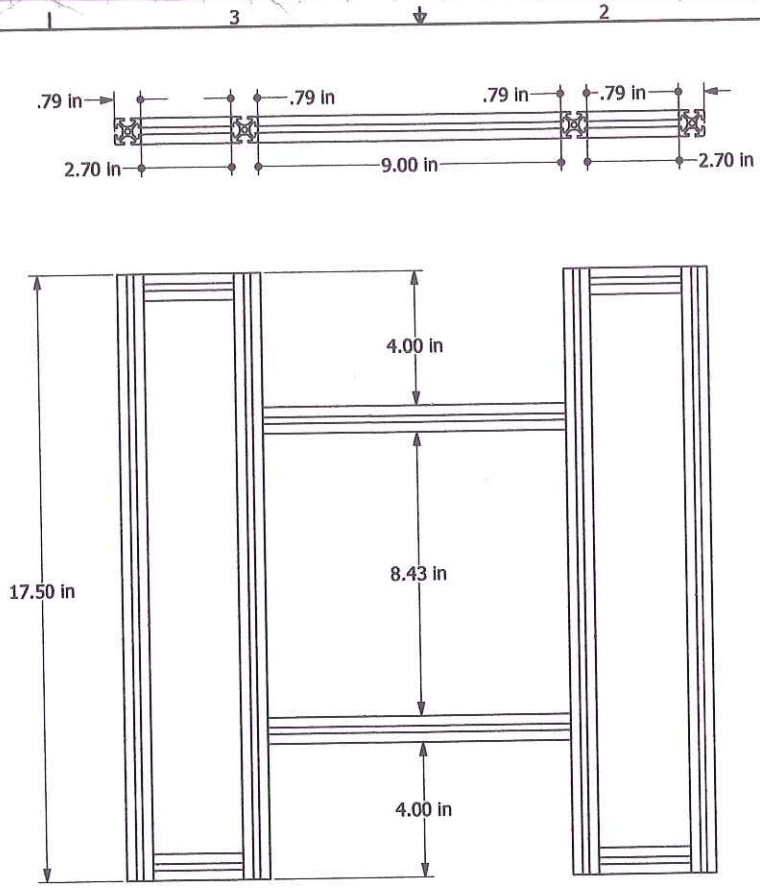
10/11/14

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DATE

PROPRIETARY INFORMATION

We also discussed which lift to use with the options being an elevator lift, a vertical scissor lift and a 45° scissor lift. We made a matrix with different categories and we rated each lift for every category. The matrix is attached to the back of this page. We scored each lift with 1 being the best and 3 being the worst. The numbers were totaled up and the elevator lift had the lowest total. Two of the categories we didn't count because they weren't very important and didn't effect how our lift would perform.



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APPROVED		
	SIZE C	DWG NO
	SCALE	REV
		SHEET 1 OF 1

Continued to page

SIGNATURE
Alan Price

DATE
10-11-14

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DATE

PROPRIETARY INFORMATION

	Vertical Scissor	Score	45 Scissor	Score	Elevator - Linear Slide	Score
Speed	1	2	1	2	Fastest	1
Stability	2	2	Harder to manipulate at lower heights	3		1
Accuracy	2	2	Harder to manipulate at lower heights	3	Very accurate	1
Extended Height	46	2	48	1	42" can be extended by one phase	3
Reach		1	Requires large reach for top goal	3		1
Footprint	11 h x 5w	3	12.5 h x 8w x 3d	2	Small, 16.5" h 2.75w" 3"d,	1
Reliability	Hard to bring down lift, chain driven	2	Hard to bring down lift, steel	2	Very r	1
Maintainable	Motor - chain, rest of lift	2	Motor - chain, rest of lift	2	Wires need to planned carefully, rack and pinion requires servo	2
Feasibility	Yes, can be built in 2 weeks, do we have parts? Shorten every phase, add another scissor phase	3	Yes, can be built in 2 weeks, do we have parts? Shorten every phase, add another scissor phase	1	Yes, Easiest	2
Lowest Motor #	1		1			1
Lowest Servo #	1		1			2
Motor Strain	Heavy strain at current time, 2	3		2		1
		22		21		14

Our Matrix we used to decide which lift to use

SIGNATURE

John Price

DATE

10-11-14

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DATE

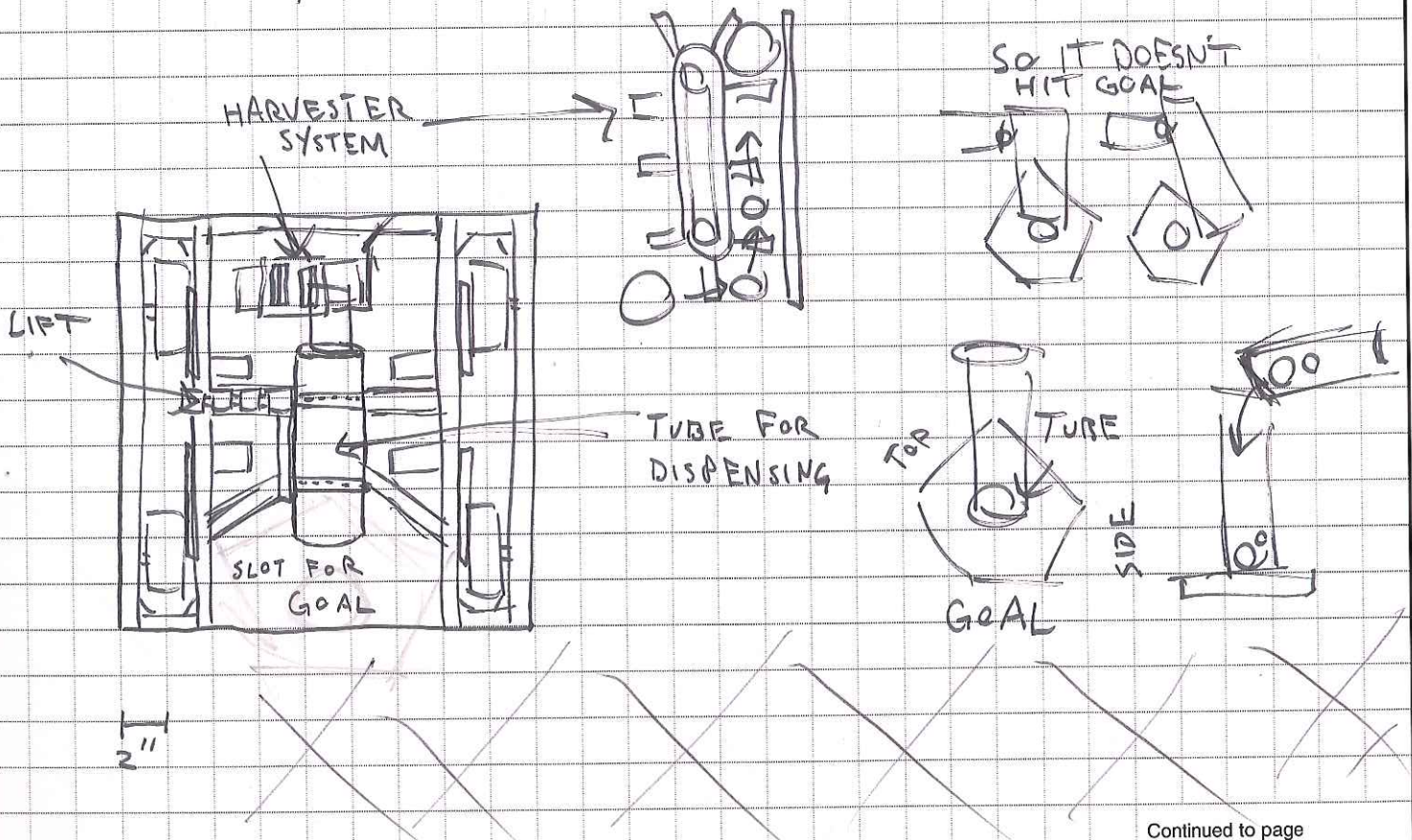
Tasks

- Work on chasis
- Work on how the parts would fit together

Reflections

- All of the part we have don't fit together
- We couldn't build the chasis

Today we discovered some of the difficulties regarding 80-20. After receiving our 20mm 80-20, we found that the slots on these pieces were 5mm, while the slots on our old pieces were 6mm. This meant that our old pieces would not work with the new part, so we had to order compatible pieces. This also meant we couldn't continue with work on the chasis. However, we could plan out the layout of the robot, which we did.



Continued to page

SIGNATURE

Whan Price

DATE

10-14-14

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PROPRIETARY INFORMATION

DEUL ON THE DELAWARE

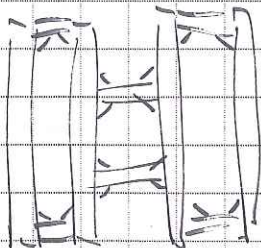
Tasks

- Get a working robot
- Test working robot

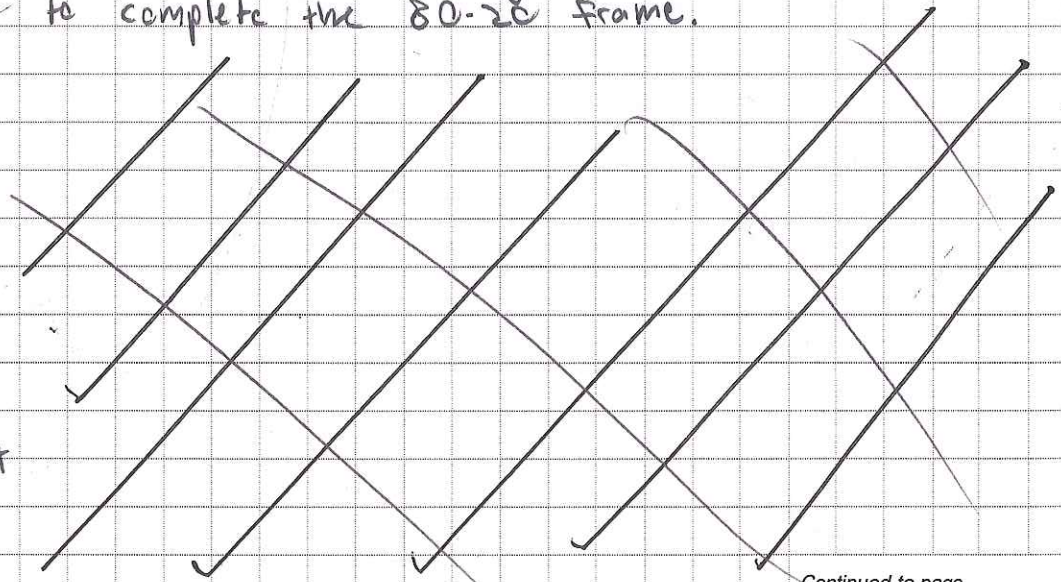
Reflections

- Buckets do not work well for this game
- We should bring our electronics stuff
- Last years robot can't reach high enough

Today was our first scrimmage, but we haven't even started on our chassis yet. So we decided to modify last year's robot with a new bucket that was the right size (to pick up balls). This wasn't too hard to do, and we were able to compete. However, we found that a bucket did not work very well for picking up the balls, and the dispensing was also difficult. We averaged one of two balls scored a match. However, we did find that we could easily push the goals with the H shape without any modifications. We also got in the parts we ordered last meeting and were able to begin work on the chassis. We were able to complete the 80-20 frame.



Basically what we built for the chassis



Continued to page

SIGNATURE

Ethan Prince

DATE

10-18-14

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PROPRIETARY INFORMATION

Meeting

Tasks

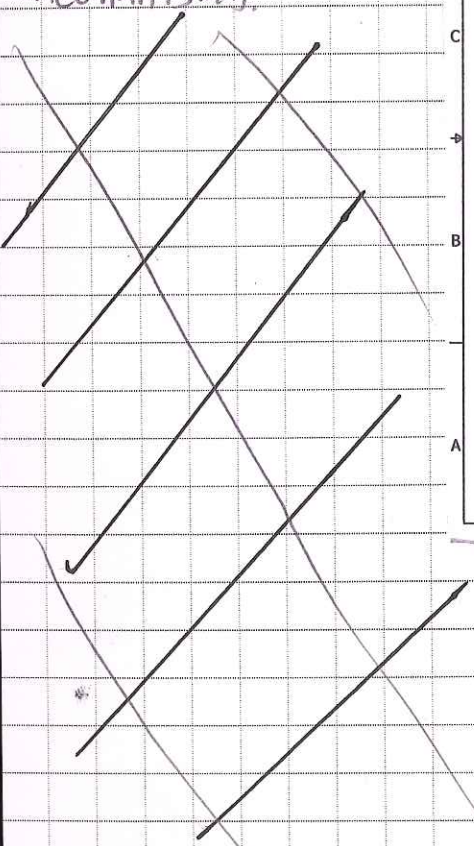
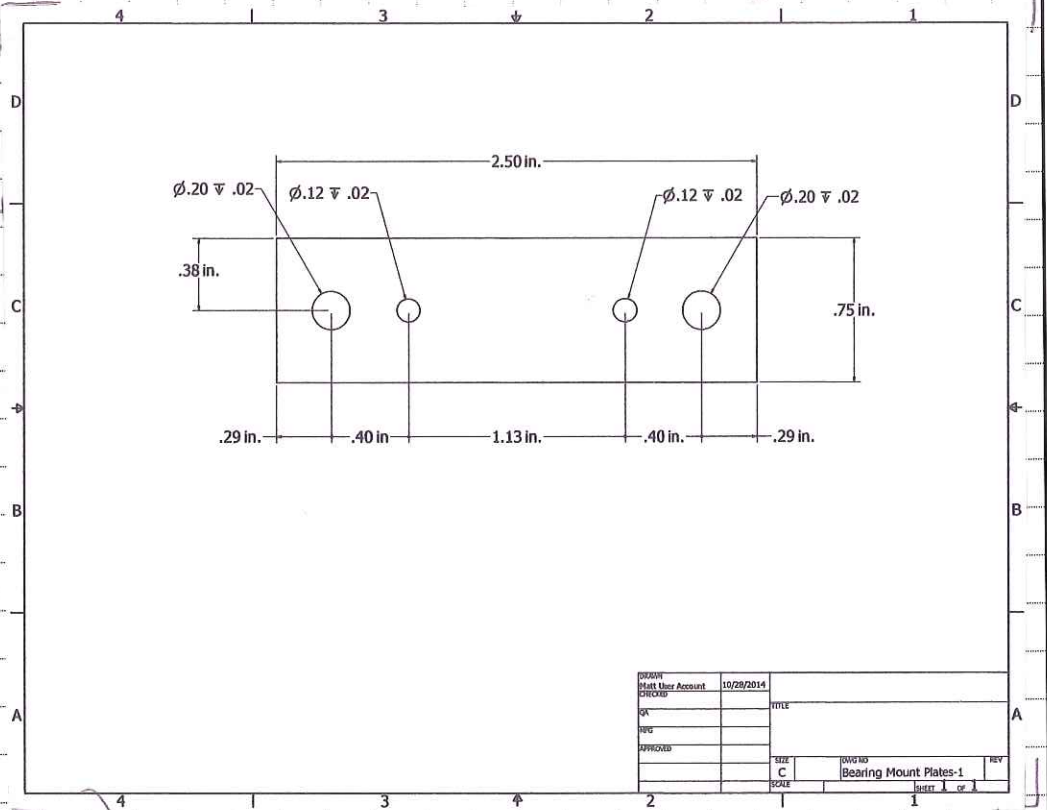
- Assemble Chassis
- Work on bearing mounts
- Continue working on lift

Reflections

- Mount plates were too short

Today we continued working on the chassis. We worked on drilling the inner 2 holes and outer holes after we realized that the previous ones were too short. We used CAD to assist with determining the positions of the new holes.

Alongside that, others were making progress on the lift and harvest mechanisms.



Continued to page

SIGNATURE

Ryle Merrill

DATE

10-21-14

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DATE

PROPRIETARY INFORMATION

Meeting - Saturday

Tasks

Continue to develop ball harvester

- Shorten and cut down ball harvester
- develop ball harvester shell casing

Work on the lift and design

- put on the rack and pinion on our lift

Continue constructing our chassis design off of Matt's CAD drawing

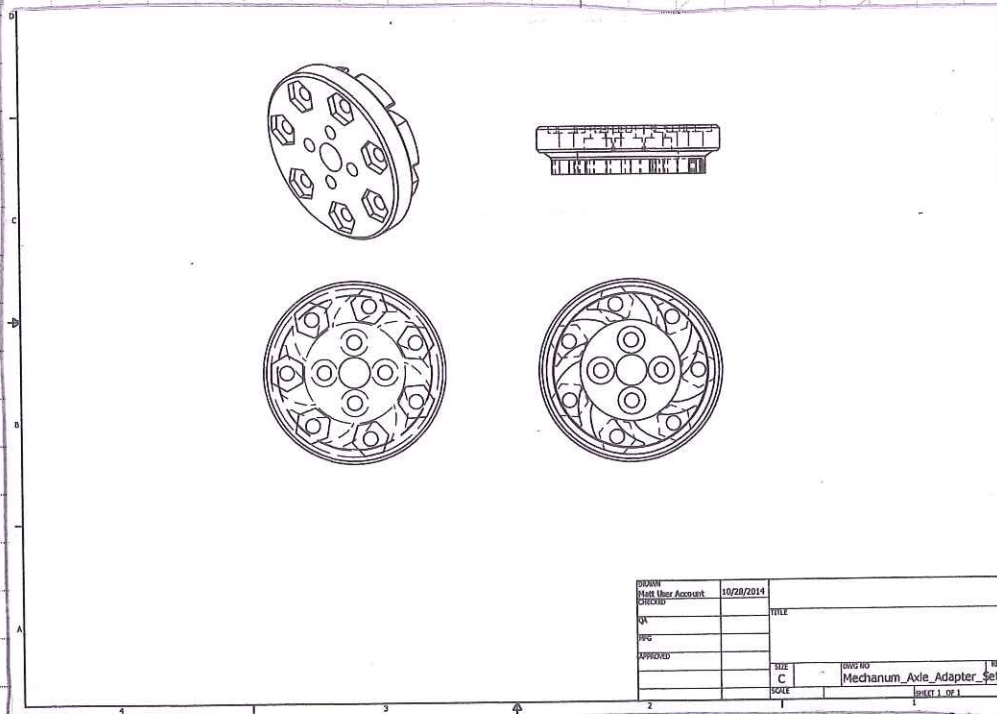
- mount the mecanum wheels

Reflections

- We were able to shorten the C channel down to 12" in order to fit in the height limit and be able to drive overtop of balls

- We were able to assemble ~~over~~ the rack and pinion and mount it to C channel

- Drilled holes into the newly cut bearing plates for mounting



Continued to page

SIGNATURE

Jack Heppman

DATE

10/25/14

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PROPRIETARY INFORMATION

Meeting - Tuesday

Tasks

Reflections

Assign Notebook Updates to people

Include CAD in the Notebook

Finish Installing Wheels

Continue work on the lift

Cut out support plates for harvester

Make ball harvester shell casing

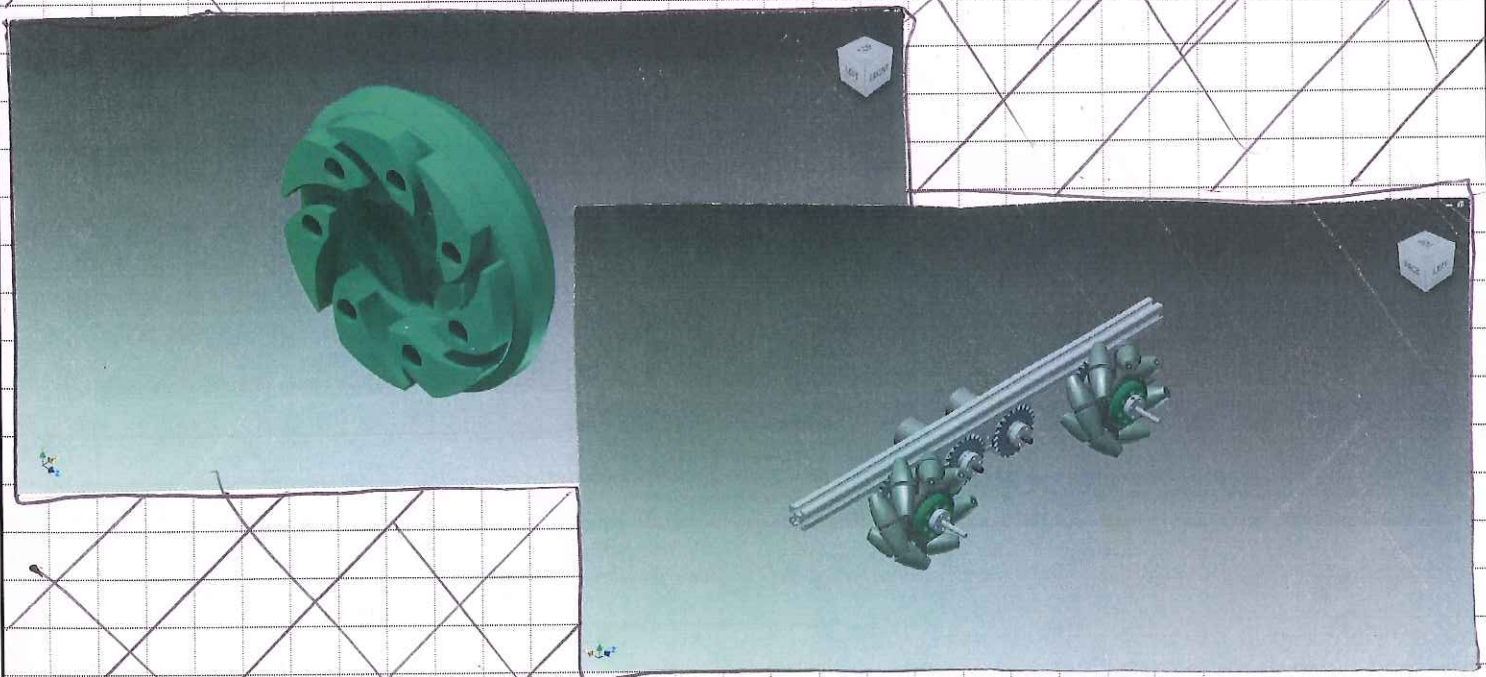
Were able to cut out and start bending our support plates for our ball harvester shell casing

Re-designed the ball harvesting ~~ing~~

Finished ~~cutting~~ ^{drilling} the bearing plates

Came across issues with the screws being to short for mounting our wheels

Took apart lift and was able to rebuild it for a better design



Continued to page

SIGNATURE

Jack Hoopman

DATE

10/28/14

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PROPRIETARY INFORMATION

Meeting

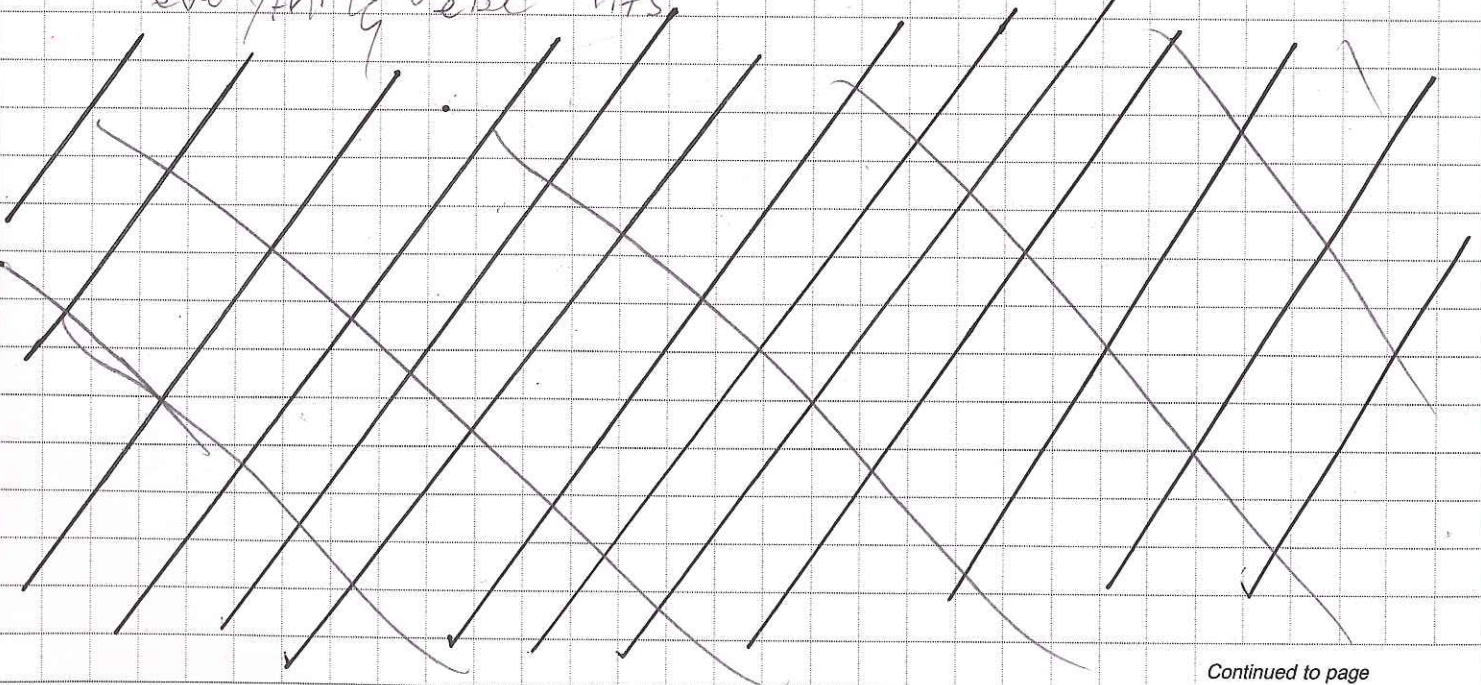
Tasks

- Attach wheels to chassis
- Ready lift of mounting on chassis
- Finish harvester

Reflections

- Wheels are mounted on chassis
- We need to figure out where the drive motors will go
- The rack and pinion doesn't work as well as hoped and needs work
- The harvester is ready to be mounted
- The support beams on the chassis need to be moved.

We were able to finally attach the wheels and we can begin putting all of the parts together, although the lift is having some problems with the rack and pinion (meshing) and we need to attach the dispersing tube. We had some conflicts with the positioning of the drive motors and we need to figure out where to put them so everything else fits.



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SIGNATURE

Ethan Price

DATE

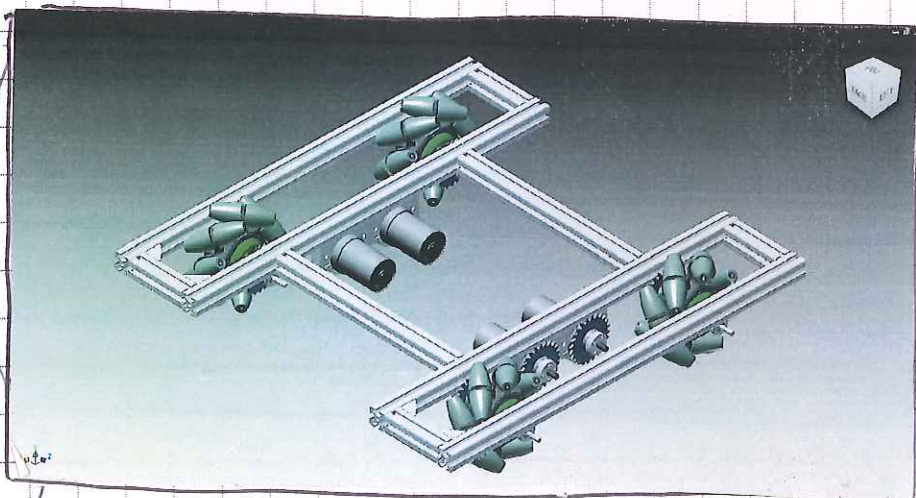
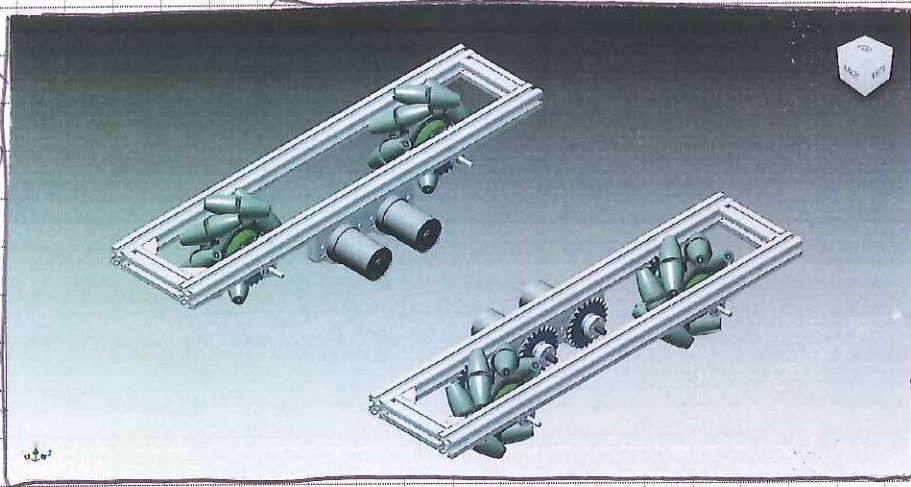
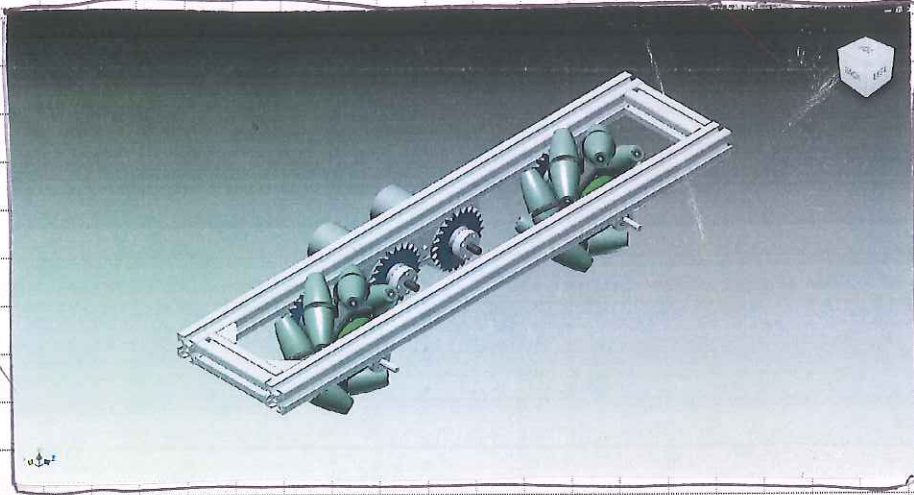
11-1-14

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PROPRIETARY INFORMATION

CAD CHASIS



Continued to page

SIGNATURE

Mike Morvill

DATE

10/21/14

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DATE

PROPRIETARY INFORMATION

Meeting

Tasks

- Take off covering from harvester
- Make Harvester shorter
- Work on Goal manipulation
- Switch gear on lift so that it doesn't hit drive motor

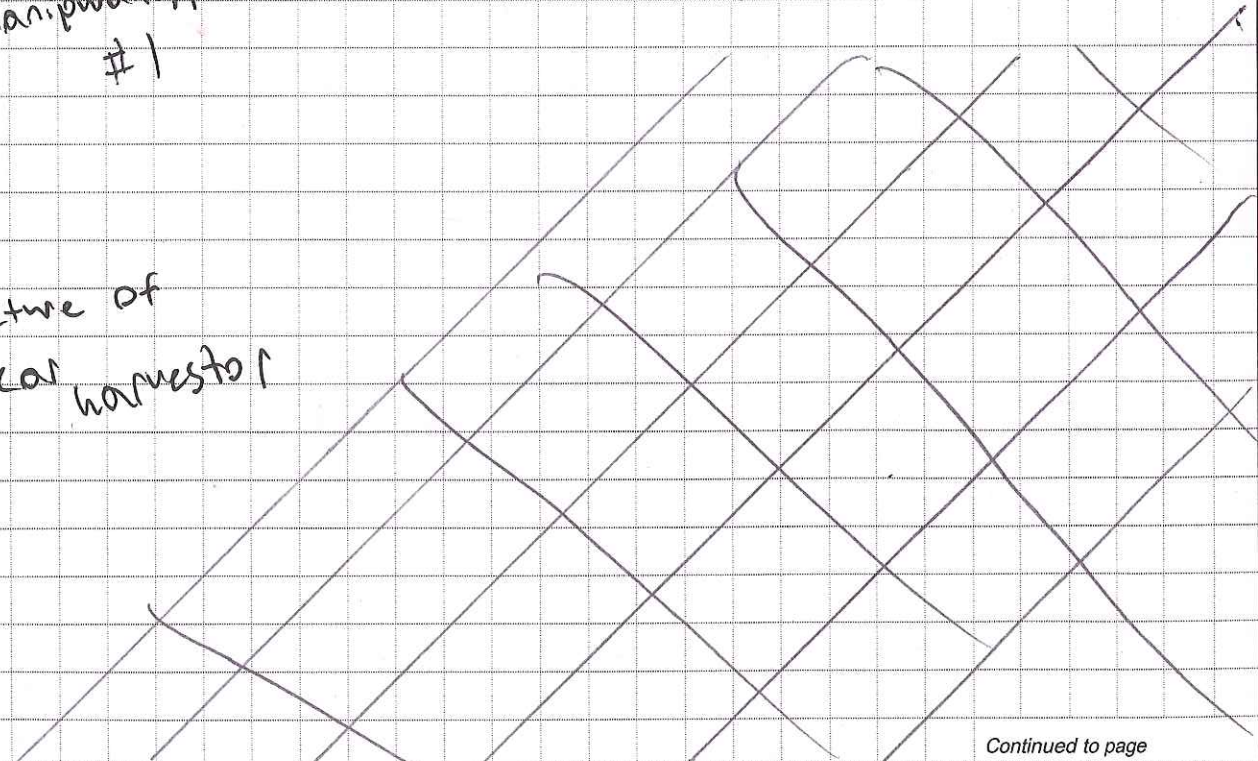
Reflections

- we took off the white covering from the harvester so that it would be clear and we could see the ball
- we had to make the harvester shorter so that we could fit a pipe to redirect the balls into the lift.
- we worked on our goal manipulation designs and had two possible options.
- we had to reverse a gear on the lift so it wouldn't hit the drive motor

Picture of Goal manipulation design #1

Picture of goal manipulation design #2

Picture of clear harvester



Continued to page

SIGNATURE

Alvresheh

Sulaiman

DATE

11/11/14

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DATE

PROPRIETARY INFORMATION



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DATE

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DATE

PROPRIETARY INFORMATION

MEETING

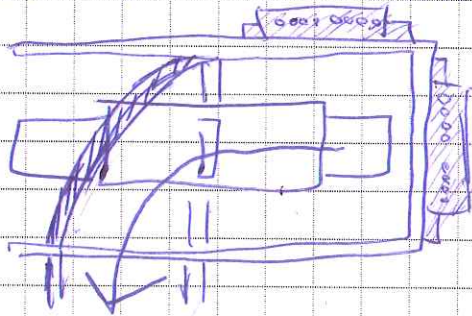
TASKS

- WIRE THE ROBOT
- REMOUNT THE LIFT
- GET THE GOAL MANIPULATOR DONE
- BUILD SIDE PANELS

REFLECTIONS

- WE NOW HAVE ALL THE MAJOR COMPONENTS ON THE ROBOT
- WE STILL NEED ELECTRONICS
- SIDE PANELS NEED TO BE PAINTED
- WE HAD TO MAKE SOME CHANGES FOR SIZING

WE FINISHED RECONSTRUCTING THE LIFT FOR THE CHANGE IN DISPENSER ROTATION. WE ALSO BEGAN CONSTRUCTION ON THE MECHANISM IN THE HARVESTER TO DIVERT THE BALLS INTO THE DISPENSER. WE HAVE BOTH A TOP PLATE AND A CURVED PANEL THAT HITS THE BALLS BUT DOES NOT HIT THE PADDLES. THIS PUSHES THE BALLS



OUT THE SIDE OF THE HARVESTER. THE GOAL SKIRT WAS ALSO FINISHED AND MOUNTED SO NOW THE GOALS LINE UP WITH IT WHEN WE PUSH THEM. WE ARE STILL WORKING ON WHERE THE ELECTRONICS WILL GO, BUT WE DID GET ALL OF THE CONTROLLERS

MOUNTED TO THE SIDES OF THE HARVESTER, THOUGH WE STILL NEED TO MOUNT THE SAMANTHA, NXT, BATTERY, AND SWITCH PANEL. THE SIDE PANELS ARE ALMOST READY TO BE PUT ON, THOUGH THEY NEED TO BE PAINTED. ONCE WE GET THOSE ON, THE ROBOT WILL BE DONE.

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SIGNATURE

DATE

11-15-14

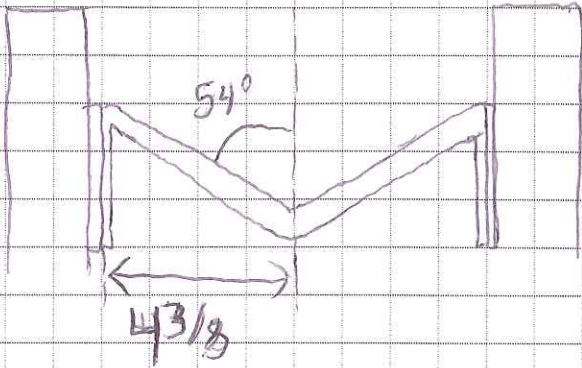
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DATE

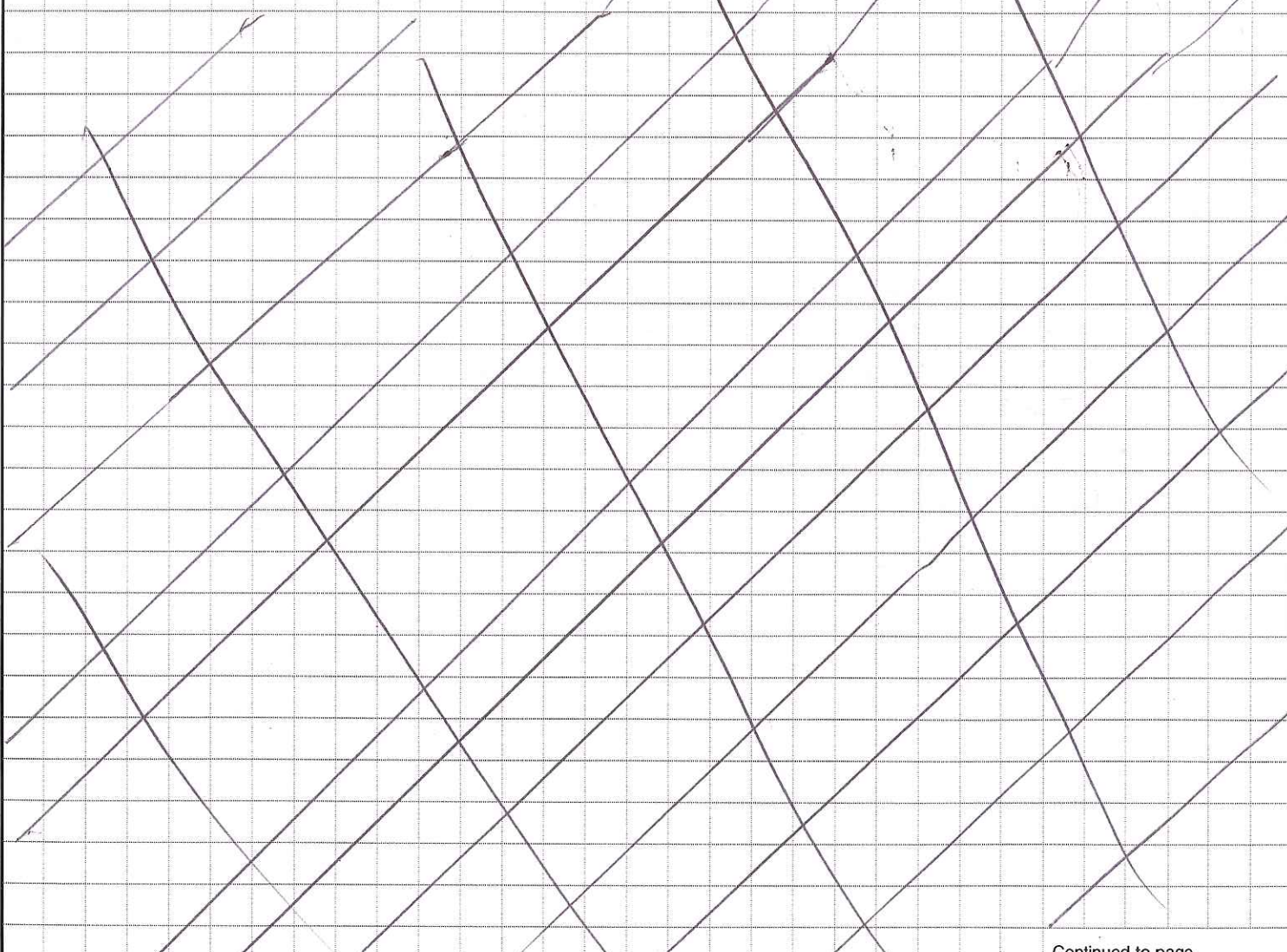
PROPRIETARY INFORMATION

Meeting Cont.

We continued to work on our rolling goal manipulator
We used trigonometry to predetermine the length of the legs for
our mount,



$$\frac{4 \frac{3}{8} \text{ in}}{\sin 54} = 5.4 \text{ in}$$



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SIGNATURE

Matt Warner

DATE

11-15-14

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DATE

PROPRIETARY INFORMATION

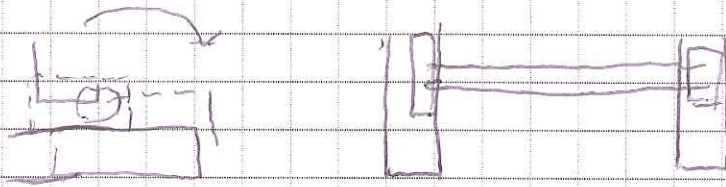
Meeting

Tasks

- Finish goal manipulator
- Refine feeder
- Make skirt
- Refine dispenser
- Mount IR sensor
- MAKE ROBOT DRIVEABLE
- ELECTRONICS
- MOUNT THE SIDE SHIELDS

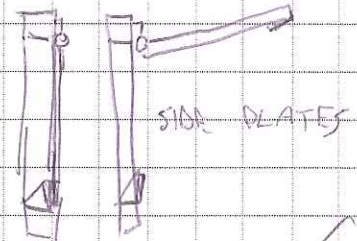
Reflections

Rolling goal manipulator



OUR MAIN GOAL FOR TODAY WAS TO GET THE ROBOT DRIVEABLE, WHICH IS SOMETHING WE ACCOMPLISHED. THIS MEANS WE GOT ALL OF THE MOTORS WIRED, THE NXT MOUNTED, AND THE

JAMANTHA MOUNTED. WE ALSO MOUNTED THE SIDE PANELS AND PUT THE HINGES AND VELCRO TO ALLOW EASY ACCESS TO ALL OF THE THINGS. WE MOVED THE DISPENSER TO LINE UP WITH THE HOLE FOR THE BALLS IN THE HARVESTER, BUT THIS CAUSED IT TO HIT THE SIDE PLATES.



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SIGNATURE

Math Warner

DATE

11/16/14

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PROPRIETARY INFORMATION

Meeting

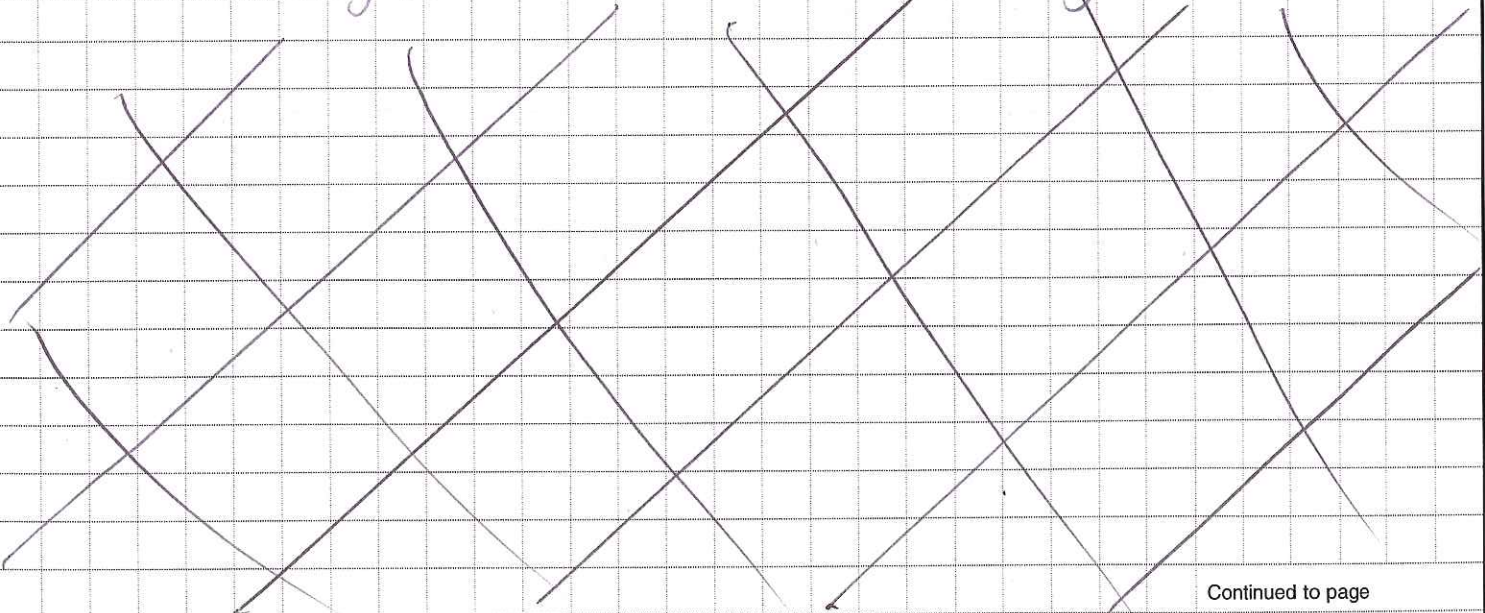
Tasks

- Get NXT and Samantha mounted and wired
- Get Servos wired
- Get motors wired
- Get harvester to dispenser complete
- Changed gate for tube to allow for clearance
- Get skirt made and mounted on robot
- Mount goal manipulator
- Get protoboard mounted

Reflections

- We have all the servos and the motors all wired
- We have NXT secured in Robot
- Clean up wiring
- Gate has good clearance from tube and prevents balls from falling out
- Skirt blocks balls from going into ball
- Ball goes from harvester to dispenser smoothly

When mounting the skirt we ran into an issue where the skirt would be blocking the goal from entering the goal manipulator on the robot. We trimmed it to allow for the goal to fit in but this allowed the small balls to enter the robot. Our solution to this was to mount zip ties to the front ~~board~~ which would allow the goal to enter while still blocking the balls.



Continued to page

SIGNATURE




DATE

11/20/14

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DATE

PROPRIETARY INFORMATION

BILL OF MATERIALS

FTC Robot Bill of Material

Team Number:

365

Please list any non-TETRIX® or non-MATRIX® parts and provide this list to the hardware inspector.

(Tip: make two copies, keep one in your Engineering Notebook, bring the other to Hardware Inspection).

Part Description	Game Rule / Forum Reference
EXAMPLE: QTY 4 Anderson Power Poles	Game Manual Pt 1: <R03.n>
EXAMPLE: QTY 3 prefabricated joining plates	Forum: Robot Parts and Materials post #5 <R02.a.1>
Mechanum wheels <vexrobotics.com> part # 276-1447	Game manual Pt
Miniature mounted bearings <http://www.mcmaster.com> part #	Game manual Pt 1: <R04.c>
Servo Blocks <servocity.com> part # 637110	Game manual Pt 1: <R04.c>
extruded aluminum corner bracket part #	Game Manual Pt 1: <R04.b>
Steel axle	Game Manual Pt 1: <R04.b>
Plastic Chain, 1/4" pitch <http://www.servocity.com>	Game Manual Pt 1: <R04.c>
80/20 T-nuts <http://www.mcmaster.com> part # 47065T233	Game Manual Pt 1: <R05>
80/20 Braces <http://www.mcmaster.com> part # 5537T81	Game Manual Pt 1: <R04.a>
80/20 <http://www.mcmaster.com> part # 5537T101	Game Manual Pt 1: <R04.e>
Clear Polycarbonate <http://www.mcmaster.com> part # 8574K63	Game Manual Pt 1: <R04.e>
Angle bracket <http://www.mcmaster.com> part # 8982K36	Game Manual Pt 1: <R04.e>
C Channel <http://www.edconsteel.com> part # ALCHN.40.20.2	Game Manual Pt 1: <R04.e>
Green toggle Switches <http://www.surpluscenter.com> part # 11-3286-G	Game Manual Pt 1: <R08.d>
Anderson Power Poles <http://www.powerex.com> part # PP15-25	Game Manual Pt 1: <R03.n>
Anderson Power Pole Distribution Hub <http://www.powerex.com part# ps-8	Game Manual Pt1: <R08.q>
Pvc tube <http://www.homedepot.com> part # 1610	Game Manual Pt 1: <R04.a>
Zipties	Game Manual Pt 1: <R06.d>
Servo City Hub Adapter <http://www.servocity.com> part # 545456	Game Manual Pt 1: <R05.d>
Spiral Cut Wrap 1/4" <http://www.mcmaster.com> part # 7378K426	Game Manual Pt 1: <R08.t>
Wire 16 Gauge	Game Manual Pt 1: <R08.r.i>
Tetrix servo wire extenders <http://store.talentcenter.com> part #	Game Manual Pt 1: <R08.r>
Poly Foam <http://www.netsolhost.com> part # polyfoam8236	Game Manual Pt 1: <R04.a>
Wheel Adapters	Game Manual Pt 1: <R07>
Goal Grabber	Game Manual Pt 1: <R07>
Hinges	Game Manual Pt 1: <R04.c>
Hose Claps	Game Manual Pt 1: <R05>
Green Gaffer Tape	Game Manual Pt 1: <R05>

Continued to page

SIGNATURE

Shirley Chapman

DATE

11/21/14

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DATE

PROPRIETARY INFORMATION

OXFORD QUALIFIER

GOALS

- DON'T BREAK THE ROBOT
- SEE HOW WELL THE ROBOT PERFORMS
- KEEP THE ROBOT IN PEAK CONDITION THROUGHOUT THE COMPETITION

REFLECTIONS

- WE HAD TO REMOVE THE SKIRT
- WE CHANGED THE GOAL GRABBER
- THE LIFT COULD USE IMPROVEMENT
- THE HARVESTER NEEDS IMPROVEMENT

MECHANICALLY, THE ROBOT WORKED SOUNDLY. THE MAIN PROBLEM WE WERE HAVING WAS WITH PICKING UP BALLS, SO WE NEEDED TO ADD A MECHANISM TO BETTER GRAB THEM. WE ALSO RAN INTO PROBLEMS WITH BALLS GETTING TRAPPED UNDER THE SKIRT, SO WE HAD TO REMOVE IT. WE ALSO HAD SOME ISSUES WITH THE GOAL MANIPULATOR, THE GRABBER HAD TO BE CHANGED TO A PEG, AND THE GUIDE DIDN'T QUITE WORK RIGHT, SO WE WERE HAVING TROUBLE LINING UP WITH SCORING. WE ALSO HAD SOME TROUBLE GETTING THE BALLS INTO THE HARVESTER. THIS ALL SHOULD BE FIXED BY THE NEXT COMPETITION.

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SIGNATURE

Walter Vance

DATE

11-22-19

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DATE

PROPRIETARY INFORMATION

Meeting

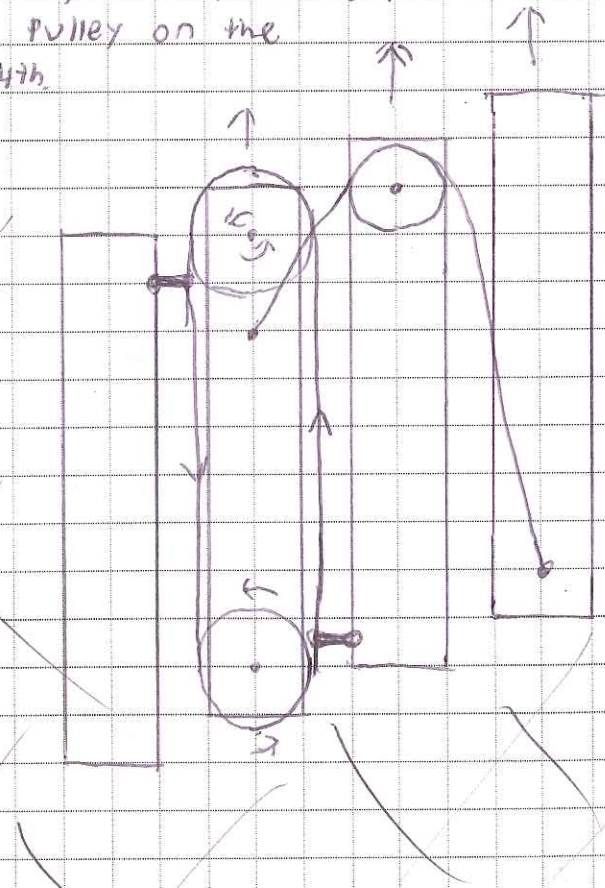
Goals

- Discuss the qualifier
- Prioritize tasks:
 - 1) Harvester improvement
 - 2) Programming/Drive practice
 - 3) ~~Go~~ Goal manipulation
 - 4) Lift improvement
 - 5) misc.: underglow

Reflections

- Task prioritization helped a lot.
- Continue improving the robot.

We started the meeting off by discussing the qualifier. Afterwards, we made a list of our tasks, prioritizing them. We split up into respective groups to work on these tasks. Programming was to be done outside of the meeting, so the robot could be directly worked on, we came up with an idea to solve our problems with the lift. We would use our old design with the chain, but replace the pinion with a 4th piece of 30/20. A wire strung over a pulley on the 3rd slide would connect to the bottom of the 4th. Raising the lift should cause the wire to pull up the 4th piece.



Continued to page

SIGNATURE

Mett W.

DATE

11-25-14

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DATE

PROPRIETARY INFORMATION

Meeting

Goals

- 1) Continue Harvester Improvement
- 2) Work on Programming
- 3) Continue Work on Lift and checkover robot
- 4) Prepare for Ambler Competition
- 5) Robot Wheel Check

Reflections

- 1) Started Development of Improved Harvester including prototyping
- 2) Continued work on robot and auton.
- 3) Fixed and looked over the lift

We looked over much of the robot and replaced the stripped loose t-nuts on the wheels. We drilled out the motor mounts in order to use larger brass bolts instead of the regular tetrix bolts to account for the t-nuts size. We discussed an improved harvester design to make it easier to pick up and score balls. We started prototyping some kind of sweeper that will pull balls into the actual harvester. During drive practice the lift broke down however we were able to fix and replace the wire which holds up the lift.

Continued to page

SIGNATURE

Jack Freeman

DATE

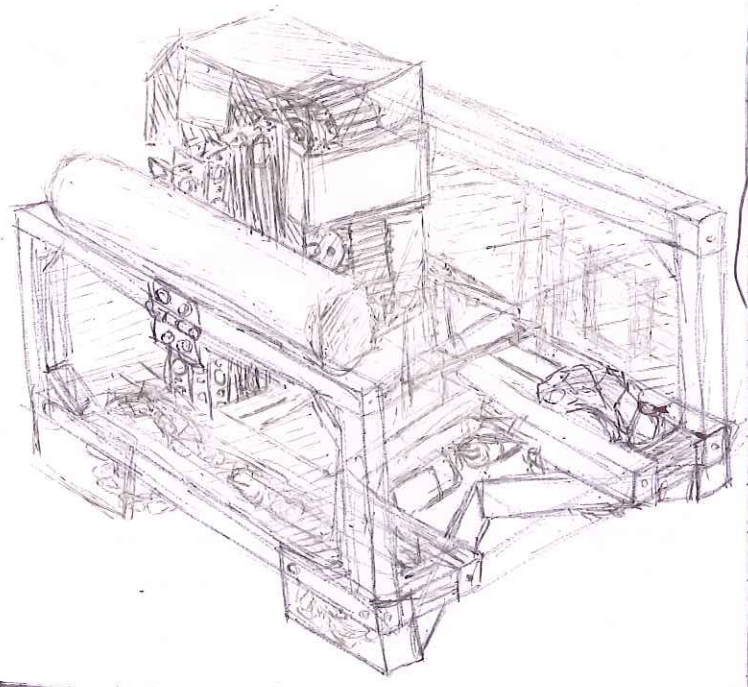
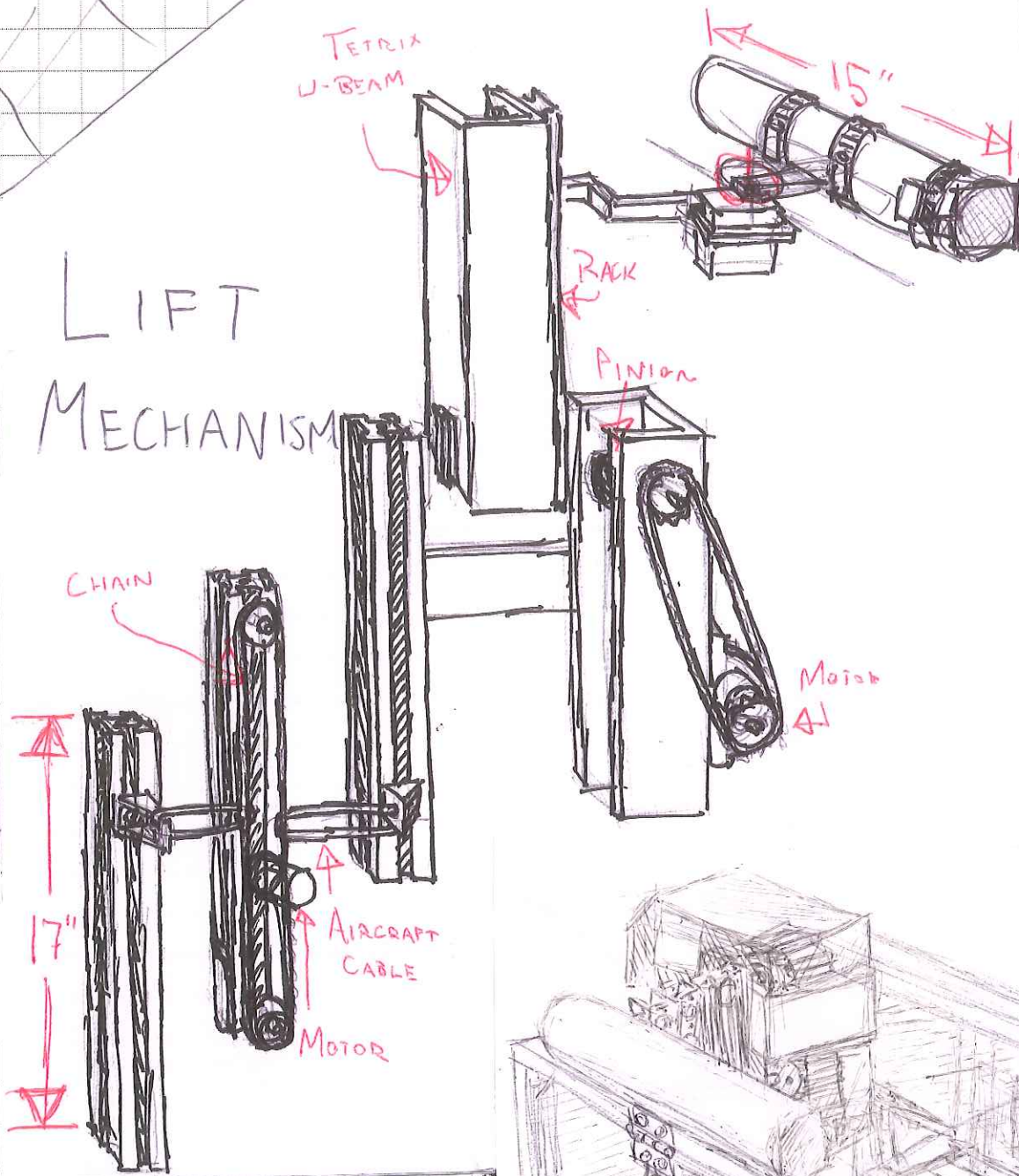
12-2-14

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PROPRIETARY INFORMATION

LIFT MECHANISM



THESE ARE SOME DRAWINGS OF THE ROBOT I DID.

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SIGNATURE

Ethan Pucc

DATE

12-3-14

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DATE

PROPRIETARY INFORMATION

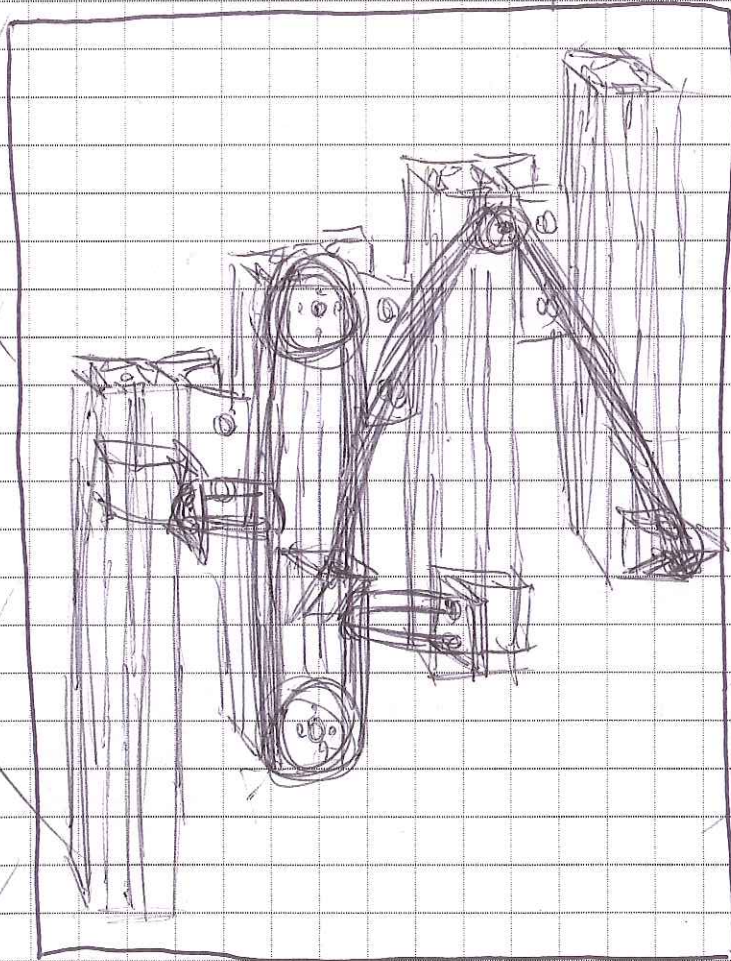
On Tuesday we planned and started building the new lift for the Robot's Scoring and also used the time to try to advance in the Robot's Autonomous and work on our Planned Scoring for Autonomous Position #1

Tasks

- Plan out how we're building the lift
- Begin construction of the lift

Reflection

- The slides are mounted
- We have a plan for assembling the lift



PLAN FOR THE LIFT MECHANISM

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SIGNATURE

Ethan Price

DATE

12-9-14

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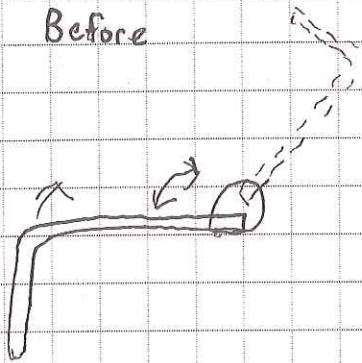
DATE

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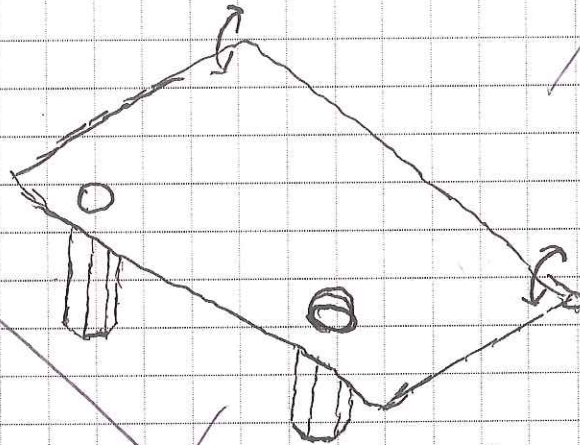
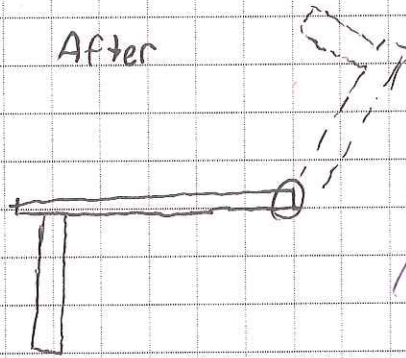
Scrimmage Modifications

At the scrimmage, we made a modification to a previous part to allow us to control rolling goals. We took our ball blocking flap and cut off the top. We then mounted pegs to it, giving us a means of grabbing the goals.

Before



After



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SIGNATURE

Matthew Warner

DATE

12-13-14

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PROPRIETARY INFORMATION

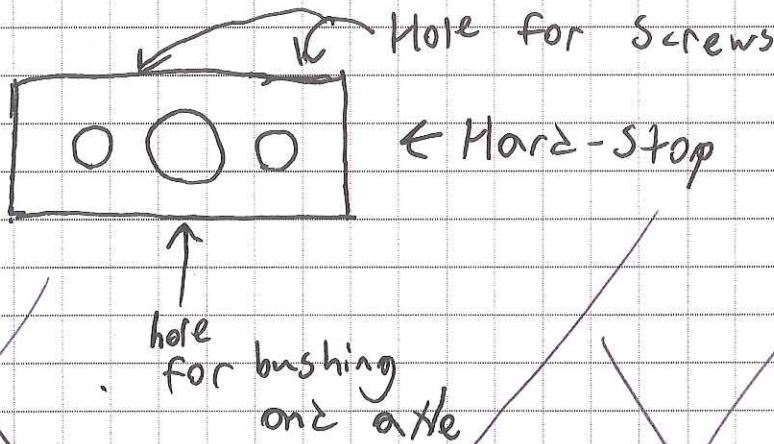
Meeting

Goals

- Make hard stops for the lift (axle-plates)
- 3D Print NXT Mount
- work on putting lift together
- put sprockets on

Reflections

- Bushing holes were a little tight but we adjusted it so that it worked
- NXT Brick printed out to small at first but we got it to print correctly



Continued to page

SIGNATURE

Almesheh

Suluramannan

DATE

12/16/14

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DATE

PROPRIETARY INFORMATION

Meeting

Goals

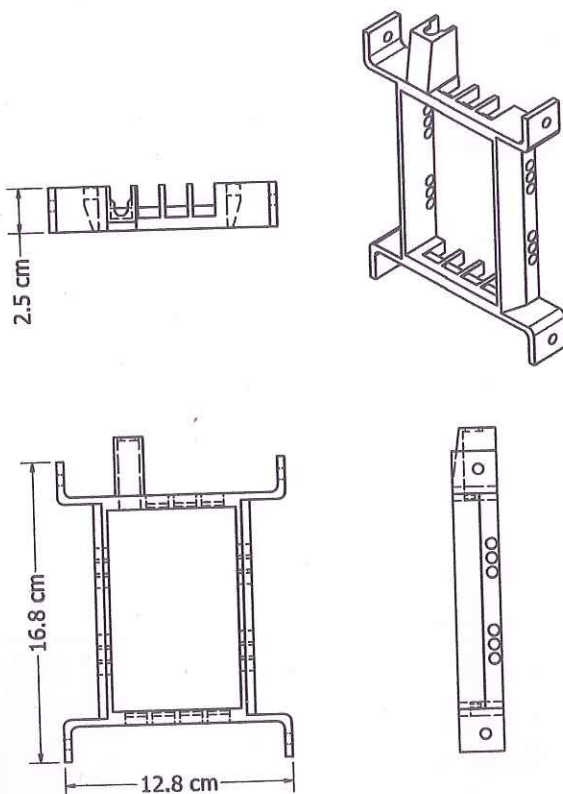
- Finish lift assembly
- Continue work on side panels

Reflections

- Lift is too short
- sliding channels need to be shortened

When we finished the lift assembly, we found that it was a few inches short. Due to our new sliding channels, the movement of the slide was constrained on one of our connections. This affected the extension of the entire lift, as this restriction was compounded to each side.

NXT CASING



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SIGNATURE

Matthew Warner

DATE

12/20/14

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PROPRIETARY INFORMATION

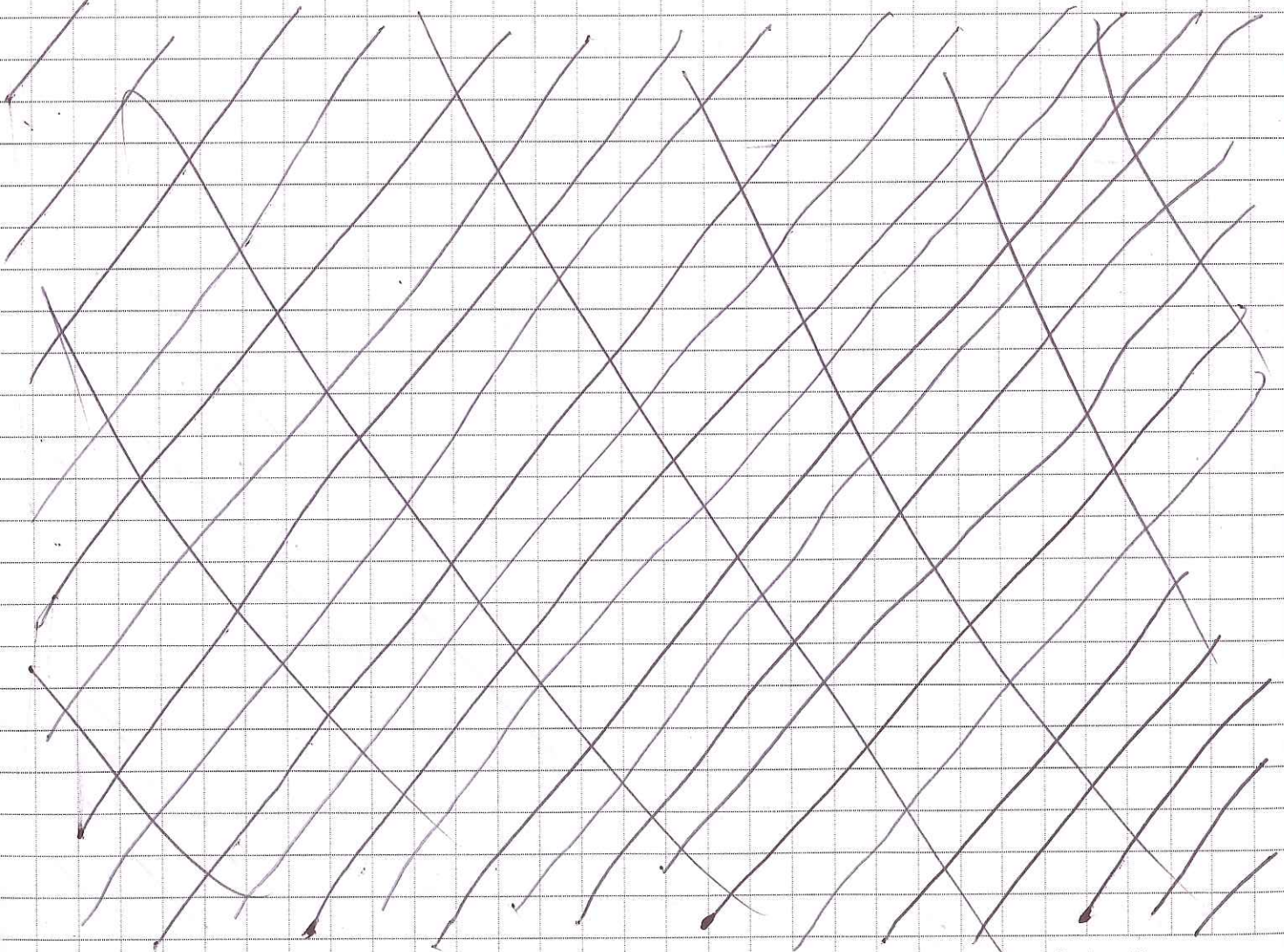
Meeting

Goals

- Finish the new shorter Nylon sliders
- Get new scoring tube with holes made and painted
- Work on autonomous
- Drive practice
- Continue assembling the lift
- Decrease diameter of Nylon pulley's

Reflections

- New sliders are very freely moving and aren't wobbly
- New sliders allow for more room for lift to extend
- Using multiple shins gives us flexibility in terms of how much the brackets move



Continued to page

SIGNATURE

Almeshed *[Signature]*

DATE

12/23/14

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DATE

PROPRIETARY INFORMATION

Saturday Meeting

Goals

- Finish Side Panels
- Finish Lift Design and Construction
- 3D Print Pulleys
- Redesign Tube and Mount
- Use 3D Printer

Reflections

The 2nd ~~design~~ design of the sidepanels put the robot over 18"

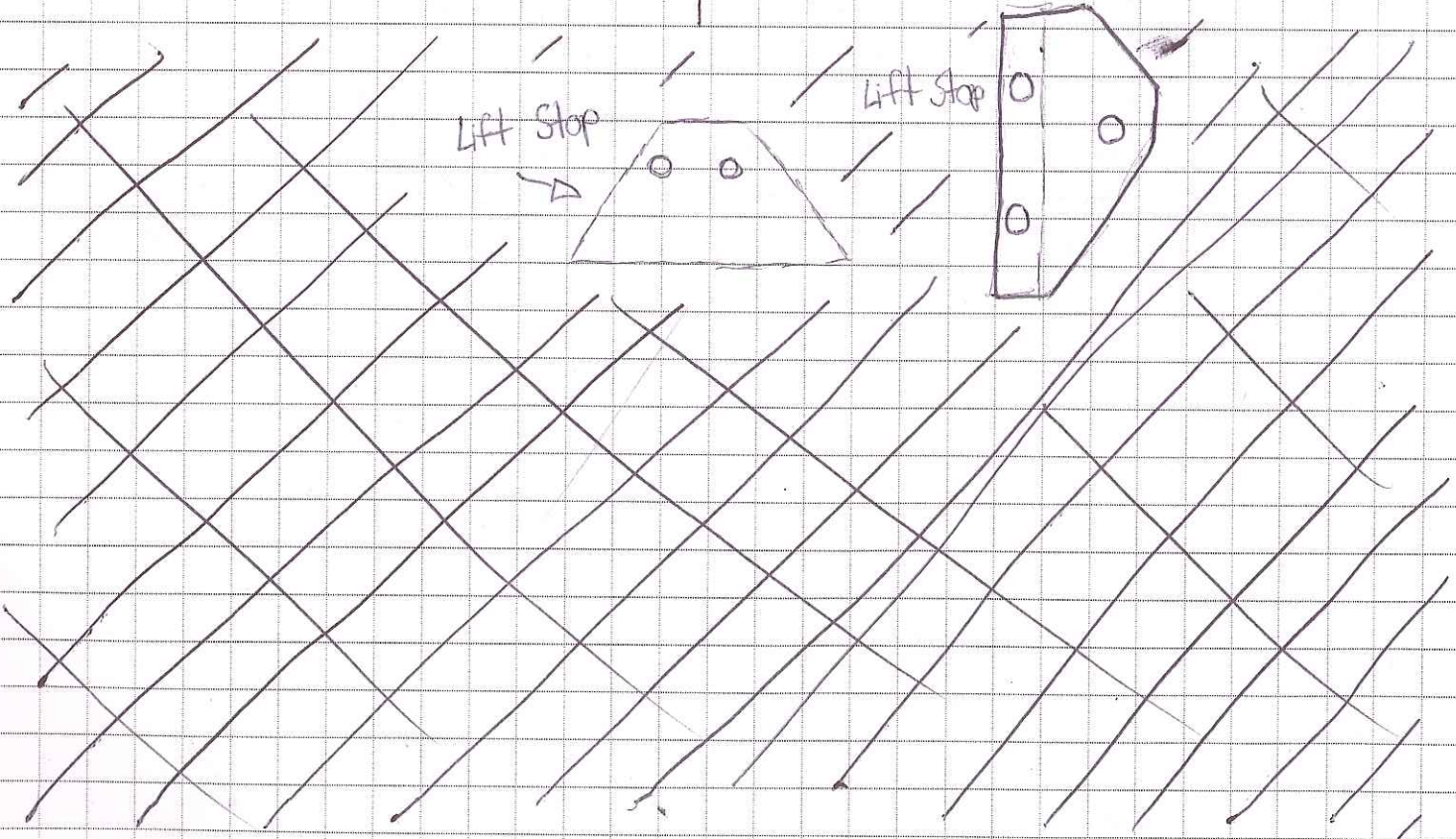
Lift design is going well need to figure out placement of stops and pulleys

were able to finish the new paint job on the scoring tube

3D Printed Pulleys for the first time

Lift Stop

Lift Stop



Continued to page

SIGNATURE

Jack Reynolds

DATE

12/27/14

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PROPRIETARY INFORMATION

Tuesday Meeting

Goals

- Finish and Mount the lift
- Assembly and second pulley to lift
- Mount and adjust dispenser tube
- *Second pulley to lift
- Make mount for ultrasonic sensors
- We had to move on lot of things to mount the lift

Today we added slider guides to the bottom of each stage of the lift for additional stability. Once we had that done, we proceeded to mount the lift. First off, the motor was hitting our compass sensor, so we moved that. Then the motor was hitting the cross-brace, so we moved that. Then the sprockets were hitting a drive motor, so we moved those. We also were securely attached various electrical components and reworked some of the wiring.

Continued to page

SIGNATURE

Chris Duce

DATE

12-30-14

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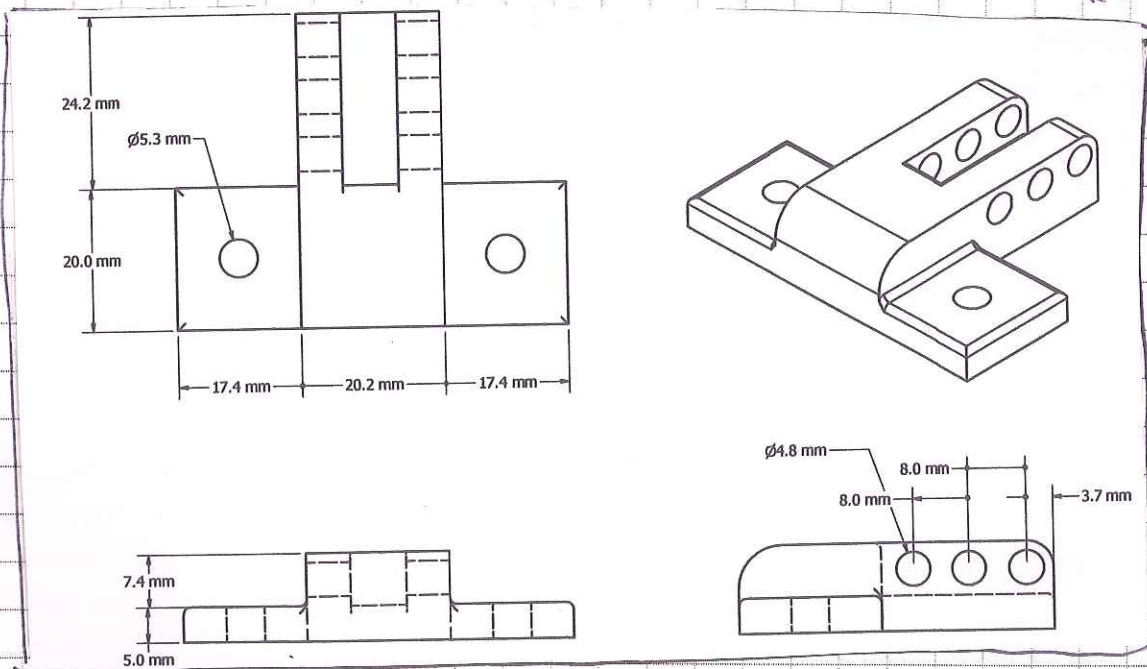
DATE

PROPRIETARY INFORMATION

Saturday Meeting.

Goals	Reflections
<ul style="list-style-type: none"> • Get Lift FINALIZED • Get tube mounted and finalized • Drive practice 	<ul style="list-style-type: none"> • Clean wiring more • Drive Practice • Autonomas.

Today we adjusted and raked the wings also we finished the lift and the tube and finally we practiced driving for ball pickup. We also attached 3D printed mounts for the ultra sound sensors. the blueprints are shown below.



Continued to page

SIGNATURE

Shw Chidho

DATE

11/3/15

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PROPRIETARY INFORMATION

Meeting

Tasks

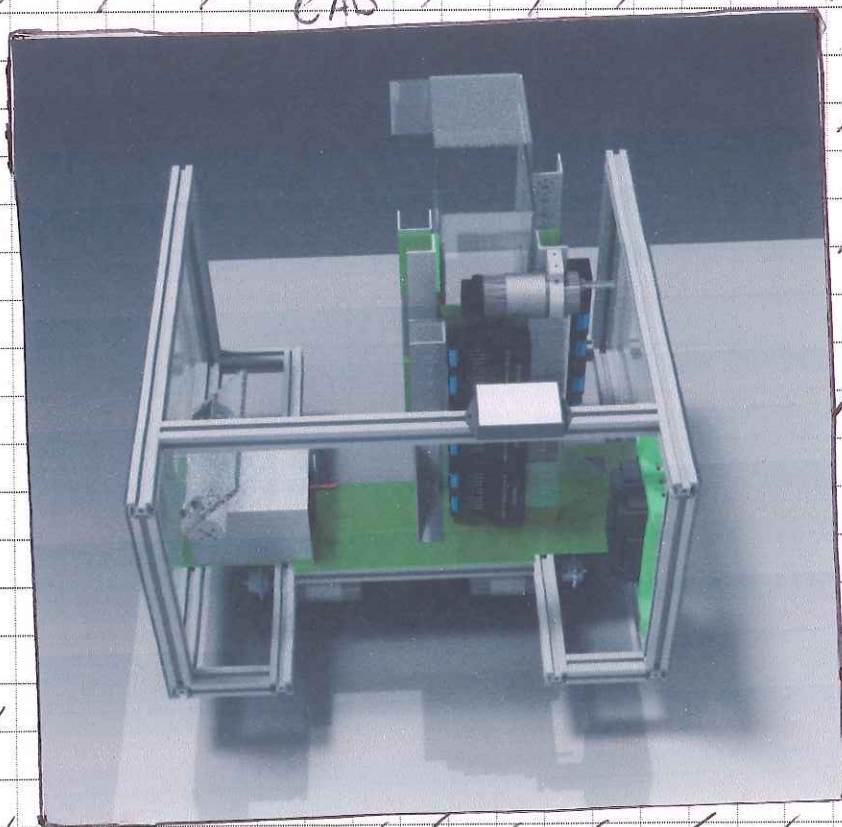
- Get drive practice
- Get autonomous practice
- Make any last minute tweaks
- Update DoM
- Pack for competition

Reflections

'We are ready for the competition!'

Today ~~I~~ was focused on getting ready for the competition. We made packing lists, and then packed things. We also made a list of things to check on the robot between matches, which will prove to be very useful. There was a bit of teleop and autonomous practicing as well, to ready our drivers. We made sure all the notebook entries were up to date and complete. Shown below is the current state of the CAD model of the robot, and on the following page is shown the packing list and between match check-list.

CAD



Continued to page 48

SIGNATURE

William Price

DATE

1-10-15

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PROPRIETARY INFORMATION

Checklist

- 1 Check Battery Voltage
- 2 Check Chassis Motors and set screws
- 3 Check the Wire Routing and NXT and Samatha wires
- 4 Check if the Lift is Working and Operating Correctly and the screws on the sliders
- 5 Check gears and Chain if Gear is on Chain and Check Master Link (good tension)
- 6 Check Strings for Ware or Tares
- 7 Check the Harvest Belt and Plastic Tabs
- 8 Check all Collars and Hubs
- 9 Check if the tube is secured on lift.

Between Match Robot Checklist

Spare Parts List

- 1 Rubber Bands
- 2 Chain (Plastic and metal)
- 3 Kevlar String
- 4 Motors and Servos
- 5 Plastic tabs
- 6 Steel/airline cables
- 7 Screws and nuts
- 8 Corner brackets
- 9 Axles
- 10 Tape (duck Tape)
- 11 Extra wires for servo and motors
- 12 Batteries, NXT Batery, Tetric Battery
- 13 Hubs for Axle
- 14 Velcro
- 15 Zip Ties
- 16 Crimp
- 17 Crimpers
- 18 Spare NXT and Samantha
- 19 DC Motor Control
- 20 L Brackets
- 21 Extra 80 -20
- 22 Extra Links and treads for the harvestor belt

List of spare parts to bring

Continued to page

SIGNATURE

Ethan Pike

DATE

1-10-15

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DATE

PROPRIETARY INFORMATION

Bill of Materials

FTC Robot Bill of Material

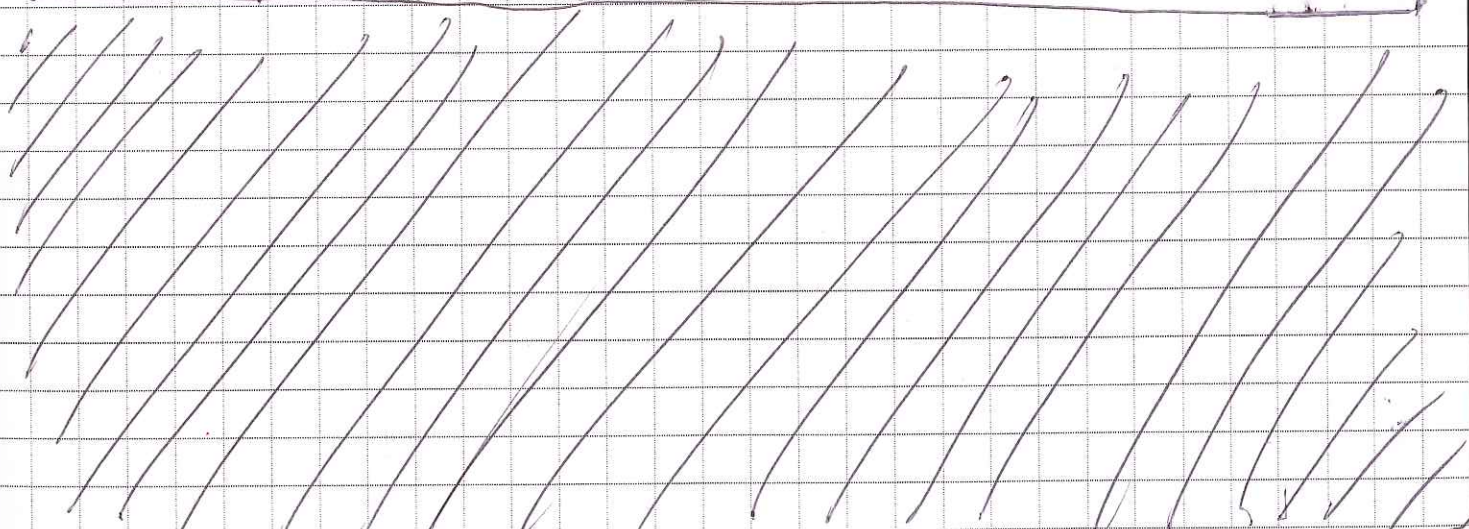
Team Number:

365

Please list any non-TETRIX® or non-MATRIX® parts and provide this list to the hardware inspector.

(Tip: make two copies, keep one in your Engineering Notebook, bring the other to Hardware Inspection).

Part Description	Game Rule / Forum Reference
EXAMPLE: QTY 4 Anderson Power Poles	Game Manual Pt 1: <R03.n>
EXAMPLE: QTY 3 prefabricated joining plates	Forum: Robot Parts and Materials post #5 <R02.a.1>
Mechanum wheels <vexrobotics.com> part # 276-1447	Game manual Pt
Miniature mounted bearings <http://www.mcmaster.com> part #	Game manual Pt 1: <R04.c>
Servo Blocks <servocity.com> part # 637110	Game Manual Pt 1: <R04.e>
extruded aluminum corner bracket part #	Game Manual Pt 1: <R04.e>
Steel axle	Game Manual Pt 1: <R04.e>
Plastic Chain, 1/4" pitch <http://www.servocity.com>	Game Manual Pt 1: <R04.e>
80/20 T-nuts <http://www.mcmaster.com> part # 47065T233	Game Manual Pt 1: <R05>
80/20 Braces <http://www.mcmaster.com> part # 5537T81	Game Manual Pt 1: <R04.a>
80/20 <http://www.mcmaster.com> part # 5537T101	Game Manual Pt 1: <R04.e>
Clear Polycarbonate <http://www.mcmaster.com> part # 8574K63	Game Manual Pt 1: <R04.e>
Angle bracket <http://www.mcmaster.com> part # 8982K36	Game Manual Pt 1: <R04.e>
C Channel <http://www.edconsteel.com> part # ALCHN.40.20.2	Game Manual Pt 1: <R04.e>
Green toggle Switches <http://www.surpluscenter.com> part # 11-3286-G	Game Manual Pt 1: <R08.d>
Anderson Power Poles <http://www.powerex.com> part # PP15-25	Game Manual Pt 1: <R03.n>
Anderson Power Pole Distribution Hub <http://www.powerex.com> part# ps-8	Game Manual Pt 1: <R08.q>
Pvc tube <http://www.homedepot.com> part # 1610	Game Manual Pt 1: <R04.a>
Zipties	Game Manual Pt 1: <R06.d>
Servo City Hub Adapter <http://www.servocity.com> part # 545456	Game Manual Pt 1: <R05.d>
Spiral Cut Wrap 1/4" <http://www.mcmaster.com> part # 7378K426	Game Manual Pt 1: <R08.t>
Wire 16 Gauge	Game Manual Pt 1: <R08.r.i>
Tetrix servo wire extenders <http://store.talentcenter.com> part #	Game Manual Pt 1: <R08.r>
Poly Foam <http://www.netsolhost.com> part # polyfoam8236	Game Manual Pt 1: <R04.a>
Wheel Adapters	Game Manual Pt 1: <R07>
Goal Grabber	Game Manual Pt 1: <R07>
Hinges	Game Manual Pt 1: <R04.c>
Pullies	Game Manual Pt 1: <R04.e>
Kevlar Sting	Game Manual Pt 1: <R04.e>



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SIGNATURE

Chris Bruno

DATE

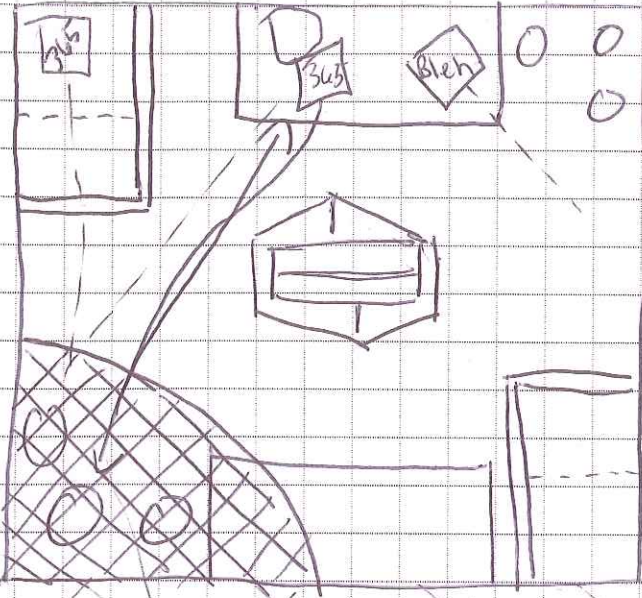
1-10-15

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PROPRIETARY INFORMATION

Drive Teams Strategy



= No Ball collecting Zones

--- = Autonomous

— = Pull ~~to~~ our goal lower

Be steadfast to our Strategy, but No Intimidating Other Teams!

Continued to page

SIGNATURE

DATE

1/24/145

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PROPRIETARY INFORMATION

Team Number:

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Part Description

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EXAMPLE: QTY 4 Anderson Power Poles

Game Manual Pt 1: <R03.n>

EXAMPLE: QTY 3 prefabricated joining plates

Forum: Robot Parts and Materials post #5 <R02.a.1>

Mechanum wheels <vexrobotics.com> part # 276-1447

Game manual Pt

Miniature mounted bearings <http://www.mcmaster.com> part #

Game manual Pt 1: <R04.c>

Servo Blocks <servocity.com> part # 637110

Game manual Pt 1: <R04.e>

extruded aluminum corner bracket part #

Game Manual Pt 1: <RO

Steel axle

Game Manual Pt 1: <R04.e>

Plastic Chain, 1/4" pitch <http://www.servocity.com

Game Manual Pt 1: <RO

80/20 T-nuts <http://www.mcmaster.com> part # 47065T233

Game Manual Pt 1: <RO

80/20 Braces <http://www.mcmaster.com> part # 5537T81

Game Manual Pt 1: <R05>

80/20 <http://www.mcmaster.com> part # 5537T101

Game Manual Pt 1: <R04.a>

Clear Polycarbonate <http://www.mcmaster.com> part # 8574K63

Game Manual Pt 1: <R04.e>

Angle bracket <http://www.mcmaster.com> part # 8982K36

Game Manual Pt 1: <R04.e>

C Channel <http://www.edconsteel.com> part # ALCHN.40.20.2

Game Manual Pt 1: <R04.e>

Green toggle Switches <http://www.surpluscenter.com> part # 11-3286-G

Game Manual Pt 1: <R08.d>

Anderson Power Poles <http://www.powerex.com> part # PP15-25

Game Manual Pt 1: <R03.n>

Anderson Power Pole Distribution Hub <http://www.powerex.com part# ps-8

Game Manual Pt1: <R08.q>

Pvc tube <http://www.homedepot.com> part # 1610

Game Manual Pt 1: <R04.a>

Zipties

Game Manual Pt 1: <R06.d>

Servo City Hub Adapter <http://www.servocity.com> part # 545456

Game Manual Pt 1: <R05.d>

Spiral Cut Wrap 1/4" <http://www.mcmaster.com> part # 7378K426

Game Manual Pt 1: <R08.t>

Wire 16 Gauge

Game Manual Pt 1: <R08.r.i>

Tetrix servo wire extenders <http://store.talentcenter.com> part #

Game Manual Pt 1: <R08.r>

Wheel Adapters

Game Manual Pt 1: <R07>

Perforated Aluminum Plate

Game Manual Pt 1: <R04.e>

SIGNATURE

Matt Warner

DATE

DISCLOSED TO AND UNDERSTOOD BY

DATE

1/27/15

PROPRIETARY INFORMATION

Reflections

- Mail out business plan
- New goal grabber
- More Drive practice
- Ball Harvester
- Floppy Servo
- ProtoBoard batteries
- Review rules
- Auto. Improvements
- Goal grabber buttons
- Lights under glow
- Lego Brick Drive
- Watch judging
- Slingshot event
- Side Panels
- Improve speed
- Surgical tubing
- Redo Tri-fold
- Putting Arrow before Ethan in judging

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DATE

2/3/15

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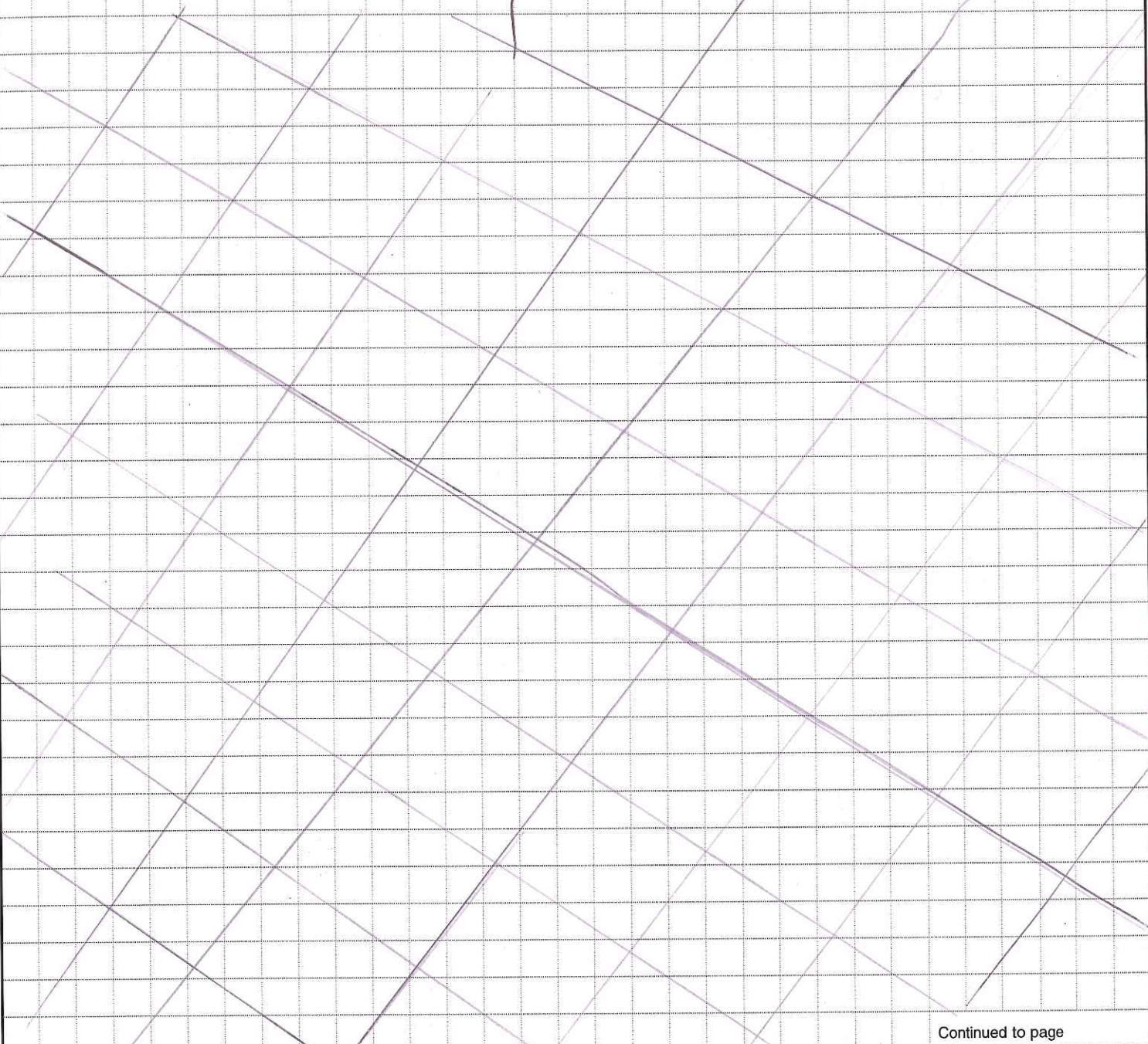
Tuesday Meeting

Goals

- Improve goal grabber
- Modify harvester
- Enhance tube mount

Reflections

The goal grabber is much more rigid and stronger now



Continued to page

SIGNATURE

Matthew Warner

DATE

2/7/15

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PROPRIETARY INFORMATION

Tuesday Meeting

Goals

- Continue Improvements on goal grabber
- Finish Harvester Design and Assembly
- Look over ~~robot~~ robot and tighten and check robot over
- Drive Practice

Reflection

- Goal Grabber works well still need to check on peg alignment
- Check over harvester and do we want the ability for the harvester to raise up and down

SIGNATURE

Jack Hejranian

DATE

2-10-15

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PROPRIETARY INFORMATION

Continued to page

Saturday Meeting

Goals

- Check over robot
- Drive Practice
- Finish Harvester and create final design
- Work on servo system and gear box for tube

Reflections

- Decided Harvester does not need raise during competition
- Goal Grabber final design was completed and works well with grabbing

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DATE

2-14-15

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PROPRIETARY INFORMATION

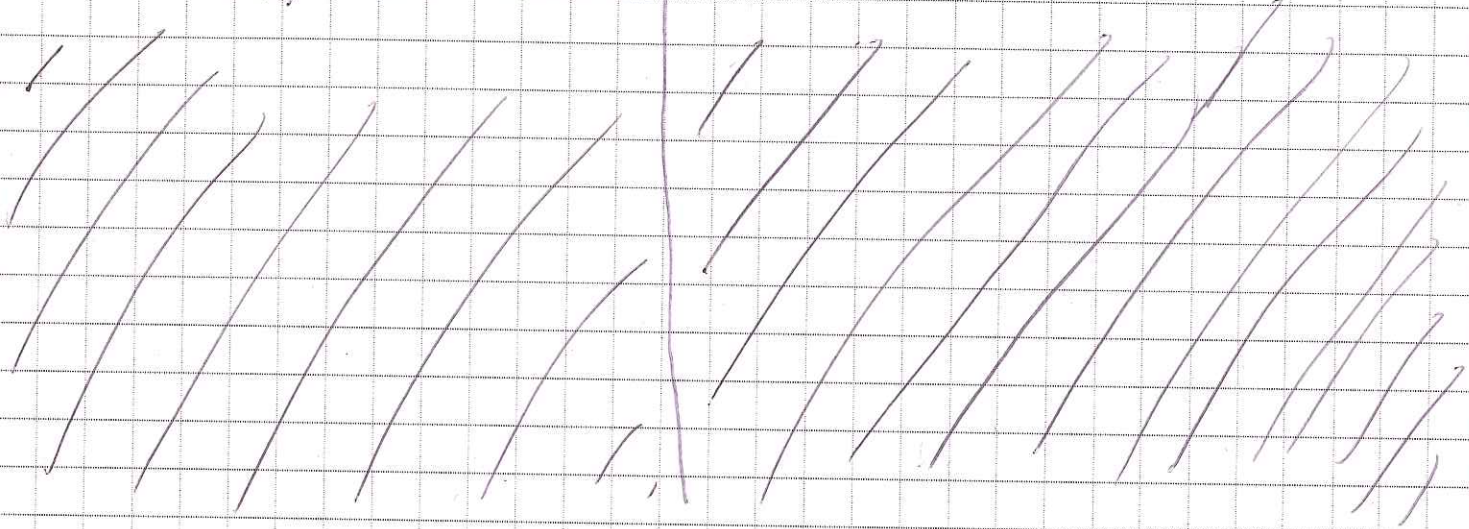
Tuesday Meeting

Tasks

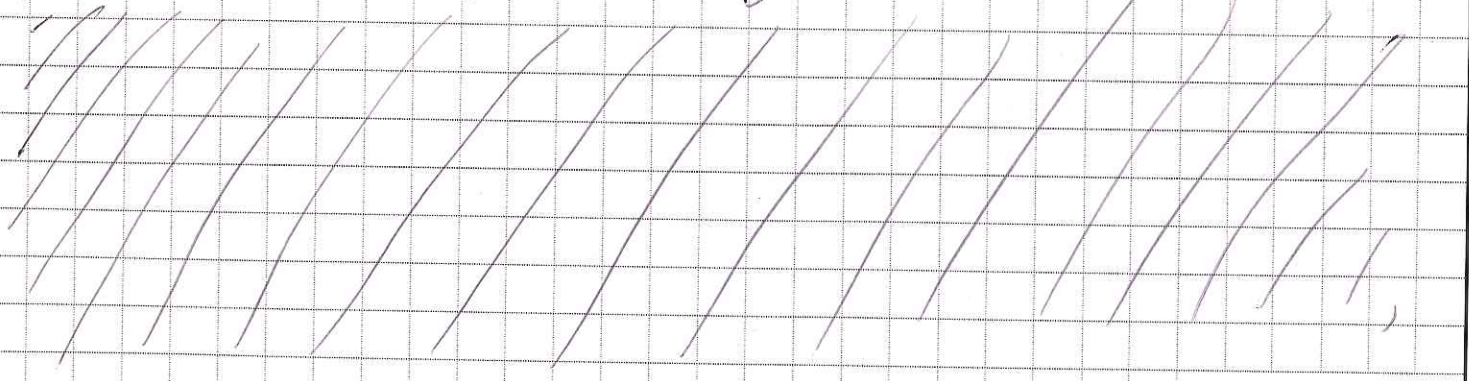
- Finalize notebooks
- Pack up tools + robot
- Drive Practice
- Check Robot
- Bill of Materials
- Software/Hardware Checklists

Reflections

- Robot is ready for competition
- Everything is ready for competition



Today is our last meeting before the Maryland state competition. We wanted to get some drive practice in, and we also made sure the robot was fully functional. The rest of the meeting was spent packing. We also began work on a new organization system for our wrenches, which uses color coding for storage and use.



SIGNATURE

Walter Duce

Continued to page

DATE

2-17-15

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Team Number:

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Game Rule / Forum Reference

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Miniature mounted bearings <http://www.mcmaster.com>	Game manual Pt 1: <R04.c>
Servo Blocks <servocity.com> part # 637110	Game Manual Pt 1: <R04.c>
extruded aluminum corner bracket	Game Manual Pt 1: <R04.a>
Steel axle	Game Manual Pt 1: <R04.c>
Plastic Chain, 1/4" pitch <http://www.servocity.com>	Game Manual Pt 1: <R04.c>
80/20 T-nuts <http://www.mcmaster.com> part # 47065T233	Game Manual Pt 1: <R05>
80/20 Braces <http://www.mcmaster.com> part # 5537T81	Game Manual Pt 1: <R04.a>
80/20 <http://www.mcmaster.com> part # 5537T101	Game Manual Pt 1: <R04.e>
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Angle bracket <http://www.mcmaster.com> part # 8982K36	Game Manual Pt 1: <R04.e>
C Channel <http://www.edconsteel.com> part # ALCHIN.40.20.2	Game Manual Pt 1: <R04.e>
Green toggle Switches <http://www.surpluscenter.com> part # 11-3286-G	Game Manual Pt 1: <R08.d>
Anderson Power Poles <http://www.powerex.com> part # PP15-25	Game Manual Pt 1: <R03.n>
Anderson Power Pole Distribution Hub <http://www.powerex.com part# ps-8	Game Manual Pt 1: <R08.g>
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Zipties	Game Manual Pt 1: <R06.d>
Servo City Hub Adapter <http://www.servocity.com> part # 545456	Game Manual Pt 1: <R05.d>
Spiral Cut Wrap 1/4" <http://www.mcmaster.com> part # 7378K426	Game Manual Pt 1: <R08.t>
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Poly Foam <http://www.netsolhost.com> part # polyfoam8236	Game Manual Pt 1: <R04.a>
Wheel Adapters	Game Manual Pt 1: <R07>
NXT Holder	Game Manual Pt 1: <R07>
Metal Bearing Mounted Pulley	Game Manual Pt 1: <R04.c>
Rubber Gripping Pad	Game Manual Pt 1: <R04.a>
Yellow Braided Cord	Game Manual Pt 1: <R04.a>
Velcro Pads	Game Manual Pt 1: <R04.a>
Surgical Tubing	Game Manual Pt 1: <R04.a>
Steel Hinges	Game Manual Pt 1: <R04.c>

SIGNATURE

Jack Hernandez

DATE

2-27-15

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PROPRIETARY INFORMATION

Continued to page

Tasks

Reflections

1. Drive Practice

1. Strategy

2. Pitch of Tube
- E-Stop

2. Screen over wheels
- Shine

3. 4 drive motors

3. Switches

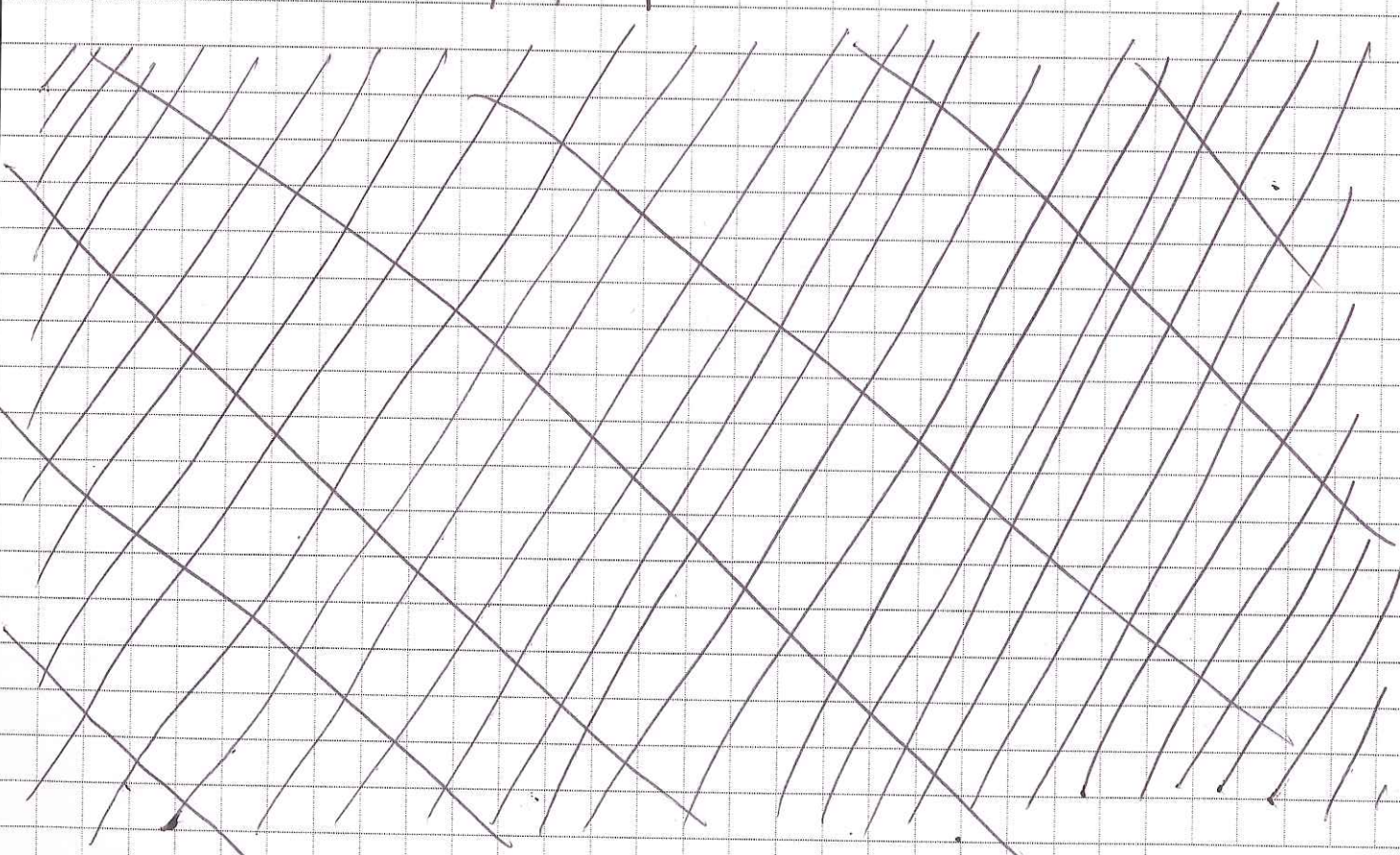
3. Gyro/Acc } Proto-Board

ch Lights

4. Add Spinning

• All repairs we wished to make were completed fully.

• Drivers got lots of practice in - Robot is functioning very well



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SIGNATURE *Chase Chylo Amar Posad*

DATE *3/6/15*

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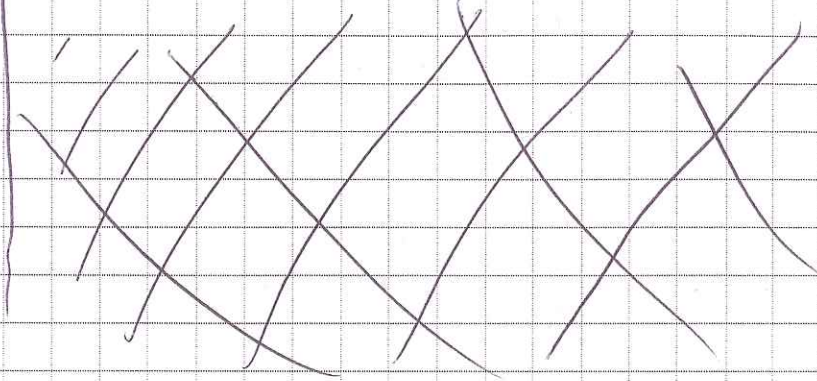
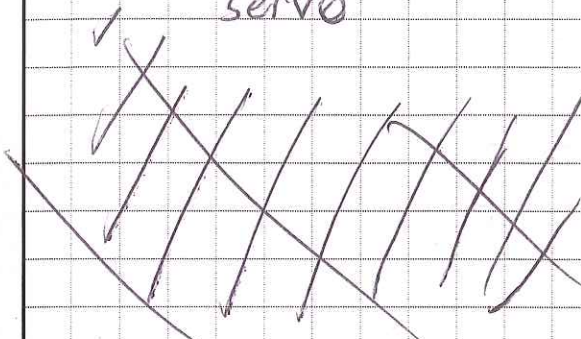
Meeting/Event Review

Tasks

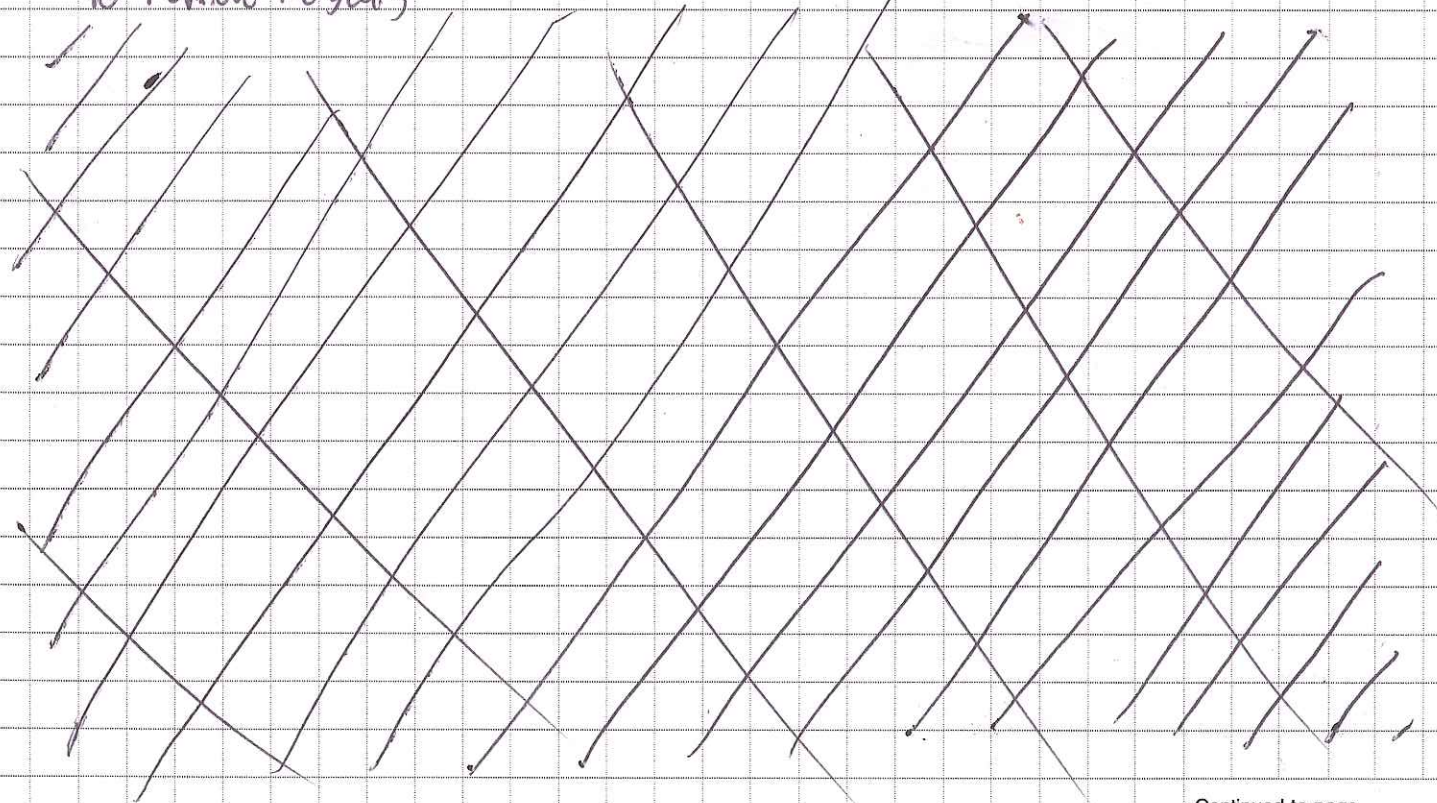
- Replace Broken wheel
- Replace drive motors
- Replace tube angle servo

Reflections

Drive system worked well



At the event, our servo which controlled the angle of the tube was broken. Given that the servo was actually broken and gave us 270° of motion, we had an issue. There are no 270° servos, only 180° & 360° . With our gear ratio to reduce the torque, we needed over 90° of motion. We decided to use a quarter scale 180° servo, allowing us to remove the gears



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SIGNATURE

Matt Warner

DATE

3/10/15

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PROPRIETARY INFORMATION

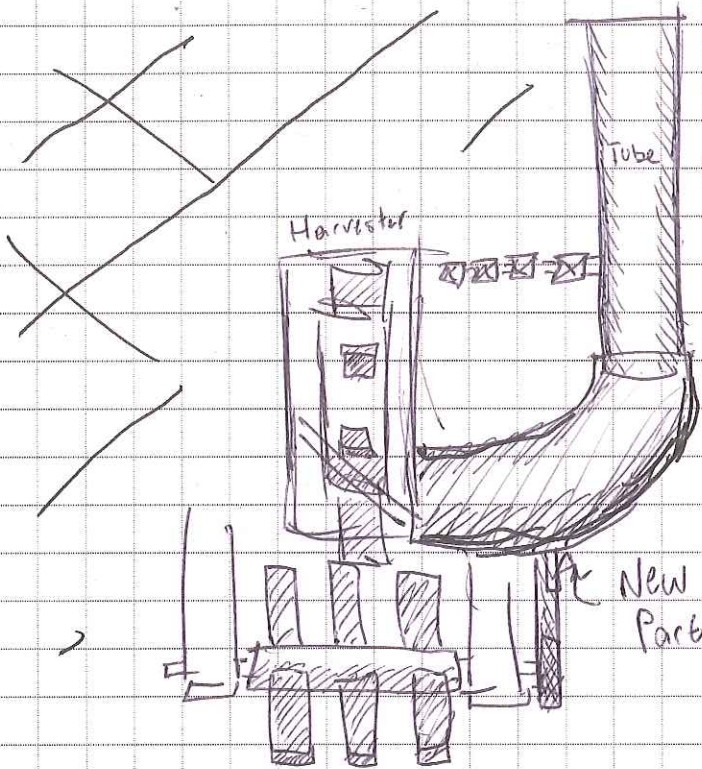
Meeting

Tasks

- Work on improving the tube mechanism
- Fine tune the extra goal grabber
- Make a new V for the goal grabber

Reflection

- We need to buy more PVC fitting for the tube
- We had to reinforce the extra goal grabber
- We now have extra Vs for the goal grabber
- The new tube modifications work great!



The new part we added allows us to score without rotating the tube, allowing for faster scoring and makes the balls transition more smoothly

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SIGNATURE

John Duce

DATE

3-28-15

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PROPRIETARY INFORMATION

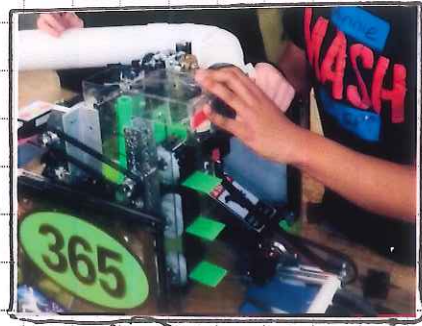
Tuesday's Meeting

Tasks

- Continue improvement and modifications of the new tube
- Discuss further changes and plans for upcoming meetings

Reflections

- We worked on positioning the tube and discussed strategy in how the position of the tube affects our game play



We continued working on the new tube design. We decided to attempt differing positions of the tube for scoring. We used several different angled PVC pieces to find the right angle. One important detail we concentrated on was keeping our ability of scoring from the side while being able to harvest in a straight position. Another important detail we made sure of was keeping the new tube design in the necessary dimensions for the sizing box.



Continued to page

SIGNATURE

Jack Keenan

DATE

3/31/15

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DATE

PROPRIETARY INFORMATION

Meeting

Tasks

- Fix goal grabber lip (hybrid approach of plastic in front and metal in back)
- Add more shielding to prevent balls from falling in the robot
- Attach new tube design

Reflections

- New goal grabber lip was much more durable than the old versions
- Shielding successfully prevents balls from falling in
- New tube allows for smooth transition to scoring position and allows for scoring from the side. ~~also~~



SIGNATURE

Ethan Price

DATE

4-4-15

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PROPRIETARY INFORMATION

Continued to page

Meeting

Tasks

- Finish new tube and get robot driveable/usable
- Drive Practice with new tube and additional goal grabber
- Design a method of ensuring balls in the tube don't roll out the back and fall out
- Drill holes in our tube so we can see and count the number of balls we are holding

Reflections

- The new tube works very well, saves us a lot of time and is very accurate. Balls don't get stuck between the harvester and the tube anymore. Also, we can still score in the center goal - which is very important.
- We currently use a zip-tie to keep balls from falling out of the back of the tube. It works okay, but we would like to improve this with a servo and controls.
- The new goal dragger is very useful, allowing us to pull the goal away from corners easily.



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SIGNATURE

Arnew Prasad

DATE

April 6, 2015

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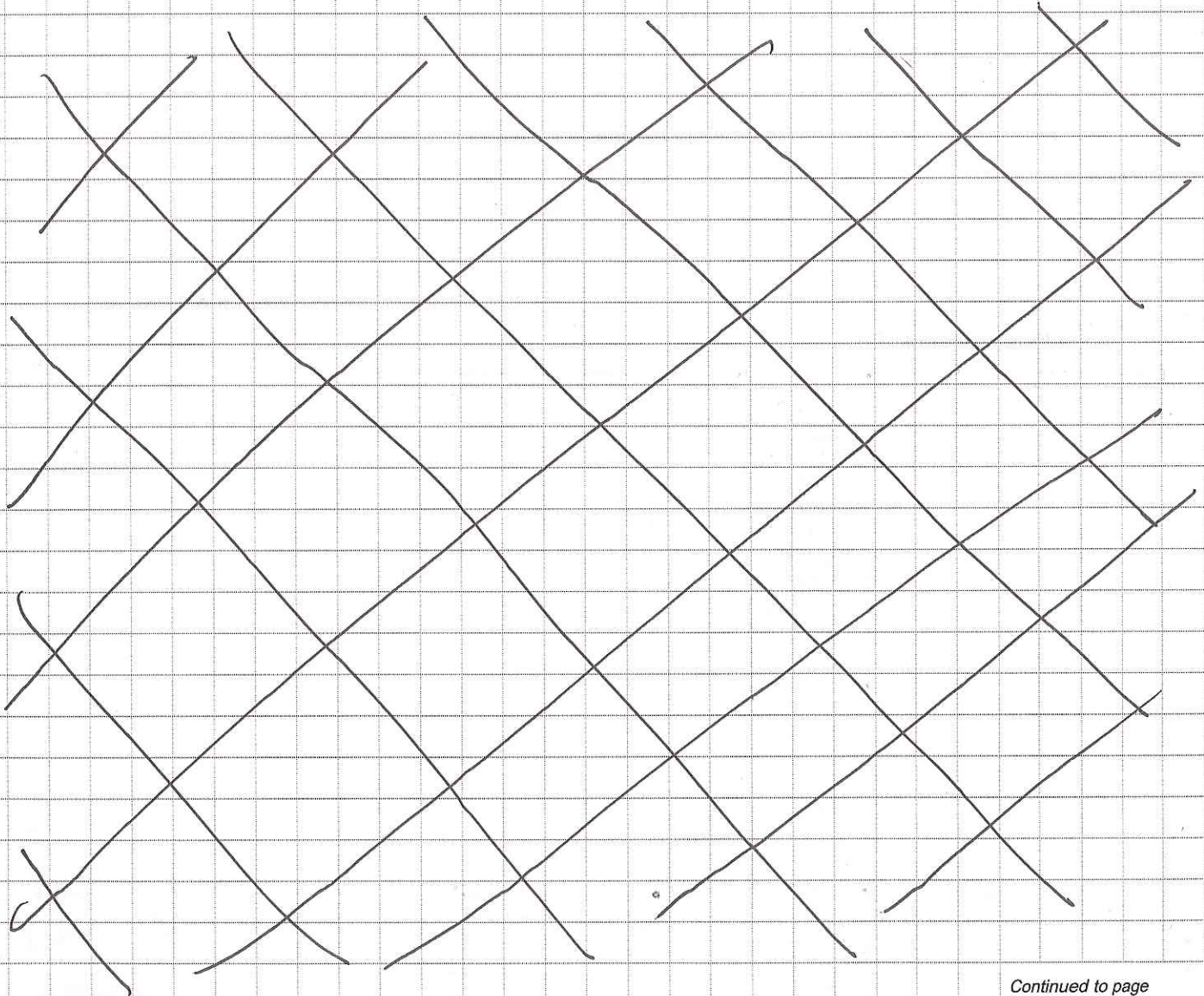
DATE

PROPRIETARY INFORMATION

Champions Challenge

The competition served as a learning point in multiple aspects. Part of the robot was modified. We removed the inner ball shield due to the complications it caused when the ball harvester was folded up.

Another significant learning point was an effective method of defense. We were able to slow down our opponents scoring greatly by harvesting balls in front of the opponent, and then dispensing them out of the front of the robot, causing them to roll across the field towards our partner.



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SIGNATURE

~~Matthew Warner~~ Matthew Warner

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DATE

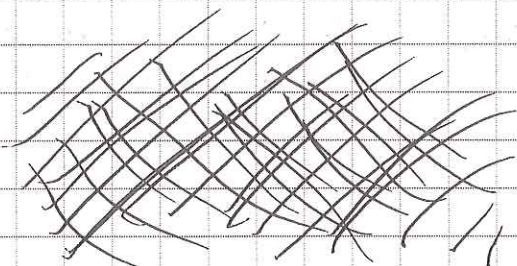
4/11/15

PROPRIETARY INFORMATION

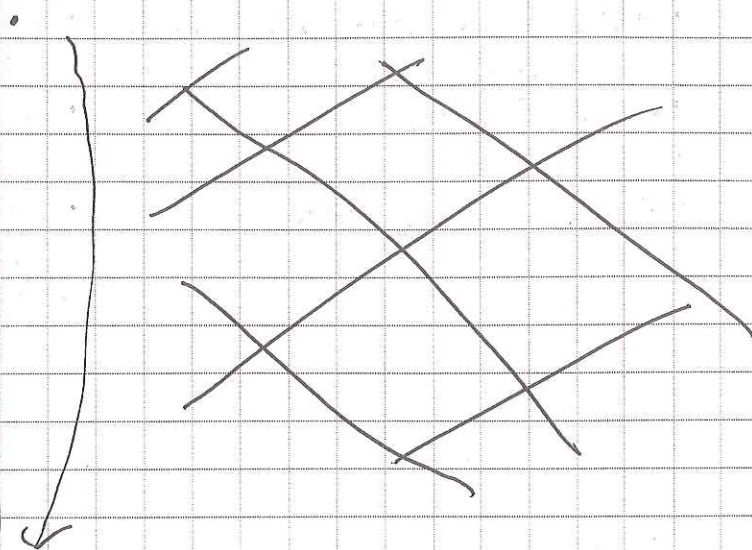
Meeting

Tasks

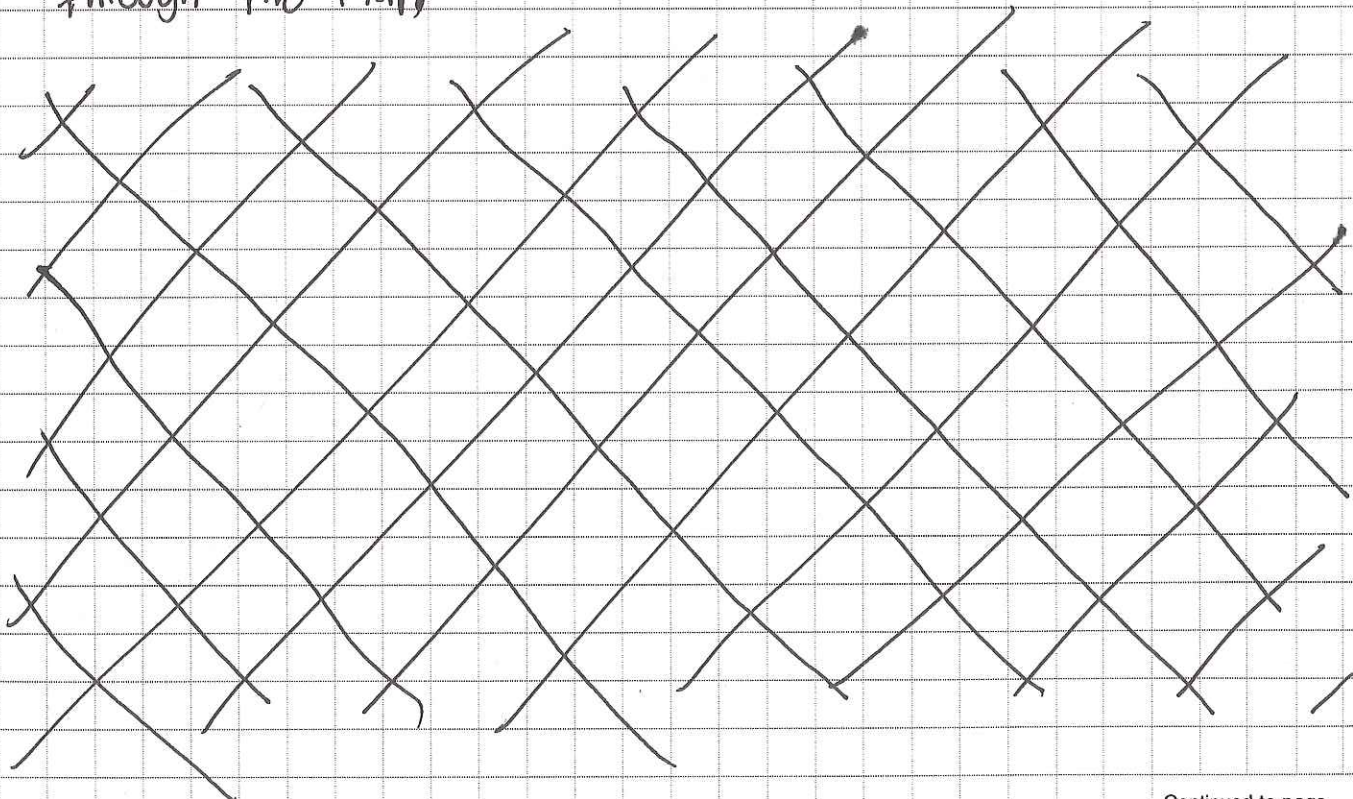
- Modify ^{secondary} goal grabber
- Replace tube
- Add servo to the back of the tube



Reflections



- The new ^{secondary} goal grabber works much better than the original.
- The new tube with the second servo works very well. The flap on the servo needs to be widened slightly, as sometimes the ball will be aligned perfectly so that the hole will pass through the flap.



Continued to page

SIGNATURE

Matthew Warner

DATE

4/14/15

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PROPRIETARY INFORMATION

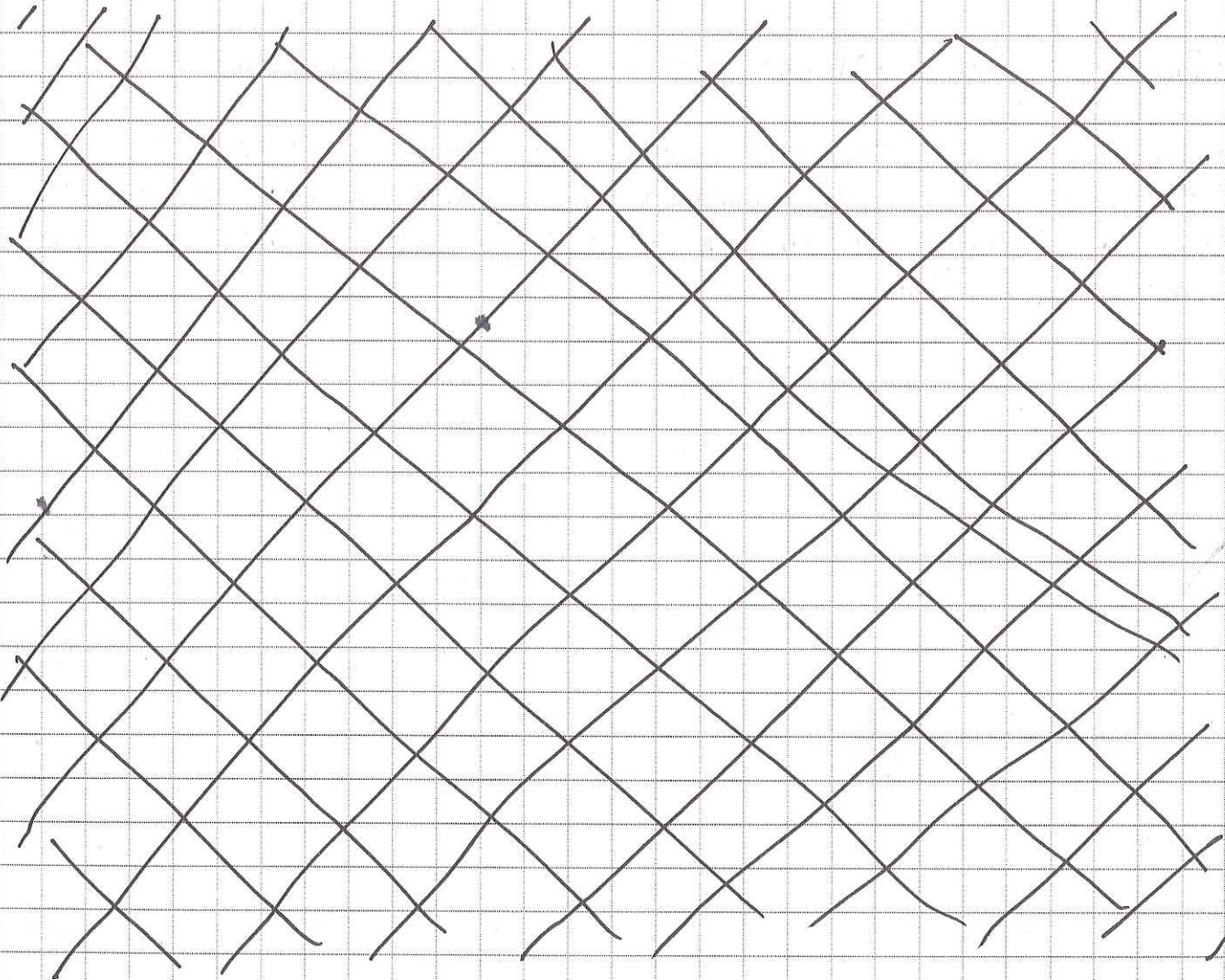
Meeting

Task

Reflections

- Pack
- Reco Shields
- Adjusting servo on back of tube
- Drive Practice
- Lights
- Extend servo wire

- The servo now works great!
- The extension for the servo wire was not necessary
- Lights are on and protoboards are mounted
- One of the mechanism wheels broke, so we replaced all of them
- We're all ready for worlds



Continued to page

SIGNATURE

Ethan Prich

DATE

4-18-15

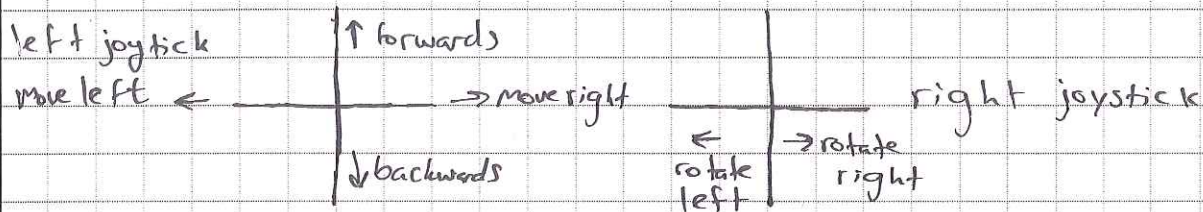
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PROPRIETARY INFORMATION

Mecanum Program Dev

The code for Mecanum wheels is somewhat different to a standard tank-drive robot. Instead of moving forwards, backwards, and pivoting, the robot can move right, left, forwards, and backwards. It can also pivot to turn. The layout on the controller looks something like this:



The code for each motor is an equation, combining inputs. In the following: y_1 = left joystick, y-axis. x_1 = left joystick, x-axis. x_2 = left/right joystick, x-axis.

$$\text{Front Left Motor: } y_1 + x_1 + x_2$$

$$\text{Front Right Motor: } y_1 - x_1 - x_2$$

$$\text{Back Left Motor: } y_1 - x_1 + x_2$$

$$\text{Back Right Motor: } y_1 + x_1 - x_2$$

Each motor is set to its own power, allowing the robot to move in many directions.

Our next project is one of the following:

- Diagonal movement and testing
- Having "forwards" ALWAYS move the robot away from the driver, irrespective of the robot's orientation.

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SIGNATURE

Amir Pasad

DATE

June 24, 2014

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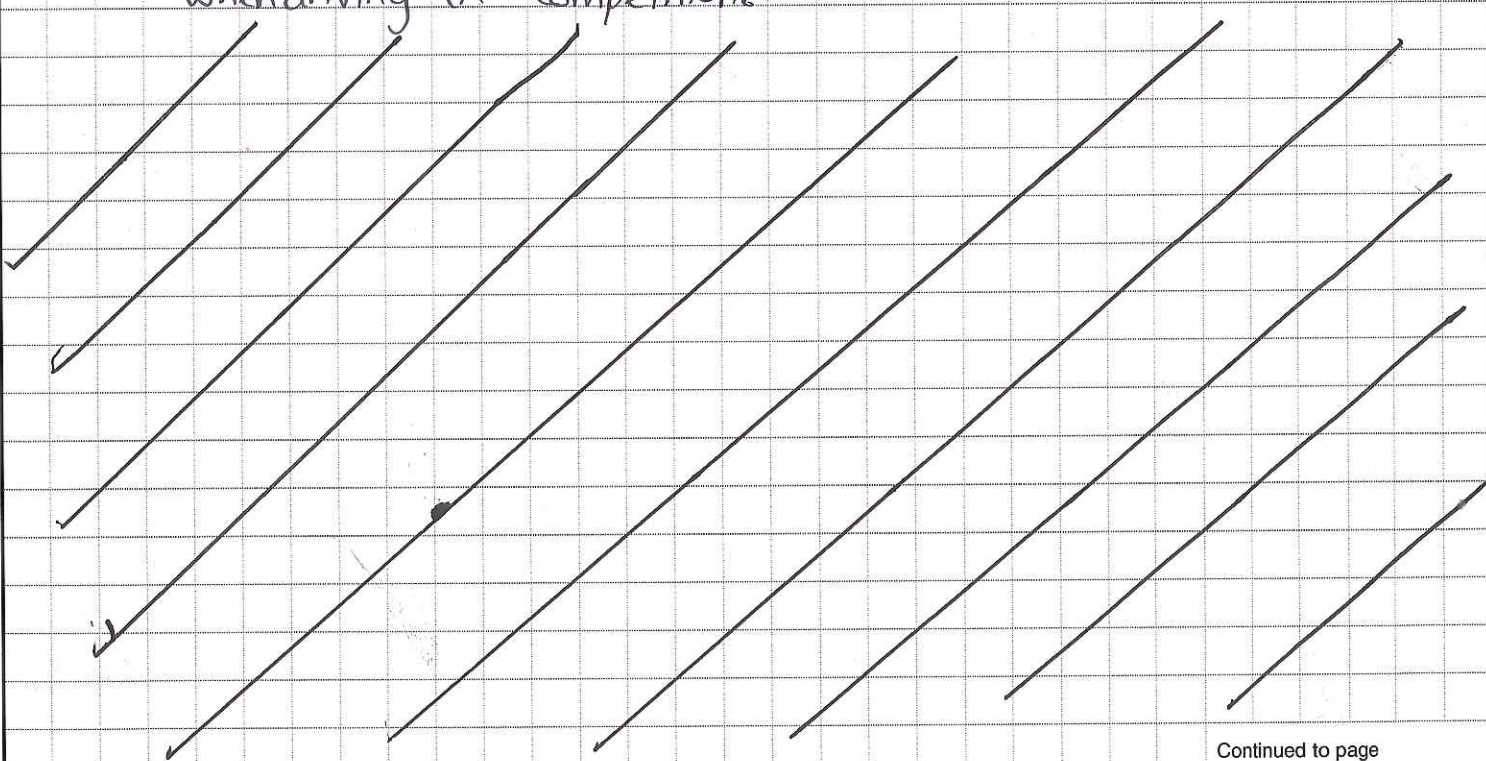
PROPRIETARY INFORMATION

Mecanum Test Robot

In today's meeting, we finished adapting our old Mini-Bot to work with mecanum wheels. The code was also finished today. We tested out the drive and handling with the robot, which worked really well. I also worked on and added a button which toggles the robot from mecanum drive mode back to a normal tank drive, just for extra options.

One concern of ours is that Mecanum wheels have rollers like omni-wheels, which were easy to push around. However, we put ~~2~~ 11lbs of weight on the robot, and that made it very difficult to push around. While moving and strafing, the robot was very easy to drive and was not easily pushed off course.

In the future, we would like to use a protoboard and lights so the driver can easily tell which mode of driving they are in, decreasing confusion when driving in competition.



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SIGNATURE

Arnan Press

DATE

July 1, 2014

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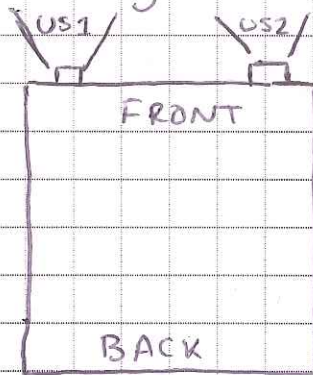
PROPRIETARY INFORMATION

Programming Summer Work - Sensors!

Over the summer, I have been testing out various sensors that can be used in next year's game. Mainly, I have been working with the LEGO-ULTRASONIC and HITECHNIC-ACCELEROMETER sensors.

Along with our own custom code, our team uses "Xander's Drivers", which are a set of drivers with custom functions made by Xander Seldaat, and can be found on GitHub. Xander's Drivers give us more freedom and flexibility we can use to greater enhance our robot's functionality.

Ultrasonic sensors measure the distance an object is from the robot. The following code is an obstacle avoidance program, requiring 2 front-facing ultrasonic sensors (shown below):



The code "sees" an object in the left sensor, moves left until the right sensor is clear of the object, and then moves forwards again.

```
waitForStart(); // Wait for the beginning of autonomous phase.
while(USreadDistInches(US1) >= 5) { // move forwards until the left ultrasonic reads less than 5 inches
  startForward(30);
}
stopDrive(); // stop moving
while(USreadDistInches(US2) <= 5) { // move left until the right ultrasonic reads greater than 5 inches
  startLeft(20);
}
stopDrive(); // stop moving
moveForwardInches(30, 5); // drive past the obstacle
```

The code below uses an accelerometer to measure the robot's tilt. It moves forwards until the robot is tilted a certain amount.

```
initSensor(&accelerometer, Accel); // Initialize the sensor, and assign it to the struct
float xTilt = accelerometer.x; // save the x axis as a float
while (xTilt < 20) { // move forwards until the tilt on the x axis is greater than 20.
  startForward(20);
}
```

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SIGNATURE

Arnav Prasad

DATE

August 16, 2014

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PROPRIETARY INFORMATION

Programming Encoder Calibration

Today we worked on finding out how many encoder ticks provided 1 inch of movement for our robot. To ballpark the amount, we did the following calculation:

Wheel Diameter $\approx 4"$

Wheel Circumference $= 4\pi"$

This means that for every 1 full rotation of the wheel, we go forwards 4π inches (approx. 12 in).

We also know that the AndyMark NeverRest 40 Motors (with built-in encoders) provide 1120 ticks / full rotation. The following proportion helped us get a good starting point for calibration:

$$\frac{1120}{4\pi} = \frac{x}{1}$$

$$\frac{1120}{4\pi} \approx 89 \text{ ticks/inch.}$$

We used this starting point, and found a more accurate value to be 86 ticks/inch for our robot. We tested this by placing the bot on the field, telling it to run forwards 72", and seeing how close to exactly 3 tiles ahead we reached. This calibration will make the rest of autonomous much easier to make.

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SIGNATURE

Arnav Pasad

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DATE

October 25, 2014

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PROPRIETARY INFORMATION

Autonomous Strategies

Our team has made some basic strategies for autonomous, before we start the actual programming. We feel that most teams will be able to drive off the ramp, scoring simple points. For that reason, we will focus mainly on starting in the parking zone.

Instead of having several programs for all the possible combinations of tasks in autonomous, we wanted to have a single "master" program. We will have several physical switches on our robot, to turn various options on and off. The robot will constantly be tracking where it is, and have a set path for all the possible starting to ending positions. This allows us to run only 1 program, saving lots of complications.

We will be attempting mainly to find the IR beacon, score in the center goal, and knock down the kickstand. Because we are starting in the parking zone, this is our best option. Navigating from the parking zone to the rolling goals provides several chances for collisions with our alliance's bot coming down the ramp. A future plan is to build in support for rolling goal scoring and manipulation as well, as well as options for starting on the ramp rather than the parking zone.

To find the IR beacon, we will use 2 IR seekers. This allows us to drive past the center structure, and scan for the beacon, without turning to check for the beacon every time.

One challenge our team is trying to overcome is the accuracy needed to score into the center goal. It is important to find a balance between accuracy and speed for this part of autonomous.

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Arren Prasad

DATE

10/27/14

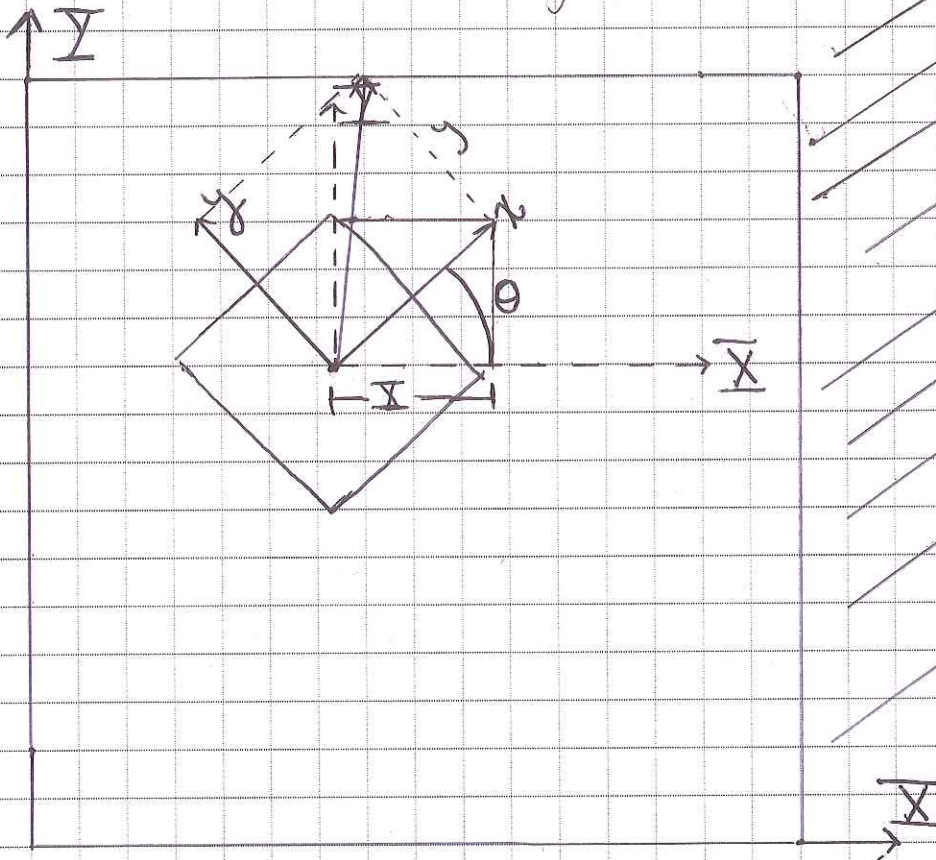
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Field Centric TeleOp

With a mecanum drive, there are two types of user control. One is "robot centric" - this means forwards, backwards, right, and left are relative to the robot, and change as the robot rotates. The other is "field centric". Field centric means all directions are relative to the driver. Pushing up on the joystick should cause the robot to move away from the driver, no matter how it is rotated. This drive system is more complicated to program, but in most ways more intuitive for the driver. We used some trigonometry to perform a coordinate transformation and program this drive:



The final equations came out to be:

$$X = x \cos \theta - y \sin \theta$$

$$Y = x \sin \theta + y \cos \theta$$

We used a gyro sensor to keep track of our heading, and were able to successfully create a comfortable field-centric drive system!

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SIGNATURE

Arman Rasheed

DATE

12/2/14

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PROPRIETARY INFORMATION

HERE IS OUR SUBMISSION FOR THE CONTROL AWARD

365 MOE Control Submission

Autonomous:

For autonomous, we have a switchboard that determines what we will achieve:



1. "RAMP" Determines our starting position.
On: says we're starting on the ramp
Off: says we're starting in the parking zone
2. "CTRGL" Determines if we drive to and score in the center goal.
On: Calculate center structure position and score high goal
Off: Do not move
3. "KICK" Determines if we knock down the kick stand.
On: Drives to kickstand from current position and knocks it down
Off: Do not move
4. "RGSCR" Determines if we drive to and score in the 60cm rolling goal.
On: Drives to 60cm rolling goal from current position and score in it
Off: Do not move
5. "RGMOVE" Determines if we drive to and drag the 60cm rolling goal to the parking zone.
On: Drives to 60cm rolling goal and drags 60cm rolling goal to parking zone
Off: Do not move

These switchboard settings are read by a *single* master autonomous program, which then moves the robot in multiple ways depending on the settings. Therefore, we do not have to upload multiple programs into the NXT brick, one for each possible route. Also, selecting between the various paths becomes very simple; all one has to do is select the proper switch settings, in consultation with our alliance partner, at the start of the match.

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Rick Morish

DATE

12/30/14

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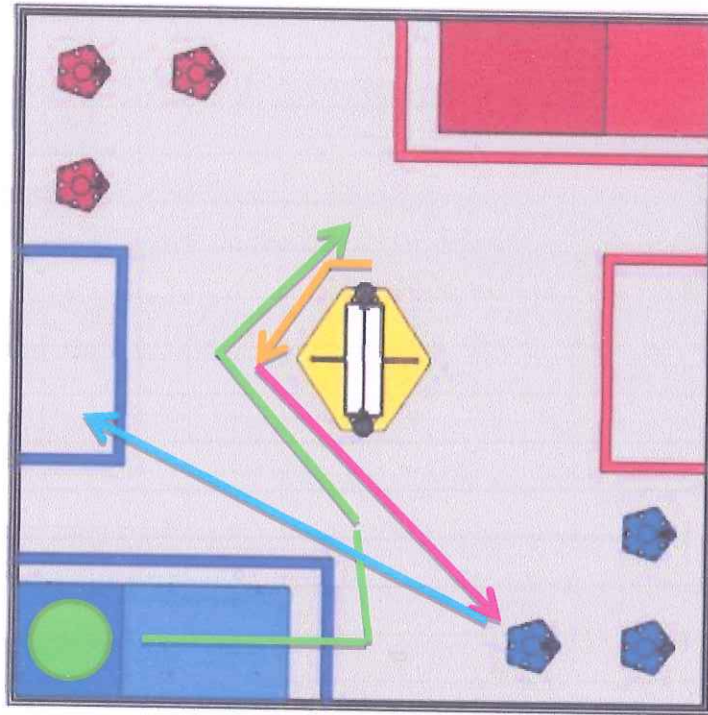
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12/30

PROPRIETARY INFORMATION

To figure out what position the center structure is set in, we use two ultrasonic sensors. Each one takes a distance reading when they ping a signal off the structure. Two close signals mean that the structure is in position 1. Mid-range signals mean position 2. Position 3 is found when both ultrasonic sensors do not read anything, and just return a fully maxed out signal.

The diagram below displays what paths the robot would take if all switches are on:



Key:

1. "RAMP" Circle
2. "CTRGL" Lime Green lines
3. "KICK" Orange
4. "RGSCR" Purple
5. "RGMOVE" Cyan

Driver Controlled:

We use mecanum wheels which allow us to move in any direction. Because of this we use a "Field Centric" teleop program. This makes our robots movement relative to the driver instead of the robot itself, allowing easier control when the robot cannot be seen. This requires a coordinate transformation between field-centric and robot-centric coordinates. The relationship between field centric coordinates (x', y') and robot-centric coordinates (x, y) are:

$$x' = x \cos \theta - y \sin \theta$$

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12/30/14

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PROPRIETARY INFORMATION

$$y' = x \sin \theta + y \cos \theta$$

For this coordinate transformation to work, we must know the orientation of the robot (θ) with respect to the field in real time. We use a HiTechnic Gyro sensor to constantly measure our rotational speed, or angular velocity (ω). From calculus, we know that if you integrate your angular velocity, you can obtain the instantaneous orientation of your robot.

$$\theta(t) = \int_0^t \omega(t) dt$$

Hence, we use an integration program running in the background to continuously track our robot's instantaneous "heading," or the amount it has turned since the beginning of the match. The HiTechnic Gyro sensor is not very precise, and it returns a small, but random, angular velocity even when the robot is perfectly still. Hence, we employ an if statement in the integration program that only accepts angular velocity values if they are larger than some threshold value.

Using the two coordinate transformation equations above, we can now calculate how much power we need to feed to each robot's wheel. We treat each driver input power as a vector, and the robot's final movement direction as the resultant vector. The coordinate transformation accounts for the robot's heading, and the robot executes whatever direction that the driver pushes on the joystick. For example, no matter how rotated the robot is, when the driver pushes right on the joystick, the robot moves right with respect to the driver. This happens even if the robot is rotated 180 degrees, in which case the robot's right is actually left according to itself. This greatly simplifies driving as the driver does not have to mentally rotate his/her heading continually as the robot turns.

Roadmap

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12/30/14

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PROPRIETARY INFORMATION

Update on Autonomous Strategies

Originally, our team planned to use a physical switch board in conjunction with a single "master" program for autonomous. This would make it easier for our drivers to know which program to run - a single program, and ~~some~~ labelled switches to turn on and off aspects of the autonomous program.

However, the implementation of this was more difficult than expected. First of all, a old ProtoBoard was not properly shielded - giving us inaccurate readings of what switches were/weren't turned off. We then switched over to a properly shielded Super ProtoBoard. We ran this through our Sensor Multiplexer - and realized using a Super protoBoard is not yet implemented through a multiplexer. Because we ran out of ports, we tried switching our Gyro sensor through the multiplexer to let the protoBoard have a direct NXT Port - But this caused too much latency in our Gyro! So we ended up not using our switch board.

It was still a great learning experience! We learned the values of time management, and how projects of this scale must be implemented from the beginning. We also learned that this switchboard is a viable option for next season, as long as we take the time in our off season to perfect it and get it properly implemented.

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Arnav Prasad

DATE

3/17/15

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PROPRIETARY INFORMATION

Autonomous Reflections from Super Regionals

Ramp Autonomous:

This program was very reliable and accurate. It even worked when partially defended by our opponents. It can be improved by being better when defended, as well as possibly getting more points by dragging goals back to the parking zone.

Parking Zone Autonomous:

The program worked very well when it correctly found the Center Structure Position. However, it was not too reliable at detecting this position. Our current hope is to improve the reliability of this program, and maybe have some failsafes for being defended.

We are quite happy with how our autonomous programs performed at Super Regionals. However, we realize that some improvements are necessary when it comes to being a strong competitor at worlds.

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Arnav Prasad

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3/24/15

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PROPRIETARY INFORMATION

Mechanical Changes + Software Adaptations

We decided to remake our dispensing tube for our robot, used in Autonomous and TeleOp. The software changes needed are not too numerous - Mostly just re-calibrating and setting new servo positions.

We also added a secondary goal "dragger" - this gives us greater reach and lets us pull goals away from the dangerous parking zone. Once safe, we can grab the goal with our primary goal grabber, which aligns the goal with the ~~robot~~ robot and dispenser.

Other than this, the only Tele-Op software changes are finding comfortable power-makes and deadzones for the drivetrain. Whatever lets our primary drivers drive more accurately, comfortably, and with the fewest penalties.

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Arnav Prasad

DATE

3/28/15

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PROPRIETARY INFORMATION

Updating our Autonomous

1) Ramp Autonomous updates:

↳ Accelerometer + Gyro sensors

- Faster down Ramp

- More accurate alignment at bottom of ramp

↳ Ultrasonic sensors

- Check for a robot in the way

- Make sure tubes are in correct locations

Overall: Should protect us from defense and possibly even correct for it.

2) Floor/Center goal Autonomous

↳ Ultrasonic Sensors: Take another reading with our ultrasonics when closer to center structure for a more accurate reading

↳ Infrared Sensor: Augment our US reading with a check with the IR

- More accurate and more reliable performance on the field

Overall: Greater reliability in determining the orientation of the center structure.

Our changes to Autonomous are designed to provide greater accuracy and reliability to our programs, even when faced with a defensive opponent.

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Amour Rashed

DATE

3/31/15

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MOE, Miracles of Engineering
FTC Team 365
2014-2015 Control Award Submission
FTC World Championships

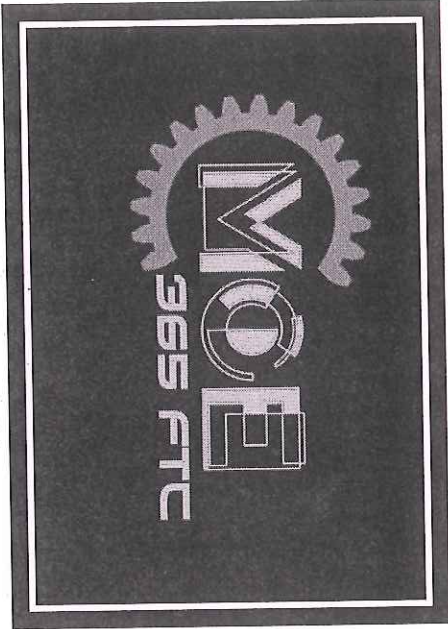


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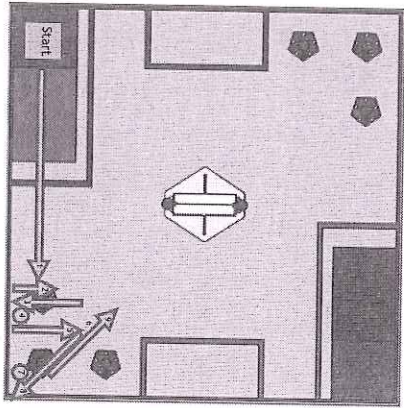
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PROPRIETARY INFORMATION

Autonomous Routine #1 (AutonomousRamp)

Start at Green Square, Green Circle indicates ball being scored



1. Forwards from ramp to grab 60cm goal (~85 inches) (20 points)
2. Strafe left to move away from wall (~8 inches)
3. Turn right 90° and drive into wall to align 60cm goal in robot (2 - 3 seconds)
4. Score pre-loaded small ball in 60cm goal (30 points)
5. Back away from 60cm goal (~6 inches)
6. Turn left 45° to face 90cm goal
7. Forwards to push and align 90cm goal (~3 seconds)
8. Score pre-loaded large ball in 90cm goal (30 points)
9. Pull 90cm goal out of corner for easy start in TeleOp (~25 inches)

Total: 80 points

3

Strengths:

- This routine works about 90% of the time, scoring 80 points very reliably.
- At the end, our robot is ready for TeleOp, controlling the 90cm goal.
- This routine complements a partner robot which has a strong parking zone routine.

Weaknesses:

- This routine can be easily defended by an opponent blocking access to the rolling goals.
- The exact alignment (rotation) of the rolling goals can, on rare occasions, affect how we grab the goal and knock us slightly off course.

Strategic Choice:

- We increased the speed of the robot as it travels down the ramp. Though this may cause a slight misalignment at the base of the ramp, it mitigates the risk of an opponent blocking us from reaching the goals.
- We decided to avoid pulling the 90cm goal back to the parking zone, because other robots tend to be in the pinch point between the ramp and center structure.

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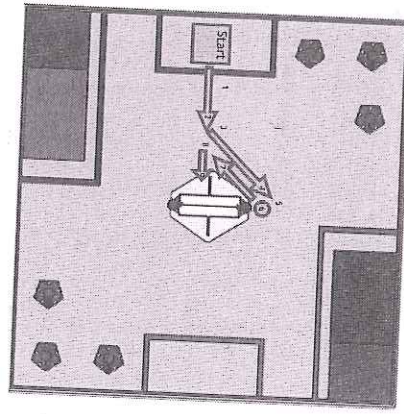
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PROPRIETARY INFORMATION

Autonomous Routine #2 (Autonomous Center)



****Start at Green Square, Green Circle indicates ball being scored****

1. Use a Lego® Ultrasonic Sensor to determine rotation of center structure
 2. Raise lift, and based on position, move forward a specific amount
 3. Turn towards center goal
 4. Move forwards to line up with center goal
 5. Rotate robot right to align dispensing tube with center goal in correct position to score
 6. Release pre-loaded autonomous balls into center goal ((40 points))
 7. Back away from center goal
 8. Rotate robot to aim toward kickstand
 9. Drive forward and knock down kickstand (30 points)
- Total: 90 points**

Continued fr

Strengths:

- This routine is designed to score 90 points while allowing our partners the opportunity to score around 50-80 points from the ramp.
- This routine is most reliable when Center Structure is in Position 3 with center goal facing the parking zone. It is about 90% effective in that position, and about 75% effective in scoring in the other two positions.
- This routine complements a partner robot which has an autonomous routine that runs off the ramp.

Weaknesses:

- This routine is about 75% effective in Positions 1 and 2. There are many field variables that can affect this routine.
- It can be defended if an opposing team drives directly into the center goal before we dispense our balls. Teams that just aim for the kickstand can disrupt our routine.
- Our robot ends up near the kickstand and in a lot of traffic.

Strategic Choice:

- We decided to avoid moving our robot toward the rolling goals at the end of the routine to avoid the potential risk of interfering with our partner's autonomous routines.

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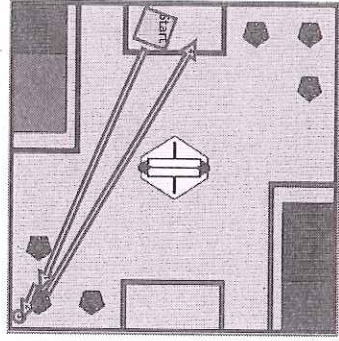
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PROPRIETARY INFORMATION

Autonomous Routine #3 (Autonomous Simple)



Start at Green Square. Green Circle indicates ball being scored

1. Drive diagonally forward from parking zone across field to grab 90cm goal
2. Push 90cm goal into corner to align it into robot
3. Score pre-loaded autonomous balls into 90cm goal (30 points)
4. Drag 90cm rolling goal back to parking zone to complete autonomous (20 points)

Total: 50 points

7

Strengths:

- This routine is designed to score 50 points from the parking zone while allowing our partner the opportunity to score around 50 points from the ramp.
- This routine complements a partner robot that has an autonomous routine that runs off the ramp, but only scores in the 60 cm tube or no tube at all.
- The routine is very reliable as long as our partner robot does not use same route.

Weaknesses:

- There is minimal room for error in navigating the field, so alignment is very important.
- This routine can interfere with our partner's routine.
- Our route can be disrupted by balls on the field if the kickstand is knocked over by opponents. This can increase the risk of tipping over the 90 cm goal.

Strategic Choice:

- This is our least-used autonomous routine because it fetches a lower point total, as well as the greater risk of getting caught in pinch points between the center goal and the ramp.

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PROPRIETARY INFORMATION

Sensors

We have employed a number of sensors to improve our robot's capabilities:

1. *Ultrasonic sensor*: This is used to locate the position of the center structure for Autonomous Routine #2. We have found that the ultrasonic sensor is more accurate than the IR sensor for this task. The ultrasonic sensor has enough sensitivity to distinguish between the three different positions with sufficient reliability.
2. *Encoders*: Encoders on the drive motors were calibrated to determine the distance traveled per tick. This is very helpful in programming the robot to move forward a given distance.
3. *Hitechnic NXT Gyroscopic Sensor*: The gyro sensor is used in two ways:
 - It is used for accurate turns during autonomous routines.
 - It is used to determine the instantaneous heading of the robot to enable field-centric operation during TeleOp (see the next section).

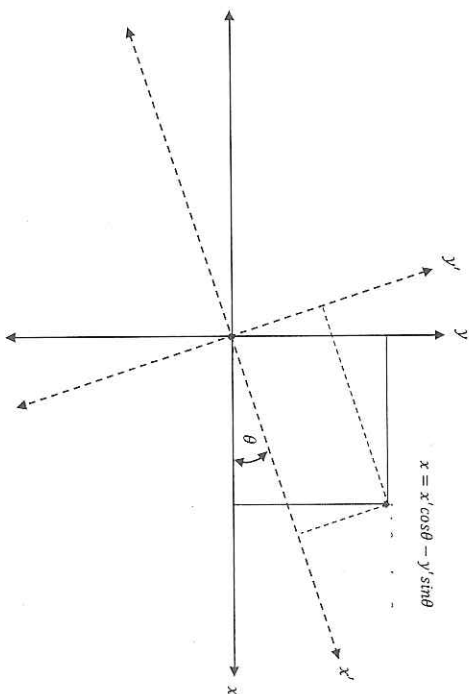
Driver Controlled (TeleOp) Features

Field-Centric Drive System

We use Mecanum wheels which allow us to move in any direction. Because of this we use a "Field Centric" TeleOp program. This allows our robot's movement to be relative to the driver, instead of the robot itself. The system allows for easier control when the robot cannot be seen (behind center structure, across the field, etc). This requires a coordinate transformation between field-centric and robot-centric coordinates. The relationship between field-centric coordinates (the modified wheel powers: x', y'), and robot-centric coordinates (the joystick powers: x, y) is:

$$\begin{aligned}x &= x' \cos\theta - y' \sin\theta \\y &= x' \sin\theta + y' \cos\theta\end{aligned}$$

We use trigonometry to perform a coordinate transformation on the robot's wheel powers, using the two equations above. We treat each driver input power from the controller as a vector, and the robot's final movement direction as the resultant vector. The coordinate transformation takes into account the robot's heading, and projects whatever direction the driver pushes on the joystick onto the robot. For example, irrespective of the robot's actual heading, when the driver pushes right on the joystick, the robot moves right with respect to the driver. This happens even if the robot is rotated 180°, in which case right for the driver is left for the robot. The diagram below illustrates the coordinate transformation from robot-centric (x, y) to field-centric (x', y') coordinates:



10

For this coordinate transformation to work, we must know the orientation of the robot with respect to the field in real time. We use a HiTechnic NXT Gyroscopic Sensor to constantly measure our rotational (angular) velocity (ω). From physics, we know that integrating angular velocity with respect to time results in the instantaneous orientation of the robot. We use this method to obtain our robot's "degree heading," which is the total number of degrees our robot has turned since the gyroscope was set to 0. The integration calculus is shown:

$$\theta(t) = \int_0^t \omega(t) dt$$

As soon as TeleOp begins, our drivers orient the robot so that it is facing away from them, and zero out the degree heading. At this point, the robot is fully enabled to function in field-centric mode.

Unfortunately, the HiTechnic NXT Gyroscopic Sensor is not very precise because it returns a small, but random, angular velocity reading even when the robot is perfectly still. Hence, we employ an "if" statement in the integration program that accepts angular velocity values only if they are larger than some prescribed threshold value. In addition, the robot's degree heading can be reset at any time to eliminate "drift," or accumulation of error due to the inaccuracy of the gyroscopic sensor.

Our drivers find the Field Centric drive system much simpler to use than the standard Robot Centric system in conjunction with our Mecanum Wheels. It is more intuitive to control, and eliminates confusion and complication in the heat of a tough match.

Intelligent Use of Servos

Our robot employs a number of servos for various tasks. These include:

1. *Orienting the Dispensing Tube:* The balls are collected by the Ball Collector and fed into the Dispensing Tube by the Harvester. The Dispensing Tube is mounted on a servo to allow it to rotate to provide additional freedom while scoring into goals that may not be perfectly centered in the robot's Goal Grabber.
2. *Dispensing Tube Gate:* This servo is used to keep the Dispensing Tube Gate closed while the balls are being loaded, and while the tube is being raised into scoring position. It then opens the Gate for scoring. The servo can open the Gate partially to allow only one small ball to score, and fully to score large balls. This feature is used during Autonomous Routine #1 to score two balls in two goals (small ball in 60 cm goal, and large ball in 90 cm goal).
3. *Goal Grabber:* This servo is used to secure the goal into the robot so that the goal can be transported across the field while staying continually in scoring position. This allows us to collect and score balls rapidly during TeleOp.

4. *Goal Peg:* Sometimes a goal can be stuck in the corner of the field, or may be blocked by other goals/robots. We use this servo to activate our Goal Peg which is a long beam with a hook at the end that can reach out and pull goals away from corners and obstacles.
5. *Ball Retainer:* This servo was a late improvement to our robot. In earlier tournaments we would lose balls out the back end of our Dispensing Tube as it was being raised for scoring due to sudden, jerky motions. So we added a small servo at the back end of the Dispensing Tube to retain the balls in the tube and prevent loss of balls out the back end. This servo has two special programming features that minimize demands on the driver's attention:
 - It automatically opens the Ball Retainer to accept balls into the tube whenever the Ball Collector and Harvester are activated. As soon as the Ball Collector and Harvester stop after the balls are loaded, the servo moves the Ball Retainer automatically to the closed position.
 - Whenever the Dispensing Tube Gate is opened by the driver, the Ball Retainer automatically rotates even further to push the balls forward, ensuring no balls remain stuck in the tube.

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