ENGG 1015

Introduction to Engineering Design and Problem Solving

Final Report

Design of a Suspended Retrieval Machine

Prepared for

Dr. Dale C. Roach

ENGG1015- Introduction to Engineering Design and Problem Solving

Prepared by

Group #3

Andrew Robart	**Thomas Van Steeg**
Joseph Crowley	**Caleb Morgan**
Tao Chen	**Amir Ansari**
Burak Koryan	**Mingxuan Gao**

December 3, 2014

December 3, 2014

Group 3
Engineering students
100 Tucker Park Road
K.C.Irving Hall, 219
UNB Saint John Campus
Saint John, New Brunswick,
Canada
E2L 4L5

Dr.Dale Roach,PhD
100 Tucker Park Road
K.C.Irving Hall, 219
UNB Saint John Campus
Saint John, New Brunswick,
Canada
E2L 4L5

Dr. Dale C. Roach;

Along with this letter you will find Group 3's final report for the ENGG 1015 term project titled "Design of a Suspended Retrieval Machine".

Early in the semester you assigned a group project with the aim of retrieving a bolt on a platform at the opposite end of an inclined wire that was hung between two poles. The report explains each step we took to design and build our product as well as how it works.

Our design is made with a steel frame, a wooden bracket, two hooks, one wheel, a DC motor, elastic bands, a on-off switch, batteries and a relay switch. Completing this project took approximately two months. We concluded that our design will most likely have the most torque out of any bot, but it will have the slowest speed.

If you have any questions or concerns, please feel free to contact us.

Respectfully yours,

Group #3

Andrew Robart	Thomas Van Steeg
Alex Crowley	Caleb Morgan
Tao Chen	Amir Ansari
Burak Koryan	Mingxuan Gao

Enclosed: Final Report

Abstract

In this report, the design process for group 2's ENGG 1015 term project is examined, along with its results. The class was assigned the task of retrieving a bolt on a platform at the opposite end of a wire suspended between two poles. Below you will see a table of contents that lists all the main content of our report. Preceding the table of contents is a list of tables and figures that provides a description of each table in the appendix, which is followed by the introduction of the report. Described in this report you will find the planning process that includes Gantt charts for visual communication (Appendix A). You will also find the QFD process (Appendix B1) and functional model (Appendix B2) used to develop the design for group 2's bot.

The detailed steps of concept generation and building are also defined in Chapter 4. Chapter 5 is a description of the results of our project on the test date. Reading further there is advice for next year's students and conclusions. After concluding the main body of the report there are works cited as well as the appendix. In the Appendix you will find design sketches, and a gallery of building and testing photos.

Content

List of Tables and Figures

Figure A1 Original Gantt chart

The original Gantt chart is graphical representations to be completed and the estimated time it will take to complete each item that was predicted at the beginning of the project using an average of the best, optimistic and pessimistic time estimates.

Figure A2 Gantt chart version 2

The second version of the Gantt chart is a table, which describes each task, its due date, and the level of completion. The due dates are more accurate time estimates completed with a greater understanding of the project.

Figure A3 Gantt chart version 3

The third version of our Gantt chart provides a description of every task, milestones achieved, whether each task was a deliverable, start and end dates, percent complete, days overdue and ahead of schedule, as well as responsibility.

Figure A4 Final Gantt chart

The final version of our Gantt chart outlines all the tasks that were completed by the group throughout the project.

Figure B1 House of Quality

The house of quality is a table that outlines all the steps completed in Quality Function Deployment. It shows the importance of customer's needs related to the known engineering specifications for the product.

Figure B2 Functional Model

The functional model is a graphical representation of interactions with our bot, and the representation of its major and minor functions.

1. Introduction

1.1 Objective

The objective of this project was to design and build a retrieval machine to pick up a bolt on a platform, that was attached to a pole at the opposite end off a wire, all without any interaction besides turning it on. In other words, imagine you were stranded on an island and there were two trees on opposite sides of the river and an object at the other end was needed. There is a cable that runs between the two trees and there is no possible way to retrieve the object yourself. The only possible way to retrieve the item is building a machine that travels across the wire, picks up the bolt object and returns. At the side of the river where the object is located there is no one. Once the bot starts nothing can touch it again as it moves across the wire over the river. It must pick up the object with its magnet and bring it back to its place of origin or starting point. The inclination of the wire was 2 meters increase over the length of 10 meters. The platform that the bolt rested on is 30cm below the wire.

The bot we created to accomplish this task was successful in retrieving the bolt, and overall, the project was a huge success. Each group member learned a lot about the design process through the various assignments and stages we completed to finish our design. The project helped us experience that has real world applications, such as working in a group, defining the problem, planning to design the solution, designing the solution, building the solution, as well as reporting its success and faults during the testing process.

2. Planning the Design Process

Initially, we believed that planning for design was an unimportant part of designing and building our project; however, it became apparent that it was one of the most essential tasks to stay organized. To organize our project, tasks and dates, we built a Gantt chart. In the beginning our Gantt chart was very basic and did communicate specific details. Over time, more detail was added and it allowed us to complete tasks much more efficiently, as we knew when they were due, and who was responsible.

Our Gantt chart evolved and grew as we learned more about the project, but it contained a description of every task, milestones achieved and to be achieved, whether each task was a deliverable, start and end dates, percent complete, days over due and ahead of schedule, as well as responsibility. Everyone had access to the Gantt chart and everyone was constantly reminded of the tasks they needed to complete

Our team met on a weekly basis to check the status of our tasks, and work out details of our design. We stayed relatively on schedule until later in the term, when our course loads became heavy. The group fell behind writing the lab report, and assigned tasks were not being completed on time. To try and get back on task, we assigned more people to particularly difficult tasks. As well, each task was assigned to the member that was most qualified. For example, Drew had the most experience building robots and using motors to lift weights, therefore he was in charge of buying materials. Relating this to the professional world, when assembling a team, you must assess the skills of each team member and delegate tasks according to the skills each member possess. Overall using the Gantt chart allowed us to see what we had accomplished, as well as what we still needed to accomplish, and essentially it was an extremely useful tool.

3. The Design Process

(See Figure B1 for House of Quality)

3.1 Developing Engineering Specifications

During the design process, we were given the task of building a house of quality and to think about the method of Quality Function Deployment (QFD). Quality Function Deployment may clarify the requirements for the product, requirements for the manufacturer, and the customer as well. One of its key purposes is to help decipher the customer wants, as this can be a difficult task. Another purpose is to measure what the product must do. A house of quality lists all the customer's wants, as well as the required engineering specifications. It also compares the product to the competitor's products and allows the group to set certain goals in form of numerical targets, which they want the product to reach.

3.2 Quality Function Deployment Steps 1-3

Firstly we needed to identify our customer. While searching, we realized that we were the customers, in the sense that we were asking for this product to be developed and we knew what we "wanted" it to do. At the same time we were the manufacturers because we were the ones building the product, therefore we simply wanted it to succeed, without any other complications. Next, we created a list of the customer's product requirements. Each requirement was then ranked by importance incase we ran over budget or fell behind in the building process and had to modify the design to save money and time. The requirements that were most important to the customer and the manufacturer were getting from one side of the wire to the other, picking up the object, coming back after picking up object, all while operating safely.

While building the product, these were the main specifications we took into consideration. Some of the specifications that were important to the customer but unimportant to the manufacturer were: cycle time, distribution, simple functionality, and that it would operate quietly. Since these properties were unimportant to the manufacturer while building, they were only taken into consideration if there was time and resources to add them. Therefore, the manufacturers' needs took priority over the customers' "wants", however the manufacturer still tried to fulfill them.

3.3 Quality Function Deployment Step 4

The next part of QFD was evaluating the competition and the product that was made. Since no competition product had been built yet the competitors were asked how they thought their product would do in each of our specification categories. The group had to trust the answers of the competitors in order to compare their products and see how important and well they want their products to do in comparison to each of the 6 groups. The problems with this step were that the competition could have been misleading. Secondly, the competition could have had other requirements for the customer; therefore we could improve our house of quality by adding these requirements.

3.4 Quality Function Deployment Steps 5-6

The following two steps were crucial to building a house of quality. The first step was to generate engineering specifications. These specifications had to meet every single one of the customer requirements that we developed in step 2. These specifications had to be able to be measured in units; therefore allowing a target value for each specification to be calculated. Our product was to have an efficient motor with lots of torque.

Next a relationship between the requirements and the specifications was developed. Each relationship fell into four categories: high relation, medium relation, low relation and no relation. For example the time it took to complete the task had a direct relationship with cycle time and it was given a high relation. That specification did not have any relation towards its simplicity, therefore that box was left blank.

3.4 Quality Function Deployment Step 7

The next step in QFD was to determine the target values for the specifications. We first compared to the competitors and asked what they thought. For example, how fast or lightweight they thought there product would be followed by the groups own target values. The group realized it would not be possible to be the best in all categories compared to the competition therefore we set some of the targets to be better and worse than the competitors. We wanted our bot to be lightweight compared to the competition as well as to have the most torque.

Finally, we rated how dependent each specification was to the others. This was split into four categories including: strong positive, positive, negative and strong negative. For example, the product having a powerful & efficient motor had a strong positive relationship with the time required to accomplish task, therefore it was given a strong positive.

After completing the house of quality and using QFD the group learned that it really helps understand not only what the customer wants but what the manufacturer wants as well. It helps one get a better understanding of designing and what is actually needed to make something. Also we learned that referring to the house of quality at times to make sure that all the requirements are being completing.

4. Developing Concepts

4.1 Design-Test-Build Method

The design method used for our project was the engineering design-build-test process. The purpose of this process is to produce many prototypes that can be tested and redesigned to perfect the final product. Our group used this designed method throughout the entire process as it allowed us to constantly modify our product without having too much prior research. Once the first prototype was completed, each week we tested our bot in various scenarios, preparing it for final testing. We believe that this method worked well for our group, only because we had a prior knowledge to how the problem would be solved; therefore we knew what may or may not work. The bot was completed three and a half weeks before final testing, and until that date, we were able to test our bot many times.

4.2 Concept Generation

To develop concepts for design, a technique called "Brainstorming" was used. Firstly, the group decided to use a remote control to control our bot, and questions were asked, such as, how was the model going to be placed on the wire, and how would it be powered. However it was discovered later as the problem was refined, that a remote control device could not be used. After making this false assumption, our group changed gears. We gathered ideas by beginning the "Brainstorming" process. Each group member was asked to come up with 2 solutions to the problem and each idea would be presented during the next meeting.

During the next meeting solutions were shared, each being communicated both verbally and visually with the help of a whiteboard. Some of the solutions were extremely far-fetched; others that did not follow any of the constraints that limited the project, which left around 6 feasible solutions. **(See Appendix Figure C3 for list of solutions)**

After an anonymous vote, the 2 best solutions were chosen based on feasibility, time, and cost. The two main ideas consisted were: using wind-up gears that switched on contact with a ferro-magnetic object, or to use of a motor with a double pole double throw relay that would reverse polarity on contact with the wall. Each group member was then asked to perform secondary research on each solution to discover which one was most the most feasible, based on the resources available.

After performing secondary research, it was concluded that using a motor and relay switch was the easiest, and most time-effective solution. Two wheels were to be placed slightly above the wheel that moved the bot to apply pressure between that wheel and the wire, allowing it to climb greater inclines without slipping. The wheel was to be attached to the motor by a belt, in this case, a bundle of elastics. Initially the body was to be made of a light substance such as Styrofoam or plastic and the body was to be suspended under the wire and pined at one point, keeping the bot level, however this was to be changed later. We were going to place the motor and batteries into holes cut into the Styrofoam. Finally it was decided that the bot was going to pick up the bolt using an extremely powerful magnet, and reverse the polarity of the motor on contact with the wall.

4.3 Product Development and Testing
(See Appendix D for time-lapse photos)

The first step we took to develop our product was gather the materials required. We bought the motor and magnet, and all other parts were found in Caleb's garage. The wheel that was being used to move the bot on the wire was a rubber castor. We grinded out a groove in the castor, creating a slot where the wire would rest.

Next we tested the motor to make sure it would have enough torque to get up the wire by trying to stop it using our hands, and it was not even possible. Next we attached the motor to an L-shaped metal bracket, bolting the wheel on above the motor. Next a wire was soldered to one of the batteries and all of the batteries were connected together in series, ready to be used. Then we put the elastic bands around the motor shaft and the wheel to act as our belt. We then tested the motor, and it turned the wheel with ease.

Next we temporarily strapped the batteries to the bracket using elastics and then tested the bot again. We noticed that the bot was slipping and would not climb the wire when there was an incline; therefore we added elastics to the groove that the wire set in. We tested it again and it climbed any incline, even almost directly vertical when the wire was wrapped around the wheel once, but it was no balanced and fell off the wire.

After discussing the results we decided to modify the design to have a bracket that would have two wheels on either side of the bot to stabilize it and add pressure to the wheel moving the bot. We gathered the parts from our houses, and found an alternate solution based on what was available. The bracket was bolted on and it was made of wood, and instead of wheels, we used hooks however it would complete the same task. Then we tested it again using a rope tied to a kitchen cupboard doorknob and the leg of a sofa. It was noted that the bot worked extremely well traveling both up and down the incline.

Finally we screwed the double pole double throw switch onto the front of the bot and connected the wires to the batteries and motor. We tested it again and the switch did not make contact with the board and the bot did not turn around. A credit card with a slot cut out was glued to the end of the switch to make sure the switch made contact with the wall. Testing it again, it switched however the bot stopped and the batteries died. We replaced the batteries and attached springs to the switch so that when it struck the opposite side, it would not get caught in the short. Testing it for the final time, it worked both up and down without any problems. We fastened the batteries in place using a round plate of EMT conduit.

5. Test Day Results

On November 27th our group arrived at 9:20 am prepared to start testing at 9:30 am. Our group had some last minute adjustments and modifications to be made before testing it; the prototype had developed a short in relay switch we were using. In between forward and reverse polarities, it would short out causing our batteries to die almost instantly therefore we had to make a component that would pull the switch through during testing. Our group attached two springs onto the end of the switch pulling it backwards, so it wouldn't short out and stop half way through the test. After this problem was fixed our group sat down and waited for our turn to test the bot.

On the way down the prototype traveled across the wire but, it struck the board and the bot malfunctioned. Our solution had not worked and the switch had shorted out in the middle. Not all the group members were aware of this flaw in our design therefore they did not push the switch back right away and the batteries were drained. The bot had picked up the bolt up however; therefore the first test was not a complete failure.

Before the second test we modified the springs and attached them further the prototype switch so the shortage would not happen again. We placed the bot at the bottom end of the wire this time to see if it would climb the incline. The prototype was successful and our switch did not malfunction this time. It travelled across the wire picked up the bolt and came back only having us touch it once to start it.

6. Advice for Next Year's Students

When you first receive this project we highly recommend that you do not panic and think rationally about the problem that lies ahead of you. Upon receiving the problem, it is likely that your team will not be given all information required to complete the project, therefore it is best that you wait till you know all the criteria about the project before designing and building right away based on assumptions. It is much easier to design a solution to a problem when the problem is fully defined. On top of that our team recommends that you seek understanding from the professor to better grasp the problem and the fine details of it.

We strongly recommend you to always stay on task, as time is very limited. It may be difficult to remain on task, but it is important that every member of your group does their part and completes it on time. The gant chart you will make at the beginning of the semester will help you stay on task and plan ahead. It is vital that your group keeps a journal throughout the term and that you are constantly working on the lab report, not leaving it to the last minute, as you will not get the results you may want. You must put many hours of work in to complete this project before the deadline with success and we recommend you start building a template for you lab report on day 1.

It will help you greatly to be done building the final prototype, well before the final testing day, as you will be able to test your bot and break it many times until it works flawlessly. Do not be afraid of throwing out an idea that you have already put work into, it may lead you down a path that has no solution. As well do not be afraid to make design changes as better solutions are thought of the more you know about the.

At the beginning of the term your class will watch a movie called “Incident at Morales” and for many reasons. In the movie, a man dies in a manufacturing plant because the engineer that designed the plant, bought cheaper parts that would save his company money but be extremely costly in the end. This will teach you should buy the proper parts when building anything. You do not need to buy extremely expensive parts, just make sure you buy parts that you know will be reliable.

7. Conclusion

7.1 Conclusions

The objective of this project was to design and build a retrieval machine to pick up a bolt on a platform attached to a pole at the opposite end off a wire without any interaction besides turning it on. Our group was successful in designing and building our product, however it had flaws that form potential sources for error if the product were to be further used. Firstly, the bot was dropped during testing and the motor stopped working and this caused one of our tests to be unsuccessful and could potentially lead to the motor not working in the future. Secondly the major possible source for error was the use of a faulty double pole double throw relay switch. The switch malfunctioned causing our bot to stop during test day on one end and drain its batteries. This was because the switch was poor quality, and it had been overused, causing the contacts within to be bent together and create a short in the center of the switch. Other potential sources for error in the future could be using the bot on an incline greater than 2/10 as the bot was not designed for this and would succumb to slipping.

7.2 What we Learned

Upon receiving this lab, we initially thought it was impossible to complete. The first thing students should do is brainstorm ideas, and narrows them down until only one effective idea remains. Proper brainstorming works very well and it is key to the design process.

Half way through the first construction meeting it was evident that only a few people could work on the model, at a time. We subsequently learned that procrastinating on the lab report was insufficient. Staying true to the Gantt chart was crucial to the success of the project because it helped reduce the stress levels of the group members as well as keep each member on task.

Finally we learned that it is essential to stay in contact and communicate with the group members, at all times, so that they are aware of the progress of the tasks assigned to each individual. One-technique students could employ in the future would be to create a Facebook group dedicated to the project, so that they interact with each other.

Works Cited

Andrews, G., & Apelvich, J. (2014). Introduction to professional engineering in Canada (4th ed.). Toronto: Pearson Prentice Hall.

Lockhart, S., & Johnson, C. (2012). Engineering design communication: Conveying design through graphics. Upper Saddle River, NJ: Prentice Hall.

Roach, D.C. (2014). *Chapters 1- 8* [PowerPoint slides]. Retrieved from https://lms.unb.ca/d2l/home/90911

Ullman, D. (2010). The mechanical design process (4 ed.). Boston: McGraw-Hill Higher Education.

Appendix A: Gantt Charts

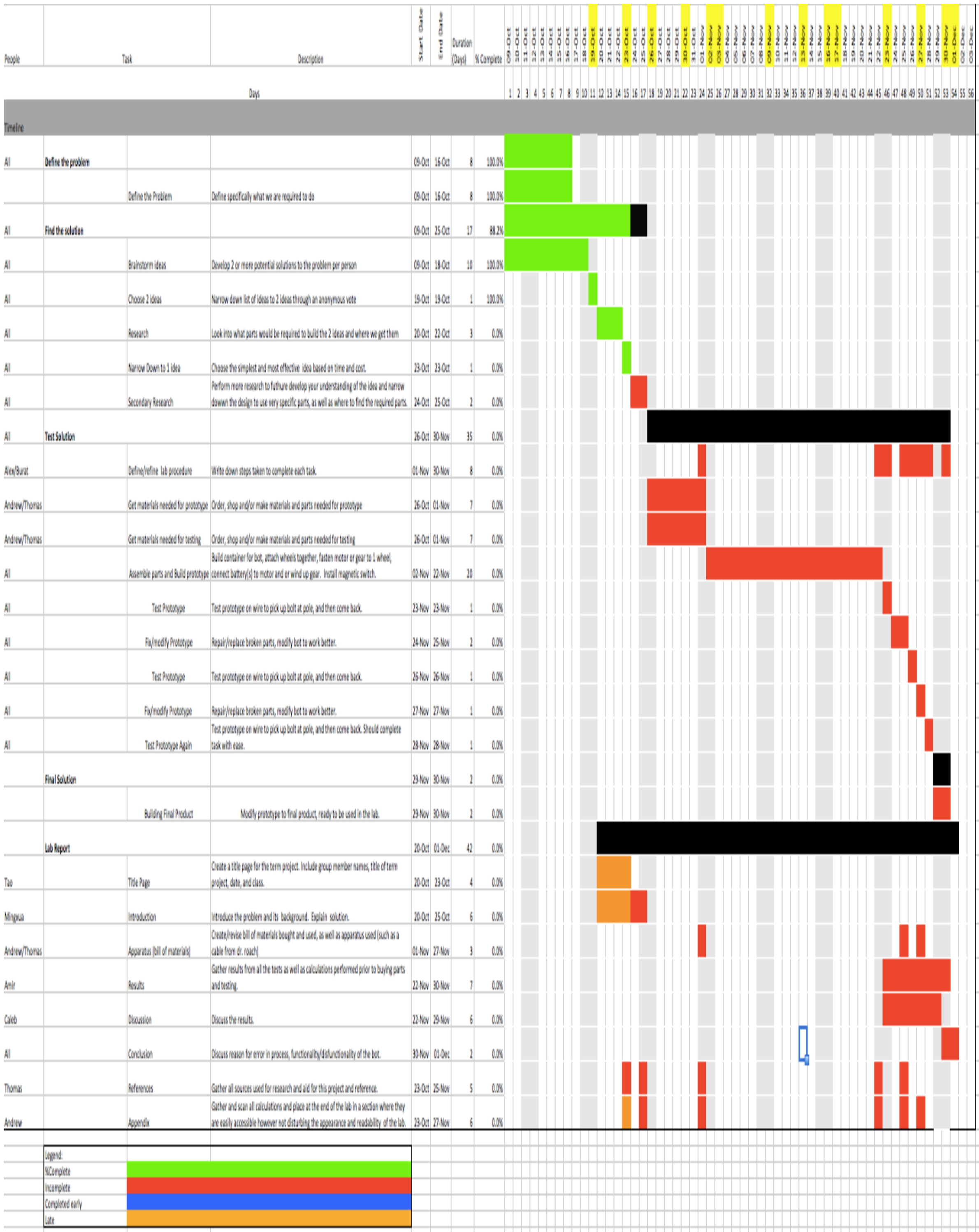
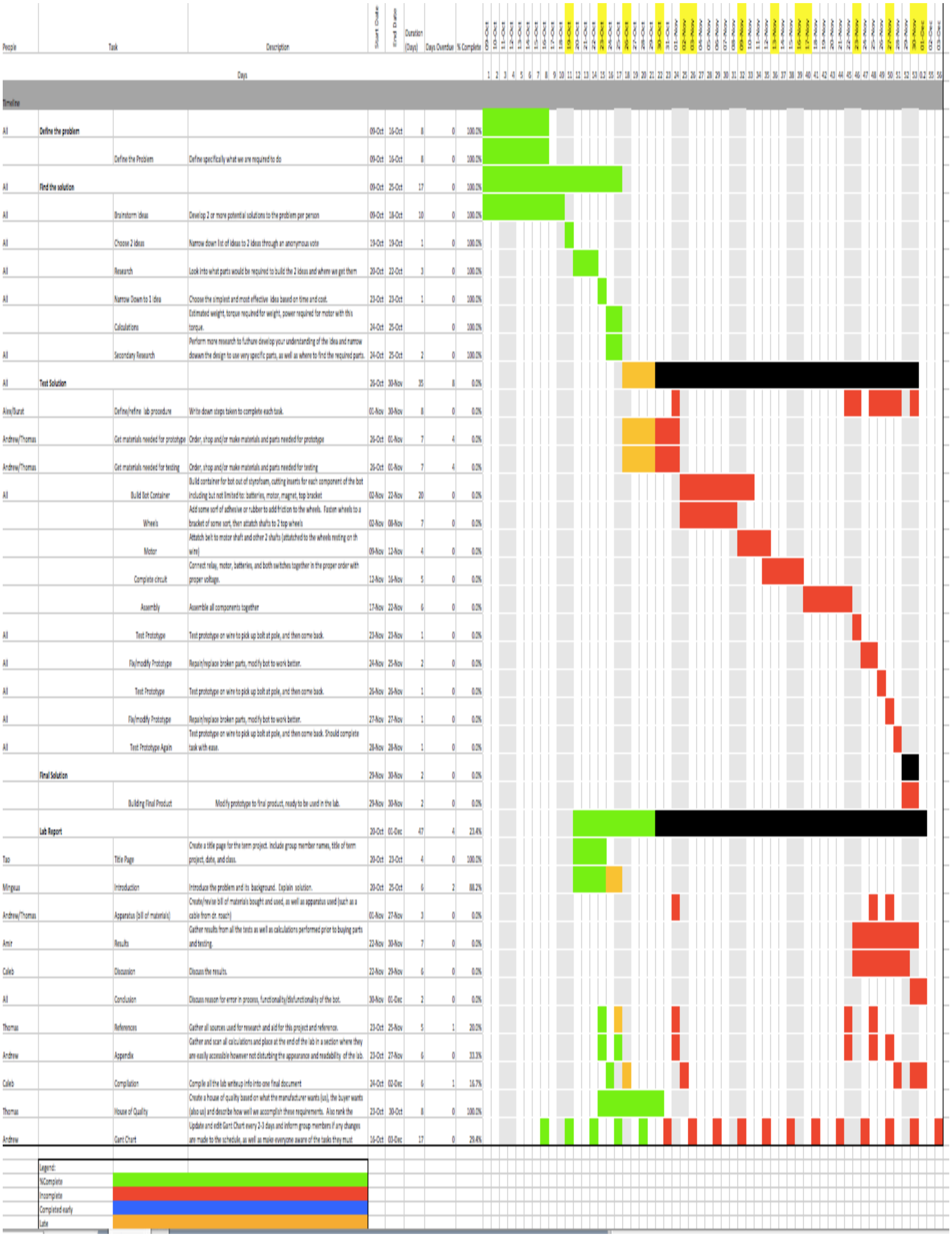


Figure A1: Original Gantt chart



People	Task		Description	Start Date	End Date	Duration (Days)	Days Overdue	% Complete
All	Define the problem			09-Oct	16-Oct	8	0	100.0%
		Define the Problem	Define specifically what we are required to do	09-Oct	16-Oct	8	0	100.0%
All	Find the solution			09-Oct	25-Oct	17	0	100.0%
All		Brainstorm ideas	Develop 2 or more potential solutions to the problem per person	09-Oct	18-Oct	10	0	100.0%
All		Choose 2 ideas	Narrow down list of ideas to 2 ideas through an anonymous vote	19-Oct	19-Oct	1	0	100.0%
All		Research	Look into what parts would be required to build the 2 ideas and where we get them	20-Oct	22-Oct	3	0	100.0%
All		Narrow Down to 1 idea	Choose the simplest and most effective idea based on time and cost.	23-Oct	23-Oct	1	0	100.0%
		Calculations	Estimated weight, torque required for weight, power required for motor with this torque.	24-Oct	25-Oct		0	100.0%
All		Secondary Research	Perform more research to future develop your understanding of the idea and narrow dowwn the design to use very specific parts, as well as where to find the required parts.	24-Oct	25-Oct	2	0	100.0%
All	Test Solution			26-Oct	30-Nov	35	8	0.0%
Alex/Burat		Define/refine lab procedure	Write down steps taken to complete each task.	01-Nov	30-Nov	8	0	0.0%
Andrew/Thomas		Get materials needed for prototype	Order, shop and/or make materials and parts needed for prototype	26-Oct	01-Nov	7	4	0.0%
Andrew/Thomas		Get materials needed for testing	Order, shop and/or make materials and parts needed for testing	26-Oct	01-Nov	7	4	0.0%
All		Build Bot Container	Build container for bot out of styrofoam, cutting inserts for each component of the bot including but not limited to: batteries, motor, magnet, top bracket	02-Nov	22-Nov	20	0	0.0%
		Wheels	Add some sort of adhesive or rubber to add friction to the wheels. Fasten wheels to a bracket of some sort, then attatch shafts to 2 top wheels	02-Nov	08-Nov	7	0	0.0%
		Motor	Attatch belt to motor shaft and other 2 shafts (attatched to the wheels resting on th wire)	09-Nov	12-Nov	4	0	0.0%
		Complete circuit	Connect relay, motor, batteries, and both switches together in the proper order with proper voltage.	12-Nov	16-Nov	5	0	0.0%
		Assembly	Assemble all components together	17-Nov	22-Nov	6	0	0.0%
All		Test Prototype	Test prototype on wire to pick up bolt at pole, and then come back.	23-Nov	23-Nov	1	0	0.0%
All		Fix/modify Prototype	Repair/replace broken parts, modify bot to work better.	24-Nov	25-Nov	2	0	0.0%
All		Test Prototype	Test prototype on wire to pick up bolt at pole, and then come back.	26-Nov	26-Nov	1	0	0.0%
All		Fix/modify Prototype	Repair/replace broken parts, modify bot to work better.	27-Nov	27-Nov	1	0	0.0%
All		Test Prototype Again	Test prototype on wire to pick up bolt at pole, and then come back. Should complete task with ease.	28-Nov	28-Nov	1	0	0.0%
	Final Solution			29-Nov	30-Nov	2	0	0.0%
		Building Final Product	Modify prototype to final product, ready to be used in the lab.	29-Nov	30-Nov	2	0	0.0%
	Lab Report			20-Oct	01-Dec	47	4	23.4%
Tao		Title Page	Create a title page for the term project. Include group member names, title of term project, date, and class.	20-Oct	23-Oct	4	0	100.0%
Mingxuan		Introduction	Introduce the problem and its background. Explain solution.	20-Oct	25-Oct	6	2	88.2%
Andrew/Thomas		Apparatus (bill of materials)	Create/revise bill of materials bought and used, as well as apparatus used (such as a cable from dr. roach)	01-Nov	27-Nov	3	0	0.0%
Amir		Results	Gather results from all the tests as well as calculations performed prior to buying parts and testing.	22-Nov	30-Nov	7	0	0.0%
Caleb		Discussion	Discuss the results.	22-Nov	29-Nov	6	0	0.0%
All		Conclusion	Discuss reason for error in process, functionality/disfunctionality of the bot.	30-Nov	01-Dec	2	0	0.0%
Thomas		References	Gather all sources used for research and aid for this project and reference.	23-Oct	25-Nov	5	1	20.0%
Andrew		Appendix	Gather and scan all calculations and place at the end of the lab in a section where they are easily accessible however not disturbing the appearance and readability of the lab.	23-Oct	27-Nov	6	0	33.3%
Caleb		Compilation	Compile all the lab write up info into one final document	24-Oct	02-Dec	6	1	16.7%
Thomas		House of Quality	Create a house of quality based on what the manufacturer wants (us), the buyer wants (also us) and describe how well we accomplish these requirements. Also rank the	23-Oct	30-Oct	8	0	100.0%
Andrew		Gant Chart	Update and edit Gant Chart every 2-3 days and inform group members if any changes are made to the schedule, as well as make everyone aware of the tasks they must	16-Oct	03-Dec	17	0	29.4%

Legend:
%Complete
Incomplete
Completed early
Late

Figure A2: Gantt chart version 2

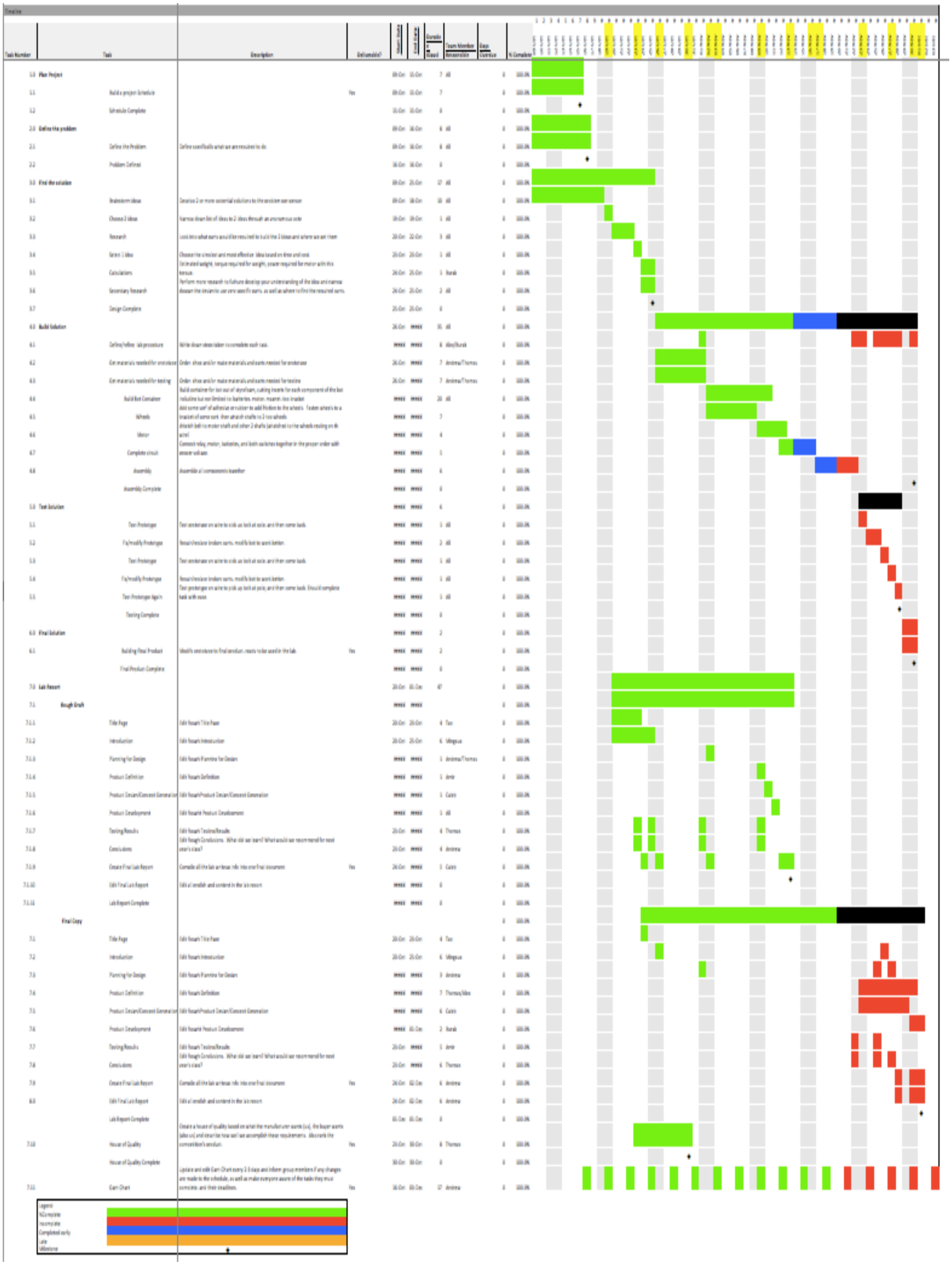


Figure A3: Gantt chart version 3

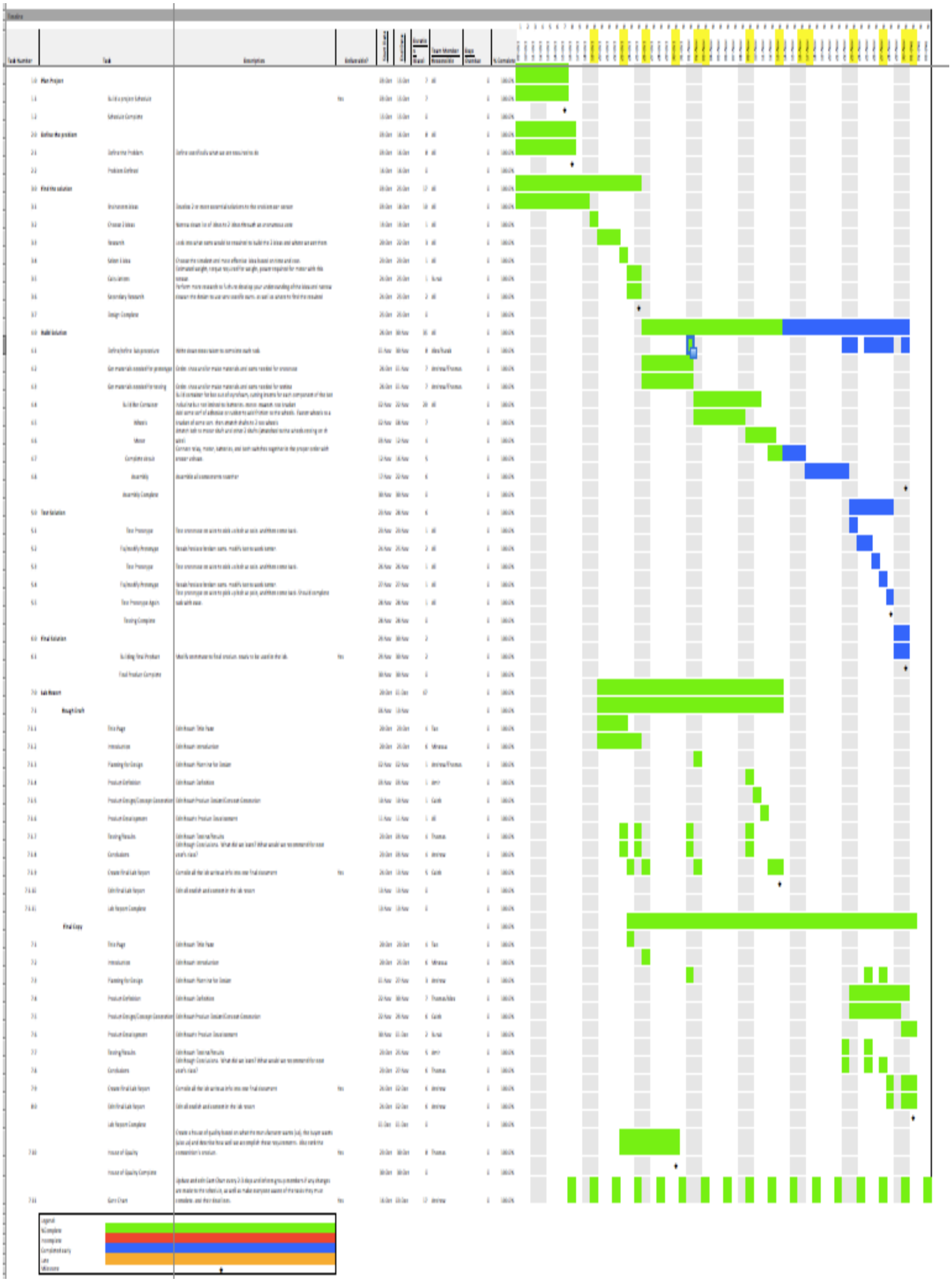


Figure A4: Final Gantt chart

Appendix B: Engineering Specifications

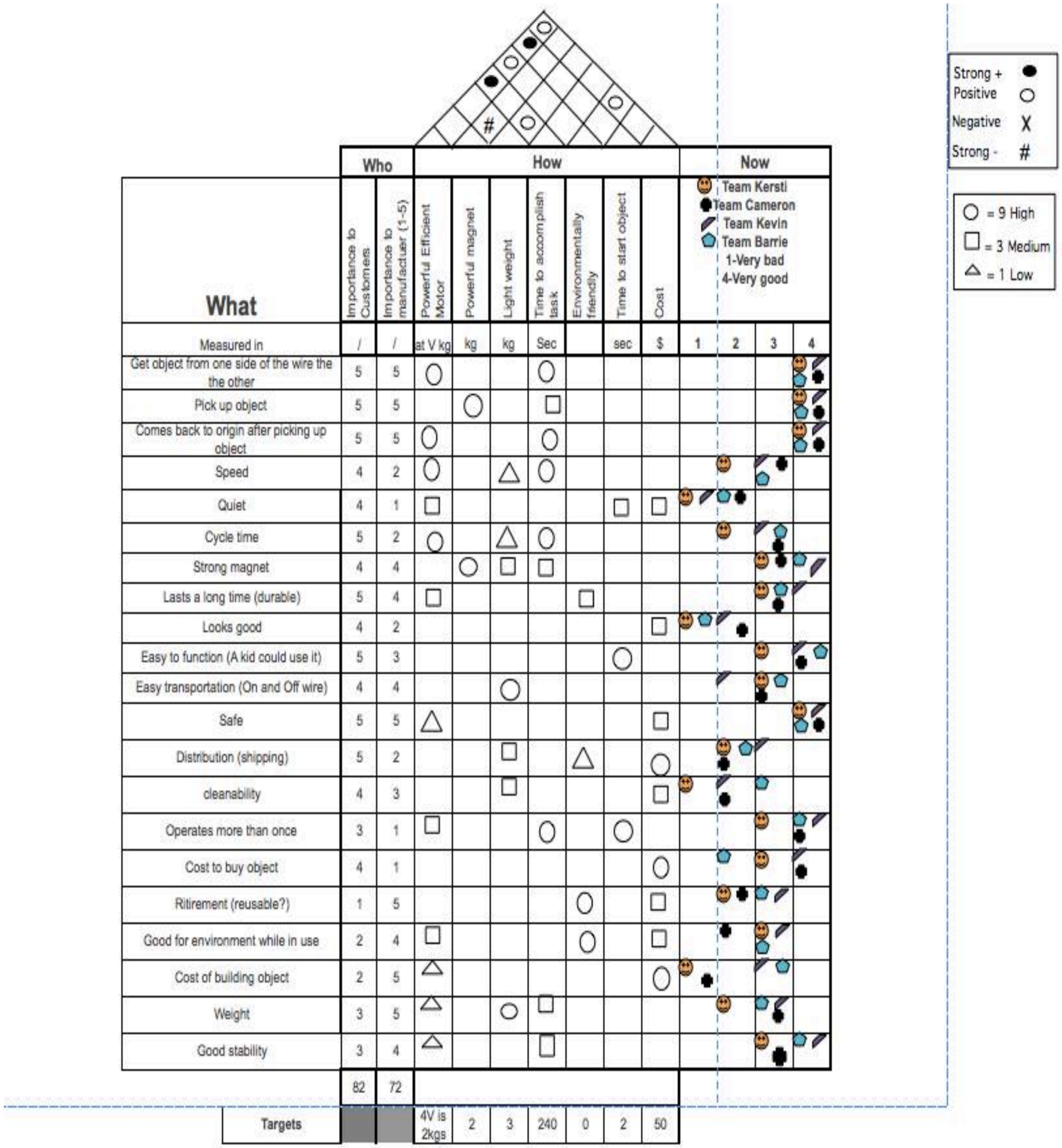


Figure B1: House of Quality

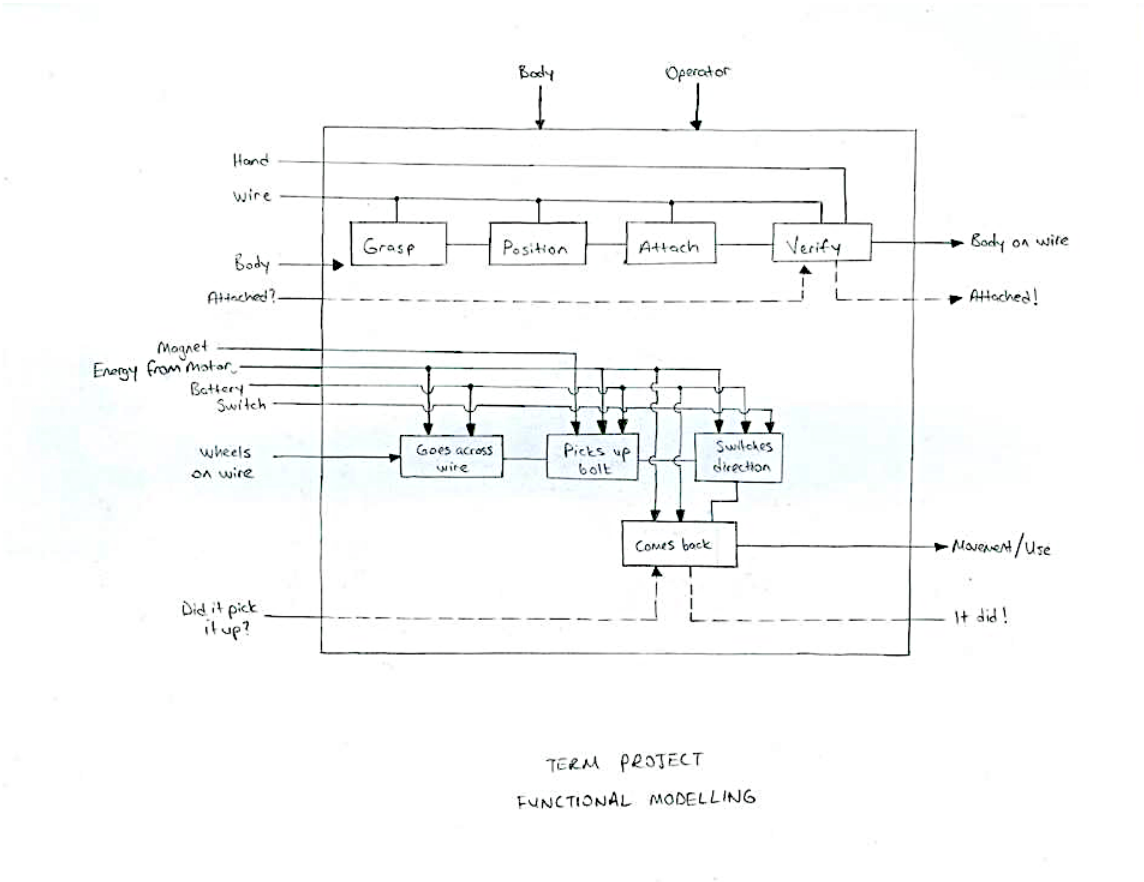


Figure B2: Functional Model

Appendix C: Design Sketches

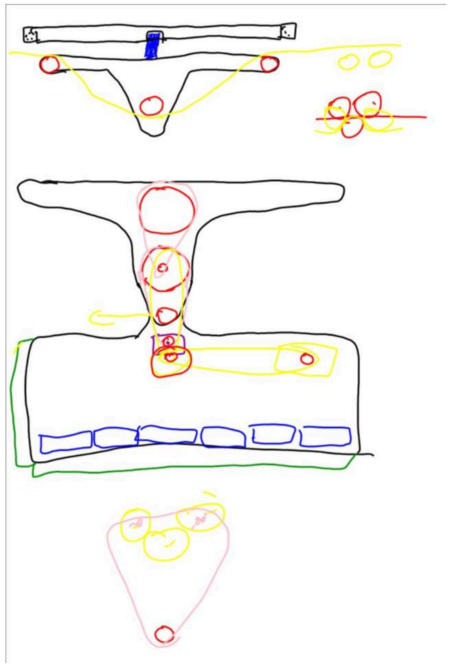


Figure C1: Tao Chen- Rough Original Design

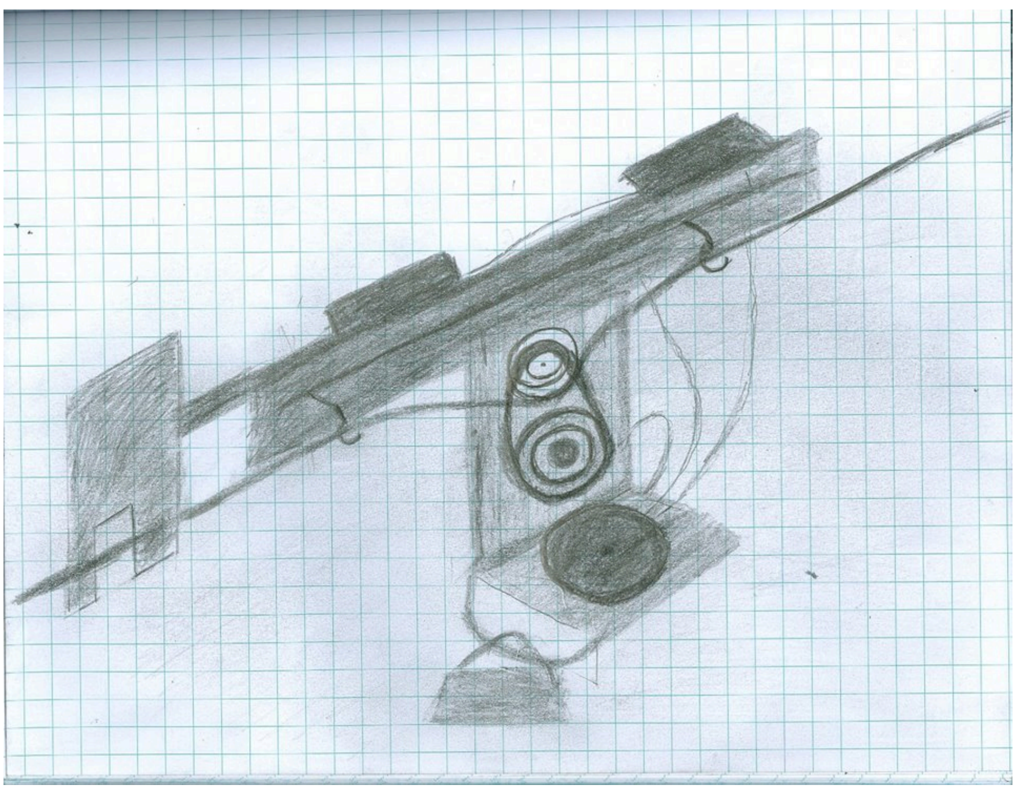
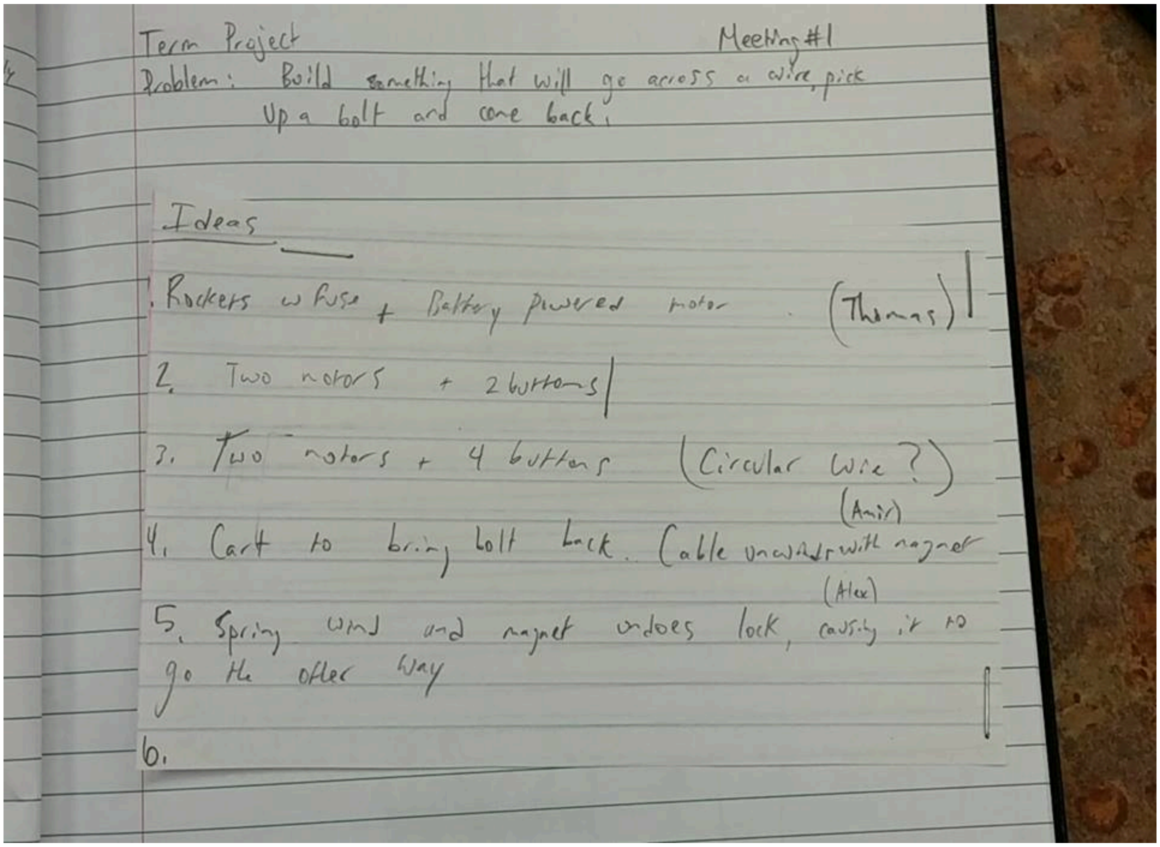


Figure C2: Amir Ansari- Final Design



Term Project Meeting #1

Problem: Build something that will go across a wire, pick up a bolt and come back.

Ideas

1. Rockets w fuse + Battery powered motor (Thomas)
2. Two motors + 2 buttons
3. Two motors + 4 buttons (Circular Wire?) (Amir)
4. Cart to bring bolt back. Cable unwinder with magnet (Alex)
5. Spring wind and magnet undoes lock, causing it to go the other way
6.

Figure C3: Brainstorming Ideas

Appendix D: Building and Testing Pictures

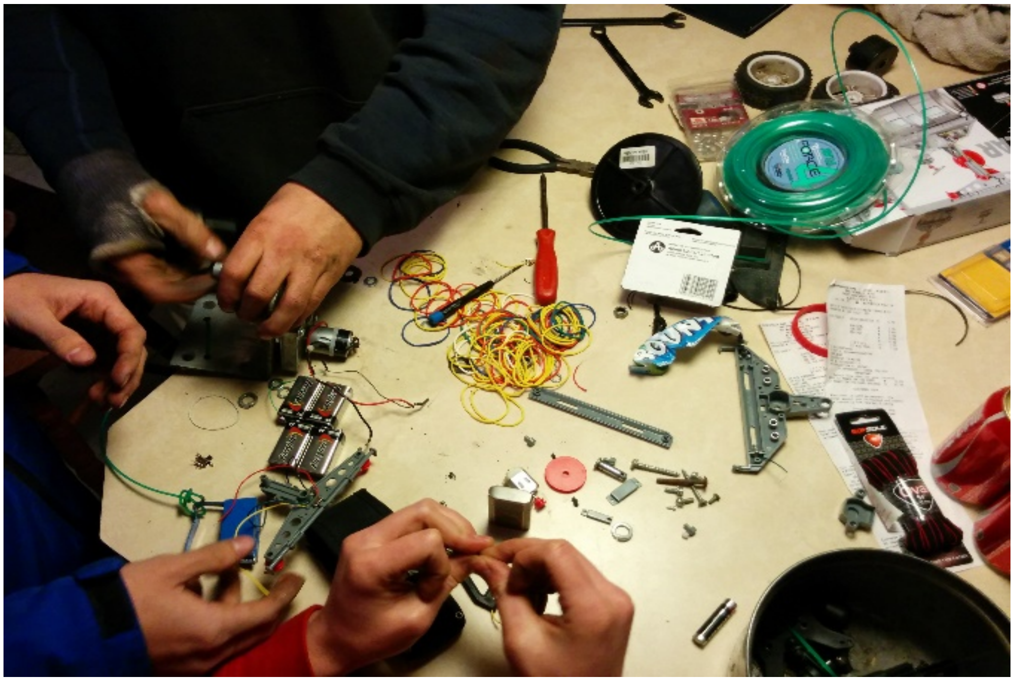


Figure C1: Assembly stage 1

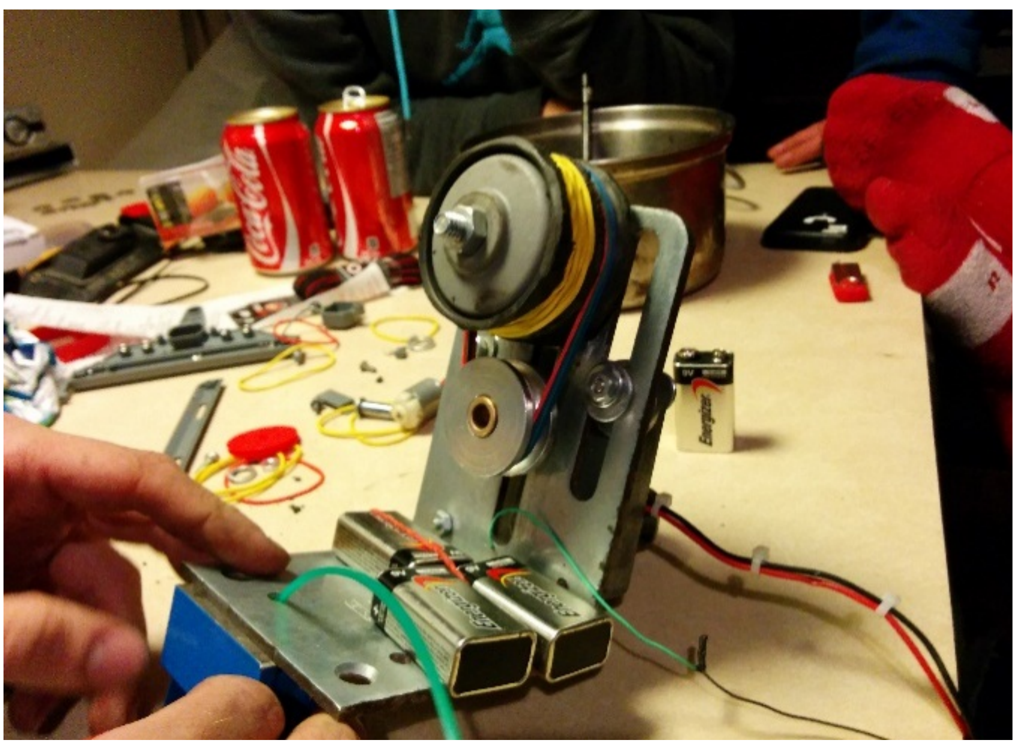


Figure C2: Assembly stage 2

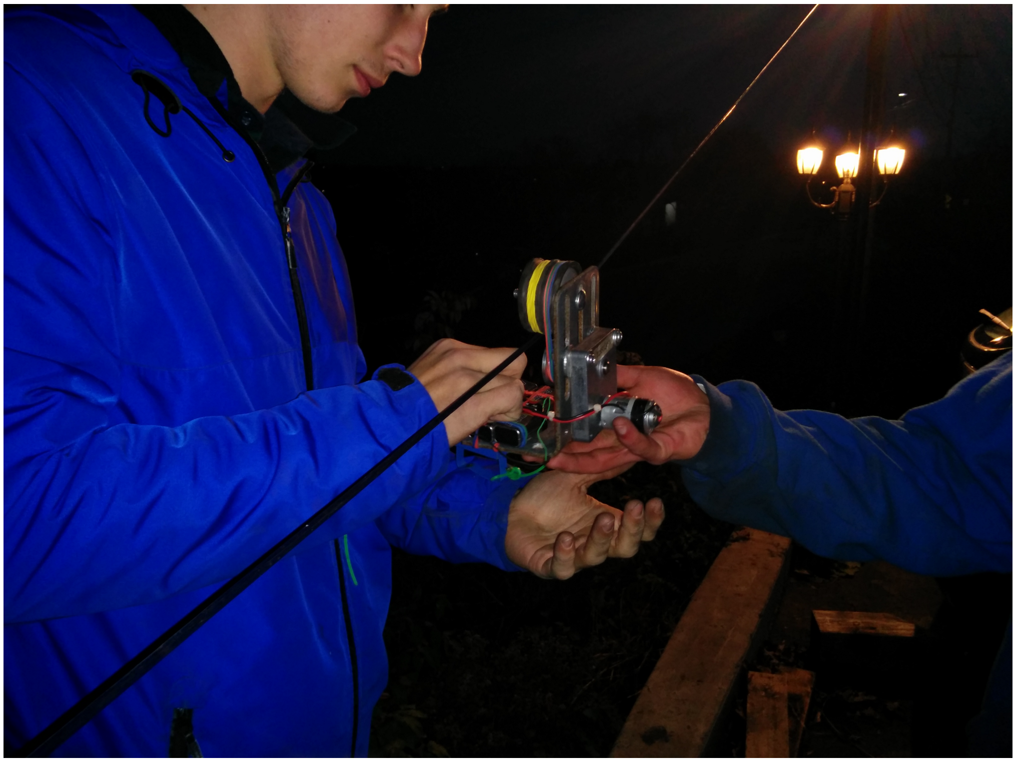


Figure C3: Test 1

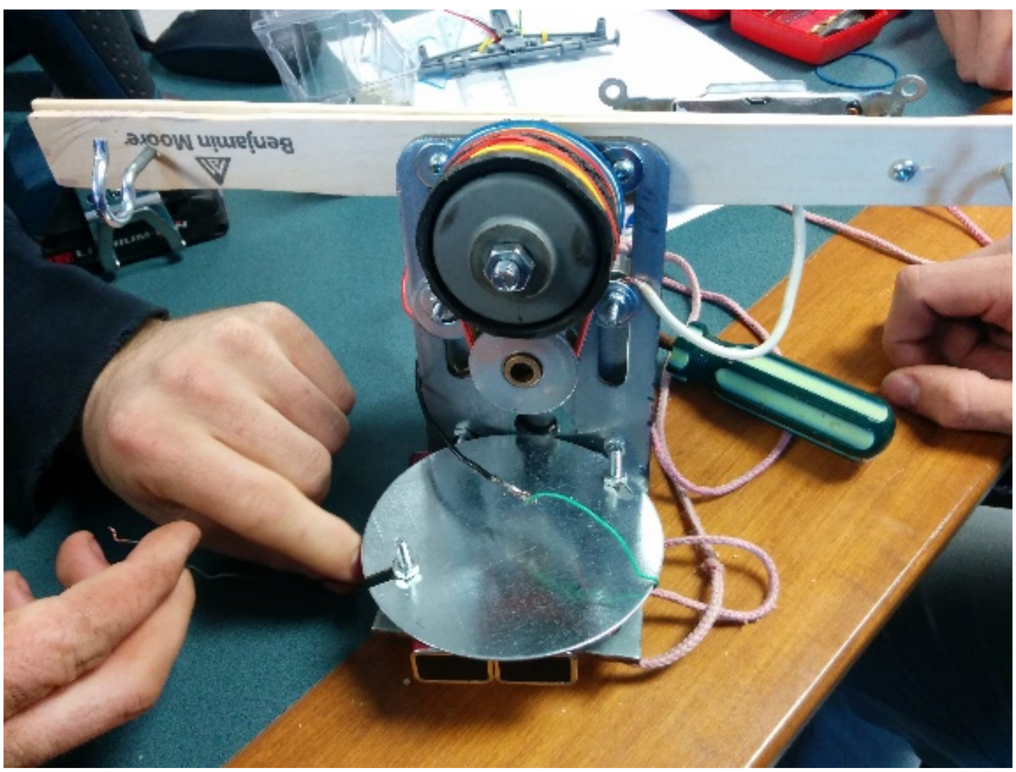


Figure C4: Assembly Stage 3

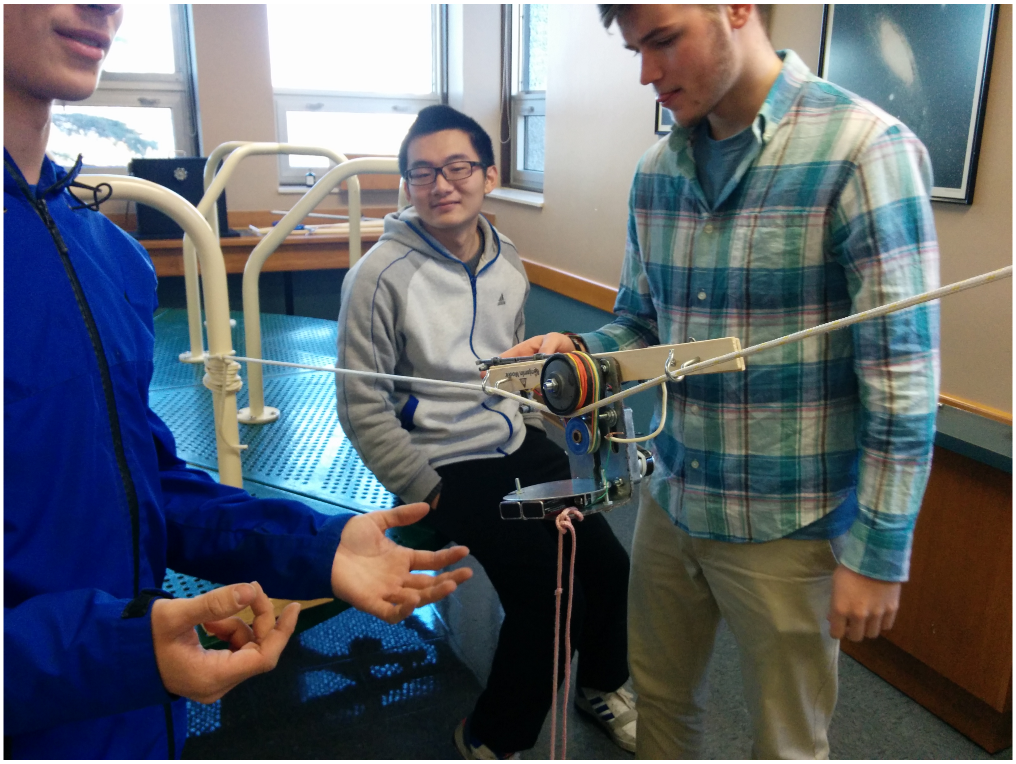


Figure C5: Test 2

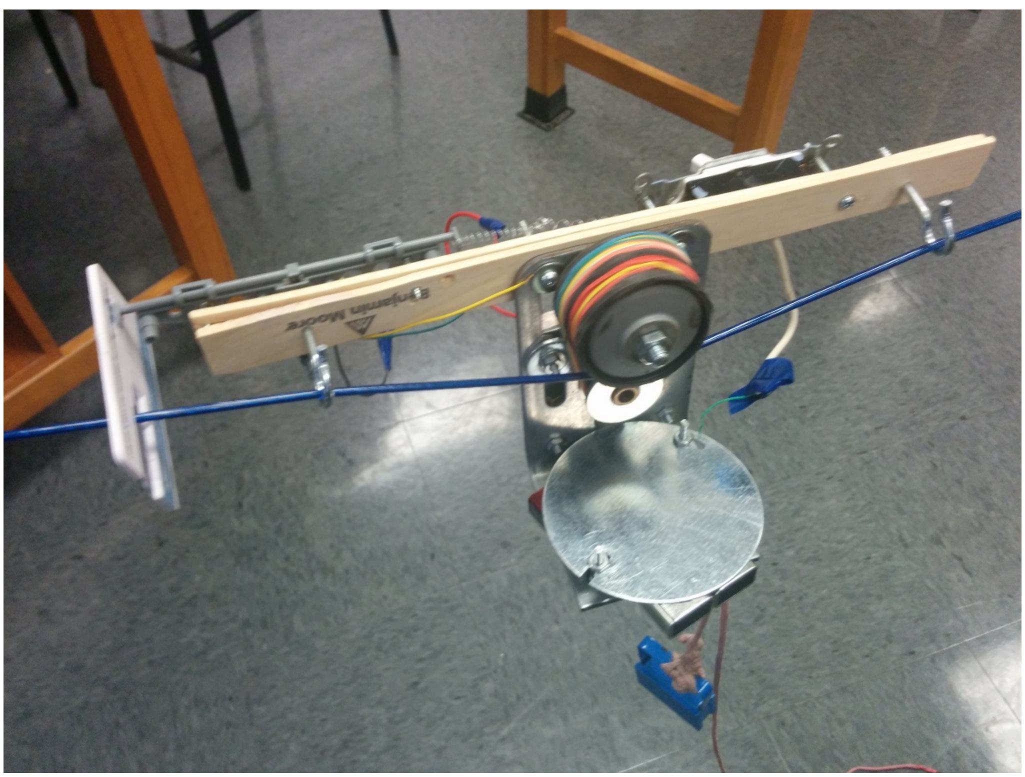


Figure C6: Final Test