PRINCIPLES OF ENGINEERING

1.1.6 Compound Machines Design Project

Project “Lift Away”

Team LITLifters

Jayson Nguyen, Margaret Pond, Khushi Saini, Jeffrey Tan

08.30.2017-0.9.9.17

Principal of Engineering Period 7

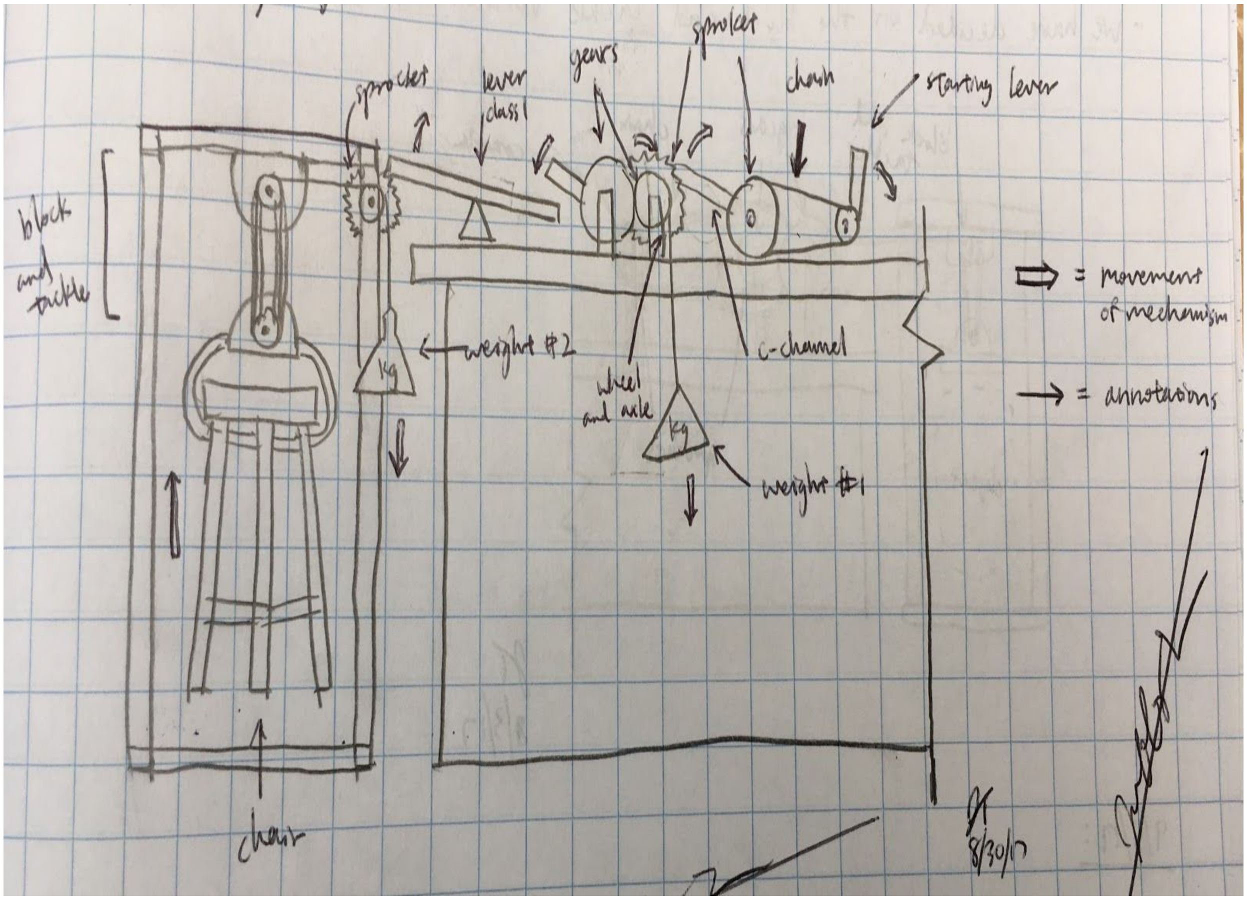
Table Of Contents

Design Brief

Client	The members of the compound
Designers	Jayson Nguyen, Maggie Pond, Khushi Saini, Jeffrey Tan
Problem Statement	The members of the compound are tired of transporting heavy materials between floors by foot. Their constant trips up and down stairs take copious amounts of time and energy, decreasing overall productivity.
Design Statement	We will solve this problem by using a block and tackle, a simple gear train, chain and sprocket, as well as a wheel an axle. Moreover, the overall plan is to add a crank which will be connected to a small sprocket (wheel and axle), and from there on, the wheel and axle will be connected to a larger sprocket using a chain (chain and sprocket). Accordingly, the larger sprocket will be connected to a small gear, which will be mated to a larger gear (simple gear train), and the larger gear will have a drum that will pull up the block and tackle (pulley system). At the end of the day, the block and tackle will ultimately pull up the heavy object.
Constraints	• The machine must include at least 4 mechanisms • the applied effort force may only be provided by a single human input • 6 days to complete this task • Any material approved by instructor is usable for building • Time management along with meeting up while keeping everyone's schedules into consideration
Deliverables	• This project, "Lift Away", included these aspects: ○ Creating a machine with four mechanisms ○ Documentation explaining the machine ○ Individual sketches which reflect upon the final sketch ○ Calculations based on the mechanisms being used ○ Presentation regarding our overall outcome and what modifications it went through along the process of building it

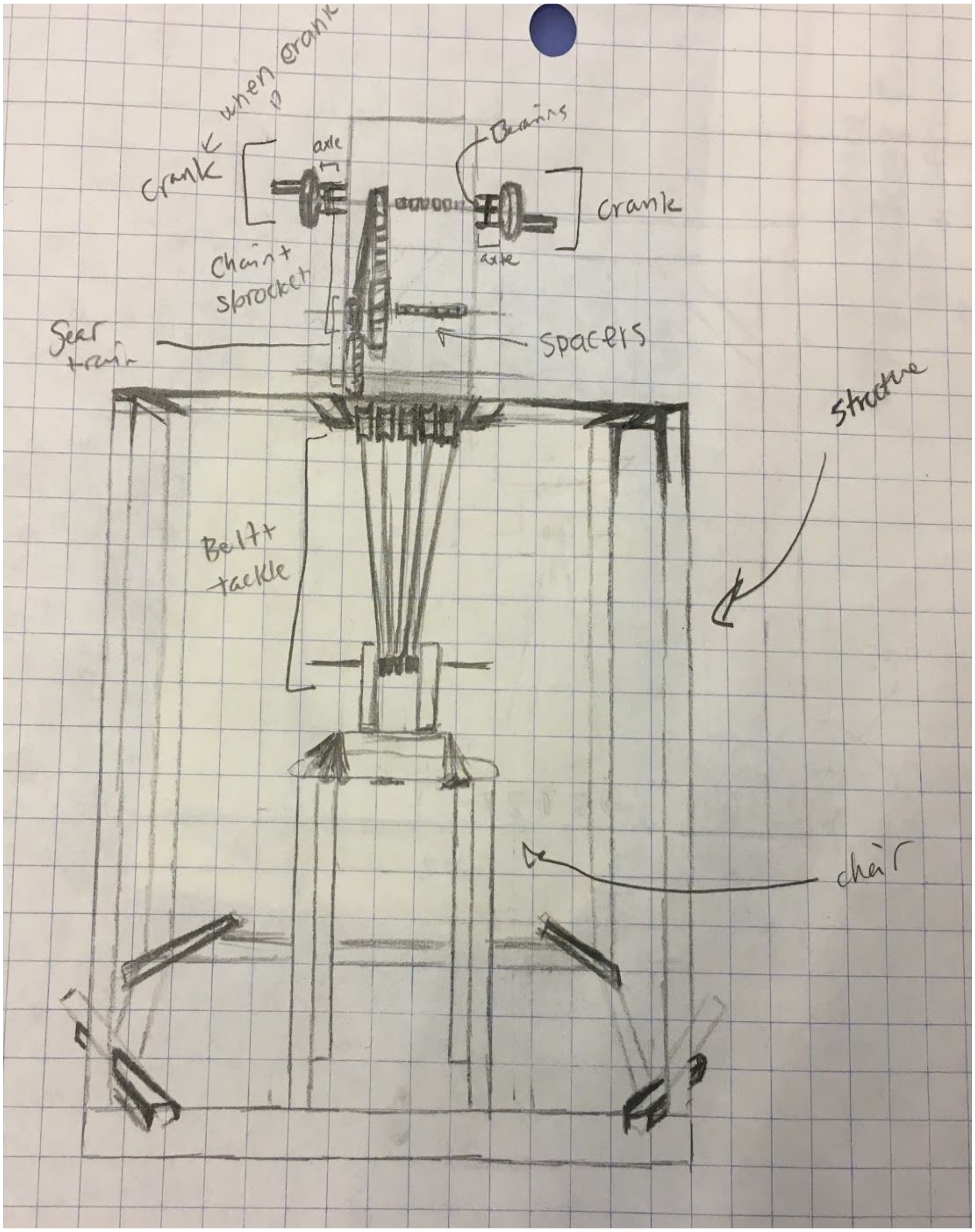
Design Photographs

Original Sketch:



Jaysson Nguyen 9/8/17 Margaret Pond 9/8/17 **Khushi Saini** 9/7/17 Jeffrey Tan 9/8/17

Final Sketch:



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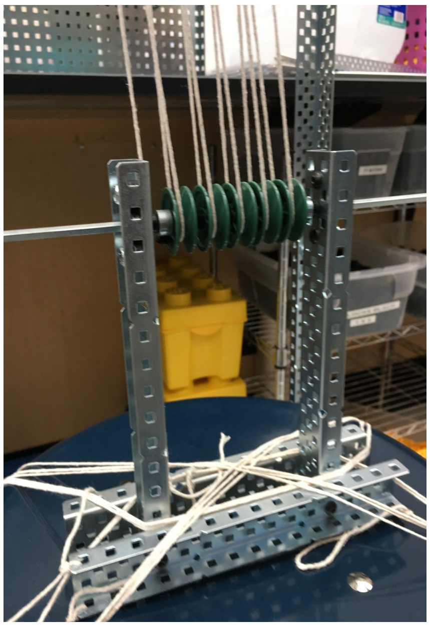
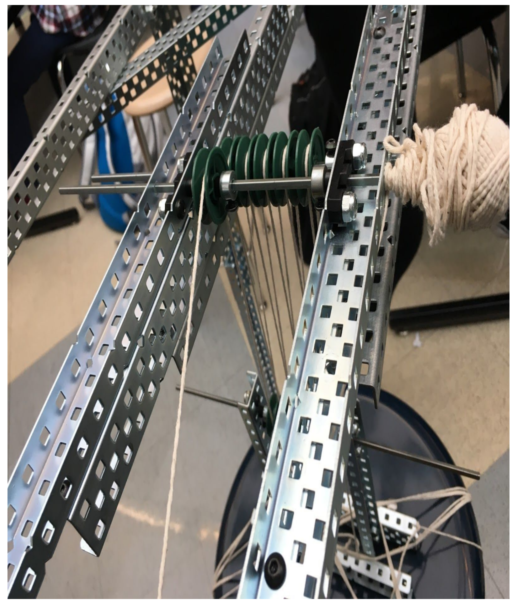
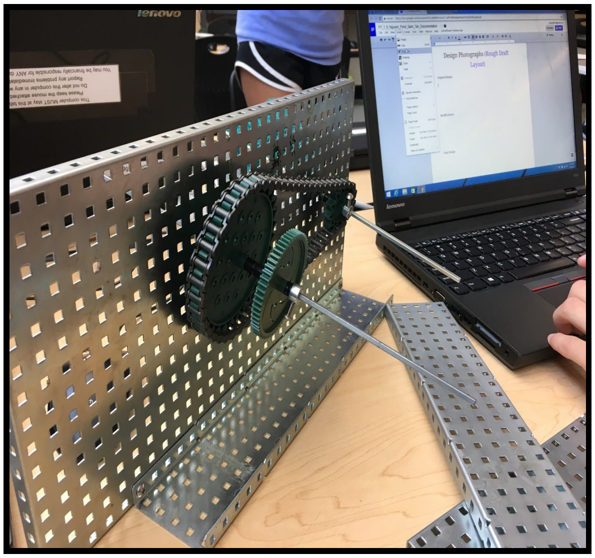
~Modifications~

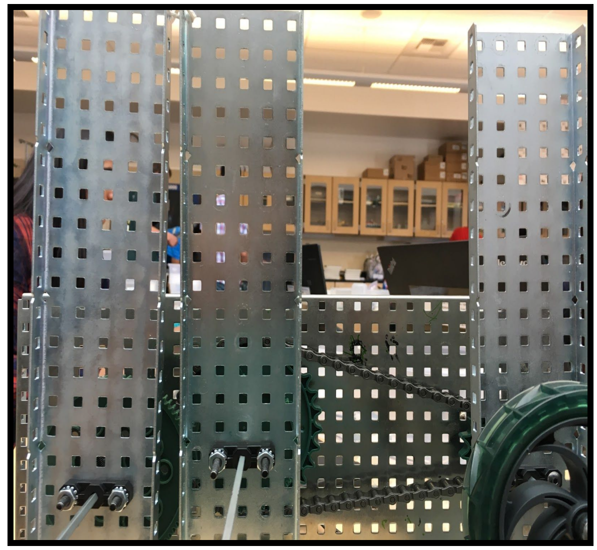
Original Design	Modified Design
 **Original Design #1~** The central part of our lifting mechanism was the block and tackle pulley system, which would provide most of the much needed torque to lift up the chair. We had 11 strands holding up the chair, an IMA of 11, and 5 pulleys on each half of the block and tackle. *Jayson Nguyen* *Margaret Pond* ***Khushi Saini*** *Jeffrey Tan* 9/6/17	 **Modified Design #1~** We decided to move the other mechanisms from a separate contraption and attaching them onto the lift tower. This would be more convenient when transporting the machine around, as we would only have to carry one object rather than two. So, in preparation for this, we added another pulley to guide the string from the block and tackle off to the side, towards the other mechanisms. *Jayson Nguyen* *Margaret Pond* ***Khushi Saini*** *Jeffrey Tan* 9/6/17



Original Image #2~
The axles were leaning downward resulting in an unstable and loose design. This in turn loosened the interactions between the various mechanisms resulting in poor function.

Jayson Nguyen
Margaret Pond
Khushi Saini
Jeffrey Tan

9/6/17



Modified Image #2~
Vertical pieces of VEX material were added to support the axles. This greatly improved the overall stability of the machine. In addition to improving stability, it sped up the function of this part.

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Khushi Saini
Jeffrey Tan

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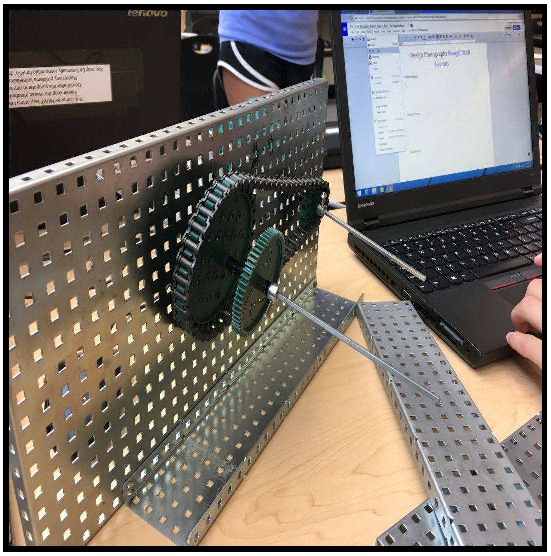

Original Image #3~
The prototype at this point was being tuned by a bare axle that slipped easily and was hard to turn. Because of this it would take even longer to lift the chair if it took a lot of energy to simply turn the first sprocket.

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Khushi Saini
Jeffrey Tan

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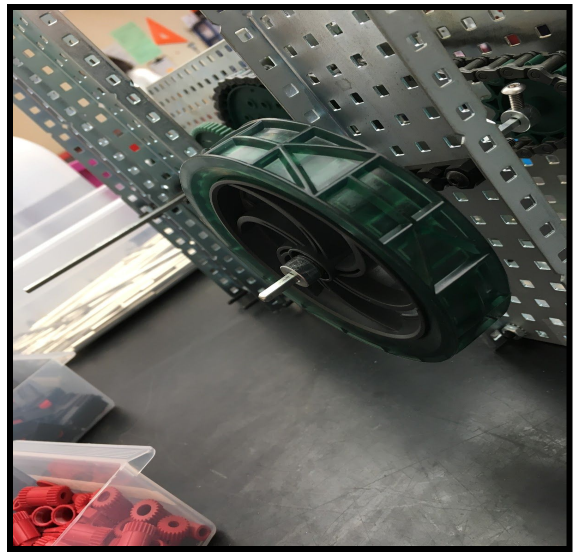

Modified Image #3~
The addition of the wheel made the mechanism much easier to turn and sped up the mechanism overall. This made the mechanism more efficient and easier to operate.

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Margaret Pond
Khushi Saini
Jeffrey Tan

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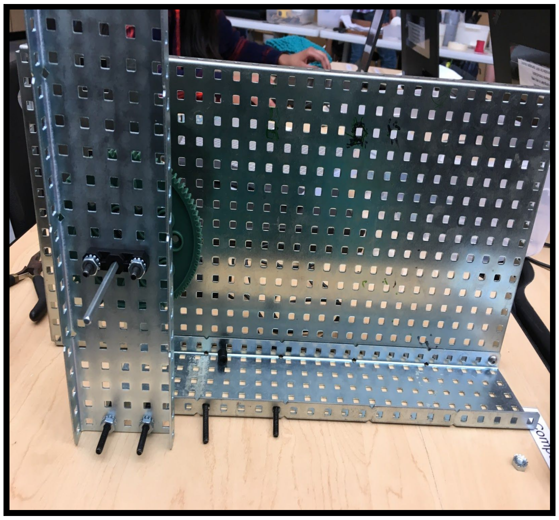

Original Image #4~

The separate mechanisms in this project that are included are the compound gears, chain and sprocket, and wheel and axle were all separate from the belt and tackle pulley. This would require an abundant amount of space to move the chair.

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Khushi Saini
Jeffrey Tan

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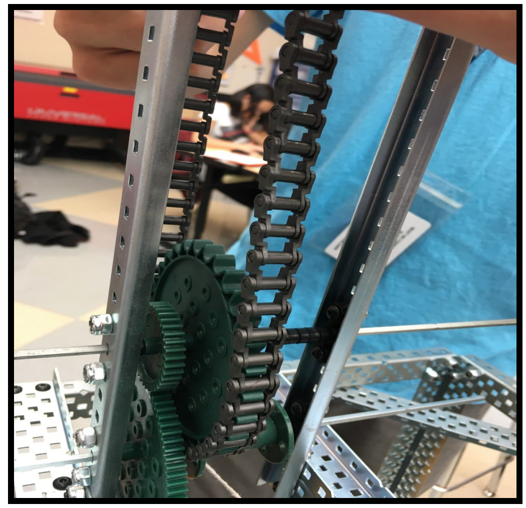

Modified Image #4~

Here the mechanisms have been joined together to promote efficiency and to decrease the space needed. This makes using the machine far more feasible in any space because, this way, it doesn't need to be next to anything. Furthermore, no one in the team could devise a way to attach the 2 pieces together that was not difficult or inefficient, so a team member (Jeffrey) took replicas of the parts and built it on the structure itself.

Jayson Nguyen
Margaret Pond
Khushi Saini
Jeffrey Tan

9/7/17

Original Image #5~
At this stage the structure lacked support and so was very flimsy and could not support much weight. If it could not support weight it would not be able to lift the chair.

Jayson Nguyen
Margaret Pond
Khushi Saini
Jeffrey Tan

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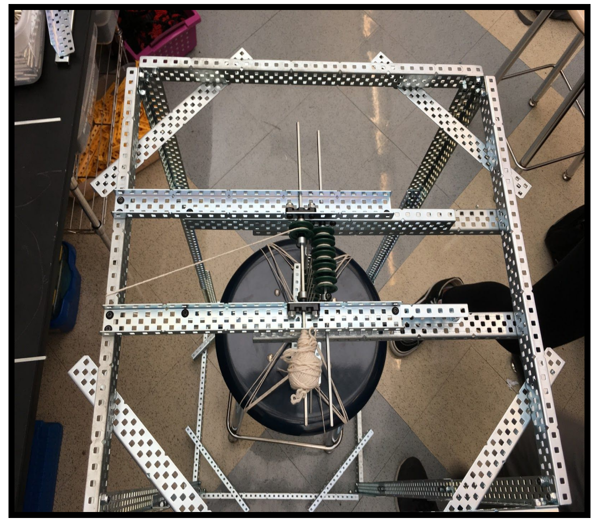

Modified Image #5~
Here bars have been added to underneath the square frame to keep the frame from folding on itself or twisting. This enabled us to build on it, attach things to it, move it, and so forth.

Jayson Nguyen
Margaret Pond
Khushi Saini
Jeffrey Tan

9/7/17

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Original Image #6~
The wheel was inefficient and hard to turn. Because the wheel lacked any leverage, turing the mechanisms either devolved into turning the wheel, letting go, and repeating or using one’s fingers to turn that slipped easily. This required a lot of energy and time.
Jayson Nguyen
Margaret Pond
Khushi Saini
Jeffrey Tan

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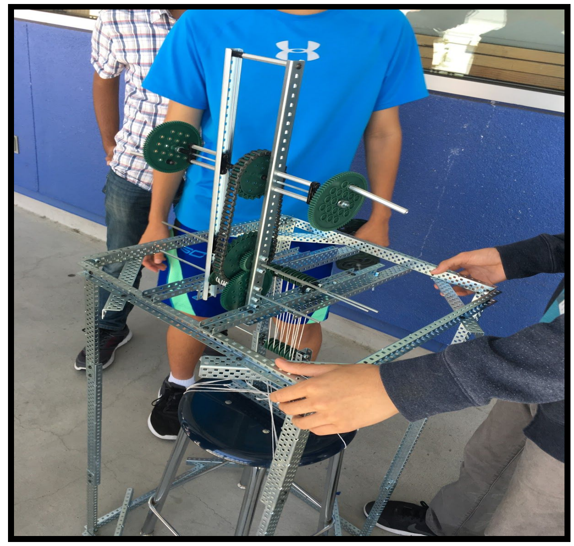

Original Image #6~
The crank was idea that helped create better efficiency for the human input. There was more torque available and less energy was needed to be supplied.
Jayson Nguyen
Margaret Pond
Khushi Saini
Jeffrey Tan

9/7/17
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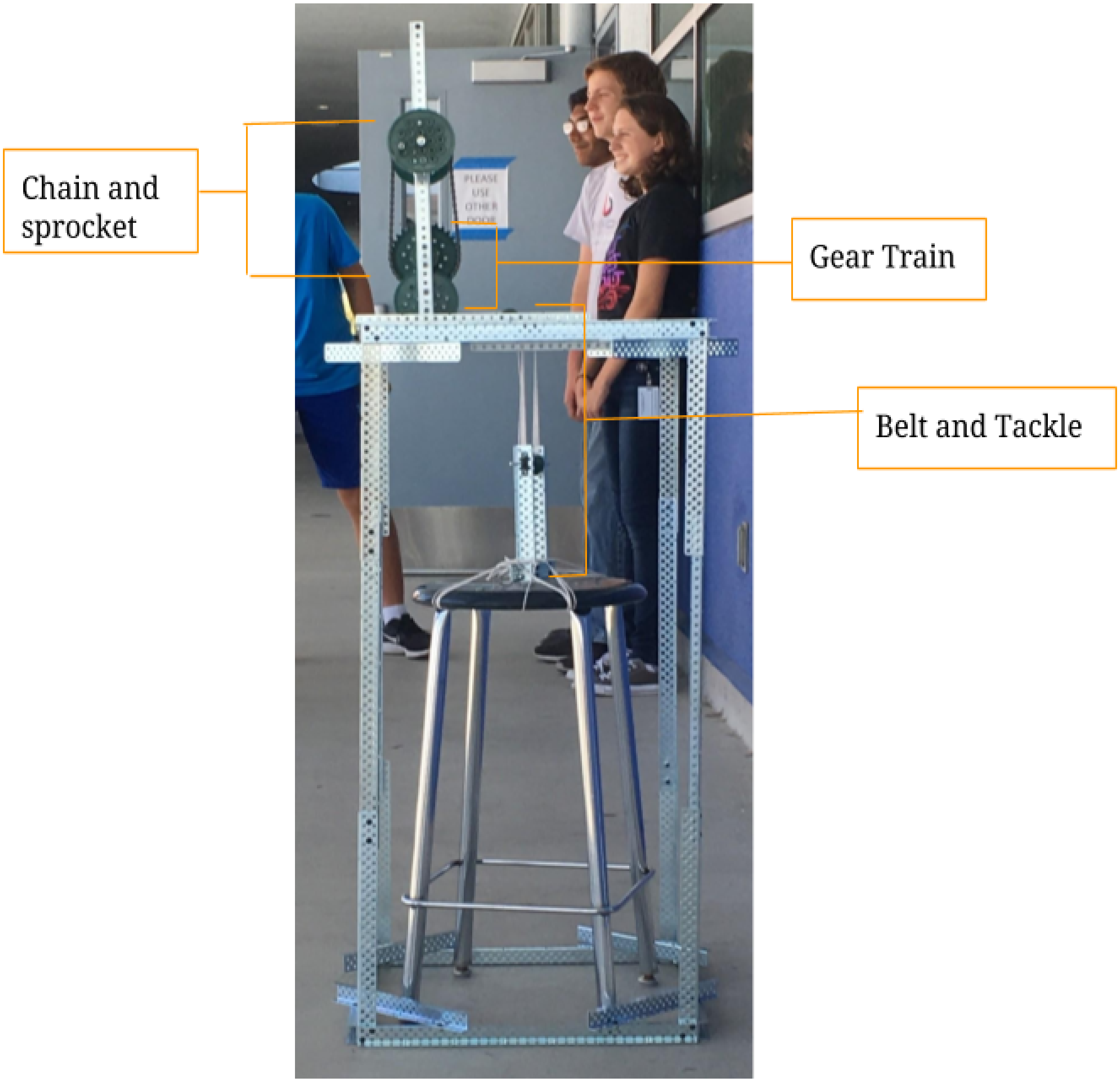
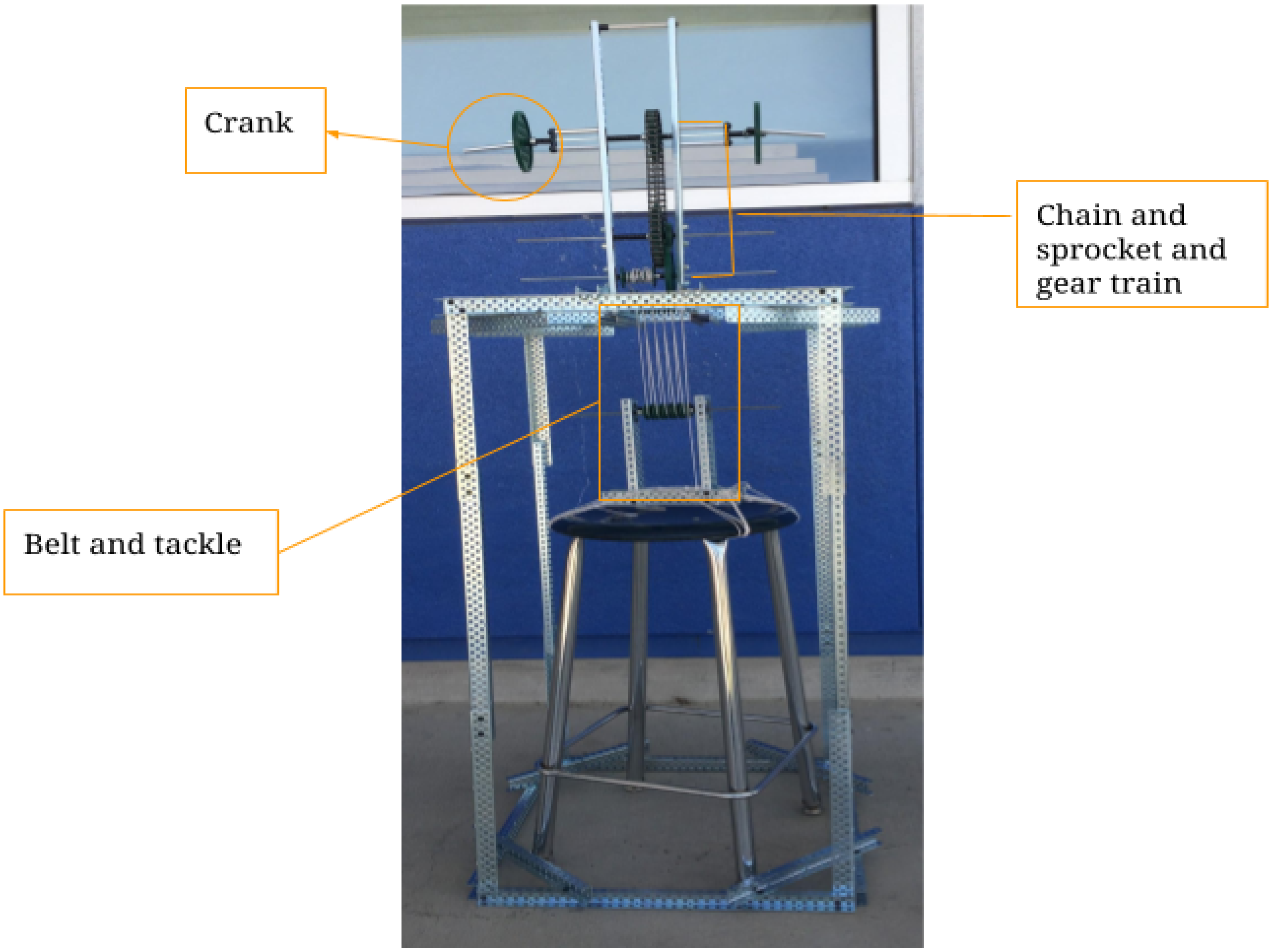
FINAL OUTCOME~





Final Design Description:

The overall design utilizes gears trains, pulleys, and sprockets and chains to achieve the goal of lifting heavy objects up to higher levels, for this mechanism, we used a chair. How the design works is that the human effort is applied to the wheel and axle, also known as the crank, which rotates the sprocket and chain, then to the compound gear train. The compound gear train was also connected to the pulley system. The pulley system has a belt and tackle that split the force resistance of the chair by having eleven strings, each holding the same amount of weight. At the end of the day, the amount of force is applied to lift the chair.

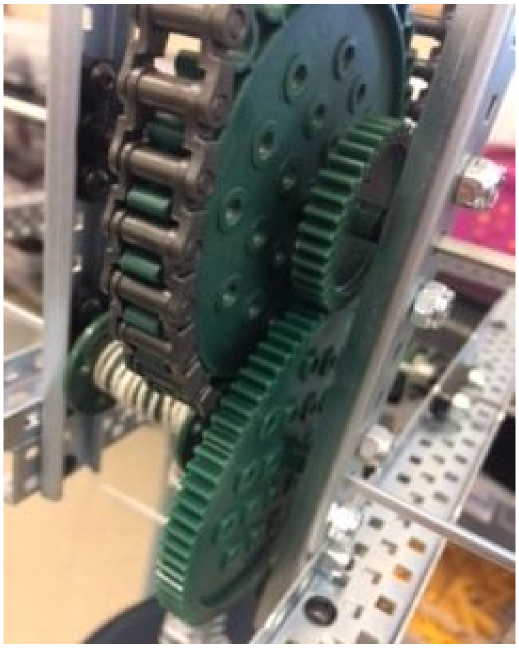
Jayson Nguyen 9/8/17 *Margaret Pond 9/8/17* ***Khushi Saini*** 9/7/17 *Jeffrey Tan 9/8/17*

Conclusion

In conclusion, this machine is able to lift objects, such as chairs, however it is incapable of moving objects over obstacles and or to very high places. With that being said.when it comes to lifting the chair being used as an example in this project, it takes a moderate amount of time for the energy to transact from the wheel and axle to the chair. Furthermore, going on to the calculations, the distance (DE) from the crank to the axle is 1.5 inches and the radius of the axle is 0.1 inches (DR) so, the crank has a gear ratio (IMA) of 15. The input gear of the chain and sprocket had 24 teeth, and the output had 30, thus the gear ratio (IMA) was 1.25 or 10/8. The input gear of the gear train has 36 teeth and the output has 84 making the gear ratio (IMA) 2.33. As per the block and tackle system, the pulley has system has 11 strings and therefore, it has an IMA of 11. The total mechanical advantage of the machine is 480.56. If our team, LITlifters, had more time we would devise a way to raise the chair in a more efficient manner, perhaps by switching the gears in the gear train so the large one was on the same axle as the second sprocket so when the large one turned around once completely the second one attached to the pulley string puller would turn more than once. We could also improve the mechanism by figuring out how to move items laterally. Overall, the machine was successful when it comes to our initial goal of moving heavy objects, however if there was a longer time span, then perhaps there would be more functions in terms of the machine being automatic and the only human force being applied was a click.

Jayson Nguyen 9/8/17 *Margaret Pond 9/8/17* ***Khushi Saini*** 9/7/17 *Jeffrey Tan 9/8/17*

Additional Pictures



The gear train and sprocket chain were originally planned to be separate from the “box” that contained the pulley system. But, we decided to attach these onto the “box” as well, making the machine more convenient and efficient.

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The block and tackle system was the original thought of how the chair would be lifted. Only the number of pulleys differed.

Jayson Nguyen 9/8/17 *Margaret Pond 9/8/17* **Khushi Saini** 9/7/17 *Jeffrey Tan 9/8/17*

Additional Pictures[continued]

The mechanism being operated in this picture is a crank, which is also a wheel and axle. Our original thought was to use a crank of sorts to create better torque. We first went to a wheel to complete this task. However, this didn't reach the full capacity we expected it to be. Instead, our member (Jeffrey) decided to create a crank with gears and a bar on the side that allows it to be turned completely.

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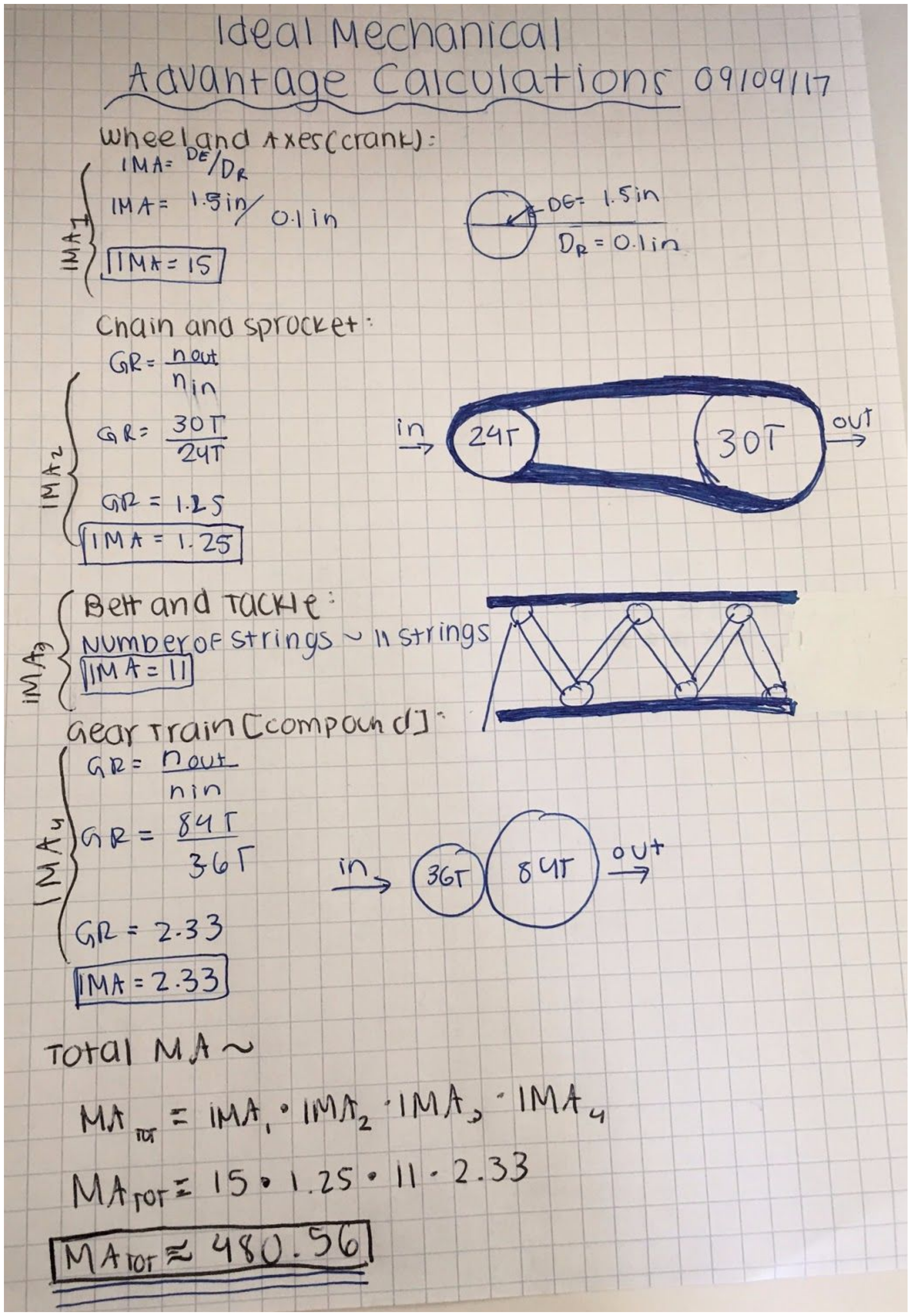
Calculations



Ideal Mechanical Advantage Calculations 09/09/17

Wheel and Axes (crank):

IMA_1: $IMA = D_E / D_R$

$IMA = 1.5in / 0.1in$

$\boxed{IMA = 15}$

$D_E = 1.5in$

$D_R = 0.1in$

Chain and sprocket:

IMA_2: $GR = \frac{n_{out}}{n_{in}}$

$GR = \frac{30T}{24T}$

$GR = 1.25$

$\boxed{IMA = 1.25}$

in 24T 30T out

Belt and Tackle:

IMA_3: Number of strings ~ 11 strings

$\boxed{IMA = 11}$

Gear train [compound]:

IMA_4: $GR = \frac{n_{out}}{n_{in}}$

$GR = \frac{84T}{36T}$

$GR = 2.33$

$\boxed{IMA = 2.33}$

in 36T 84T out

Total MA ~

$MA_{TOT} = IMA_1 \cdot IMA_2 \cdot IMA_3 \cdot IMA_4$

$MA_{TOT} = 15 \cdot 1.25 \cdot 11 \cdot 2.33$

$\boxed{MA_{TOT} \approx 480.56}$

Jayson Nguyen 9/9/17 Margaret Pond 9/9/17 **Khushi Saini** 9/9/17 Jeffrey Tan 9/9/17

Calculations[continued]

Written Calculations~

Crank- IMA=15

Chain and Sprocket- IMA=1.25

Gear Train- IMA=2.33

Belt and Tackle- IMA= 11

Total MA: 480.56

Jayson Nguyen 9/9/17 Margaret Pond 9/9/17 ***Khushi Saini*** 9/9/17 *Jeffrey Tan 9/9/17*