# 1.1.6 Compound Machines Design

# Principles of Engineering Block 3

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## Design Problem:

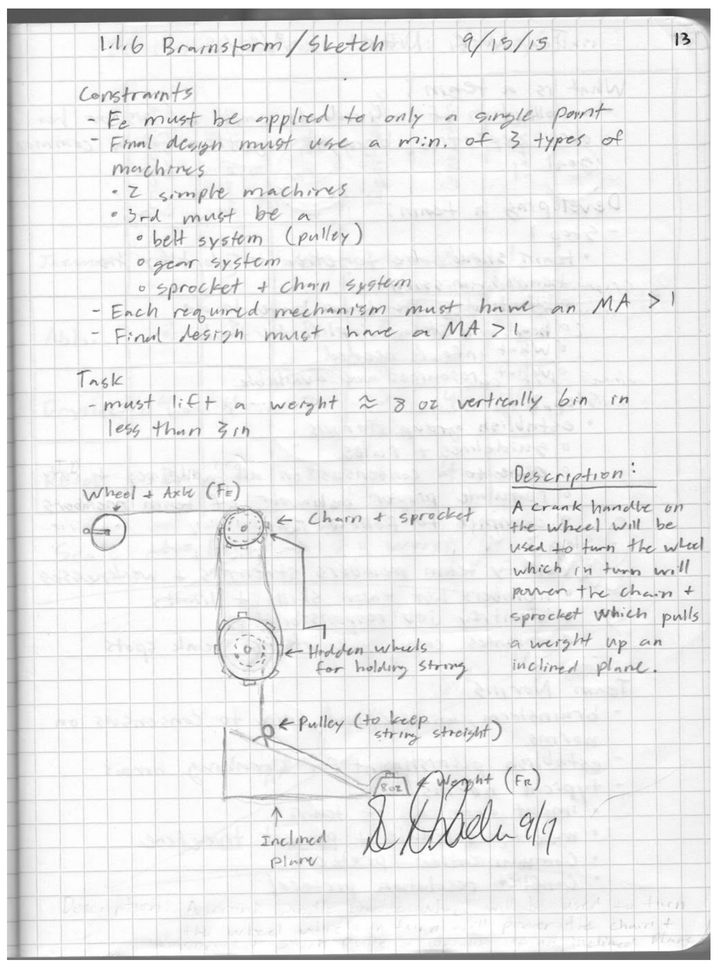
The design problem we are aiming to address in this project is to build a machine that can lift an eight ounce weight a vertical distance of six inches in under three minutes.

Some of the additional criteria we must meet are that the applied force must be provided by a single point of human input, the design must include at least three different types of mechanisms, 2 simple machines and 1 pulley belt system, chain sprocket system, or gear system. Each mechanism must have a mechanical advantage greater than one, and the final design as a whole must have a mechanical advantage greater than one.

We are pursuing this project in hopes to understand how elements of design can affect mechanical advantage, understand how simple machines work together to accomplish a task, compare efficiency of different simple machines in a working situation, and learn more about the capabilities and limitations of VEX components for future projects.

## Brainstorming:

To the right of the page you can see an image of my proposed machine to accomplish the task.



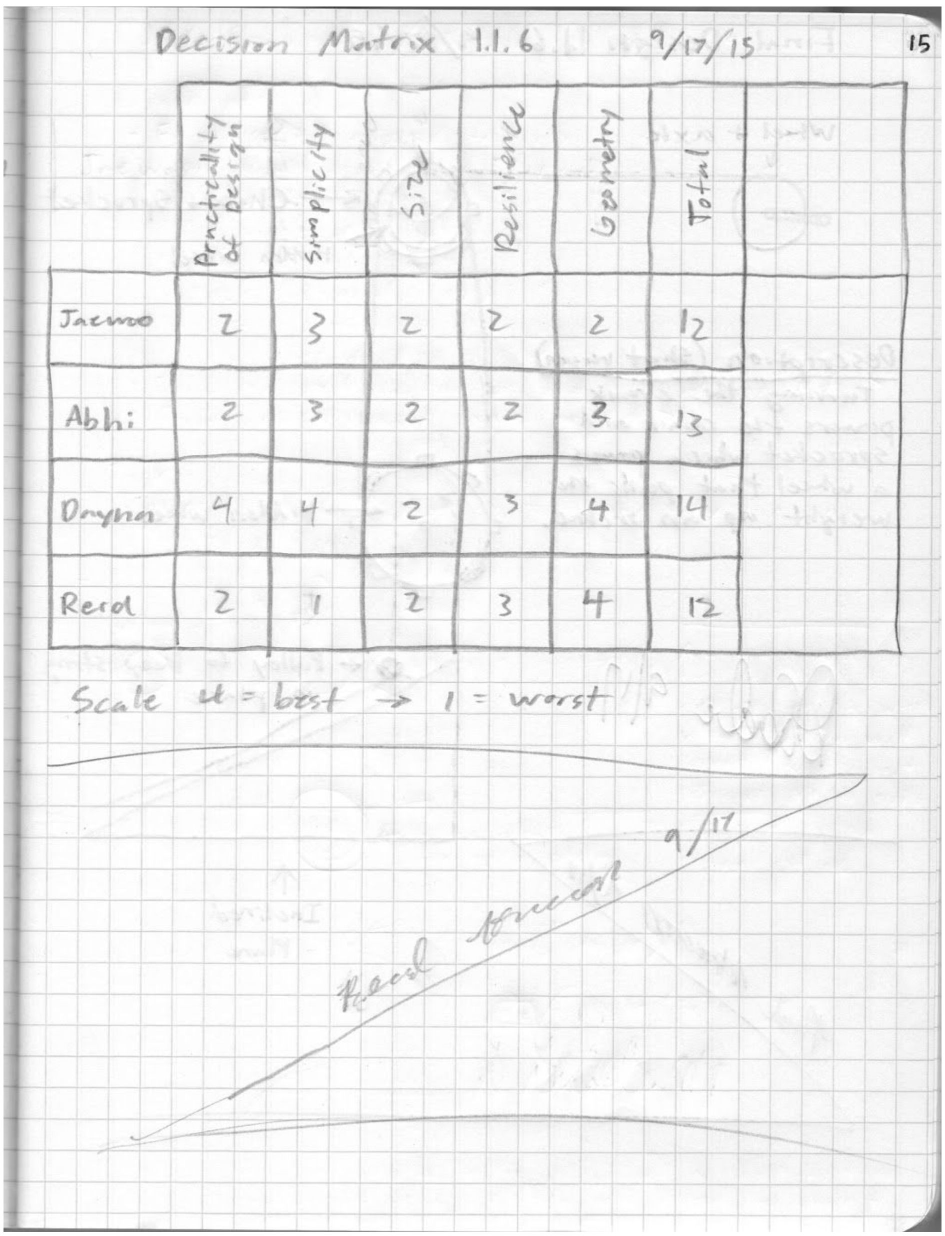

**Description:**

Power is put into the machine via a wheel and axle with a crank handle. As the crank is turned, a string attached to the wheel is wound around the wheel which powers a second wheel. As the second wheel turns, it also turns a axle connected to a chain and sprocket system, which in turn powers yet another axle. The wheel on this axle winds up another string which goes down and is fed through a pulley that holds it in alignment with an inclined plane.The end of the string is attached to a weight. If the system is working properly the result will be that the weight is pulled up the inclined plane.

## Final Proposed Design:

In the end, my design was chosen to act as our final proposed design after a selection process that involved us rating our designs on a decision matrix and discussing the pros and cons to each design in detail. The details of our designs that we rated were the design's practicality (meaning that it can reasonably be built with time and supply constraints), simplicity, size, resilience (how sturdy it is), and geometry (functional shape). Below are images of the design matrix as well as the final proposed design.

**Decision Matrix**



Decision Matrix 1.1.6 9/17/15 15

| | Practicality of design | Simplicity | Size | Resilience | Geometry | Total | |
|---|---|---|---|---|---|---|---|
| Jacwo | 2 | 3 | 2 | 2 | 2 | 12 | |
| Abhi | 2 | 3 | 2 | 2 | 3 | 13 | |
| Dryna | 4 | 4 | 2 | 3 | 4 | 14 | |
| Reed | 2 | 1 | 2 | 3 | 4 | 12 | |

Scale 4 = best → 1 = worst

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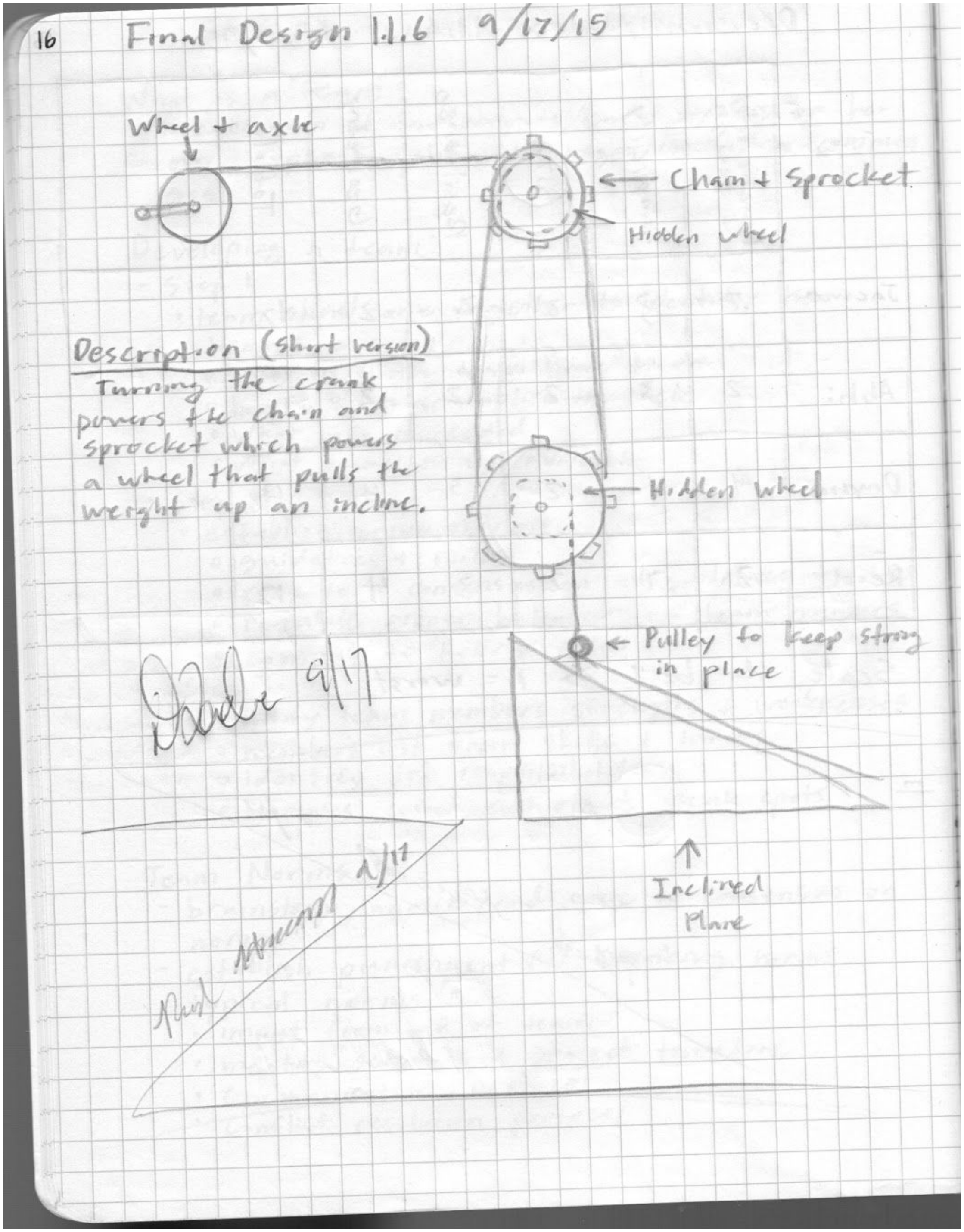
**Final Proposed Design**

Since the final proposed design is the same as my brainstormed idea, no additional description of function has been listed here.



## Design Modifications:

As soon as we began building we ran into several problems. The wobbliness of our various components was one of the most prominent. In order to fix this issue several changes were made to the initial design. We added several supporting braces to the back of the peg board to provide increased stability, we tied a string around the axle holding up the first sprocket and ran it through our pegboard to hold the axle in place, and we used some bushings and collars to try to lock the axles into a slightly more stable set up. In the end these modifications worked to satisfactory degree and decreased the wobbling making the operation of our machine much smoother.

Another problem we faced was time. As a result of being in a shortage of time, instead of incorporating a pulley to hold the string to the inclined plane we instead took a more time saving quick fix and threaded the string through a loop on one of the small black pieces that was in our kit. This design decision definitely saved us some time and on top of this it worked marvelously.

Lastly, we faced several issues with our crank handle. Initially we had some trouble with the size of our crank handle which prompted us to use a different type of crank. However issues continued to plague this aspect of our design. For example, it became very hard to get an accurate reading of the $F_e$ of our design because the spring scale wouldn't stay on our crank handle. In the end we got rid of the crank altogether and replaced it with a larger wheel. This change made it easier to operate the machine and enabled us to more accurately measure our machine's $F_e$.

## Final Design:

The final iteration of our machine worked to an acceptable standard for the amount of time and development that we were able to put into it. It successfully accomplished the targeted task and it did so meeting all of the requirements including completing the task in under three minutes. Below you can find an annotated picture of our final design as well as the IMA, AMA, and efficiency statistics.

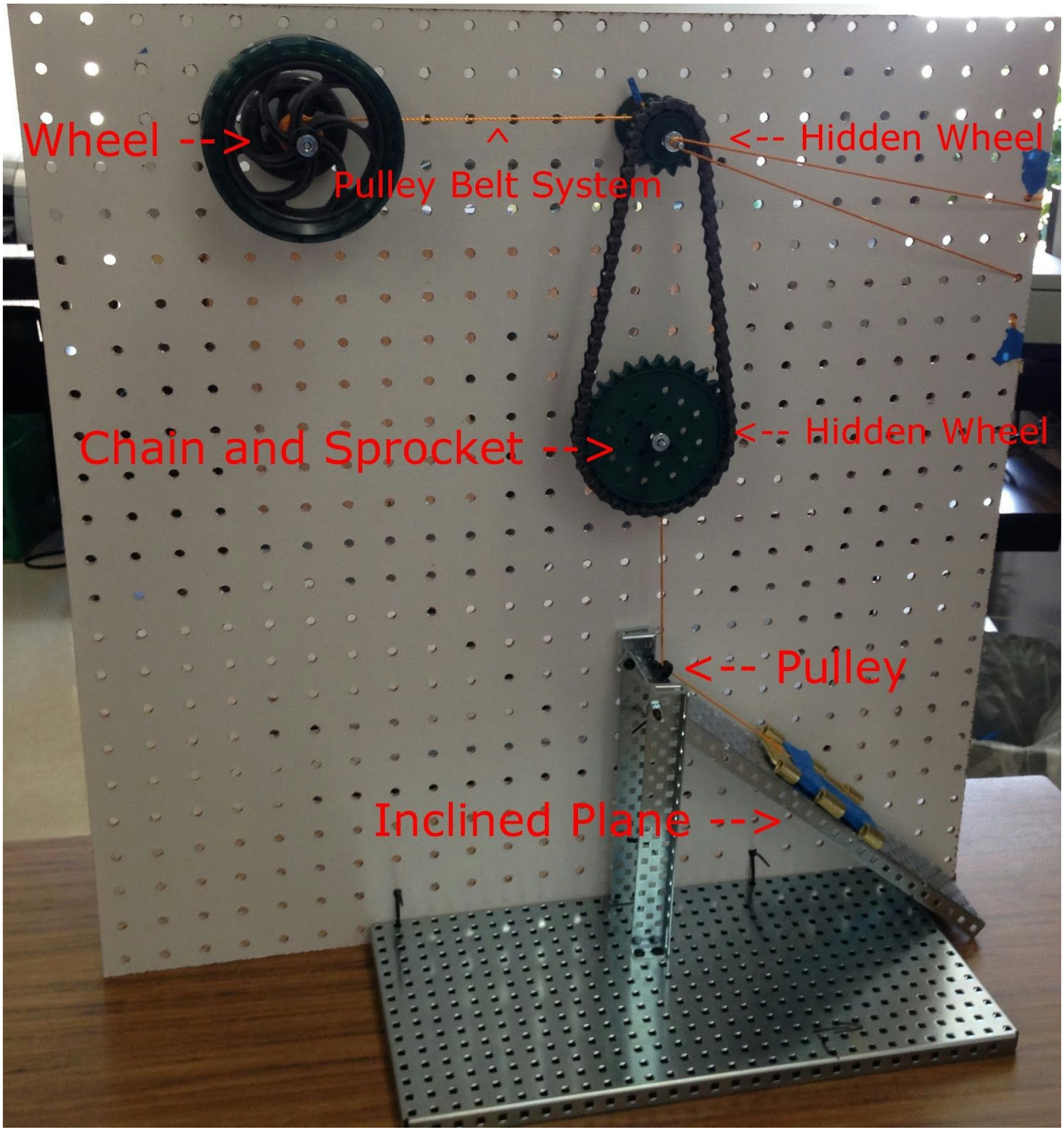
**Overall IMA: 6716.57**

- Inclined Plane = 1.61
- Chain and Sprocket = 2.5
- Large wheel =24.39
- Small wheel 1 =4.09
- Small wheel 2 =4.09
- Pulley = 1
- Pulley and Belt =4.09

**Overall AMA: 1.12**

**Efficiency: 0.017%**

**Final Design**



## Team Evaluation:

**Jaewoo Kim:**

Jaewoo always had his part done and he helped out all through out the creation of our machine. On days when people had come back from being absent he took charge and helped them get back on track. He held a slight leadership role in our team and made sure things worked smoothly. He followed our group norms thoroughly and showed up to all the behind schedule meetings that he could.

**Abhi Gohil:**

Abhi got his portion of the work done and helped with the building of our machine, especially the inclined plane and chain and sprocket system. He also followed all of our group norms and showed up to as many of the behind schedule meetings that he could.

**Dayna Alaina:**

Dayna got her work done, and on the day she came back from being absent she made sure she did the necessary steps to catch up. She followed our set group norms and she showed up to all of our behind schedule meetings. She assisted me in the building of the crank and the belt and pulley system, and she took charge of keeping record of our group's measurements.

**Self-evaluation:**

Though I missed our initial project start day, I feel that after I came back I made sure to stay on schedule with my portion of the work. I helped build the crank and belt and pulley system. I also helped Dayna with taking some of our measurements. I made an effort to show up to as many of our behind schedule meetings as possible, and I made an effort at sticking to our group norms.

## Post-Mortem Reflection:

1. I think that our chain and sprocket system proved to be the easiest mechanism that affected our MA to calculate the IMA for as all we had to do is count the teeth on each sprocket and set up our ratio.
2. I think that the wheels on our machine proved to be the most difficult to calculate the IMA for because they were much more involved than lots of the other machines in their calculations,
3. If we had more time I would have tried to further decrease the wobble in our axles as well as experiment further with different sizes of sprockets, wheels, etc.

4. If we could do everything all over again there are some changes I would have made. The biggest change I would make, and the biggest regret I have is that we didn't share more than one form of communication, as not everyone in our group seems to check their email very regularly. At times communication through cell phone calls, or text would have been more effective.