1.1.6 Compound Machine Design Challenge Example

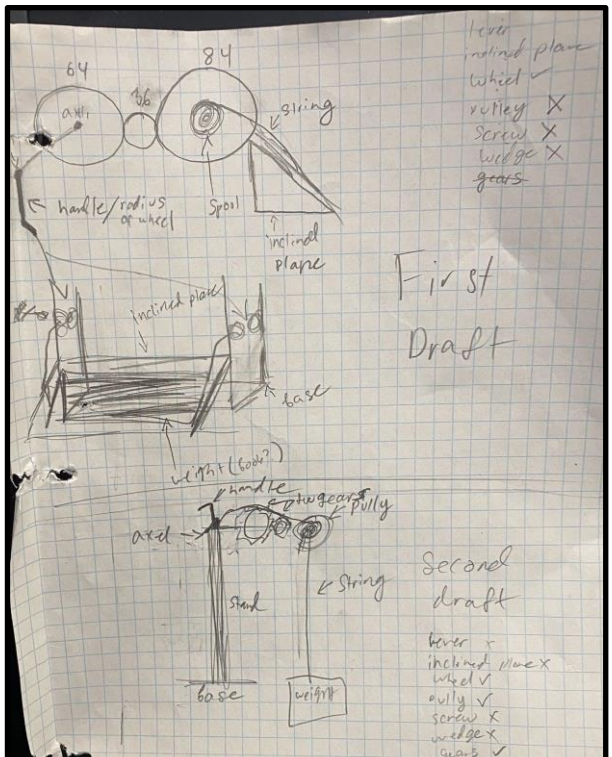
Design Brief

Design Brief Component	Description
Designers	Student Name 1 and Student Name 2
Problem Statement	Design and build a compound machine that can help an elderly person lift heavy books onto a shelf.
Design Statement	We will build a machine with 3 basic mechanisms (inclined plane, wheel and axle, and gear train) that will allow an eldery person to lift a heavy dictionary onto a shelf using only one arm/hand. We will show our prototype has a mechanical advantage greater than 1 with IMA, AMA, and Efficiency calculations. ● Goal: lift a book with more ease. ● Handle: we wanted to make it easier for the user to lift/put down the object. ● Gears/Spool: helped the force effort transfer to the force resistance. ● Wheel: acts as a guidance for the longer length of string and it basically acts as an “idler gear” meaning it doesn’t affect the overall IMA ● Inclined Plane: helps lift the object to the intended height .
Criteria/Constraints	● The applied effort force may only be provided by a single human input. ● The final design must include a minimum of three mechanisms including any of the simple machines: a gear system; a belt and pulley system; and/or a sprocket and chain system. ● The compound machine must have a mechanical advantage greater than 1.

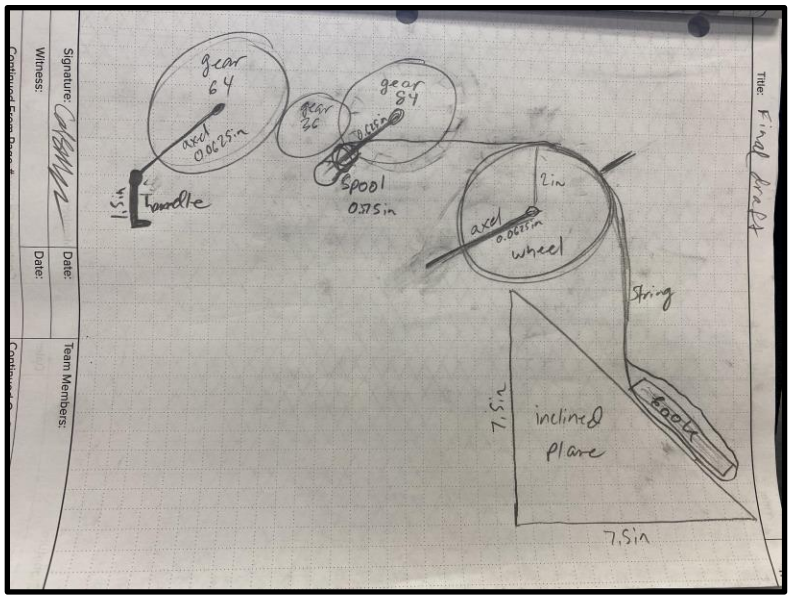
Generate Concepts

Below are images of the sketches and plans we made of potential solutions to the problem.

Draft Ideas:

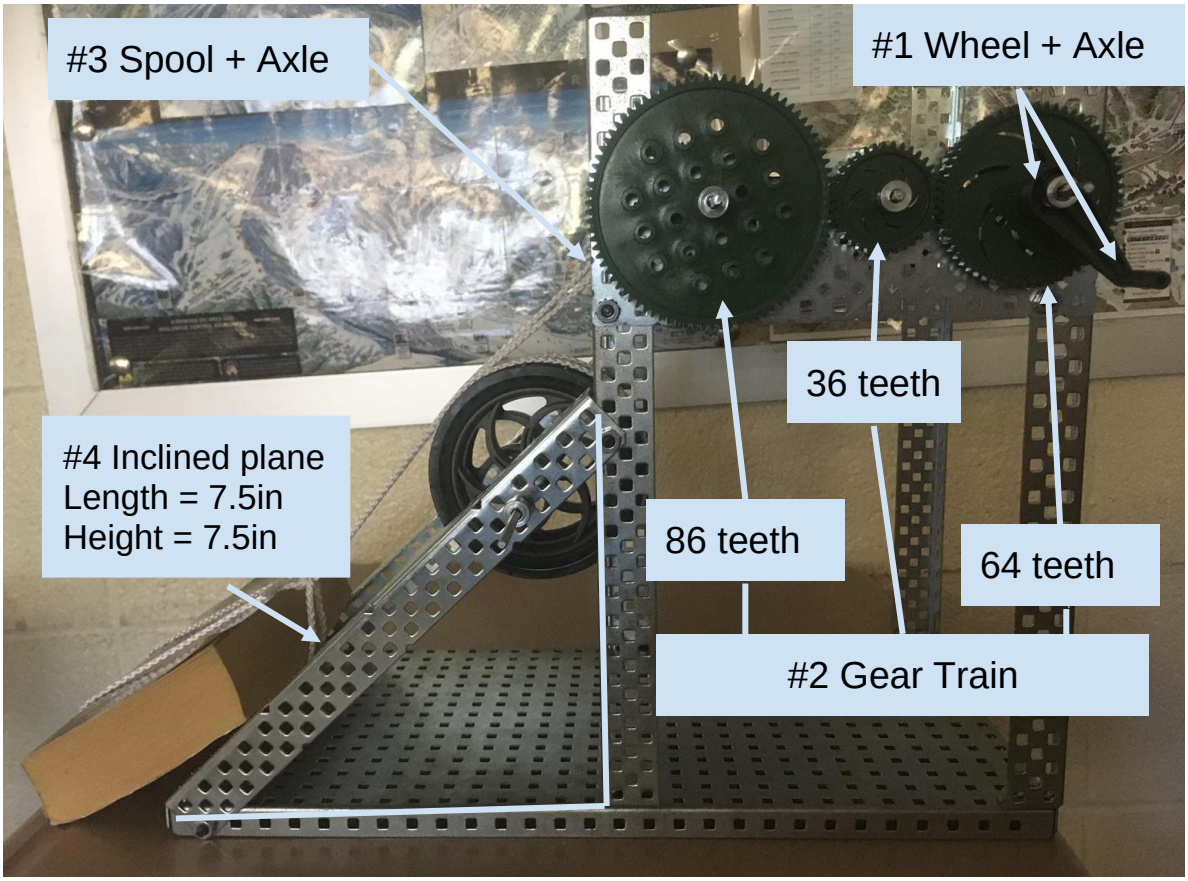


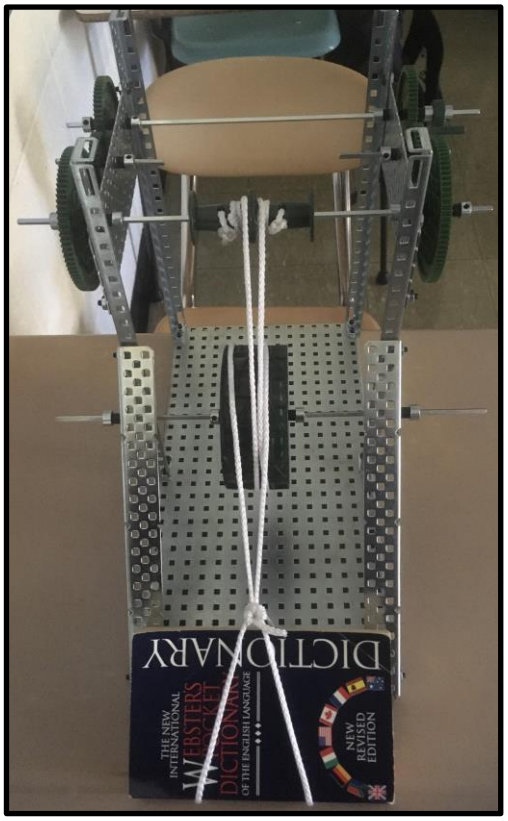
Final Sketch:



Construct and Test

Below are images of our completed compound machine.



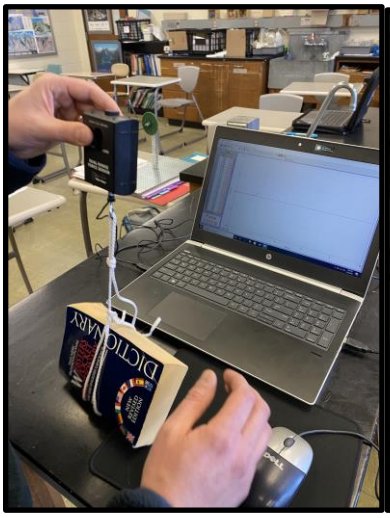


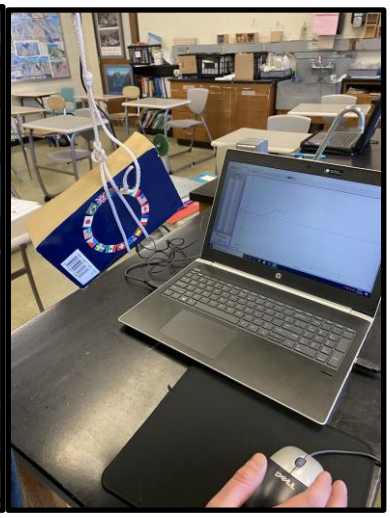
Test

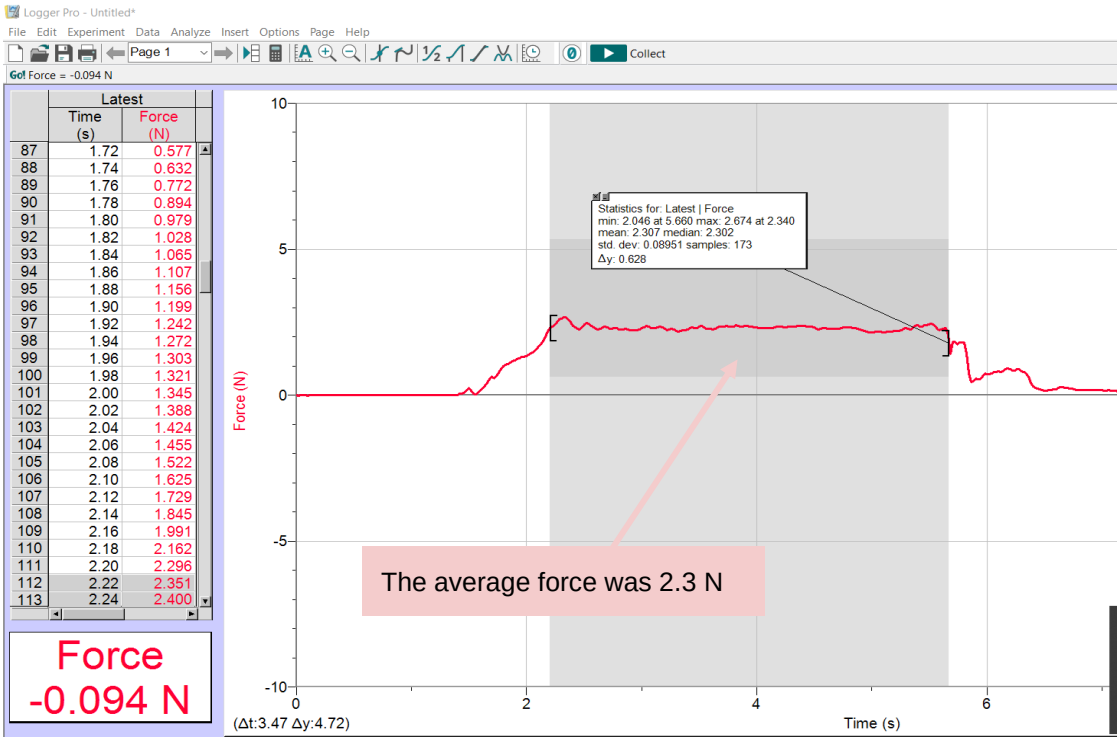
Below are our IMA,AMA, and Efficiency Calculations. We used the Vernier Dual Force Sensor to log the input force on our machine.

<u>FR (resistance force)</u>:

We lifted the dictionary with the force sensor and found the average force in Newtons.



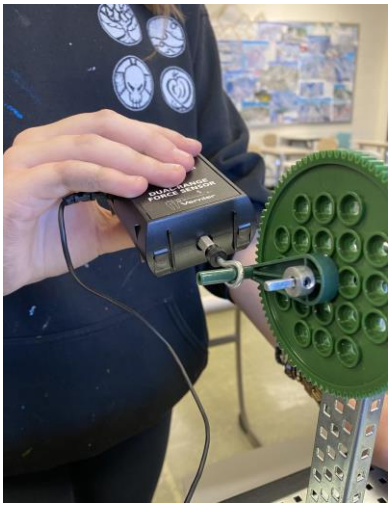


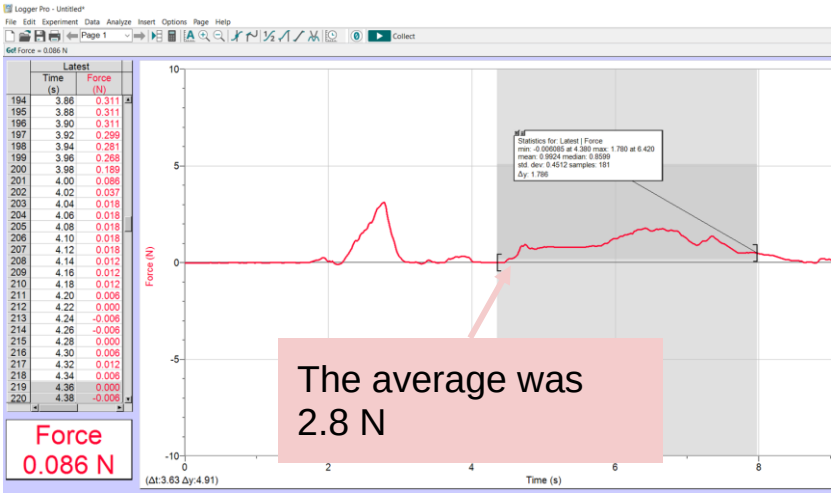


FE (effort force):

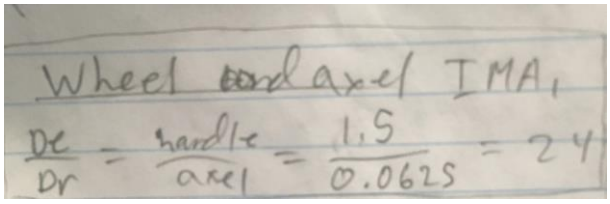
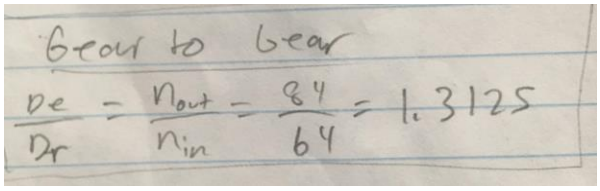
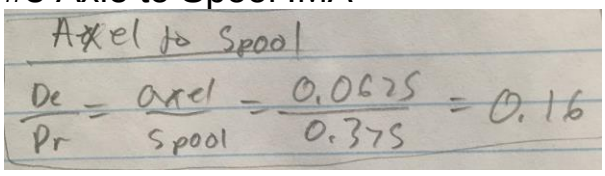
We turned the crank with the force sensor and found the average force in Newtons.

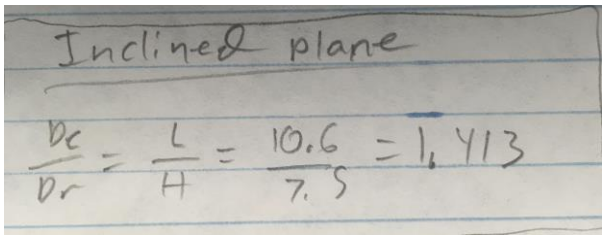
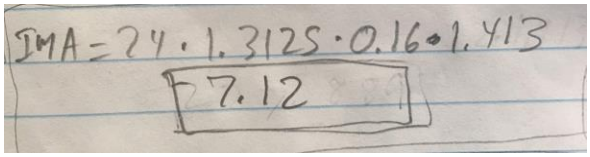
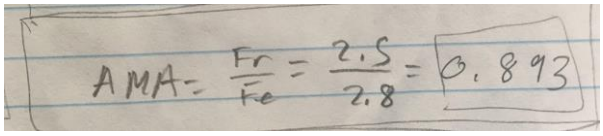
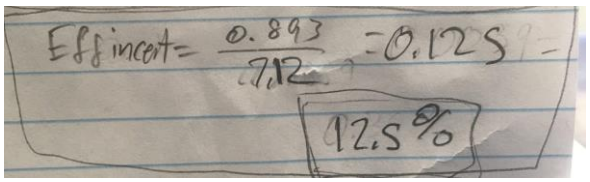
*This was difficult to get a good reading because the force sensor takes linear measurements and our hand crank is rotational.





Calculations

#1 Hand crank Wheel to Axle IMA 	De/Dr = 1.5in/0.0625in =**24**
#2 Gear Train 	Nout/Nin = 84 teeth/64 teeth = **1.3125**
#3 Axle to Spool IMA 	De/Dr= 0.0625 in/0.375in = **0.16**
#4 Inclined Plane IMA	De/Dr = 10.6in /7.5in = **1.413**

	
TOTAL IMA 	IMA1 x IMA2 x IMA3 = 24 x 1.3125 x 0.16 x 1.413 = **7.12**
AMA 	Fr/Fe =2.5 N/2.8 N = **0.893**
EFFICIENCY 	(AMA/IMA)*100 = (0.893/7.12)*100 = **12.5%**

Conclusion Reflections

1. *For which mechanism was it the easiest to determine the mechanical advantage or drive ratio? Why was it the easiest?*

Student 1: Gears were definitely the easiest and that's why we made it the main part of our design.
Student 2: It was easiest to determine the mechanical advantage/ drive ratio for the gears since we were given the gear teeth count so we just had to plug it into the equation for gear ratios.

2. *For which mechanism was it the most difficult to determine the mechanical advantage or drive ratio? Why was it the most difficult?*

Student 1: We knew from the start we didn't want to use a screw or pulley though, because in our practices they had been the hardest. In our final design, probably all of the wheels and axles because of how small the axles were the most difficult because there were a lot of decimals points.
Student 2: It was the most difficult to determine the mechanical advantage for the wheel and axles since it would switch the inputs and outputs (like the wheel being the input, or the axel being the input) and at certain points in our design it was confusing since they would intersect.

3. *What modifications could you make to your compound machine to make it more mechanically efficient?*

Student 1: We probably could have gotten rid of the one big wheel in the middle that is just there for decoration. When we were making it we thought it would add to our values, but it ended up not mattering. We could also make the inclined plane a little steeper.
Student 2: I think getting rid of any slop and removing unnecessary components such as the large wheel in the middle of the final pulley would improve the efficiency. Calculating ratios beforehand might also allow us to see where we may lose efficiency and find a way to improve on it.

4. *Two goals of this project are to:*
    - *Identify the individual mechanisms in a compound machine.*
    - *Calculate mechanical advantage and drive ratios of mechanisms.*

   Describe one idea you contributed to the project that a teammate recognized as an original or creative idea. Explain why you think your teammate thought that.

Student 1: When designing we each shot out different ideas, for example I would like to use gears, I think having a very nice square base would make it easy to work on etc. However at one point I said that maybe we could double up all of the simple machines to see how it would impact the final numbers. So, we decided we should do that because it would be interesting.
Student 2: One idea I contributed to the project was the hand crank which actually added a lot of IMA (24). It allowed the user to put in less effort to move an object to a certain point. It was also the only handle available so it added a “fun” component to our compound machine.