Spring 2021

MEEN 361: Materials and Manufacturing Design Lab

# DESIGN TERM PROJECT

## Report

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| **Section: 508** | **Group: 2** |
| **Date of Submission: 4/16/21** | |

*All authors have contributed to the preparation of the memo and have read the final version of it.*

*On my honor, as an Aggie, I have neither given nor received unauthorized aid on this academic work.*

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1. **A short description of your design**

For this design project, the option chosen was to build a new design from scratch. The materials provided included a rod that was ½" in diameter and approximately 12" long, a bar that was of the dimensions, ½" X 2" X 12", and a plate that was 8" X 12" and 1/16 " thick. In this design, the bottom plate was 3D printed and the top plate was machined. To machine the top plate, it was first cut using a bandsaw to meet the design dimensions, bent to create two flaps on either side of the plate, and slots were milled into those flaps to connect the arms to the top plate, which would allow the scissor lift to lift and lower. The rod with 20 threads per inch thread was used as the central piece to the mechanism that caused the scissor lift to rise and lower as the rod was twisted. Four arms were cut out of the bar using a bandsaw to connect the base to the top plate. Once the arms were cut, the ends were grinded down to be rounded to allow for more fluidity of motion and holes were milled on each end of the arm to connect to the slots in the top plate. The arms crossed paths to form an X shape and on each side, one of the arms was bolted to the bottom plate on one side, the other arm was bolted to the top plate on the same side, and the ends of the arms on the opposite sides of the X were allowed to move within a slot on the top plate and base. The 3D printed block was threaded using the rod so that when the rod was rotated, the block would move forward or backward with it. This in turn would bring the ends of the arms closer together which would lift the top plate, or make it fall. Due to the mechanism being quite central, the design proved to be very stable, with little deflection.

2. **Objective/constraint analysis**

The first objective of the design was to lift a 9 [kg] weight with a footprint of 6 x 8 [in]. To ensure the design was stable, the top plate was designed so the surface area of the plate was greater than the footprint of the weight so the weight could be centered on the plate. The final design was able to achieve this objective by successfully lifting the required weight. The next constraint was to make sure that the platform was able to travel at least 200 [mm] vertically. To do so, slots were machined to be long enough so the platform was able to reach this height when the arms were fully extended. At the same time, caution was taken to ensure that the design remained stable at the maximum height. The final design was able to reach a travel height of 208.17 [mm] during testing while remaining stable.

The next constraint was for the platform to have a height less than 50 [mm] when closed. To make sure this was achieved, the top plate was machined on the sides to have thinner flaps and the 3D printed bottom plate was designed to be short enough to decrease the height, while still being thick enough to accommodate the holes and slots where the arms were connected. The final height of the closed design was 47.43 [mm]. Lastly, the scissor lift had to be manually operated to rise and lower. To do so, the lead screw was placed centrally and the 3D printed bottom block was employed as the moving part to fulfill this requirement. This was accomplished as seen during testing. Lastly, the final design was fairly stable with a deflection of 4.41 [mm] and a weight of 957 [g].

3. **All needed part and assembly drawings**

The dimensions for each part were chosen in order to meet the requirements set for the project. The dimensions of the bottom plate were chosen so there would be enough space between the top and bottom plates for the central glider and rod to fit. It also had to be considered that the design should be less than 50 [mm] when closed. Secondly, the top plate had to have a larger surface area than the footprint of the weights, in order for the design to be stable. Therefore, these were the dimensions chosen for the top plate. The bottom glider had to fit within the bottom plate, but also be wide enough for the rod to pass through. In addition, the vertical travel had to reach a minimum of 200 [mm] which was considered when designing the length of the arm. The ranking of the optimizations for this design was first that it was stable when at its maximum height, second that it was less than 50 [mm] when closed, and third that it would travel at least 200 [mm]. The weight and deflection considerations were not weighted as heavily when designing this structure. The Solidworks drawings for each component can be seen in Fig.1-5.

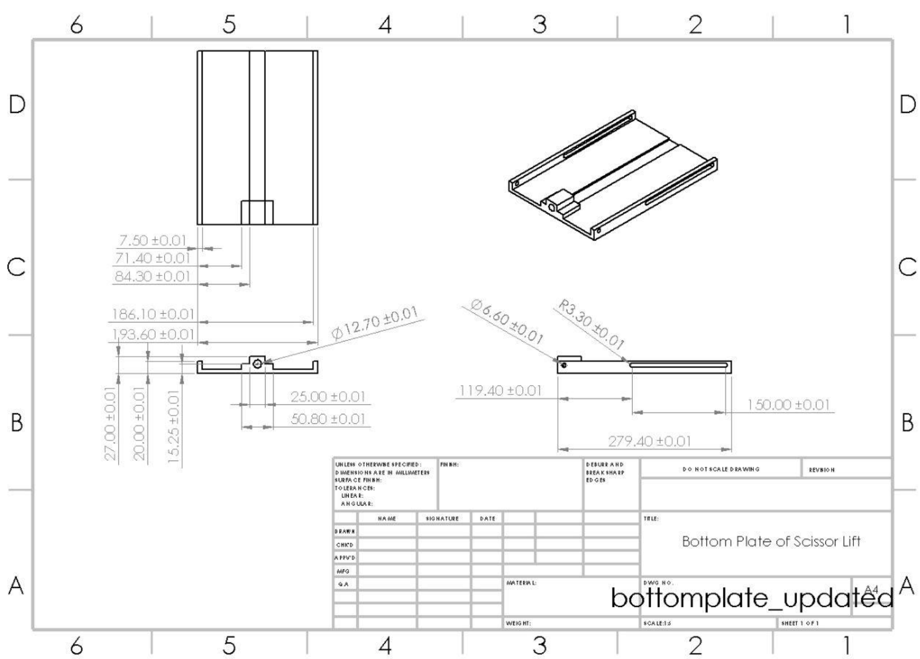


Figure 1: Bottom plate

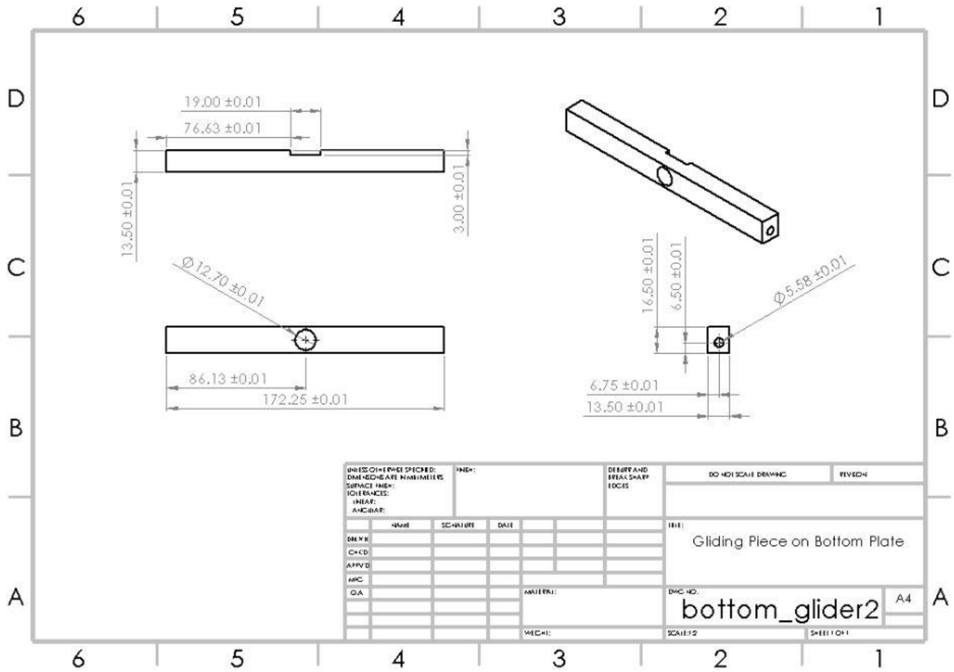


Figure 2: Bottom glider

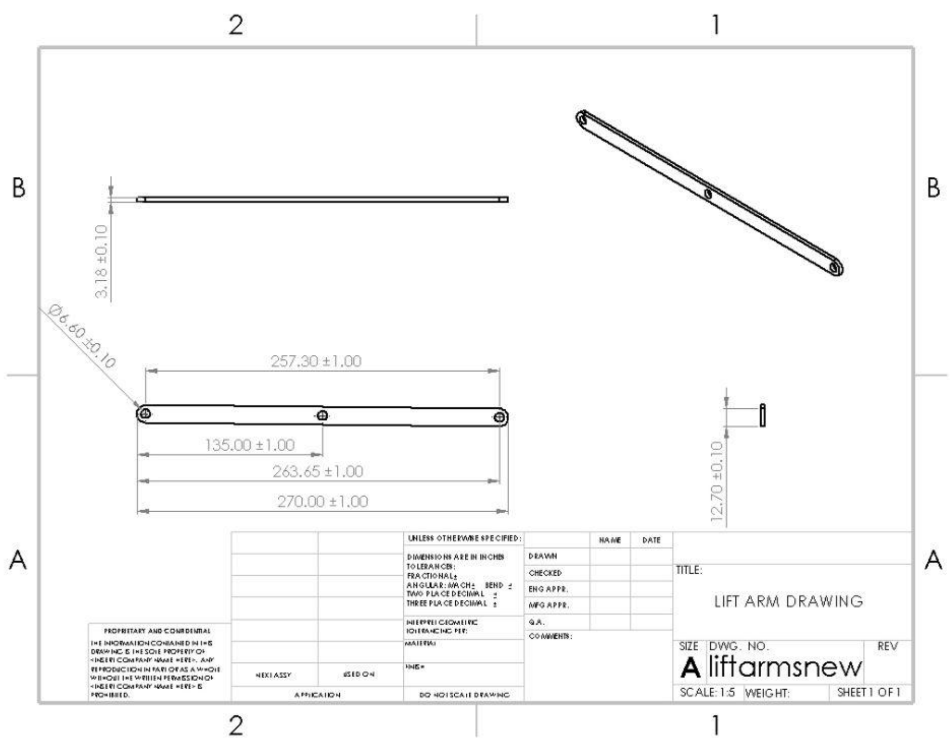


Figure 3: Lift Arms

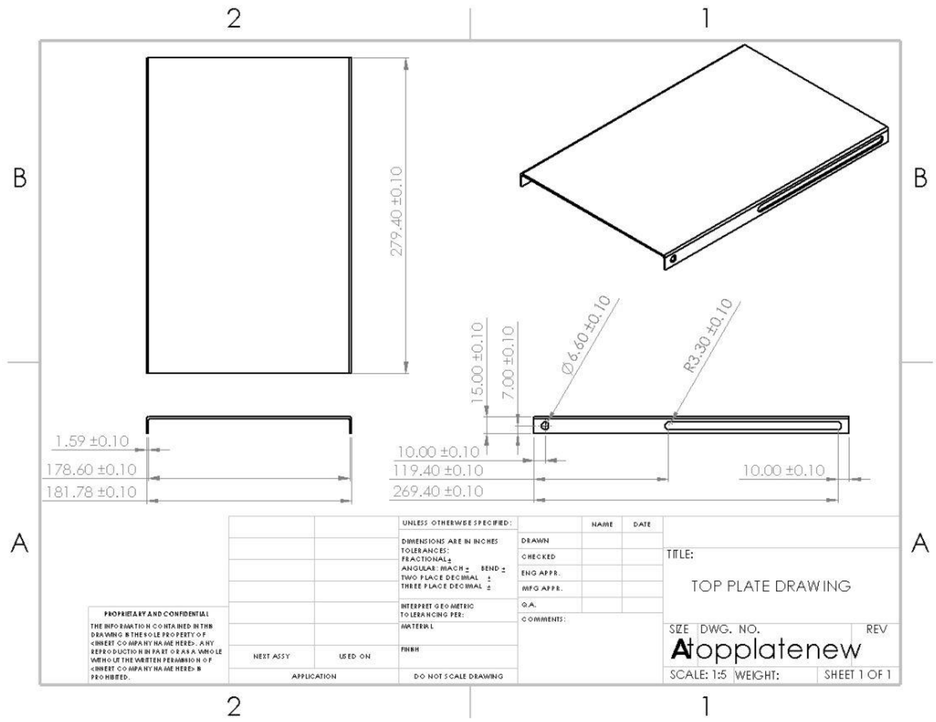


Figure 4: Top plate

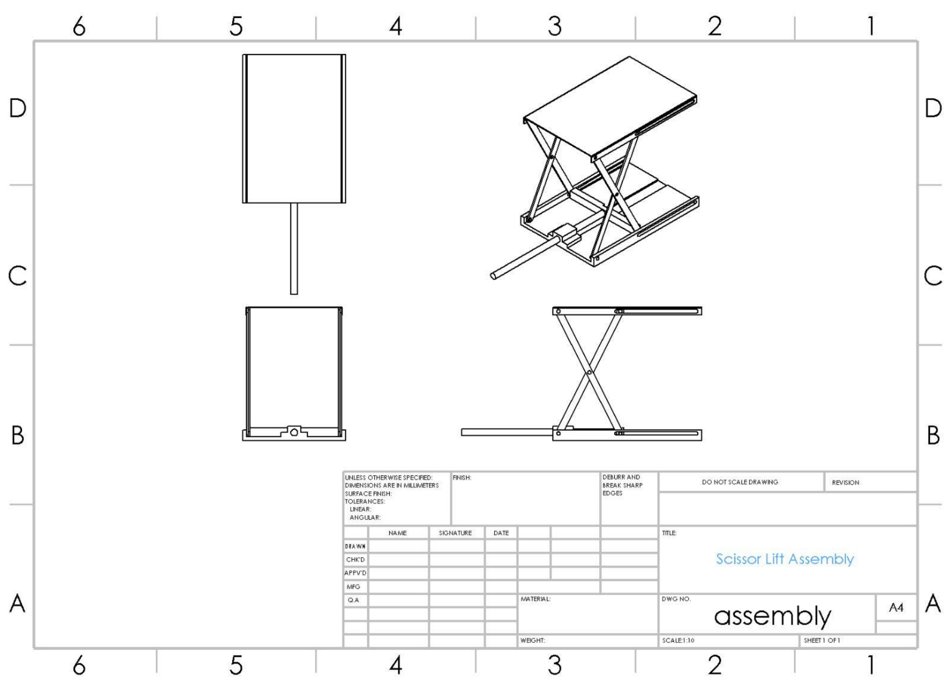


Figure 5: Assembly

4. **Calculations of the weight estimate, comparison with the actual weight observed during testing.**

To estimate the weight of the scissor lift, the material properties tool within SOLIDWORKS was used. In doing so, the volume was measured.

$V_{rod}$ =2.356 in^3

$V_{plate}$ =5.441 in^3

$V_{bar}$ =0.638 in^3

With this volume and the density of the materials used, the mass of each component could be calculated as seen below. The total mass of each type of component was calculated by multiplying the nominal mass by the number of components and the mass of aluminum was calculated by multiplying the density by the volume ("Density Of Metals"). The mass of the 3D printed material was calculated by dividing the total volume of the material by the cost per gram as provided by the JCAIN (Powell).

$M_{bolt1}$ =8 g * 10

$M_{nut1}$ =9 g * 10

$M_{nut2}$ =17 g * 3

$mass_{aluminum} = Density_{aluminum} \times Volume_{aluminum}$= 1.014202 lb = 460 g

$mass_{extra\ parts}$ =221 g

Cost of 3D print per gram .029 cents

Cost of entire printed parts $6.77

$mass_{3d\ printed}$ =cost of all parts/cost per gram = 233.4 g

The estimated and actual weights of the scissor lift were relatively similar but differed slightly. The difference in weights was determined to be from the washers that needed to be added to various parts of the scissor lift to add stability. Additionally, there was extra weight within the top plate due to the machining process which prevented certain dimensions from being reached exactly.

$theoretical\ mass_{total}$ =914.44 g

$Actual\ mass_{total}$ =957 g

## 5. Discussion

The final design ended up being quite stable since the top plate remained horizontal throughout the test and did not deflect sideways, even at maximum height. The final weight was 0.957 [kg], however, this could have been reduced by decreasing the infill of the 3D printed base, along with taking out material from the base and the top plate to create a grid of holes that were small enough to maintain stability while decreasing the weight.

To further minimize the weight of the scissor lift, the width of the top and bottom plates could be reduced, thus making it more efficient. However, that would cause the area moment of inertia to be reduced which could cause the structure to become destabilized when a force is applied to the side, which in this case, is not relevant to the objective which is to withstand a vertical load.

3D printing the base turned out to be effective since it required less machining to create the slots in the base and the support for the rod. In addition, attaching the rod to the 3D printed block turned out to be effective as that mechanism allowed the structure to have greater stability to prevent sideways deflection. It can be noted that the design took a significant amount of time to be fully extended from its initial closed condition. This was due to how narrow the threads were on the rod and 3D printed block. As there was no time constraint and the narrow threads offered greater stability to the design, this was acceptable for this project but could be improved in the future if the use of a motor were allowed to turn the rod at a faster pace.

The final design reached a vertical travel of 208.17 [mm] and deflected 4.41 [mm]. The deflection could be reduced in the future by including a small groove at the end of the slots where the arms would be at maximum height. This would prevent the arms from sliding backwards in the slot when the weight was applied and could be applied to the top plate (adding a groove at the top of the slot) and the bottom plate (adding a groove to the bottom of the slot).

## 6. References

"Density Of Metals". *Coolmagnetman.Com*, 2021, https://www.coolmagnetman.com/magconda.html.

Powell, Carl. "The Real Cost of Cheap 3D Printer Filament." *3D*, 3D-Fuel, 19 Mar. 2018, www.3dfuel.com/blogs/news/the-real-cost-of-cheap-3d-printer-filament.