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FEA Solidworks Assignment

1 Introduction

In response to the design challenge presented by ME321 Corporation, this report outlines the development and analysis of a truss-based stand intended for supporting industrial fluid systems. The objective is to engineer a robust and efficient structure that meets stringent criteria while aligning with the specifications provided.

The design problem entails creating a stand with a rectangular base (12frx4ft), maximum height of 5 feet, anchoring legs, utilizing 2024 Aluminum Alloy, and adhering to a weight limitation of 3000kg. Furthermore, the stand must exhibit high load-bearing capacity, ensuring safety with a minimum factor of safety of 1.5 while being capable of supporting at least 30 times its own weight.

To address this challenge, I designed each truss with the required material and then conducted an FEA analysis of each truss system, including a Factor of Safety report. From this I was able to calculate the efficacy of each of the truss iterations.

2 Final Truss Design

My final design for the truss was constructed out of 2024 Aluminium Alloy as required. The truss has a 12 foot by 4 foot base and is a total of 4 feet tall, which is less than the 5 foot maximum height prescribed. Each side of the truss has 7 members, and the top and bottom each have one member to enable ease of manufacturing of the truss design. For further information on the design of the truss and its specifications, please see Appendix Figure A3 and A4. The truss weighs 5766.45 lbs (2615.62 kg), which is also less than the maximum mass of 3000 kg.

Further, the truss is able to support 30 times the mass of the truss with a minimum factor of safety of 3.7, passing the minimum FoS requirement of 1.5. This truss design meets all the design criteria and has an efficiency of 74.569. Please see Table 1 to see all these values laid out.

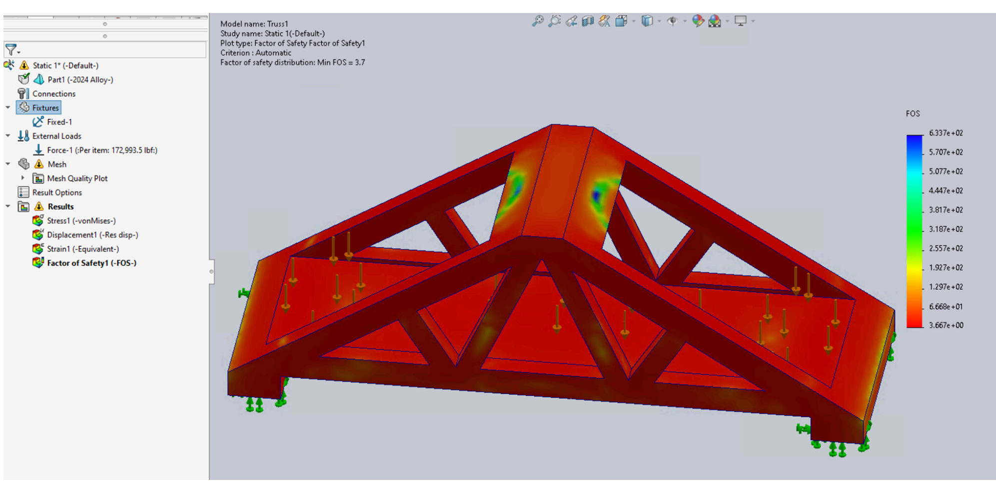


Figure 1: FInal Truss Design Factor of Safety Simulation

3 Iterative Design Process

Iteration	Total Height (ft)	Weight (lbs / kg)	Applied Load (lbf)	Minimum FoS	Maximum Supported Load (lbf)	Efficiency	Pass/ Fail
1	3.5	5907.09 / 2679.41	177212.7	2.1	265000	44.861	Pass
2	3.5	5646.11 / 2561.03	169383.3	2.7	300000	53.134	Pass
3	4	5766.45 / 2615.62	172993.4	3.7	430000	74.569	Pass

Table 1: Design Iteration Parameters

3.1 Iteration 1

In my first iteration, the truss was 42 inches tall and contained 8 members on each side. The highest stress on the truss in this model was within the upper members and the joints between the vertical members and the top and bottom of the truss. From the stress simulation of the truss it seemed like one of the primary modes of failure would be from the buckling of the vertical members of the truss. The minimum FoS of this design was 2.1, which was above the required minimum of 1.5, and therefore this design passed. Please see Appendix Figure A1 for proof of FEA. To iterate on this design of the truss, I decided it would be best to remove the vertical truss members to see if the load was then more evenly distributed amongst the members. In addition, by removing these two members from each side it would reduce the overall weight of the truss and therefore improve the efficiency.

3.2 Iteration 2

In this second iteration of my truss design, I removed the vertical truss members, therefore only had 6 members on each side. This truss was also 42 inches tall. The highest stress on this truss was also in the top member and in the base next to the ground supports. However, this design had a higher minimum factor of safety than the previous design, with a minimum FoS of 2.7. In addition, this truss design was able to carry a higher maximum load of 300,000 lbf whilst also weighing less than the previous model, and therefore had a higher efficiency than the previous iteration. This design also passed. Please see Appendix Figure A2 for proof of FEA. To iterate on this design, I decided in order to increase the efficiency of the truss further, it would be good to reduce the weight of the truss while still keeping the maximum load high. In order to do this, I decided to remove the top member to create a triangle shape instead of a trapezium shape.

3.3 Final Iteration

In my third and final iteration on the truss design, I had a triangular shaped truss with 7 members on each side and one connecting member on the top. The truss design was 48 inches tall. This design had a slightly higher mass than the previous model due to the increase in height, however it was able to support a significantly higher maximum load while still having a minimum factor of safety of 1.5. This gave a significantly higher efficiency than the previous two iterations. Please see Appendix Figure A3 for proof of FEA.

The highest stress on this truss was in the two side members of the triangle and in the base next to the ground supports. Further iterations to continue to improve efficiency could be to reduce the overall height of the truss, which will reduce the weight of the truss, whilst not causing a significant change in the maximum load. In addition, the ground supports could be moved slightly in on the base to help reduce the high stress next to the ground supports as the load would be distributed more evenly over the ground supports.

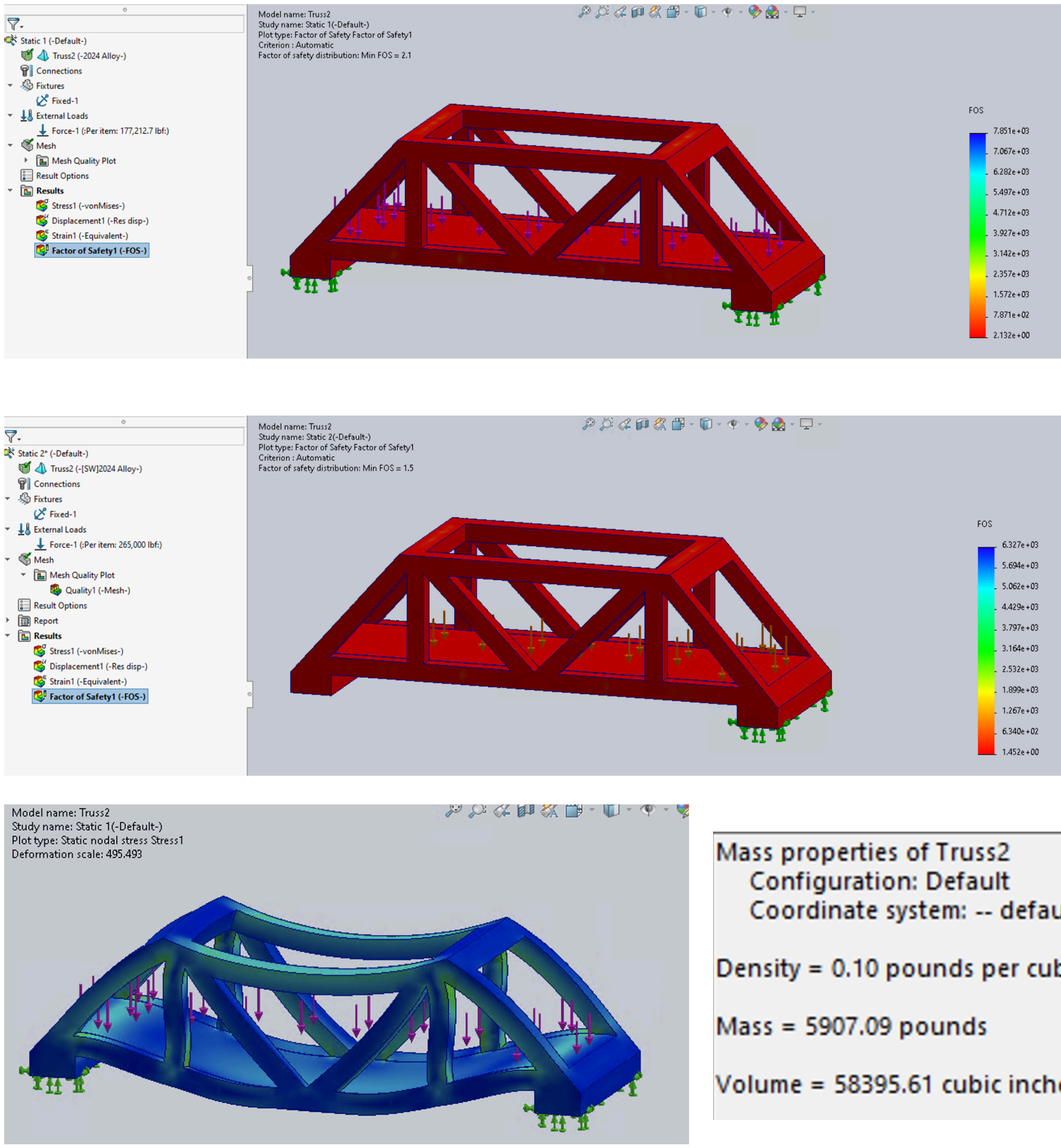
4 Conclusion

As stated in section 2, the final design for the truss passes all design criteria. The truss has a 12 foot by 4 foot base and is a total of 4 feet tall, which is less than the 5 foot maximum height. Each side of the truss has 7 members, and the top and bottom each have one member to enable ease of manufacturing of the truss design. The truss weighs 5766.45 lbs (2615.62 kg), which is also less than the maximum mass of 3000 kg. Further, the truss is able to support 30 times the mass of the truss with a minimum factor of safety of 3.7, passing the minimum FoS requirement of 1.5. This truss design can support a maximum load of 430,000 lbf with a 1.5 factor of safety, to give an efficiency of 74.569.

The previous iterations aided with the development of this final design, as I was able to see that by reducing the overall weight of the structure by making the top panel shorter, this would increase the overall efficiency. In addition, from the first iteration, I noticed that the vertical members were the highest stress point, and therefore were the most likely to fail, therefore I removed any vertical members in my structure and utilized triangles to evenly distribute the load.

Future iterations of this design could be further improved by further reducing the weight of the truss structure by decreasing the height slightly to 3 feet, as this will not significantly affect the maximum load. In addition, one could experiment further with truss designs that are equally as strong with fewer members as this would also help to reduce the weight.

Appendix



(a)

(b)

Mass properties of Truss2
Configuration: Default
Coordinate system: -- default --

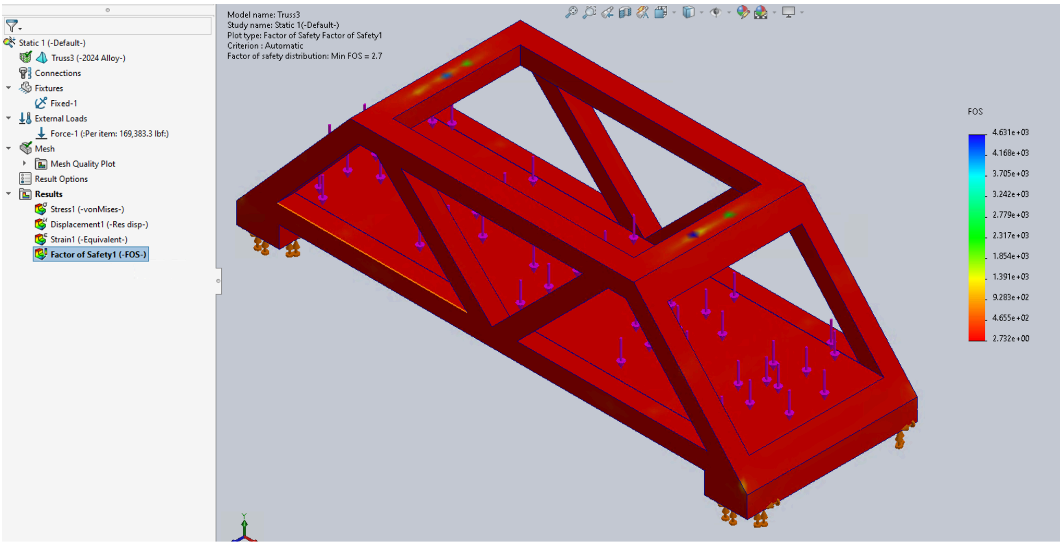
Density = 0.10 pounds per cubic inch

Mass = 5907.09 pounds

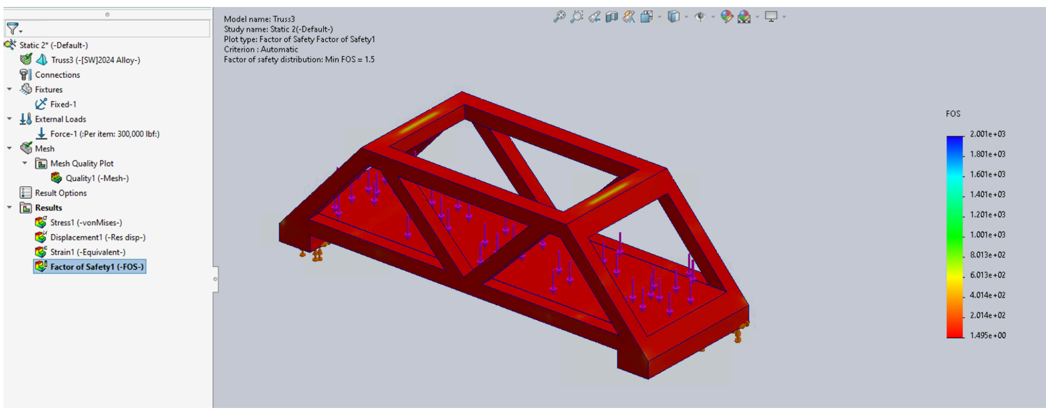
Volume = 58395.61 cubic inches

(c) (d)

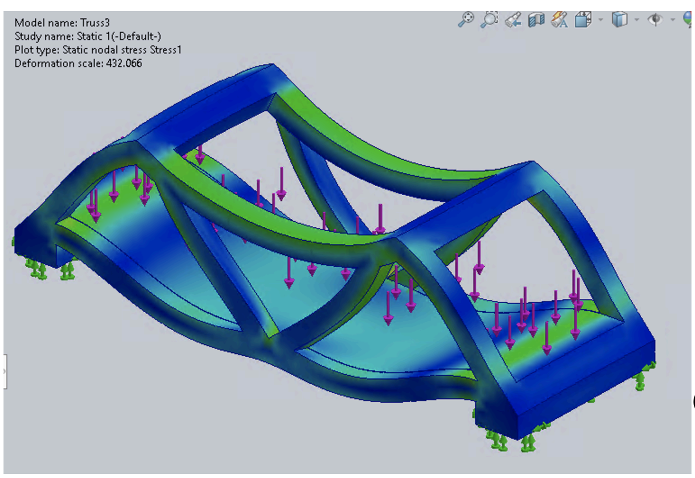
Figure A1: Truss Iteration 1, (a) FoS with Applied Load 30 times weight, (b) FoS with Maximum Applied Load, (c) Stress Simulation, (d) Proof of Mass



(a)



(b)



Mass properties of Truss3
Configuration: Default
Coordinate system: -- default --

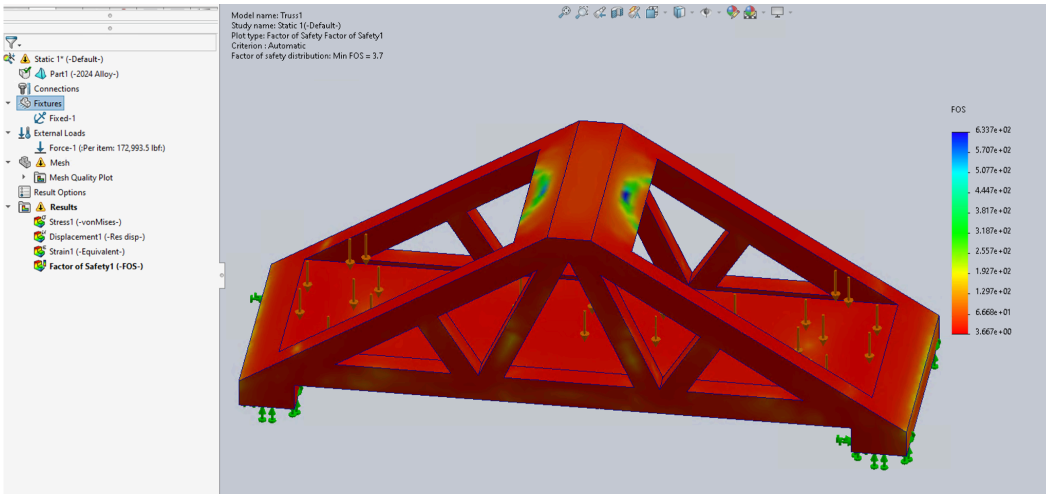
Density = 0.10 pounds per cubic inch

Mass = 5646.11 pounds

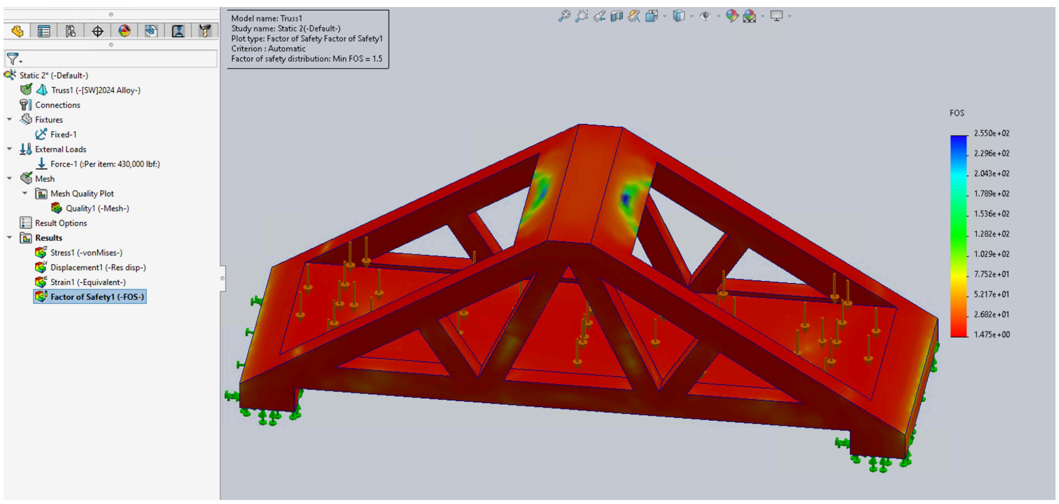
(c)

(d)

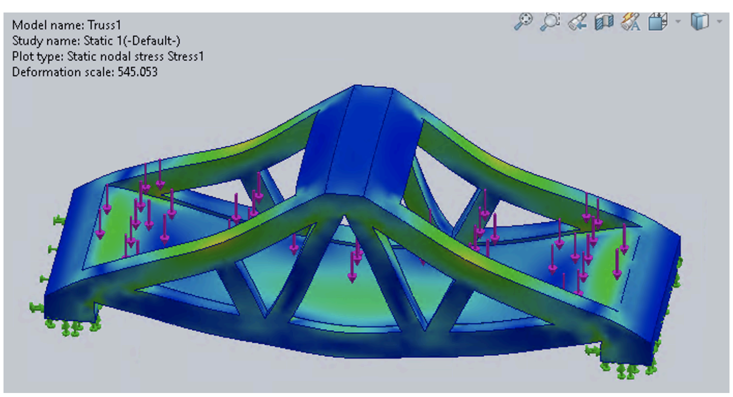
Figure A2: Truss Iteration 2, (a) FoS with Applied Load 30 times weight, (b) FoS with Maximum Applied Load, (c) Stress Simulation, (d) Proof of Mass



(a)



(b)



Mass properties of Truss1
Configuration: Default
Coordinate system: -- default --

Density = 0.10 pounds per cubic inch

Mass = 5766.45 pounds

Volume = 57005.27 cubic inches

(c) *(d)*

Figure A3: Truss Iteration 3, (a) FoS with Applied Load 30 times weight, (b) FoS with Maximum Applied Load, (c) Stress Simulation, (d) Proof of Mass

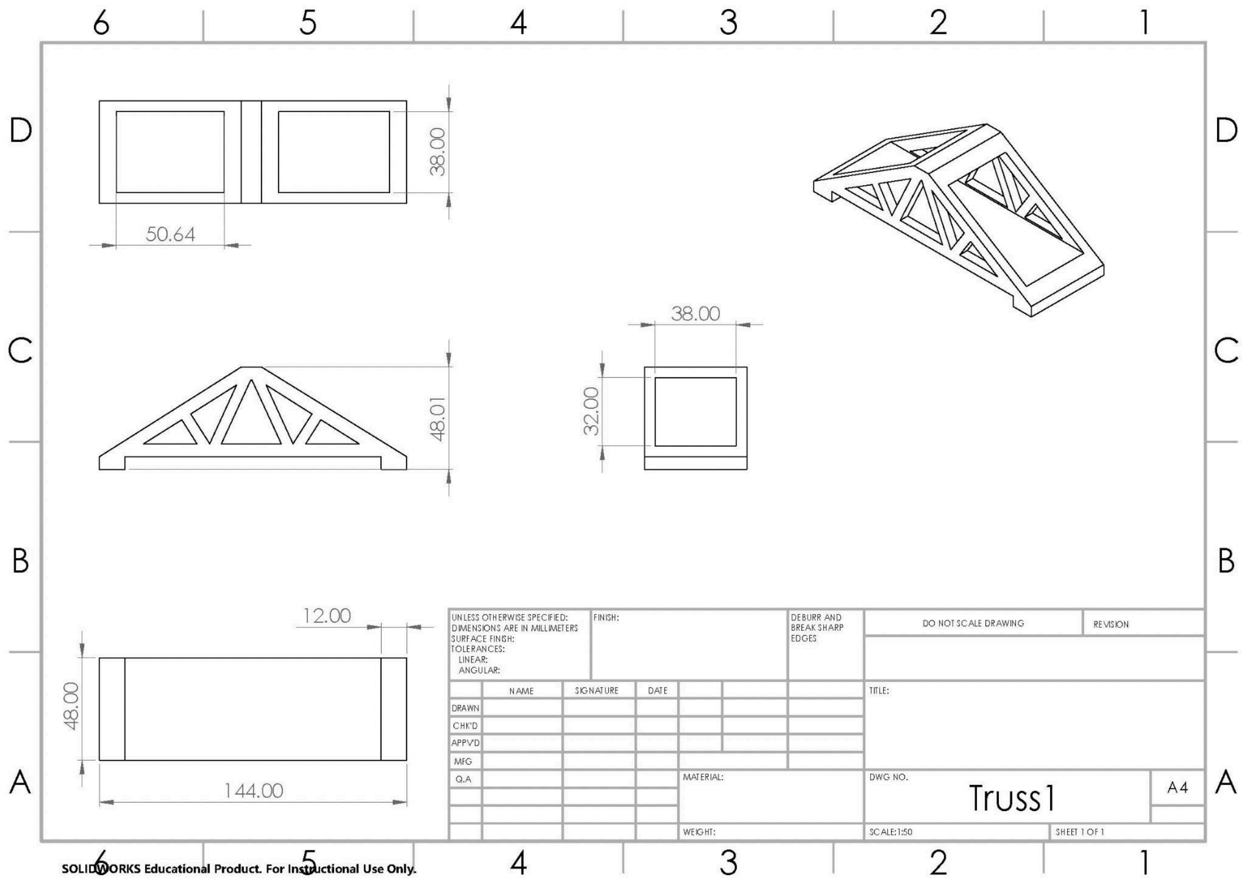


Figure A4: Dimensioned Drawing of Final Truss Design