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LMJ³ Part Two - The Final Design and Technical Report

Integrating Project (ACHA4008)

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1 Introduction

This technical report will showcase the soapbox that was designed as part of the Group Project. It will go into detail on the design process, which software and why, and why Computer-Aided Design (CAD) is the most suitable way to portray the original design ideas had by the group. The Software used was SOLIDWORKS (solidworks,2022). This report will be covering the suitability of the design and how the earlier drawings translated into a 3D model. How the moving parts, such as the steering system, went from hand drawn ideas to functioning parts. This report will also reflect on the quality of the results, and if they matched expectations set before the project began.

2 The Final Design

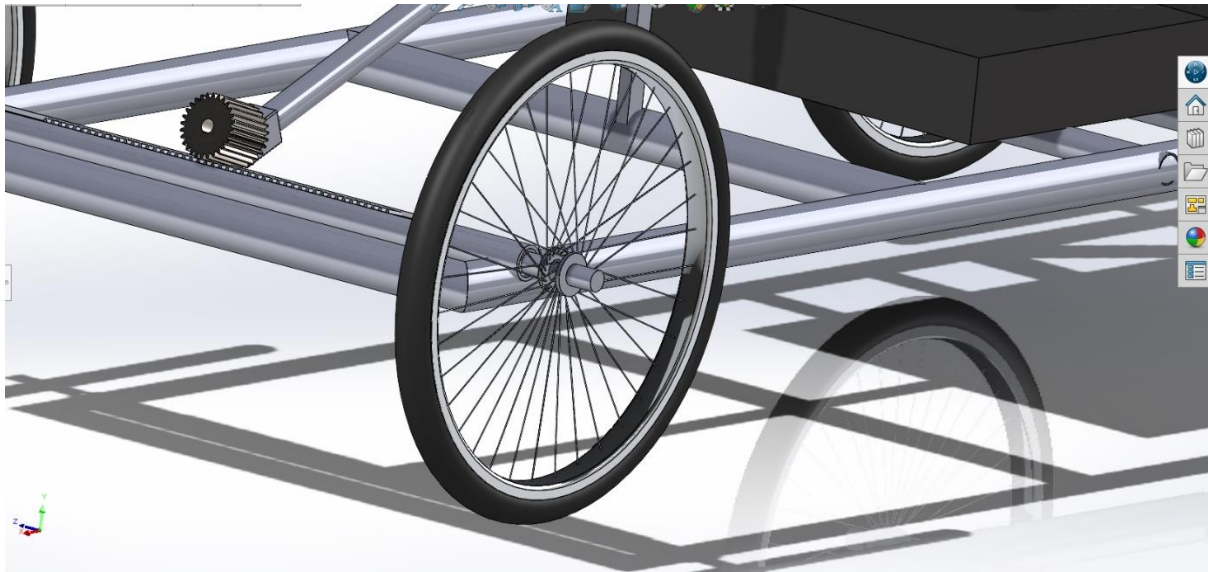


Figure 1 - Close up of Soapbox Wheels (Aganon, 2022)

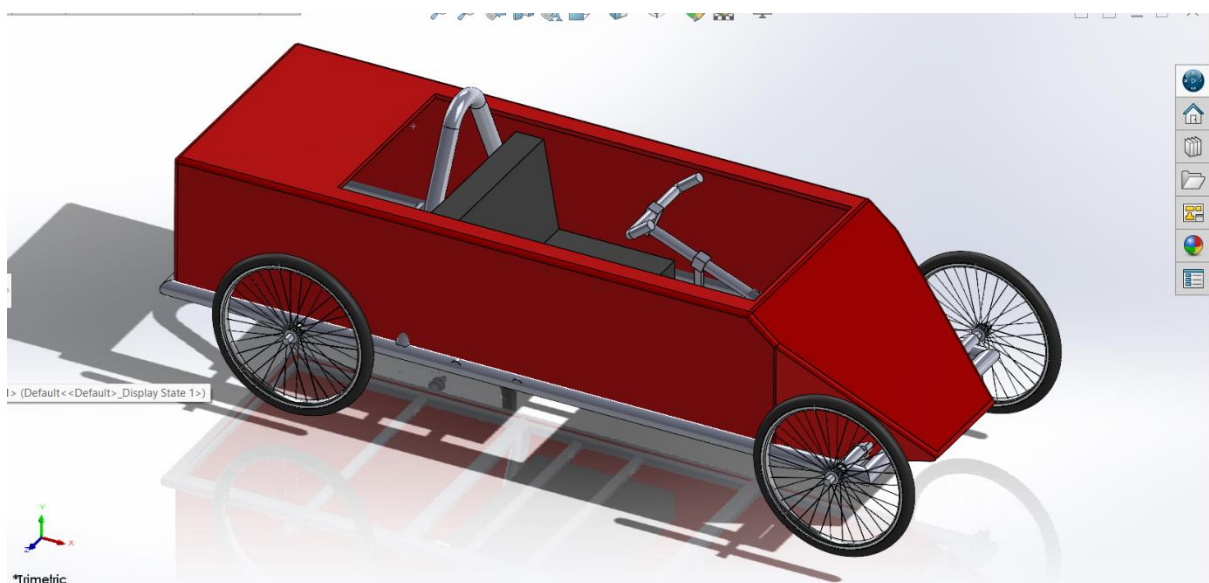


Figure 2 - Above view of the finished Soapbox (Aganon, 2022)

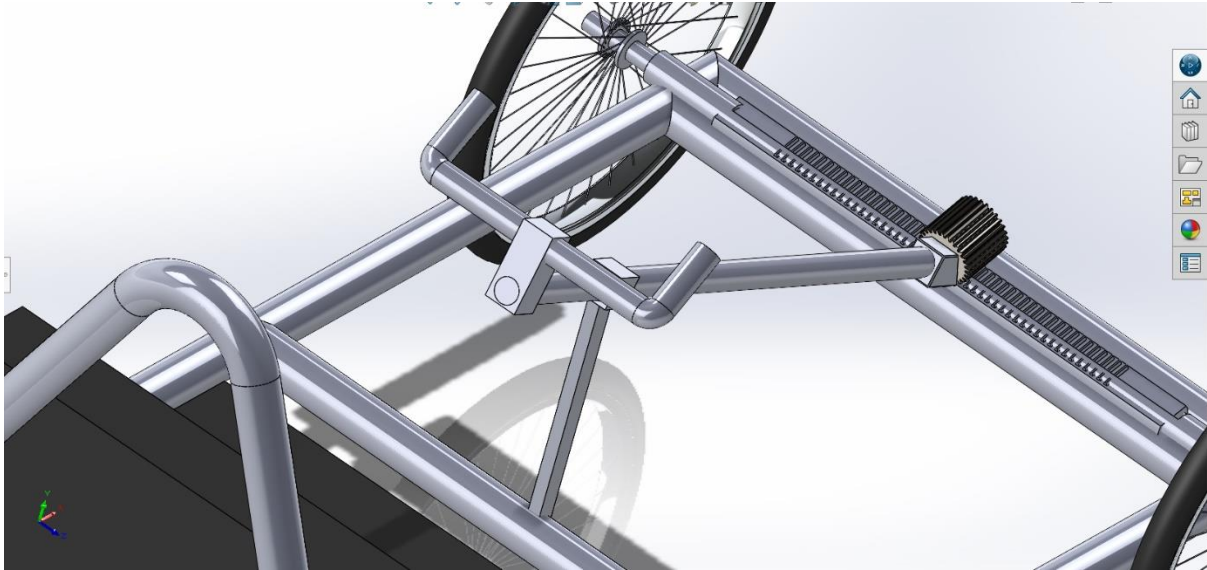


Figure 3 - Soapbox steering system (Aganon,2022)



Figure 4 - Figure 4 - Close up of the rack and pinion steering system (Aganon, 2022)

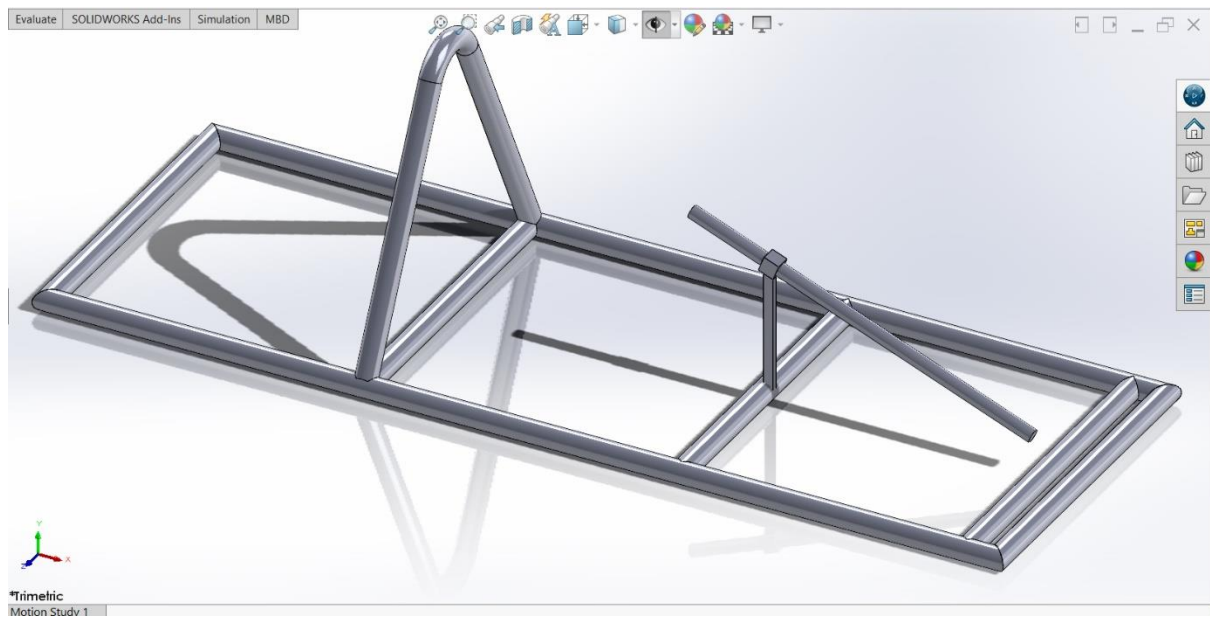


Figure 5 - Bare Chassis without Components (Aganon, 2022)

3 The Design Process

3.1 Designing the Soapbox

Firstly, the ladder-box chassis (*Figure 5*) was designed, using 4140 mild steels in 20mm sections, created with the measurements provided from the original designs. This created the base for the other components to be built around. Secondly, the wheels, as seen in *Figure 2* were created, built based on bicycle wheels that had been previously researched, on the first attempt, when it came to mate the components, they were unproportioned and needed to be scaled down suit the chassis. After the lesson learnt from the sizing issues, the later components were found to be easier to scale, such as the rollbar and steering rack.

The roll bar was made from the same steel as the rest of the chassis but due to regulations made for Richard Castle Soapbox racing (Richard Castle Soapbox Derby, 2020). The roll cage had to be 35mm above the driver head. The Steering rack (*Figure 4*) was made using a rack and pinion design, using mod 1.5 gearing to match the narrow style of course. Lastly, the bodywork was made from fibreglass panels and then a seat was fitted, this can be seen in *Figure 2*.

3.2 Suitability of the Design.

Due to the simple design agreed on, the soapbox's straight beams and simplistic body panels transferred well into CAD and the biggest problem arose when trying to get the correct scales to mate these components together. A problem that would be fixed with more time and experience using the software.

When the weight of the materials was calculated, it sat under the 100kg limit and would be near to the 78kg predicted in the original design brief.

It would have easily stayed within the theoretical budget, with the use of 4140 mild steel, sticking to the original idea that it was a budget soap box. And not an over-the-top engineless race car.

3.3 Quality Of the Final Design

The quality of the final design was to a high standard overall, the Soapbox was proven to work. The parts mated and are fully functioning. The Soapbox was made within the rules and regulations provided (Richard Castle Soap Box Derby, 2020) while sticking to the agreed materials decided in the original design brief. Sizing remained consistent with the original drawings.

4 Analytics

The analytics of this Technical Report focus on the overall mass of the Soapbox and Driver, and how changing the driver's mass can impact the amount of force applied to the Soapbox during the timed runs. The variable mass's of 70kg, 80kg, 90kg and 100kg, have been combined with the expected Soapbox mass of 78kg. Different mathematical and scientific techniques have been used together to predict the possible impact of changing mass. Furthermore, it is assumed that the driver will not use the brakes during the run and will reach 45mph (Richard Castle Soap Box Derby, 2020). Firstly, the track length of 550m and estimated total decent of 50m (Richard Castle Soap Box Derby, 2020) have been combined together in Pythagoras's Theorem to predict the total Soapbox's displacement while completing a timed run. $550^2 + 50^2 = 552.3^2$. Both the initial and final velocities have been determined as 0 and 20.12m/s respectively. Using the SUVAT equation of $\frac{v^2 - u^2}{2xs} = a$, acceleration can be calculated and multiplied with the overall mass of the Soapbox and Driver to work out the force. As you can see from Table 1, the mass and force are proportionate to each other.

Table 1 – Briefly outlying the impact of driver mass

Driver Mass (kg)	Force Experienced by Soapbox and Driver (N)
70	54.24
80	57.90
90	61.57
100	65.23

5 Conclusion

To conclude, all the necessary steps were completed to take this Soapbox from its original hand-drawn design to a functioning CAD model, using research carried out by the group, on materials and methods, to create a competitive soapbox. With the experience made throughout this project, certain aspects would be approached differently in future but overall, the targets set out at the beginning of the project were met by the team.

6 Further Study

If the opportunity arose to tackle this project again, the Group agreed that a more complex design would have been possible, such as using more exotic materials, like Carbon Fibre. Trying out a different type of design such as a space-frame chassis and different processes could have been tried and tested to build a more competitive soapbox. An example of this would be to import car parts, instead of bicycle parts, or adding a suspension system.

7 References

Richards Castle's Soap box Derby rules (2020), Richard Castle Soap Box Derby

SOLIDWORKS (2022), Dassault Systèmes Solidworks Corporation

8 Appendix

8.1 Designs

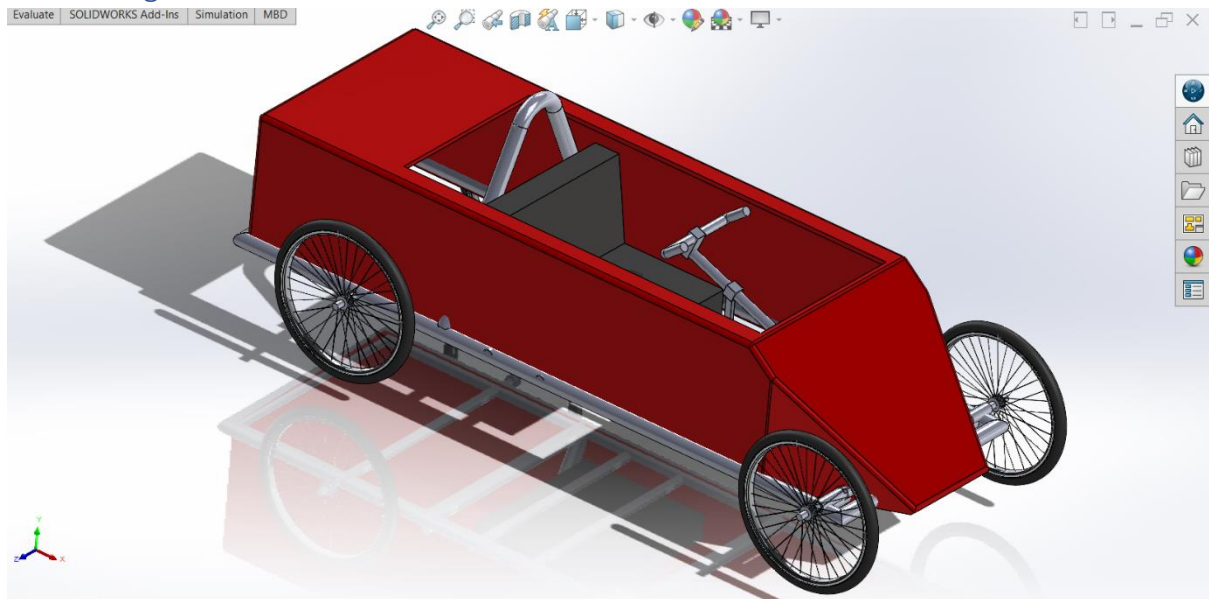


Figure 6 - Above photo of the final soapbox

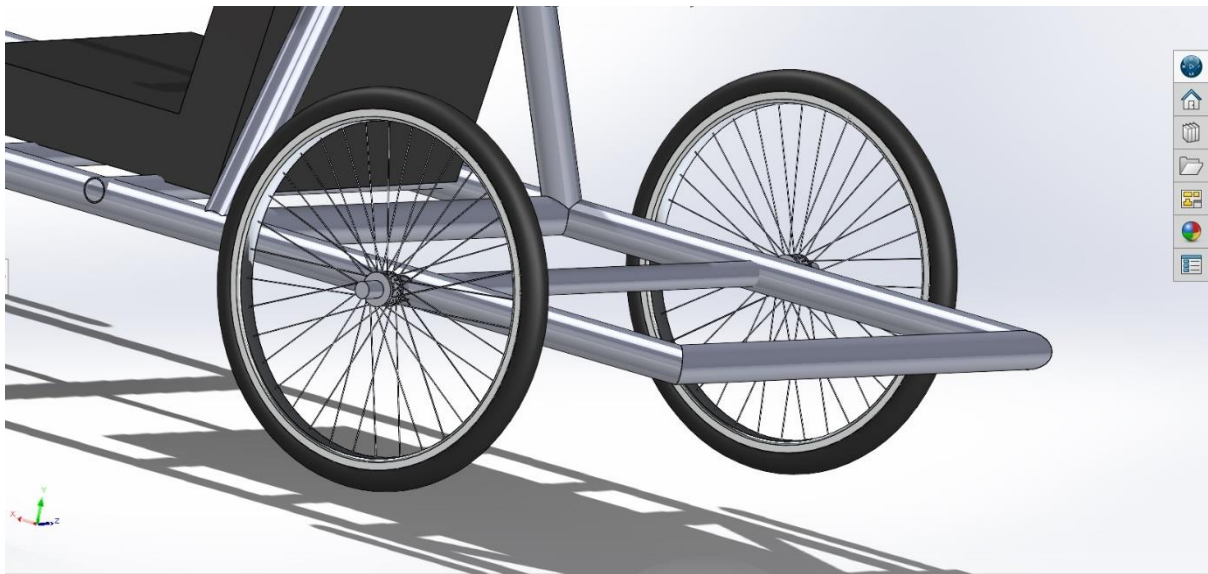


Figure 7 - Soapbox wheels and rear of the chassis

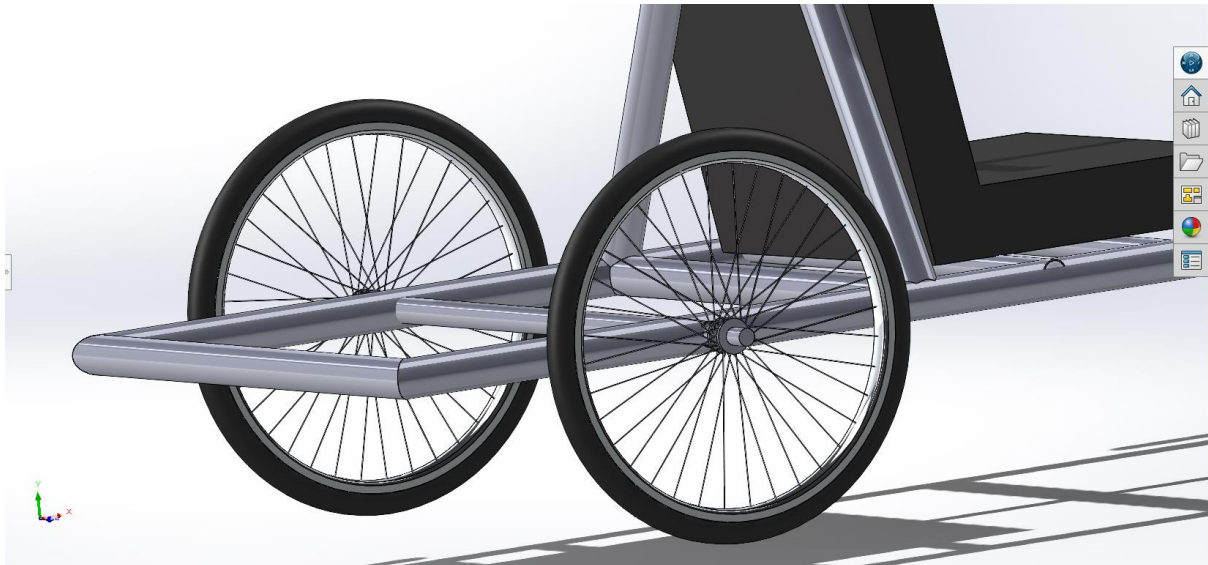


Figure 8 - Rear view of chassis and wheels

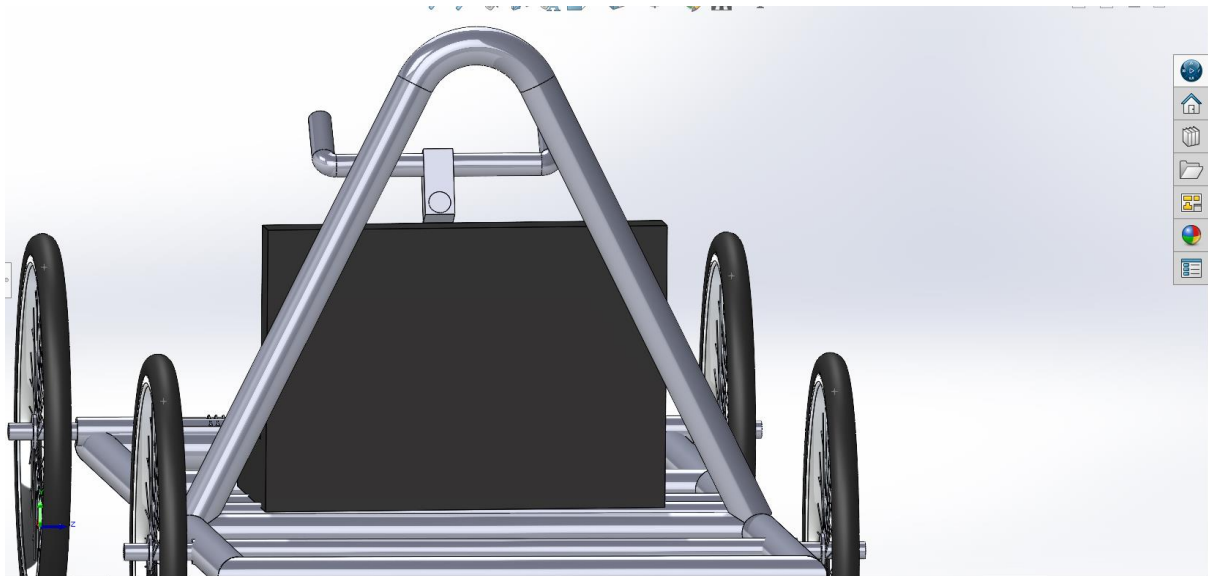


Figure 9 - Rear view of roll cage

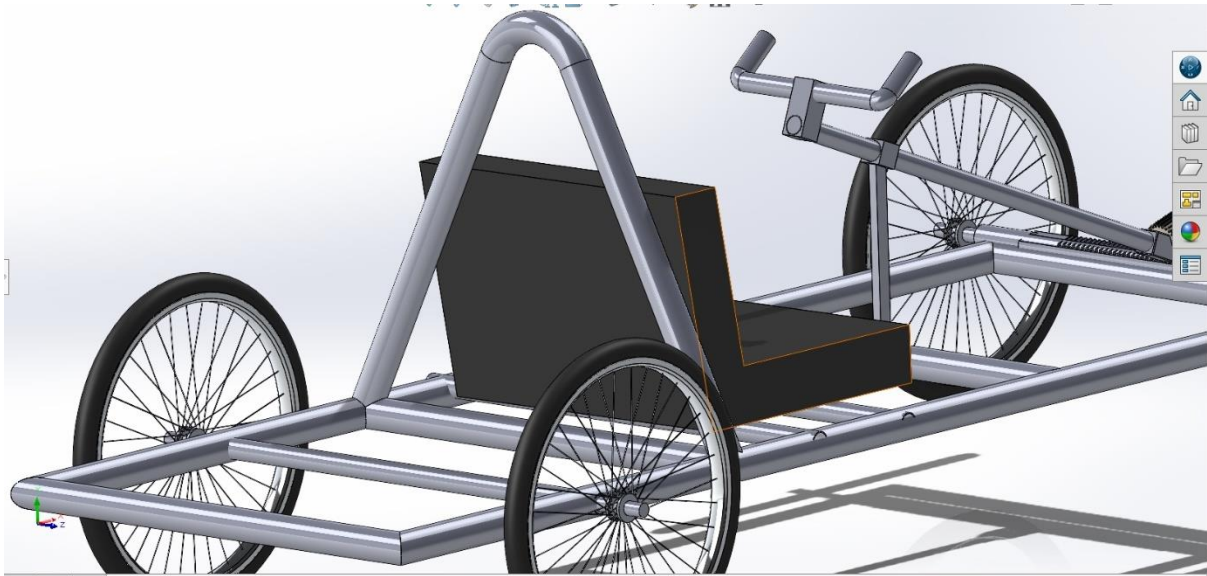


Figure 10 - Close up of roll cage

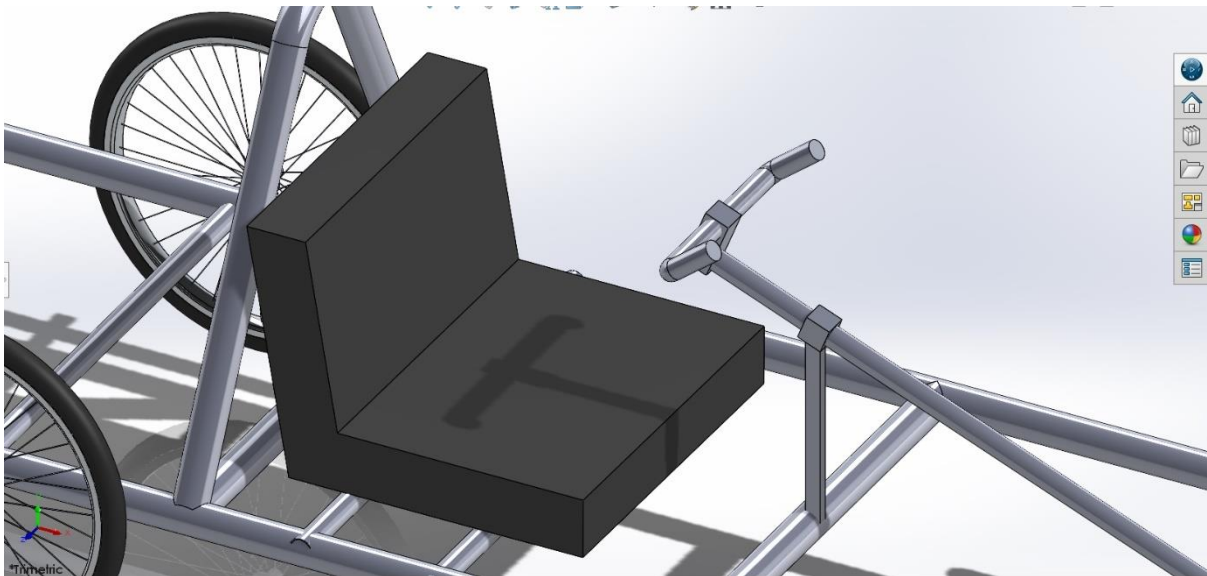


Figure 11 - Soapbox seat and steering yoke

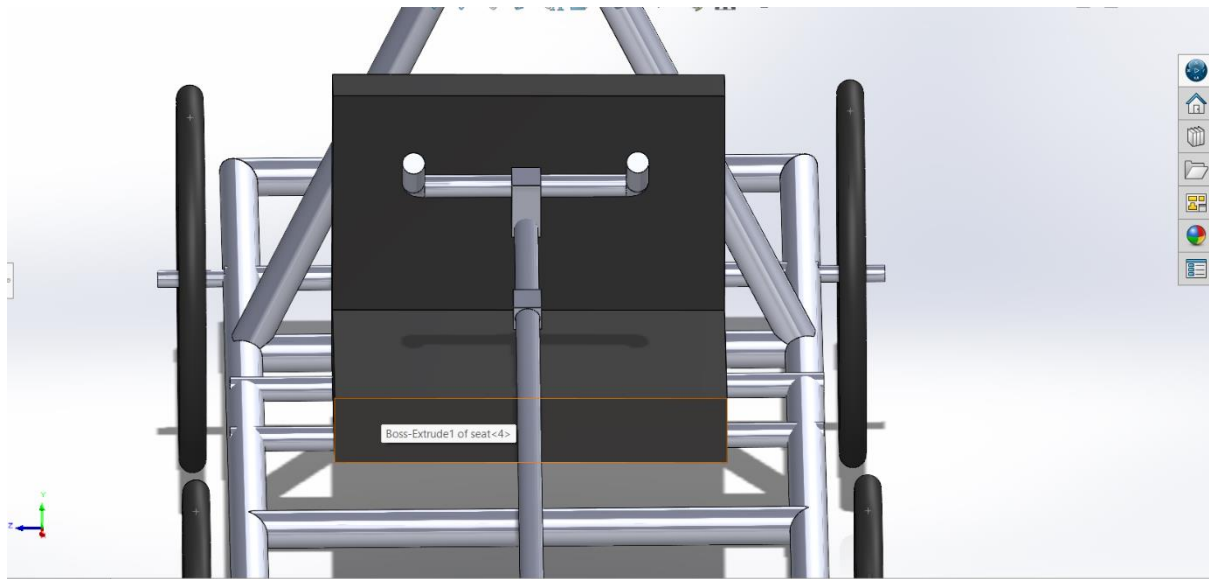


Figure 12 - Front view of soapbox without bodywork

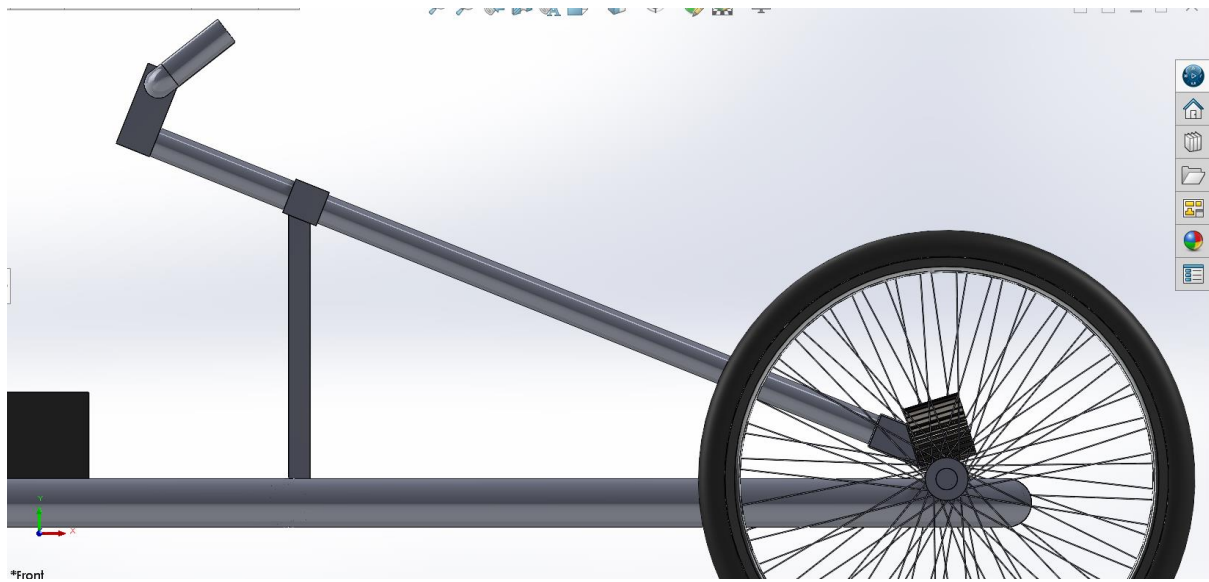


Figure 13 - Side view of wheels and steering system

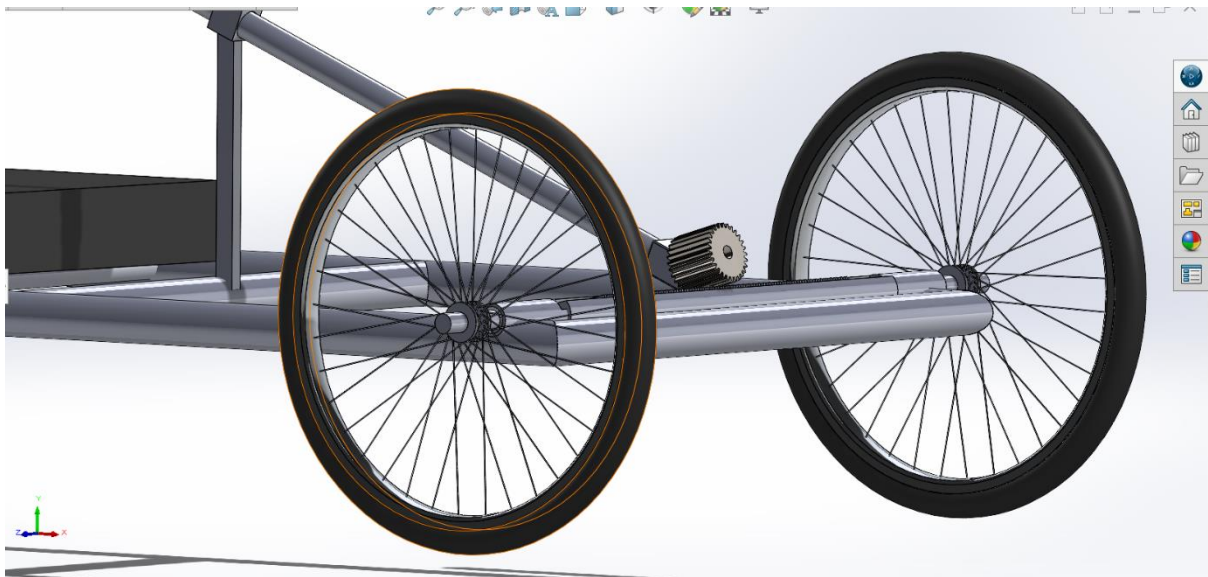


Figure 14 - Lower view of rack and pinion steering system

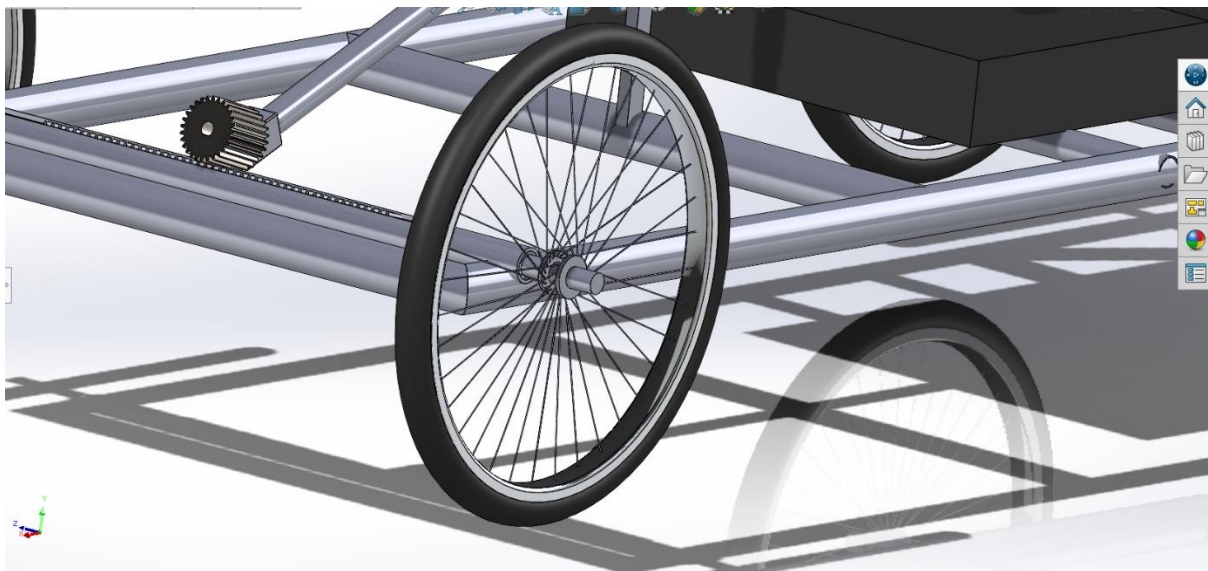


Figure 15 - Upper view of rack and pinion steering system

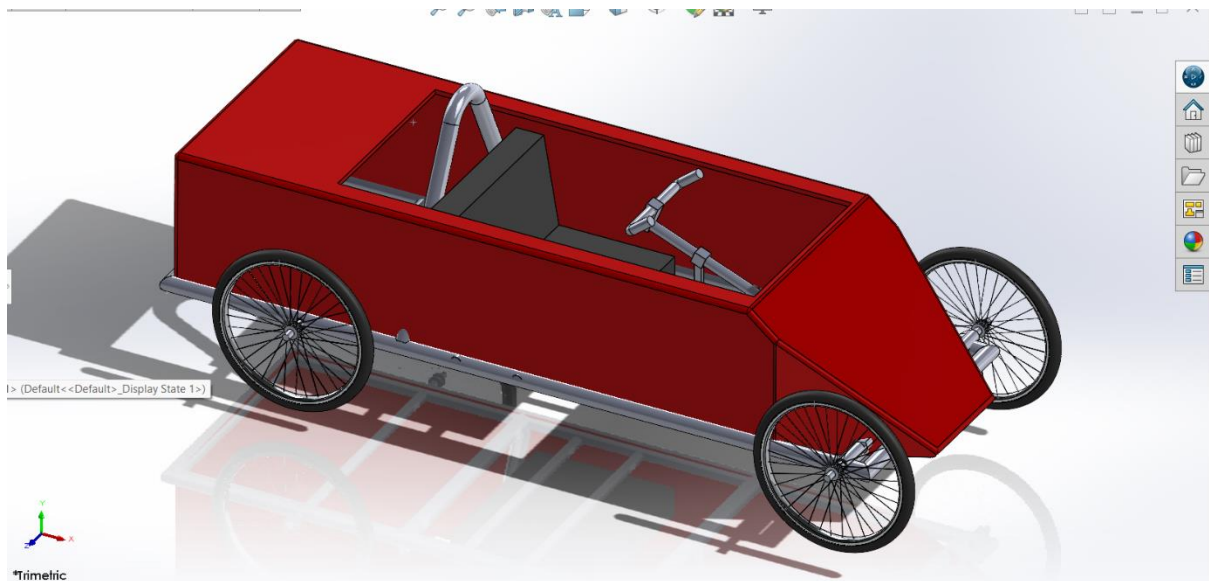


Figure 16 - Upper view of finished soapbox



Figure 17 - Steering yoke and rack and pinion system