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Group Project ACHA4008

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1 Introduction

This report will show the final design produced from the previous assignment. Computer Aided Design (CAD) models have been included to show the final design. Throughout the assignment the group has analysed and produced calculations on the final design. These calculations will show the forces acting on the soapbox when in use.

1.1 Aims

- To analyse the forces acting on the soapbox when in use.
- Explain why the final design was chosen for the project.
- Complete a CAD of the final design.

1.2 Objectives

- Research different equations/formulas that can be used to calculate the forces acting on the soapbox.
- Discuss the individual feature of the final design and the advantages of each feature.
- Use Solidworks to produce the final designs of the soapbox.

2 Computer Aided Design (CAD) Model

The Chassis has been designed using the 3D sketch and weldments tools within Solidworks. When using weldments, an aluminium tubing was selected to ensure the chassis is lightweight and provides good handling characteristics.

When creating the 3D model, the group insured that the chassis would be compliant with the regulations. The length of the chassis must be inferior to 2500mm, and the maximum width of the soapbox cannot exceed 1500mm (Richard Castle Soap Box Derby, 2023). Along with the dimensions of the soapbox the group had to implement two roll bars into the design, one at least 35mm above the driver's helmet (Richard Castle Soap Box Derby, 2023) and a second roll bar situated at a minimum of 25mm above the drivers gloved hands placed at 12 o'clock on the steering wheel (Richard Castle Soap Box Derby, 2023).

It is also stated in the regulations that the soapbox must have a minimum ground clearance of 50mm allowing it to clear the start ramp. This is something that was considered when designing the wish bones while considering the size of wheels that will be used allowing the soapbox to be as low to the ground as possible to ensure a lower centre of gravity and therefore more stability.

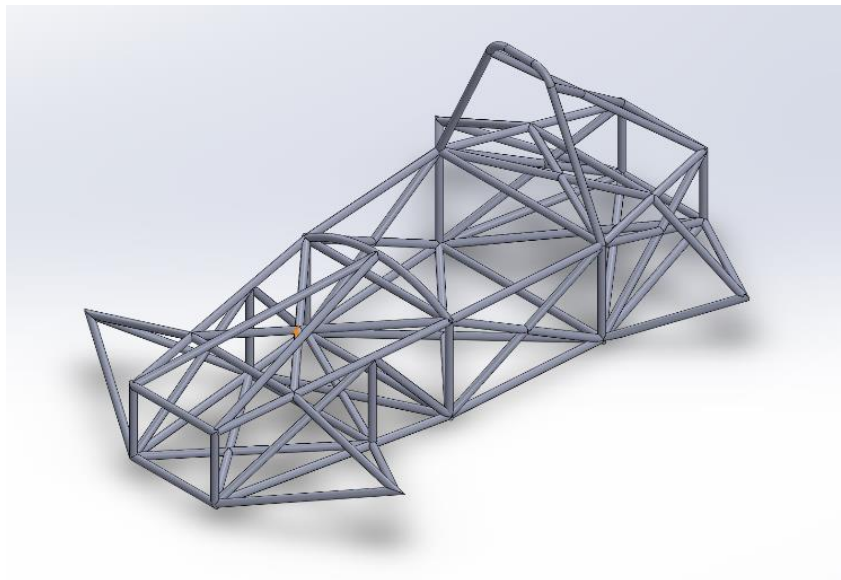


Figure 1 – Isometric view of the space frame chassis of the soap box.

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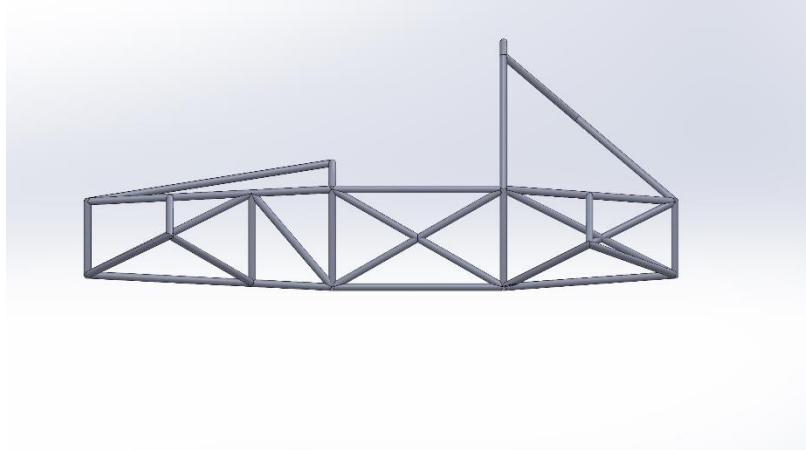


Figure 2 - Side view of the space frame chassis of the soap box

When designing the soapbox, the two roll hoops were designed to sit higher than the minimum dimensions in the regulations to create more clearance above the helmet of a taller driver.

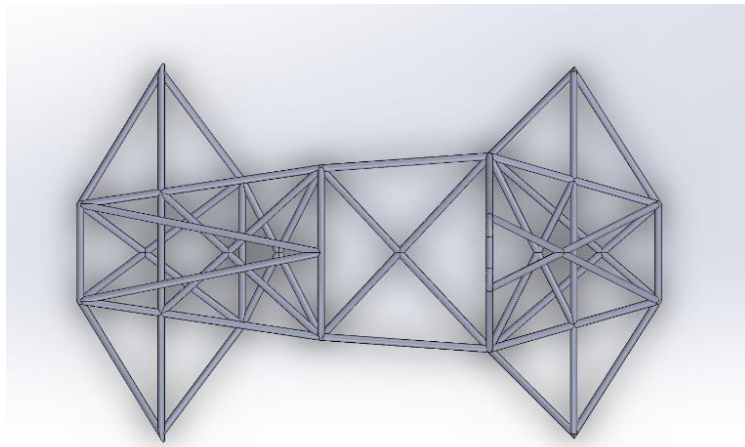


Figure 3 - Top view of the space frame chassis of the soap box

Final design of the soap box features a sleek aerodynamic design allowing for the kart to reach high speeds down the course. The shell will be made from lightweight fibreglass, this will provide the aerodynamics needed to reach competitive speeds. The shell is a very simplistic design, this reduces manufacturing costs. Furthermore, the shell will consist of thin layers of fiberglass, this will decrease weight and costs.

When designing the chassis it went through 3 design phases, the final design incorporated structures to ensure the chassis provided good handling and safety. The wishbones were designed to lower the soap boxes centre of gravity. The chassis will be made from tubular aluminium, which offers great strength-to-weight ratio and allows the project to be cost-effective.

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The kart is fitted with hydraulic brakes to ensure great stopping power, these brakes are very simple to maintain whilst being effective. When traveling down the course the speeds that can be reached will need effective braking, hydraulic brakes ensure the rider is capable to stop and be competitive. The steering used in the soap box is based on a Go-karts steering system. This is an efficient form of steering.

Overall, the final design offers great handling qualities whilst being cost effective and safe. It has a very aerodynamic shape allowing for it to reach high speeds on the course. All materials costs have increased recently; however, aluminium is easy to recycle and abundant.

3 Analysis

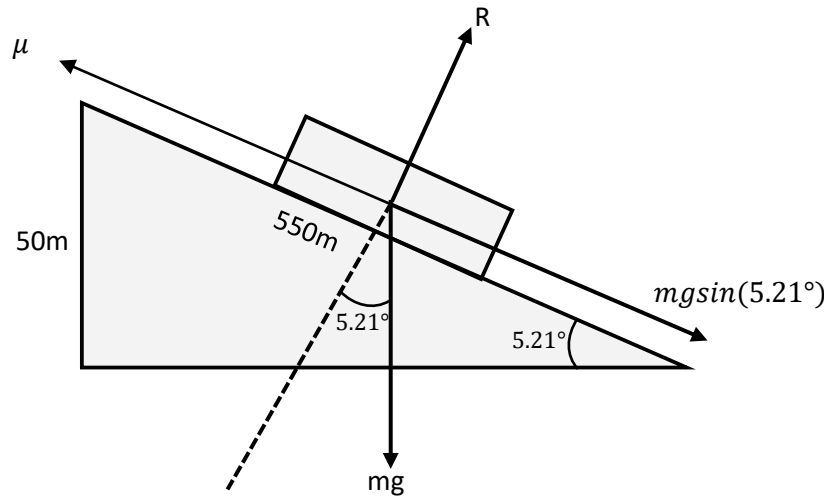


Figure 4 - Above is a forces diagram representing the soap box on the course.

3.1 Estimate values:

Chassis – 19kg value given by Solidworks.

Wheels – 10kg, 2.5kg per wheel

Brakes – 6kg

Steering system – 6kg

Stub axles – 5kg

Seat and seatbelt – 4kg

Shell – 10kg

Total masse of the soap box: 130kg

Gravity will be assumed at 9.81m/s

3.2 Average angle of the slop of the course:

The values for the opposite and hypotenuse have originated from the soapbox regulations. (Richard Castle Soap Box Derby, 2023)

$$\sin(x) = \frac{Opp}{Hyp}$$

$$\sin(x) = \frac{50}{550}$$

$$x = \sin^{-1}\left(\frac{50}{550}\right)$$

$$x = 5.21^\circ$$

3.3 Forces acting downhill:

$$F = mg \sin \theta$$

$$F = 130 \times 9.81 \times \sin(5.21)$$

$$F = 115.81 \text{ Newtons}$$

3.4 Using Newtons 2nd law, rearrange the formula to calculate the acceleration:

$$F = ma$$

$$a = \frac{F}{m}$$

$$a = \frac{115.81}{130} = 0.89 \text{ m/s}^2$$

3.5 Using the SUVAT equations, calculate the time and velocity of the soapbox going down the slope:

3.5.1 Calculate Time

$$S = ut + \frac{at^2}{2}$$

$$2S = ut + at^2 \quad u = 0, \text{ therefore } u \times t = 0$$

$$2s = at^2$$

$$\frac{2S}{a} = t^2$$

$$t = \sqrt{\frac{2S}{a}}$$

$$t = \sqrt{\frac{2 \times 550}{0.89}} = 35.16 \text{ seconds}$$

3.5.2 Calculate Velocity

$$v = u + at$$

$$v = 0 + 0.89 \times 35.16$$

$$v = 31.29 \text{ m/s}$$

3.6 Kinetic Energy of the soap box:

$$KE = \frac{1}{2}mv^2$$

$$KE = \frac{1}{2} \times 130 \times 31.29^2$$

$$KE = 63\,639.17 \text{ J}$$

$$= 63.64 \text{ KJ}$$

3.7 Work Done of the soap box:

$$WD = F \cdot s$$

$$WD = 115.81 \times 550$$

$$WD = 63\,695.5 \text{ J}$$

$$= 63.70 \text{ KJ}$$

3.8 Calculate the theoretical power of the soap box car to then calculate the friction value for μ :

$$P = F \cdot v$$

$$P = 115.81 \times 31.29$$

$$P = 3\,623.69 \text{ W}$$

$$= 3.62 \text{ KW}$$

3.9 Using the formula to calculate Force and the formula for power, rearrange them to calculate the friction (μ):

$$P = F \cdot v \quad F = \mu mg$$

$$\text{Therefore, } P = \mu mg \cdot v$$

$$\mu = \frac{P}{mgv}$$

$$\mu = \frac{3623.69}{130 \times 9.81 \times 31.29}$$

$$\mu = 0.09$$

3.10 Theoretical values:

$$F = 115.81 \text{ N}$$

$$a = 0.89 \text{ m/s}^2$$

$$t = 35.16 \text{ seconds}$$

$$v = 31.29 \text{ m/s}$$

$$\text{K.E} = 63\,639.17 \text{ J}$$

$$\text{W.D} = 63\,695.5 \text{ J}$$

$$P = 3\,623.69 \text{ W}$$

$$\mu = 0.09$$

4 Conclusion

Throughout this assignment the group has used Solidworks to design a model of the soapbox. This group went through design phases of the chassis. Each design is an evolution of the design before, this is shown in figures 1-3. The tubular chassis that has been developed is very stiff which will allow for good handling on the course.

Analysis of the soap box consisted of finding the total weight of the cart. Through Solidworks the group was able to attain the weight of the chassis which was 19kg. However, when looking at the weight the group believes that this may not be correct, and the software may be at fault. When calculating the total weight, the weight of all components were found, and this led to the value of 60kg. The average driver weight is considered to be 70kg. The total weight going down the course would be 130kg. Using this information Newtons 2nd law and SUVAT equations were used to calculate the forces of the soapbox acting down a slope and the theoretical velocity.

Finally, the assignment states the advantages of the final design and the reasoning behind the design. The group has produced a final design with a CAD model as well as analysis on the forces acting on the soap box when in use.

5 References

Richard Castle Soap Box Derby. (2023). *Technical, Design and Structural Regulations*.