

University Of Trinity Saint David

Wales Institute of Science and Art



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

**Report Detailing Information on the Scientific
Calculations for the Soap Box Course and the Process
of Designing Concepts for the Car using CAD.**

Integrating Project (ACHA4008)

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1. Introduction

This report will break down the CAD Design Process of the soap box car and the scientific calculations that were made in conjunction with it. This report aims to give the reader a brief understanding overall of the scientific calculations made as well as the design process of the CAD model.

2. Scientific Calculations (Mass and Forces).

$$Mass = Volume \times Density$$

In order to calculate mass of the frame of our soap box car, the total volume for every beam which will be used to construct it will be needed. For a single beam, the volume is calculated as such:

$$Volume = Height \times Width \times Depth$$

$$Volume = 2cm \times 2cm \times 100cm$$

$$Volume = 400cm^3$$

Given that the quantity of beams needed to construct the frame of our Soap Box car is 13, this figure must be multiplied by 13 to get the true total volume of the entire frame.

$$400 \times 13 = 5200cm^3$$

$$5200cm^3 = 0.0052m^3$$

Bearing in mind that the density for aluminium is universally known as being $2710kg$, we now have every variable needed to calculate mass of the frame.

$$Mass = Volume \times Density$$

$$Mass = 0.0052 \times 2710$$

$$Mass = 14.1kg$$

Body Panels.

To work out the mass for the body panels of the car, all of the previous calculations have to be repeated for using the figures relevant to the panels being used to build the car.

$$Volume = 0.1cm \times 25cm \times 50cm$$

$$Volume = 125cm^3$$

$$Qty \text{ of panels: } 13$$

$$Total \ Volume = 125cm^3 \times 13$$

$$Total \ Volume = 1625cm^3 \ (0.001265)$$

$$Density \text{ of Steel: } 7850kgm^3$$

$$Mass = 0.001265 \times 7850$$

$$Mass = 9.93kg$$

$$Mass \text{ of Bucket Seat: } 10kg$$

$$Mass \text{ of 4 wheels: } 9.4kg$$

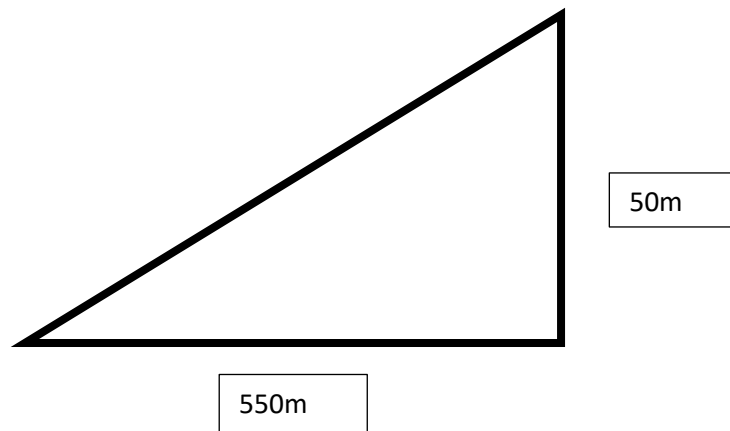
Total Mass of Car.

$$38.43kg$$

Potential Driver Weights.

$$Lightest = 53kg$$

$$Heaviest = 114kg$$

Richard's Castle Soap Box Derby Incline Calculations.

$$\tan \theta (50/550)$$

$$\theta = \tan^{-1} (50/550)$$

$$\theta = 5.19^\circ$$

$\therefore$ Average track incline = 5.19°

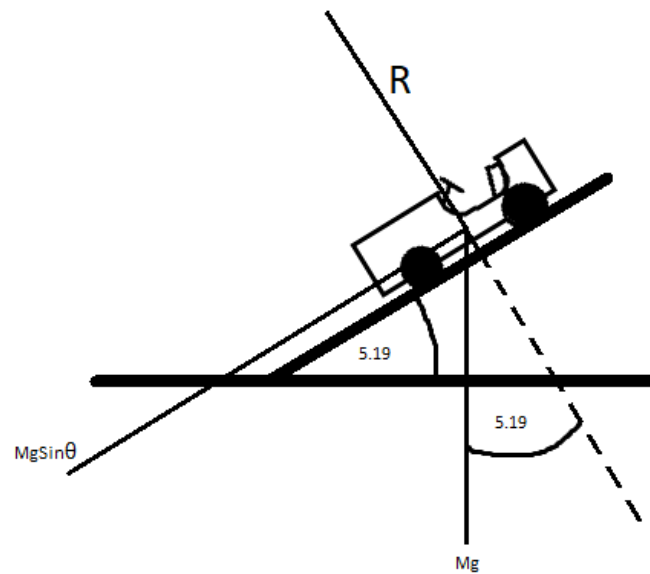
Weight Calculations at 3 Driver Weights.

Lightest Driver = 53kg

Middle Weight = 80.84kg

Heaviest Driver = 107.96kg

(Soap Box Derby | Richards Castle | Race Your Carts 26th June 2022, n.d.)

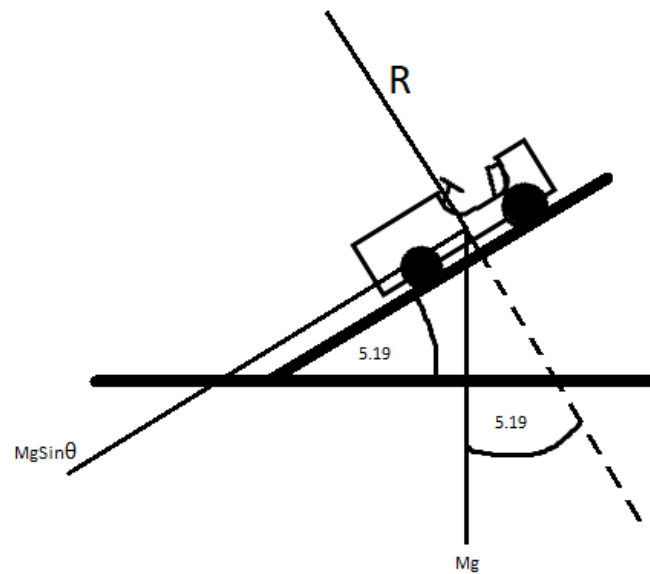
Heaviest Possible Car Weight ($107.96 + 38.43 = 146.39\text{kg}$)

$$Mg = 146.39 \times 9.81$$

Forces Downhill

$$Mg\sin\theta = (146.39 \times 9.81) \sin 5.19 = \underline{129.91\text{N}}$$

^ Force of Weight Pulling Downhill ^

Middle Car Weight ($80.48 + 38.43 = 118.91\text{kg}$)

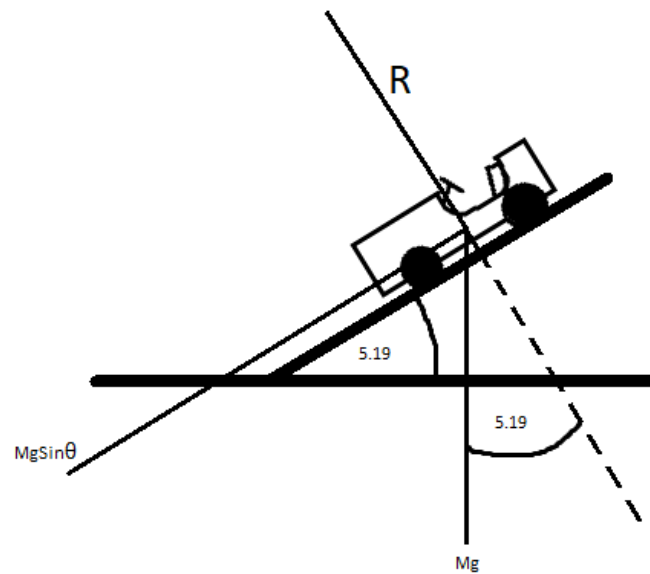
$$Mg = 118.91 \times 9.81$$

Forces Downhill

$$Mg\sin\theta = (118.91 \times 9.81) \sin 5.19 = \underline{105.52\text{N}}$$

^ Force of Weight Pulling Downhill ^

(DIPLOMA COURSE IN ENGINEERING FIRST AND SECOND SEMESTER, n.d.)

Lightest Possible Car Weight ($53 + 38.43 = 91.43\text{kg}$)

$$Mg = 91.43 \times 9.81$$

Forces Downhill

$$Mg\sin\theta = (91.43 \times 9.81) \sin 5.19 = \underline{81.14\text{N}}$$

^ Force of Weight Pulling Downhill ^

2.1. CAD Design.

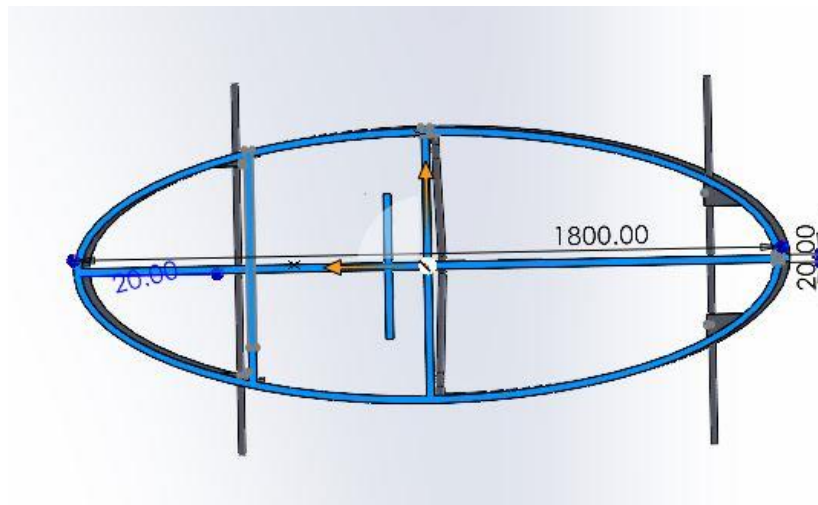


Figure 1: A top view of the CAD design for the frame of the soap box car in question.

Chassis:

starting with the basic chassis of the car, it was desirable to make the soapbox car an oblong shape with two axles and four wheels. Firstly, the centrepiece that goes down the centre of the car was designed and that provided a basis to build from. Once the frame of the car was made, posts for the seat mount were added, along with a steering shaft with a male end so that a steering wheel could mate onto it. A front and rear axle was designed then that would be held on by U-clamps to demonstrate how the axle would be fastened. Once these components were created, the design advanced to make the wheels, seat and steering wheel.

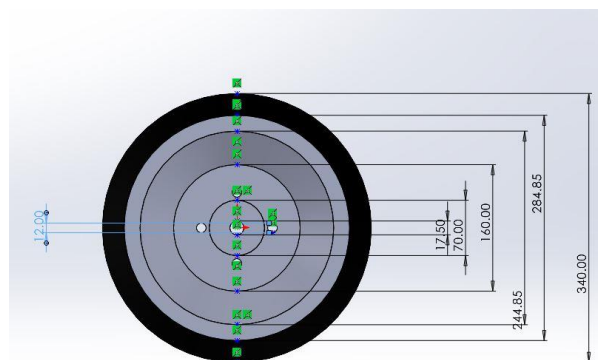


Figure 2: A CAD Design of the Wheel Rim.

Wheels:

For the wheels, a revolve feature had been utilised as this option would make the design process less complicated to make the process of designing round objects with detail and depth easier. The wheel rim was designed first giving the face a 45-degree angle to create a negative offset so that the rims would have more width therefore more tires can be made. The rims would be based on something similar to a go kart. Once the wheel rims were made, a tyre was then designed, and the paint feature was used to better demonstrate the difference between the tyre and rim.

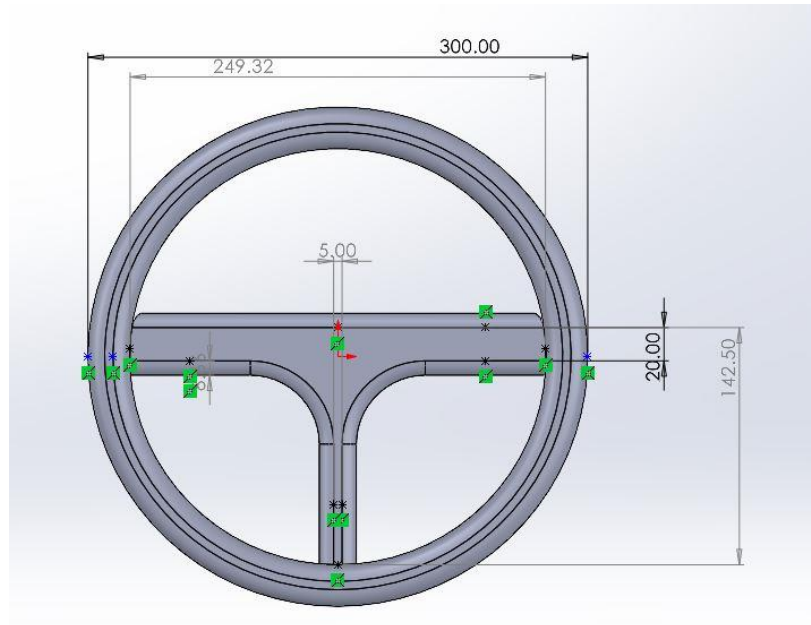


Figure 3: A CAD Design of the steering wheel for the soap box car including dimensions.

Steering Wheel:

In the case of the steering wheel there had to be designed a round object with ergonomic spokes in the centre, this was done by making a 2D shape on top view and using the extrude boss tool they were made 3D at different levels. Once that was done the fillet tool was used to round off the edges to make it seem smoother. The design of the back of the wheel was then worked on to make the female end of the steering shaft so that it could mate the steering wheel to the steering shaft easily and doing so will allow the steering wheel to turn on the shaft. The Extrude Boss and Extrude Cut tool was used to create the shape that was desired.

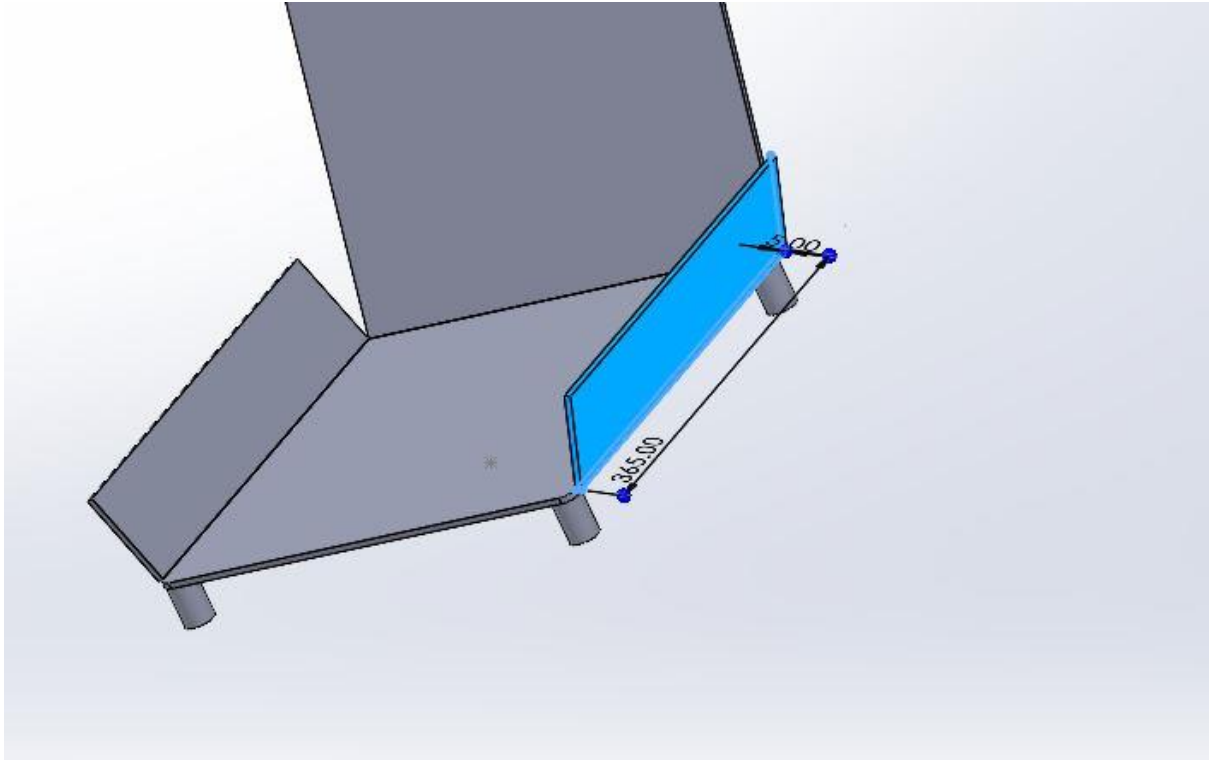


Figure 4: A CAD Design of a seat for the soap box car with dimensions.

Seat:

For the seat the four posts on the chassis were measured and then the seat was made to the appropriate dimensions, the seat started with the base, and using sketch fillet tool, the angles that the back and the sides of the seat have were made, this gave the seat an aggressive racing look which is what the soapbox car is going to be used for. Then the four female posts at the bottom were made which will allow it to mate to the car at the perfect place.

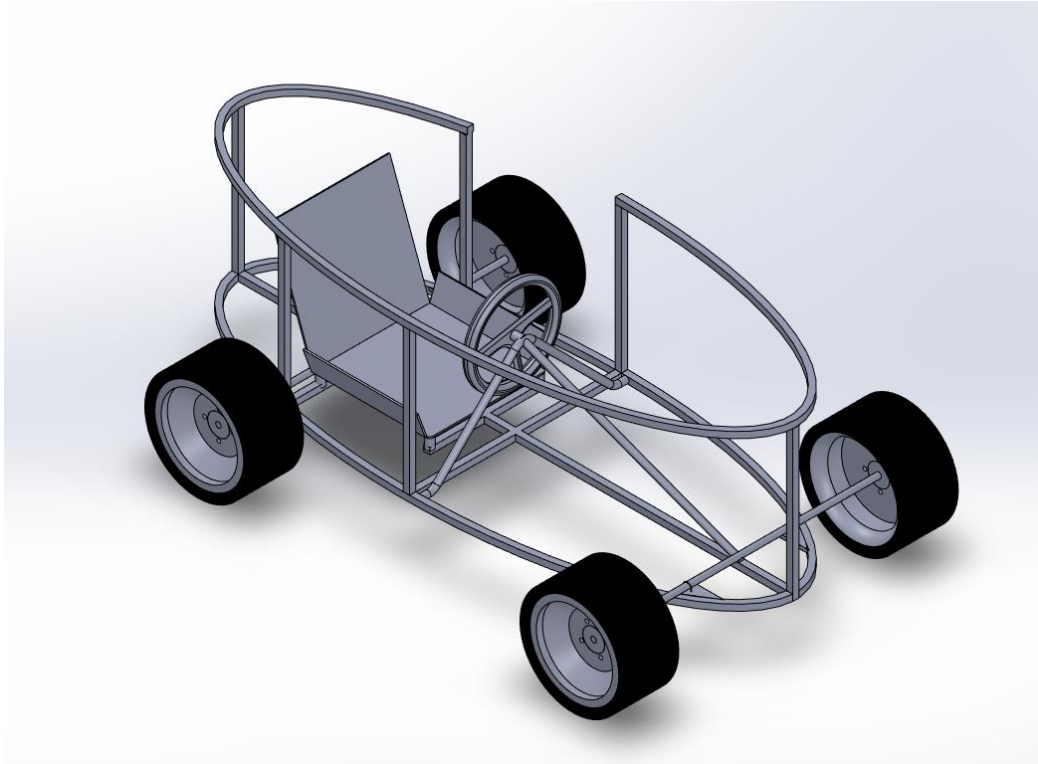


Figure 5: The full CAD assembly of the soap box car after all sub-components had been mated.

Assembly:

The assembly started off with the chassis as this would be easiest as all the other subcomponents are going to connect to it. Once it was inserted in assembly mode, the wheels were the first sub-component that were mated to the frame. The wheels were mated onto the axles, and it had been mated in such a way that all four wheels can rotate. Then the steering wheel would be mated to the steering shaft, this was very simple due to the male and female ends that had been made earlier. Then finally the seat had to be mounted with the mate tool but making sure the seat was fixed as opposed to rotating as obviously you do not want that it to move under force.

2. Conclusion

In conclusion its evident from the contents of this document that all of the necessary research has been carried out in order to satisfy the development of this soap box car, and the project is in a position to be carried forward into further development and manufacturing.

3. References

DIPLOMA COURSE IN ENGINEERING FIRST AND SECOND SEMESTER. (n.d.).

Soap Box Derby | Richards Castle | Race your carts 26th June 2022. (n.d.). Retrieved May 12, 2022, from <https://www.richardscastlesoapbox.co.uk/>