

University of Wales Trinity Saint David

Wales Institute of Science and Art



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Integrating Project - ACHA4008

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1.Admin

Team Name: Newton's Knights

Whilst designing the soapbox the team met up on multiple occasions. Initially to discuss roles of each team member and overall design philosophy and meeting up to talk about progress. With the initial meetings being in November we then had a series of follow up meetings up until the 12th January. We used a variety of ways to communicate as a team. Besides from meetings we used Teams to share documents so we were able to work effectively as a team to use a file we could all edit simultaneously to work collaboratively. Along with using chats on teams and other platforms to communicate efficiently.

2.Driveability

2.1 Overall design

The design of the soapbox is inspired by a modern interpretation of vintage cars like the Cooper-JAP MKVIII formula 3 car due to their weight, simplicity and subtle tapered body good for aerodynamics close to the ideal teardrop shape. The philosophy of this design was also based around durability, where we utilise components found on road cars and incorporate them into the design as we believe this will be beneficial after multiple runs down the rough road of Richard's castle. Based on a simple spaceframe chassis like the Cooper. The spaceframe chassis offers great torsional strength that'll help during cornering. And with the torsional rigidity being stronger but more complex relative to other designs such as the ladder frame design upon review of the course it is a high-speed course with only a couple of corners. So whilst a spaceframe design is good for cornering ability, a simplified design will allow for good cornering performance we can remain lightweight with slightly easier fabrication. The overall length of the soapbox will be 2450mm long ± 25 mm to optimise the length available, but with room for error in case of discrepancies to ensure it passes scrutineering. The overall width will measure 1400mm ± 25 mm with the chassis being 950mm ± 25 mm at the widest point, a decent combination of width for stability whilst minimising the frontal aerodynamic profile to

help with straight line speed/weight. The height of the soapbox will be 900mm $\pm$ 25mm excluding the roll bar which will depend on the driver's height as regulations state that the bar must be 35mm above the centreline of the driver's helmet and 25mm above their hands.



THE COOPER-JAP MKVIII [BONHAMS CARS](#) : 1954 COOPER-JAP MARK VIII FORMULA 3 SINGLE-SEATER CHASSIS NO. MK42/54 ENGINE NO. JOS/D22346/7

2.3 Wheels

Wheels are key in soapboxes for good handling. The less unsprung mass the better, which allows for easier and more responsive steering. The regulations state that they recommend a minimum ground clearance of 50mm to clear the start ramp, tyre size will heavily affect the ground clearance. Aiming for a small rim size with a relatively low aspect ratio will allow us to have a small rim lowering weight without having to go for an excessively high sidewall stopping lateral movement whilst cornering. The distance of the hub to the undercarriage is 215mm. Therefore, the wheel/tyre size required would be 175/70 R13. As seen in the equation below:

$$13inch \times 25.4 = 330.2mm \text{ (rim size)}$$

$$175 \times 0.70 = 122.5mm \text{ (sidewall height)}$$

$$575.2 \div 2 = 287.6mm \text{ (radius)}$$

$$287.6 - 215 = 72.6mm \text{ (clearance)}$$

This figure does not consider the depression of the suspension. Assuming that the soapbox weighs 80kg and the driver 70kg. Partially using the front suspension system

from a Caterham 7 and the rear from a Westfield kit car with suitable dampers for a lighter application. For simplification assuming all corners of the vehicle have a spring rate of 30 n/m and a 50/50 weight distribution.



This show using springs with a constant of 30N/m, leaves 60mm of ground clearance. Not taking into account preload, which leaves 10mm available for preload. Which should leave enough to clear the start ramp whilst remaining low enough to have a lowered centre of gravity to help through corners.

3. Chassis Systems (brakes/suspension/steering)

The Chassis will be a tubular design due to it being lightweight yet strong and durable. This design for the project soapbox car would be ideal for maintaining the structure of the car when it is in operation. Depending on the shape and geometry of the tubular chassis it can allow for better aerodynamics eliminating factors like air resistance allowing for faster times on a track. Although the tubular chassis has limitations such as how complex some designs maybe to manufacture due to the design needing accurate welding and fabrication techniques.

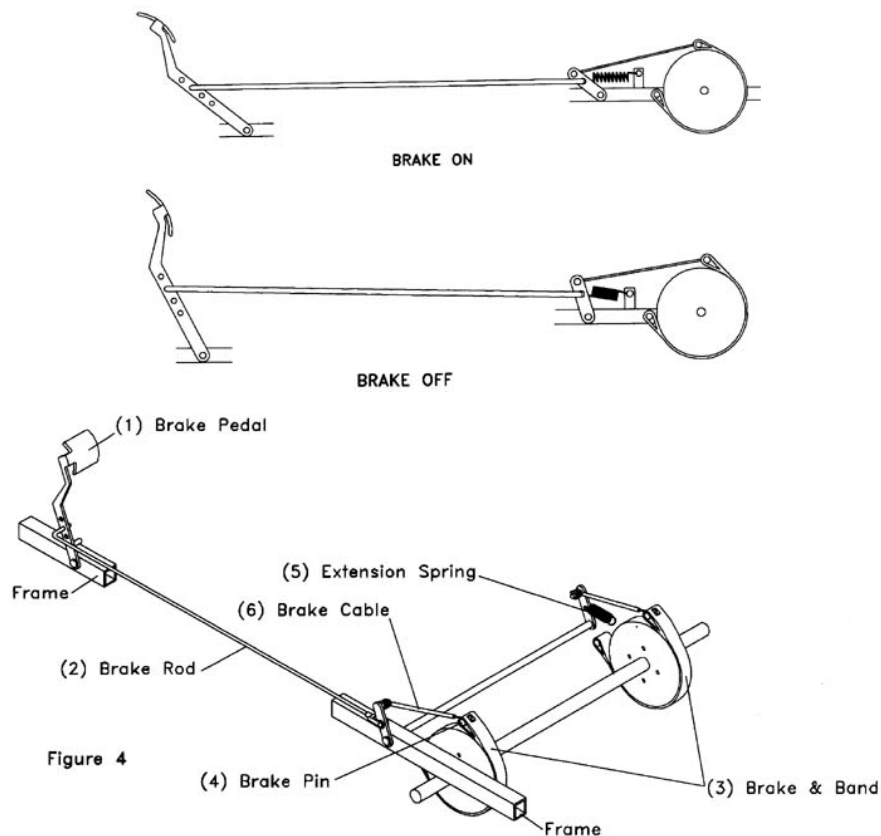


(Example images from facebook marketplace displaying the tubular chassis designs)

It is important to have a sturdy frame to support the body of the soapbox car during races due to the types of terrain it'll be facing, Improper placement and alignment of components can eventually lead to issues with control and balancing. The tubular chassis' weight will affect the speed, stability and manoeuvrability of the soapbox car especially when the body is also installed in the final assembly.

Brake system

The brake system is crucial as it is also a safety precaution. The brake pedal will be located on the floor of the footwell. This placement will allow the person operating the soapbox car to easily access the brakes while still being able to maintain stability steering. The brake system should be functional for quick and effective braking. Simple disc brakes would be a good choice because they can provide strong and consistent stopping power.



(Example source from <https://www.buildyourowngokart.com/oneperson/BrakingSystem.php>)

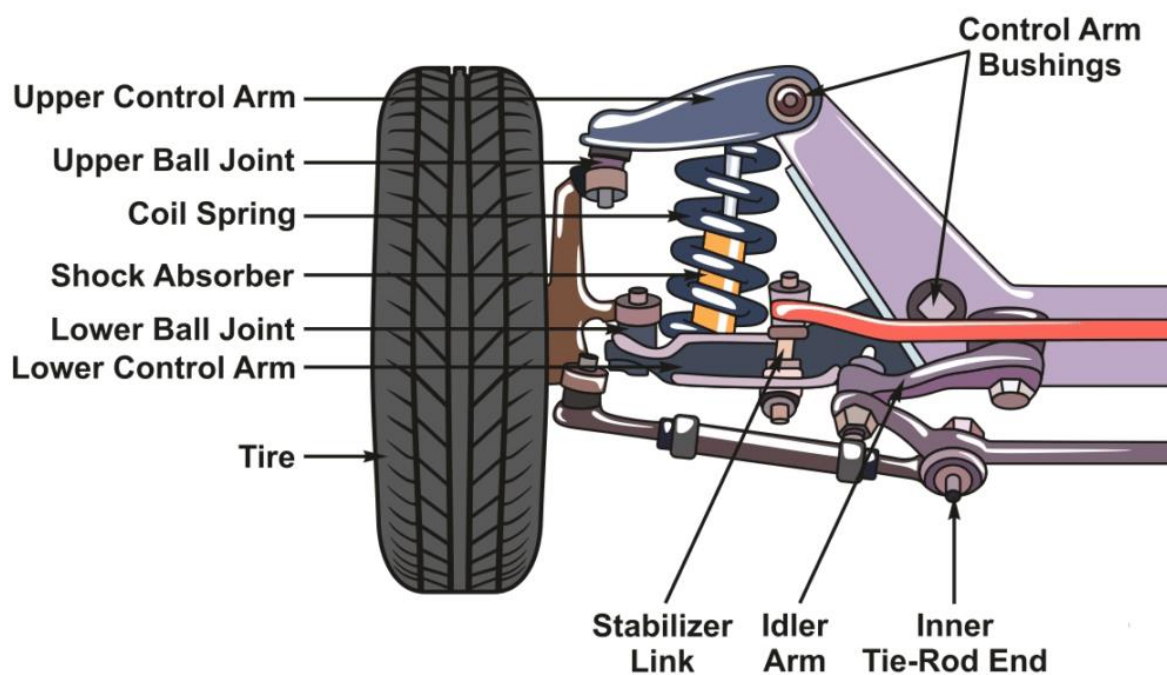
Unlike friction brakes, disc brakes allow for better heat distribution which is necessary for the prolonged use and operation of the soapbox car. Having disc brakes will allow us to use the system in riskier environments and weather conditions compared to the

friction brakes. Although a disadvantage that comes with disc brakes is that they are heavier than friction brakes which might affect the performance of the soapbox car.

In addition to this if a repair cost is required it would be more expensive to replace disc brakes than it would to have friction brakes.

Suspension

Coil springs compress and expand easily allowing them to provide comfort while operating and be faster on tracks through the ability of increasing performance. They can effectively absorb shock helping the soapbox car keep in contact with the ground, this will improve our traction and further increase stability. They are relatively lightweight and can be adjusted to different levels of stiffness.



(Example source from <https://cu8hdau071bc73amm75g.enhanceconnection.co.in/01-v2/?cid=9de27154c91>)

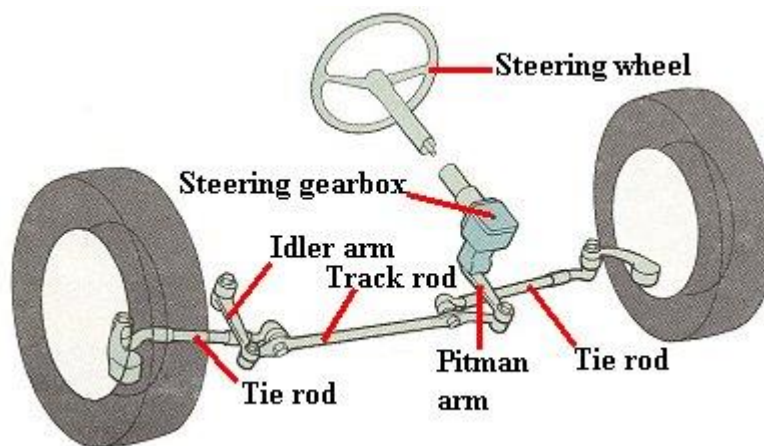
Although Coil springs can be quite complex to design and manufacture and if not properly tuned the soapbox car will not have appropriate handling characteristics. Coil springs also require maintenance, repairs and replacements to run at their highest

capacity. The soapbox must have shock absorption in conjunction with the coil springs to help manage the springs oscillation and improve the quality of ride while operating the soapbox car.

Steering

A simple tie rod connected steering mechanism would be both responsive and functional. Having this system installed on the soapbox car would mean we would have precise control over the movements and direction of the car via the steering wheel.

The pivot points within the steering system will allow for smooth rotation of the steering wheel, proper wheel alignment is important as the front wheels should be parallel to each other and perpendicular to the ground, so that the car can be stable during operating.



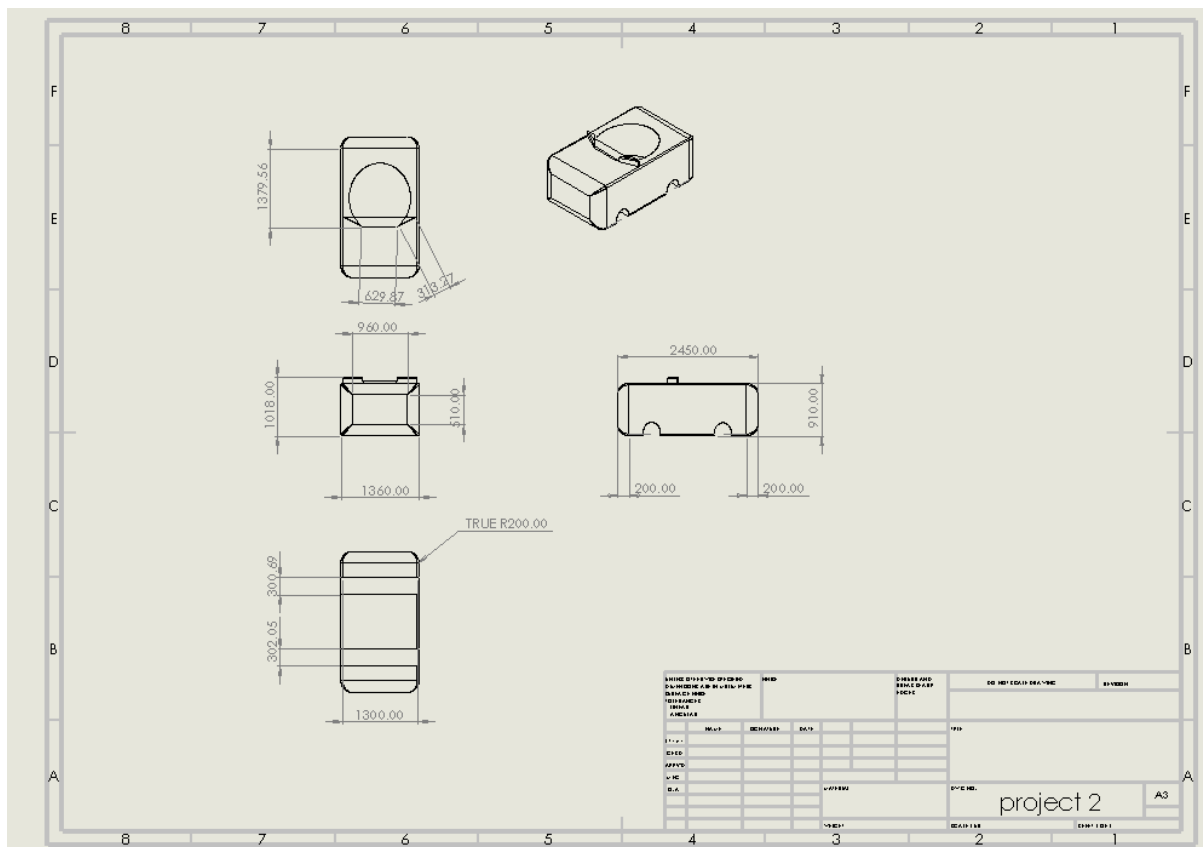
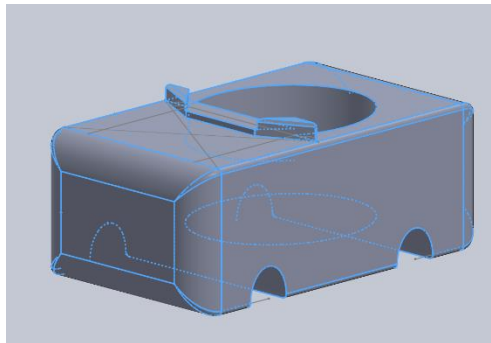
(Example source from schematiccables.z13.web.core.windows.net)

Aluminium would be the optimal lightweight material for the steering system, it's important that the material is strong enough to withstand the forces exerted while carrying out steering manoeuvres. Once the soapbox is assembled, we should test the steering system and evaluate its performance, making adjustments as we see fit and as we go along to ensure there is no chance of malfunction in public or without warning.

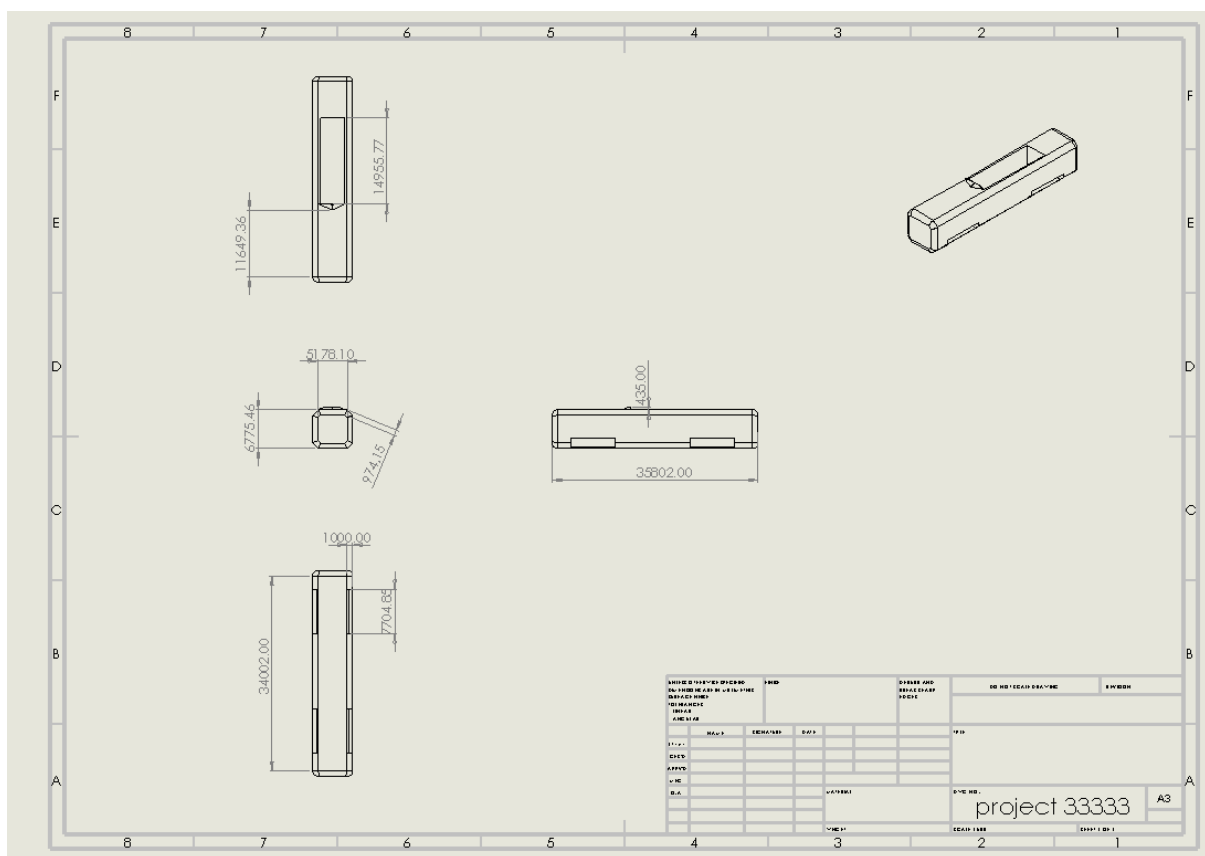
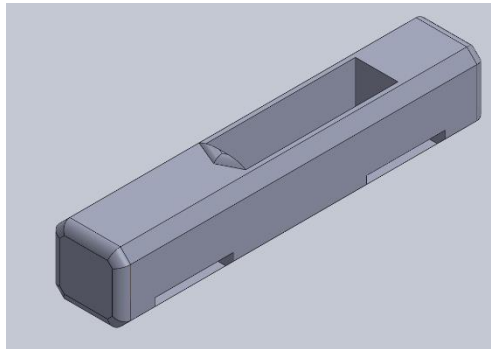
3.1 Draft Designs of body

Using Cad draft designs for the soapbox car were created.

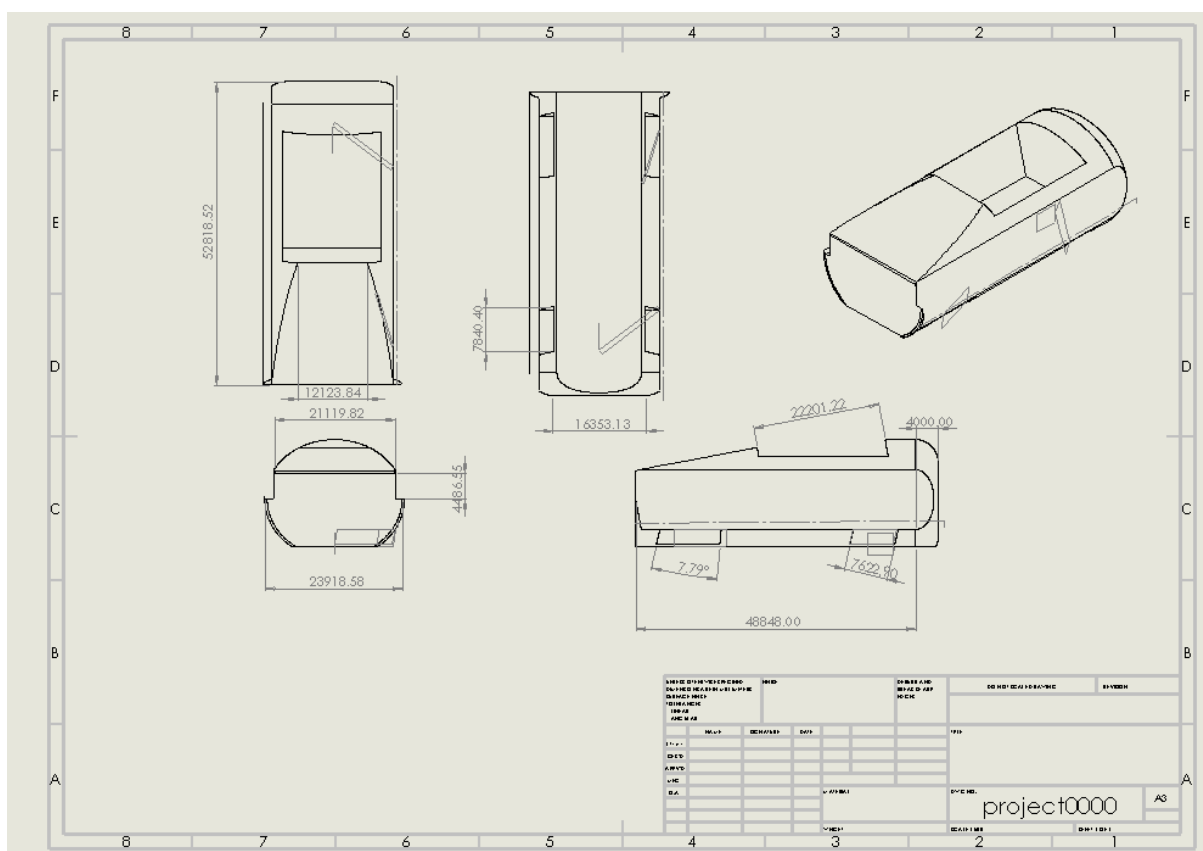
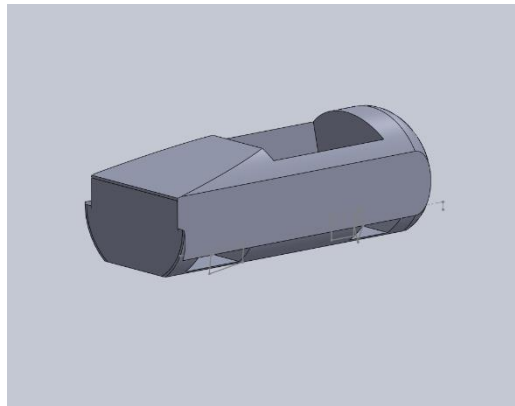
First design draft 1



First design draft 2



First design draft 3



Analysis

First design 1

Strengths – The design is simple and would be easy to manufacture using plywood meaning when the body is complete additional time can be spent on the chassis or the steering system

Weakness – The design lacks a profile and would not do well in subpar weather conditions this design would need a lot of power to function

Opportunities – since the design is not complex more time can be allocated to researching other areas in the project or adding cosmetics

Threats – The weight of the front and back is too heavy, a lot of the weight could have been reduced through the design

First design 2

Strengths – pencil like design allows for less contact with the air

Weakness – balancing and steering will become harder manoeuvres to pull off which may lead to more crashes overall

Opportunities – improving on this design could lead to a balanced soapbox

Threats - more dangerous to drive as the incline of the seat would be closer to a race car

First design 3

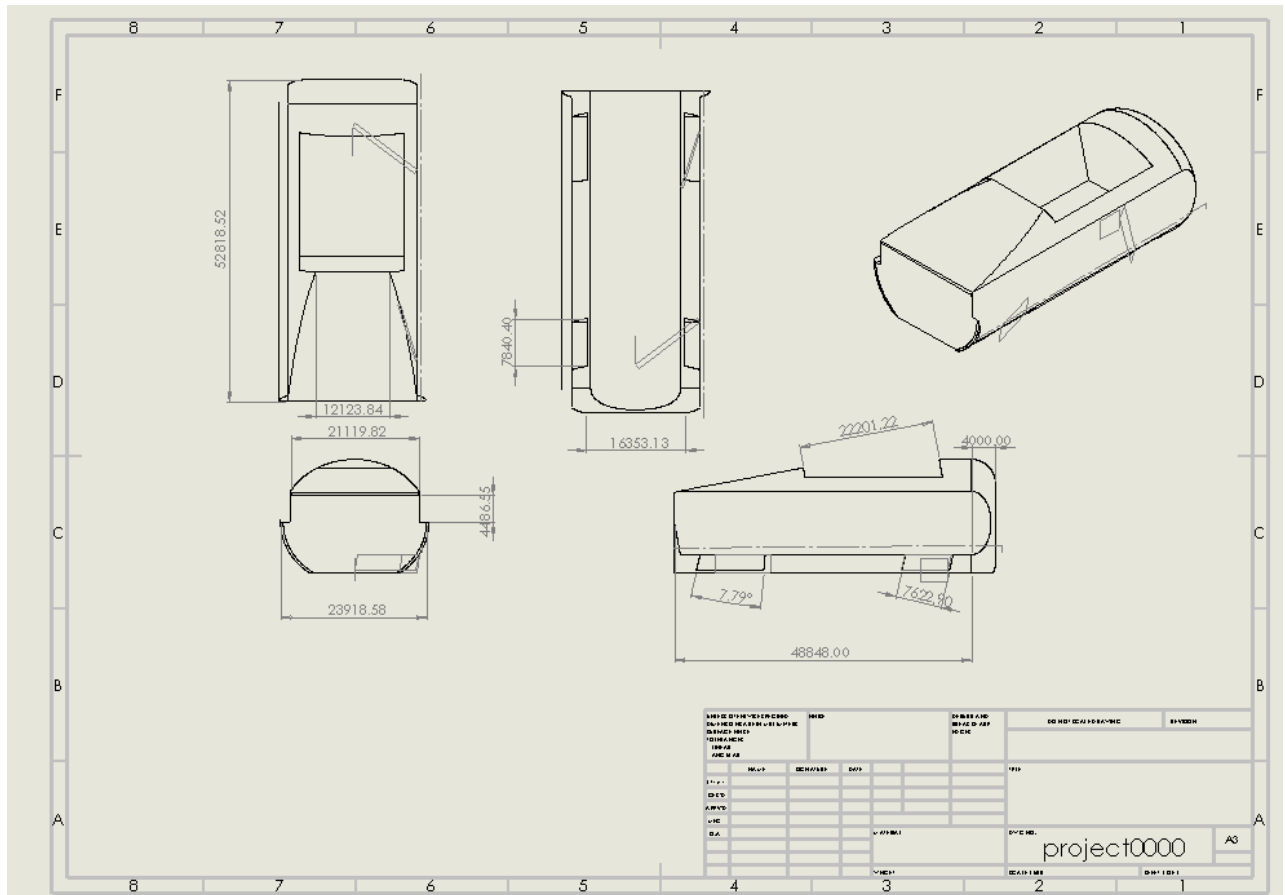
Strengths – unique design, which is balanced and stable yet still contains elements of trying to be aerodynamic

Weakness - unique design means more panels and parts are going to have to be made and it would be longer to draw it in 2D to make technical drawings for it without CAD

Opportunities – Continuing this design in conjunction with the tubular chassis would be highly effective towards weight distribution and the performance

Threats – in a second draft areas to place components need to be altered meaning time would be taken out of the project

Final decision – First Design Draft 3



FDDa3 (first design draft 3 formerly project0000) has been choice to be the team's design moving forward.

Here are some key aspects of the FDDa3 we will be looking to improve upon:

Design:

We must ensure that the tubular chassis aligns FDDa3 so that they can be functional together, changing the front to something more aerodynamic or at least adding appropriate air intake are more things that could be altered on the FDDa3 that could enhance performance and aesthetics.

Performance:

We must start to analysis and monitor the outputs and limitations of our soapbox car. The design of FDDa3 must adhere to performance and this must be seen throughout the rest of the projects design A more streamlined design should be implemented to help further reduce air resistance, which will allow for faster speeds. We should try incorporating more shapes that would optimize airflow. Lowering the chassis would also help lower the center of gravity.

Manufacturing:

We must find a way to improve our CAD so we can use more advanced techniques and machinery to do our manufacturing and construction like incorporating CNC machinery and software.

In future we will improve our manufacturing process by investigating the strength of the materials needed, allowing us to pick the one most beneficial.

Materials:

We must start the use of composite materials such as fiberglass and carbon fiber. Which have additional perks like excellent strength to weight ratio. These materials also have benefits to speed and manoeuvrability and in some cases can withstand significant stresses and impacts making them a useful material for future designs.

Materials and Costing

There are many different materials to consider when constructing a soap box car, as their driveability and structural rigidity can vary significantly based on the materials chosen. Some common materials are:

Wooden boards, such as Plywood are quite common in the construction of bodywork on soapbox cars due to its relatively low cost, its light weight, and because it's an easy

material to work with, as it can be cut and shaped with regular garden or household tools, such as hand saws. However, in high-speed accidents with the amount of momentum a soapbox car can generate on the course at Richard's castle, it wouldn't hold up particularly well and would need to be completely replaced, which as mentioned it makes up for with affordability. It's also very easy to purchase, as it can be found at most hardware stores, such as B&Q.



Aluminium is another option for the bodywork of the soapbox, as like plywood, it is lightweight, and very durable. Aluminium can also be manipulated into different shapes without breaking, if it needed to curve around the frame for a more aerodynamic body shape than the straight lines you can get from wooden boards. Aluminium is however much more expensive per square meter, and cannot be found in sheets quite as large or as thick as plywood. It is also significantly heavier than plywood.



Steel is a very strong material structurally with little flexibility. This makes it ideal for the chassis of a soapbox car, as it will perform well on the rough course at Richard's castle, holding the driver and all of the other vehicle components in place. Steel is generally quite heavy however, and difficult to work with, as different parts would need to be welded together to construct the vehicle chassis.



Ideally, our soapbox would have a steel frame for the rigidity, and a low centre of mass enabling it to stick to the track, and take corners at much more significant speeds, reducing the time down the hill. Combined with an aluminium body, for better aerodynamics over a wooden body due to how it can be manipulated into almost any desired shape. Aluminium would, like steel, stay in good condition over multiple runs of Richard’s castle, and need less repairs or maintenance than a wooden frame or body that is susceptible to fatigue and cracking much sooner than metals.

There are many other costs in this project, aside from the materials used in the chassis. For example, the wheels. A set of 4 wheels to the specifications found earlier are available brand new on ebay at £329.99, though as they are a standard trailer size, they could be found used for less if required. Similarly, compatible wheel hubs can be found in hardware stores for a similar price, these ones from B&Q at £342.87



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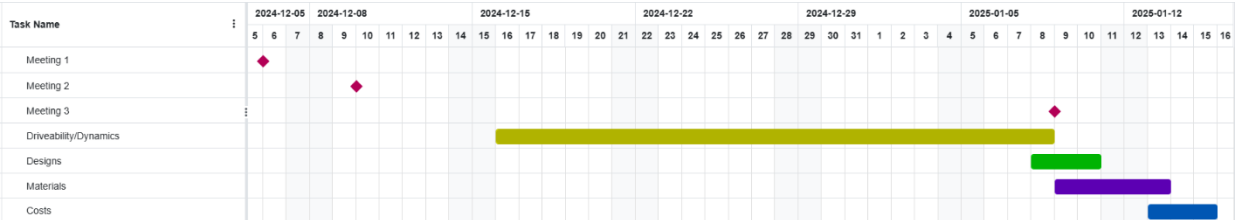
Wheel Bolts Indespension

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Available online only and not stocked in B&Q stores

★★★★★

£342.87



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