

University of Wales Trinity Saint David



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Wales Institute of Science & Art

Project First Report

Integrating Project ACHA4008

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Team F – Soap Box Car Project

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Introduction and Aims

Our aim is to design a viable soapbox car following the regulations set by Richards Castle Soap Box Derby 2023. We will be conducting extensive research on each area needed to develop a soapbox car. The team managing the organisation and communications for the project will focus on team time management and organising meeting minutes, using tools such as Gantt charts and recording the minutes and therefore actions from each gathering.

The team member managing the design work will create different design options for the soapbox by creating rough sketches and different design techniques. This role will also focus on discussing the benefits and drawbacks of each and why we ultimately chose the design that is put forward.

The materials section of the project will involve research into different materials that would be most suitable for the project and to create different parts for the chosen soapbox design. Finance and costing will be a part of this section of the project and will be compiled using the results of research carried out on the cost of potential materials to be considered for the soapbox.

The dynamics and driveability section will include the technical aspects of the soapbox such as braking, suspension aerodynamics etc.

Materials

Plywood (AI-generated suggestion, ChatGPT) will be used for the main body of the car to provide strength but keep the car lightweight. It can be used to create the main body and other structural components. Plywood will be the main material used and most likely make up most of the soapbox. The maximum length of the soapbox from front to rear must be 2500mm and the maximum width measured from outside to outside must be 1500mm. (Richards Castle soapbox derby 2023 regulations)

Steel rods (AI-generated suggestion, ChatGPT) can be used for the underbody, chassis, roll cage, axles and possibly for the steering mechanism. (Ellison, 2022) Steel is very easy to acquire and work with making it a good material to use. Steel has a good weight distribution allowing for the chassis and roll cage to be equally weighted. Another benefit of using steel is its compatibility with welding, it is a very easy material to work with and is very versatile. The soapbox requires a strong and durable enough to stay intact in the event of a crash, this can be achieved by using steel rods. They will need to be welded together and will act as the main chassis of the car.

The wheels must be fitted with pneumatic tires (AI-generated suggestion, ChatGPT) to follow the regulations that have been set. (Richards Castle soapbox derby 2023 regulations) The wheels will be made from stainless steel to provide strength and stability. Our design has four wheels, one in each corner. The wheels will need to raise the soapbox at least 50mm from the ground to follow the regulations.

The steering mechanism will be made from welded steel to ensure it does not break during use. It will be a simple mechanism using a rod from the steering wheel that will be welded to a perpendicular rod attached to the wheels. (Figure 1: Reddit user u/Randomcrafter)

The seat will have padding on it to ensure safety in the event of a crash. The padding will be made from foam, possibly using pool noodles or something similar as they are cheap and lightweight, and they will be able to absorb impact forces.

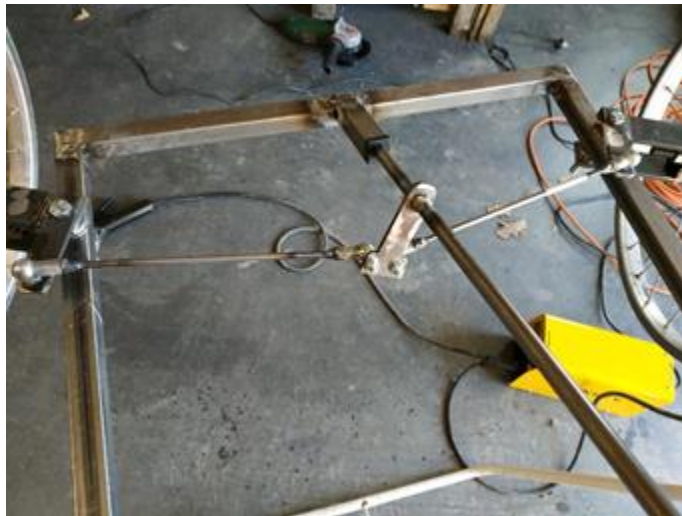


Figure 1 (Source: https://www.reddit.com/r/metalworking/comments/audnzy/steering_system_for_my_son_soapbox_lots_of_small/?rdt=62984)

Costing

When building a soapbox, the main costs we will run into are materials, tools, safety gear, labour, and any optional features we want to add onto our soapbox.

As buying machines for welding or machining is economically unviable for us as a team, we will have to look at using handheld, cheaper manual tools to machine and weld our individual parts together.

For the materials, we have chosen a blend of plywood and steel for the body work, suspension and steering systems, rubber pneumatic tires and seat padding made of foam.

We have looked at different kinds of wood, and as a team decided that making the bodywork out of plywood would be our ideal material. Compared to woods like hardboard or MDF, as they're very densely compacted wood, the stress limit and elastic limit are much lower compared to plywood.

Material	Cost per M ²	Amount Needed	Total Cost (£)
Plywood	10.75	500m ²	5375
Steel rods	32.6	250m ²	8150
Pneumatic tires	N/A	4 Tires	200
Seat	N/A	1	150
Brakes	N/A	4	72
Steering system	N/A	1	300

Table 0-1 Amount Needed and Cost of Materials

Tool	Cost (£)
Mitre Saw	65
Handsaw	12
Torque Screwdriver Set	140
Welding Torch	30
Electric Drill + Impact Driver	150

Table 0-2 Tools and their Cost

Equipment	Cost (£)	Total Cost (£)
Welding Helmets	30	150
Overalls	50	250
Gloves	10	50
Boots	40	200

Table 0-3 Equipment and their Cost

Panel Products - Mechanical Properties			
Panel	Density - ρ - (kg/m ³) (lb/ft ³)	Fibre Stress at Elastic Limit - σ_y - (MPa) (psi)	Modulus of Elasticity - E - (GPa) (psi)
Hardboard	900 - 1000	31 - 56	3.1 - 5.5
MDF - Medium Density Fiberboard	700 - 900	36	3.6
Particleboard	600 - 800	15 - 24	2.8 - 4.1
OSB - Oriented Strandboard	500 - 800	22 - 35	4.4 - 6.3
Plywood	400 - 600	34 - 43	7 - 8.6

Table 0-4 Showing Density/Elastic Limit/Elasticity of Potential Woods

In total we are looking at spending a total of approximately £15,294 on all the materials, tools and safety equipment we require to construct our soapbox.

Dynamics/Drivability

The chosen design for the Soapbox is this sketch—figure 2.

We have decided to use the maximum length and maximum width for the soapbox including the tyres that the regulation can allow as this can significantly affect the manoeuvrability and performance of the soapbox. Utilising a wider soapbox affects the stability and its cornering ability, allowing higher cornering speed at a turn due to a lower weight transfer. (Reid, 2017)

The soapbox is designed as an open-wheel car as it utilises fewer materials which reduces material costs compared to a closed-wheel car. This also reduces the drag on the soapbox as it lacks the bodywork encasing the wheels. (MOTORSPORT ENGINEER, 2021)

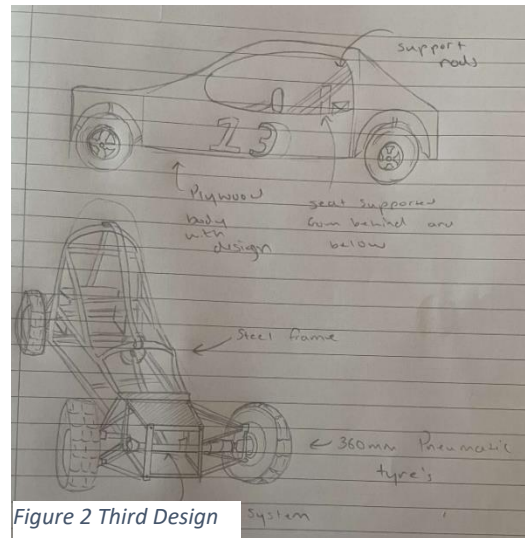


Figure 2 Third Design

Steering System

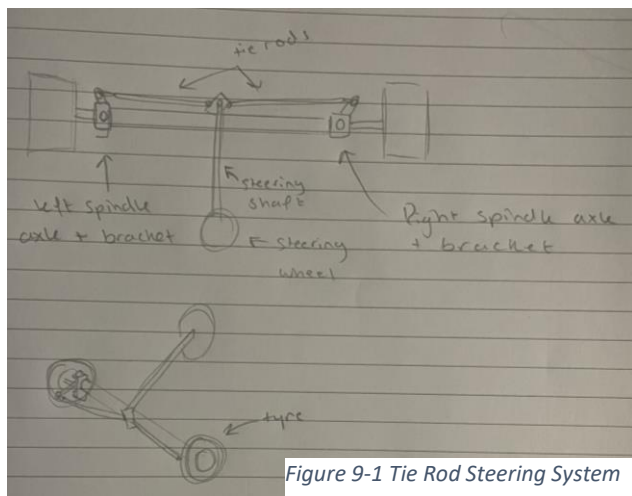


Figure 9-1 Tie Rod Steering System

Our soapbox will operate on a steering system that consists of a tie rod kit that uses two tie rods connected to the steering shaft or “hub” which each end of the rod connects to the spindle axles and brackets. This is a simplistic yet effective steering system for a soapbox. It does the job of steering the soapbox in the desired direction but also, this system keeps the budget cost low as the parts are cheap and it requires fewer parts to produce.

There are other steering systems that we could have utilised. An example is Rack and Pinion Steering, Recirculating ball Steering and Worm and Sector Steering. These steering systems are great, but they will cost more and include more parts.

Brake System

The brake system that our soapbox will operate on is the standard disc braking system. It has proven the most effective brake system as it is widely used in the industry. It is commonly used in cars, motorbikes and bicycles. Disc brakes provide a higher stopping power than any other brakes and are less prone to brake fading due to being able to dissipate heat more efficiently. (Cotta, 2021)

The disc brake system in our soapbox will utilise a foot-operated pedal imitating the car's brake system. The pedal is connected to a master cylinder full of brake fluids with two brake lines connecting to each calliper which then press the brake pads into the disc brake when the pedal is depressed.

Organisation & Communications

Fluid communication and thought-out organising were crucial for the success of this project.

Different aspects of the project were split between each member of the team. Our team abided by a bi-weekly formal meeting schedule, a measure we took to unimpeded our other studies. As such, it was crucial that the time we spent speaking about the project was put to good use.

We strived to make our in-person meetings focused on the project and encouraged taking notes beforehand to have talking points at hand.

Even still, most of the work was done independently. As every system and aspect of this project relied on others, we had to ensure we were able to communicate and collaborate smoothly, even when not in person.

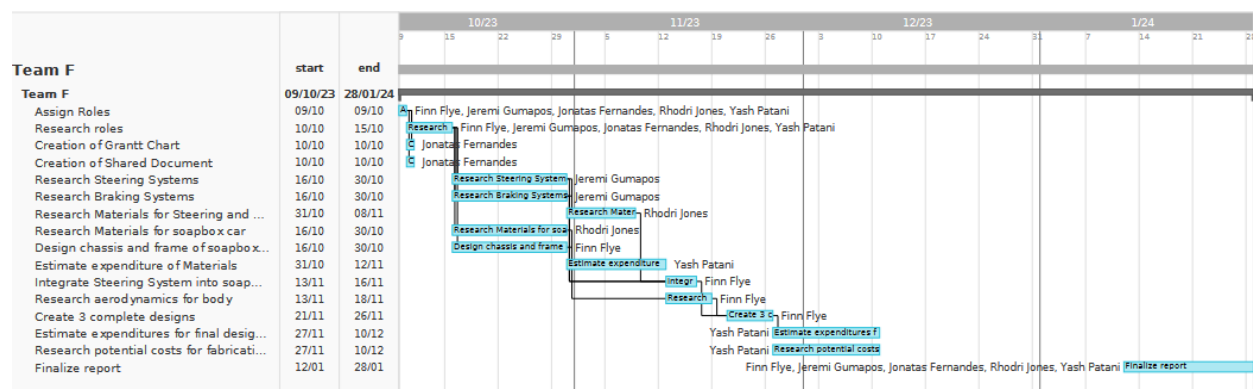
To satisfy this, we created a shared document that could be worked on concurrently. Not only could we all collaborate in real-time, but we used certain features included in these services, like comments, to communicate quickly between departments. If one person needed some information on what materials would be viable for a specific application, leaving a comment was an easy way to prompt a response.

For communication outside of the shared document, we also created a group chat in an internet messaging service, having a dedicated platform for discussion was useful when perhaps the topic of discussion was a bit too complex for simple comments.

A major concern that persisted throughout the project was time management. For many of us we had not had much experience in a group project with a long deadline, and making sure we were on target was imperative. Gantt charts, which were listed as a requirement in the briefing for this project, fit the bill for managing how much time we spent on each section. After our first meeting, we laid out roughly how long we thought each section would take, and what those sections would be. And as we went on and got a better scope of the requirements, the Gantt chart morphed to better suit our developing ideas.

It was an interesting concept for us to explore, most of us have some intrinsic time management for day-to-day life, but truly working in the confines of a schedule we logically created was refreshing.

The minutes for our meetings have been included at the bottom of this document.



Design Work

Initial Designs

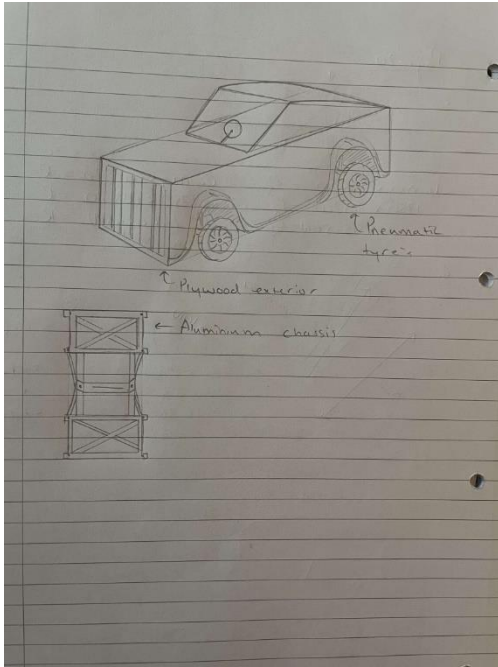


Figure 7-0-1 Design 1

- The first design that was produced, which entails a plywood exterior design that is 2380mm in length, with a width of 1250mm. The design itself is rectangular in shape as this will create aerodynamic properties, however with the length of the soapbox and the smaller wheels, tight turns will be proven difficult with the chance of toppling. 260mm Pneumatic Tire's with the axle having both braked wheels. The chassis will be made from aluminum as this is lightweight and will allow for the soap box to glide down the track at higher speeds, thus giving a quicker finish time.

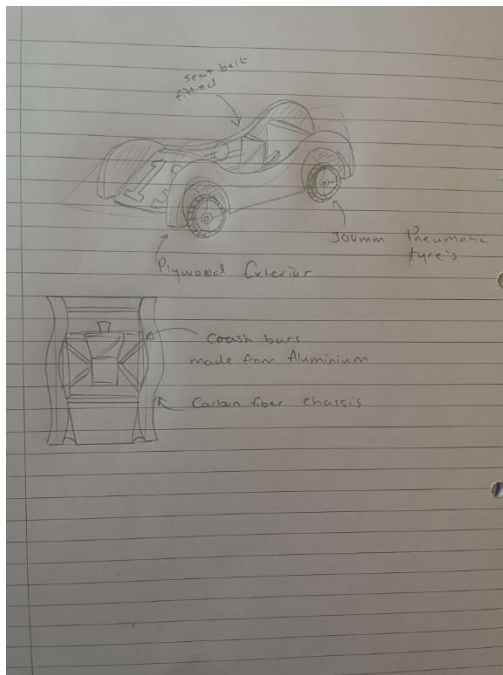


Figure 7-0-2 Design 2

- The second design was inspired by F1 cars as it utilizes the curved body with a length of 2450mm and a width of 1300mm, this shape is seen on the majority of the F1's designs, this allows for better airflow alongside and above the soap box when maneuvering through the soap box course. This design implements the usage of aluminum crash bars in the event that the driver were to crash either directly or impacted from the side it would provide protection for the driver from both angles. The chassis will be made from carbon fiber as this will decrease the weight of the soap box significantly and increase rigidity and strength although this will be expensive as 'carbon fiber per ton is between £11,813 and £14,175 (Astute Analytica, 2023)', however the performance overall will be better.

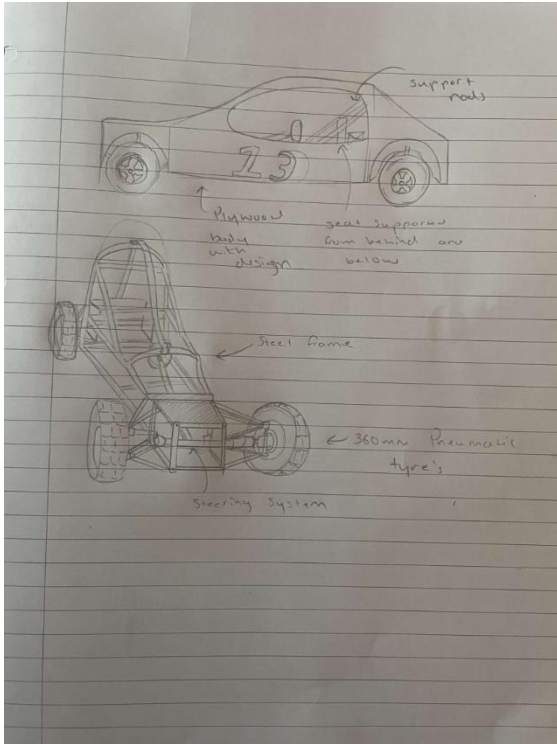


Figure 8-1 Design 3

- The third and chosen design has a chassis that is made from steel that represents the shape of a “buggy”, we chose this design because we found that even with the increased weight that the shape would provide enough aerodynamic properties that it would outweigh the cost of the weight of steel. This design would be more cost effective than others as ‘steel per ton is £1300 in the UK (Checktrade, 2023)’, ‘while aluminum is slightly less per ton at £1260 (ScrapLocal.co.uk, 2023), however, Steel is stronger and more durable than aluminum, thus the chassis won’t warp or bend from forces or in colder weather. The tires used will be 360mm Pneumatic tires to ensure that the soap box is above the 50mm minimum height limit from the ground/ramp. The design provides both crash bars either side of the drive and two roll bars, one that is placed 40mm above the helmet of the driver when seated and the other placed at the bottom of the overhead roll bar 30mm away from the steering wheel.
- The body is made from plywood which gives the soap box and overall ‘length of 2500mm and an overall width of 1500mm (Castle, 2023) meeting the maximum dimensions for the soap box regulations.

Minute meetings

Group F Meeting Minutes

9th of October 2023

Attendees: Finn Flye – Design, Jeremi Gumapos – Dynamics & Driveability, Jonatas Fernandes – Organisation & Communication, Rhodri Jones – Materials, Yash Patani – Costing

13:30 – Meeting called to order.

13:45 – Roles are assigned as follows:

- Finn Flye – Design
- Jeremi Gumapos – Dynamics & Driveability
- Jonatas Fernandes – Organisation & Communication
- Rhodri Jones - Materials
- Yash Patani – Costing

13:50 – Attendees are tasked with reading over their roles for the next meeting.

13:50 – Meeting is adjourned

Group F Meeting Minutes

16th of October 2023

Attendees: Finn Flye – Design, Jeremi Gumapos – Dynamics & Driveability, Jonatas Fernandes – Organisation & Communication, Rhodri Jones – Materials, Yash Patani – Costing

13:30 – Meeting called to order.

13:31 – Fernandes moves to establish an overview of the research each department must conduct and what they will require from each other to support that.

13:35 – Gumapos' research:

- Steering systems
- Braking systems

Gumapos' requirements:

- Appropriate materials list from Jones
- Expenditure bracket for said systems from Patani

13:45 – Jones' research:

- Materials for chassis
- Materials for frame
- Materials for body
- Materials for roll bar
- Materials for Gumapos' systems
- Materials for tyres for Flye

Jones' requirements:

- Expenditure brackets for materials from Patani
- Design chassis, frame & body from Flye

14:00 – Patani's research:

- Expenditure estimations for steering and braking systems
- Expenditure estimations for applications of different materials

Patani's requirements:

- Materials list from Jones
- Design & dimensions from Flye for estimation of cost
- Steering & Braking system designs from Gumapos

14:15 – Flye’s research:

- Valid designs for chassis and frame of soapbox car
- Integration of steering and braking systems into the designs
- Integration of roll cage into the designs
- Aerodynamic research for the body
- Suitable tyre choices for the soapbox car

Flye’s requirements:

- Steering & braking systems from Gumapos
- Materials list from Jones
- Expenditure estimations from Patani

14:20 – Fernandes’ research:

- Creation of Gantt charts for project management
- Compilation of data from all departments
- Liaison between departments

14:30 – Fernandes will create a shared document to be updated regularly with each department’s research to ensure fluidity in development.

14:31 – All attendees to research their assignments and report back for next meeting.

14:32 – Meeting adjourned

Group F Meeting Minutes

30th of October 2023

Attendees: Finn Flye – Design, Jeremi Gumapos – Dynamics & Driveability, Jonatas Fernandes – Organisation & Communication, Rhodri Jones – Materials, Yash Patani – Costing

13:30 – Meeting called to order.

13:31 – Gumapos has researched basic steering and braking designs. During research he found that soapbox cars must be durable. Suggests strong materials and simple steering & braking systems.

13:35 – Researched steering and braking systems relayed to Jones for material choices.

13:40 – Flye has sketched multiple designs that fit the criteria of the project. These will be prone to change with implementation of necessary features but provide a visual aide of where we will need to fit everything roughly.

Flye has conducted research into aerodynamics to keep in mind when designing the body.

13:50 – Jones has compiled a list of materials commonly used in soapbox cars, along with their advantages and disadvantages, this has been relayed to Flye for consideration in the design of the body and frame.

14:00 – List of materials relayed to Patani for expenditure estimates.

14:15 – Meeting adjourned.

Group F Meeting Minutes

13th of November 2023

Attendees: Finn Flye – Design, Jeremi Gumapos – Dynamics & Driveability, Jonatas Fernandes – Organisation & Communication, Rhodri Jones – Materials, Yash Patani – Costing

13:30 – Meeting called to order.

13:31 – Jones has selected appropriate materials for steering and braking systems from Gumapos. Relayed to Flye for integrating into soapbox designs.

13:40 – Patani has rough estimates on costs for selected materials by weight. Further research will be necessary in the future to improve these estimates.

13:50 – Flye will begin designing a suitable body for the soapbox whilst further researching the aerodynamic qualities it should have.

Flye moves to make the soapbox cars open-wheeled due to the simplicity of the design and reductions in weight and materials needed.

All in approval

14:00 – Gumapos states a lower centre of mass will aid with stability, Flye to amend design to house the seat lower to reduce this.

14:01 – Meeting adjourned

Group F Meeting Minutes

27th of November 2023

Attendees: Finn Flye – Design, Jeremi Gumapos – Dynamics & Driveability, Jonatas Fernandes – Organisation & Communication, Rhodri Jones – Materials, Yash Patani – Costing

13:30 – Meeting called to order.

13:31 – Flye has produced three (3) designs incorporating the chosen steering and braking systems. Forwarded final dimensions to Patani for expenses.

13:40 – Patani has begun researching potential prices for fabrication of metal structures. Including but not limited to welding and CNC machining.

13:50 – Meeting adjourned

Group F Meeting Minutes

11th of December 2023

Attendees: Finn Flye – Design, Jeremi Gumapos – Dynamics & Driveability, Jonatas Fernandes – Organisation & Communication, Rhodri Jones – Materials, Yash Patani – Costing

13:30 – Meeting called to order.

13:31 – Patani provides potential expenses for the designs, and rough estimates on fabrication costs.

13:35 – Flye moves to finalize the designs.

All in favour

13:40 – Meeting adjourned

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