

University of Wales Trinity Saint David

Wales Institute of Science & Art



Prifysgol Cymru

Y Drindod Dewi Sant

University of Wales

Trinity Saint David

Project First Report

MercedeDAS

Integrated Project (ACHA4008)

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1 Introduction

This report consists of research into the different aspects of building a soapbox to a set of regulations including the cost & materials. Three designs have then been created from the research we have done into each category, set to a budget.

1.1 Team Organisation

We were organised into groups of six by the lecturer. In our first meeting as a group, we discussed our ideas and set the different roles we would need to research to achieve our aims. Everyone was given a category to research and to produce information so that we as a group could create a design. We also decided on a team name via suggestions and voting by team members.

1.2 Aims

The aim of this report is to research and design three different soapboxes that will adhere to certain regulations.

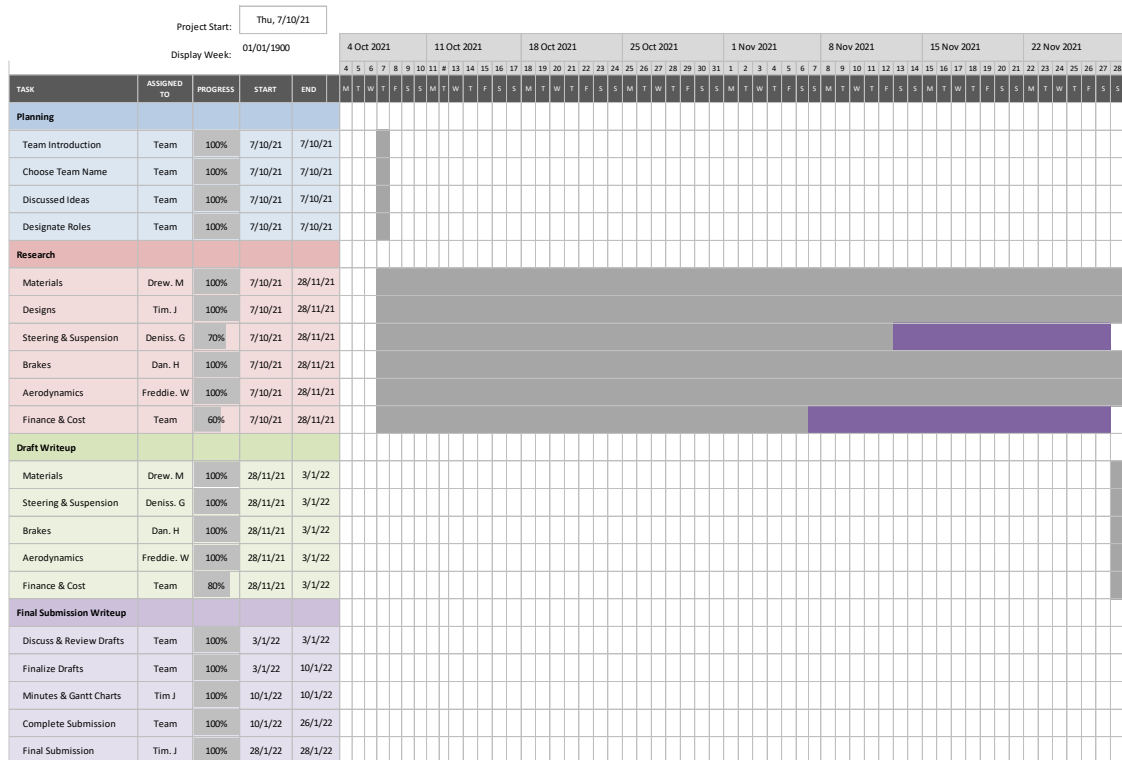
To research and design three different soapboxes consisting of different materials & budgets set by the team.

To evaluate which design best fits our criteria

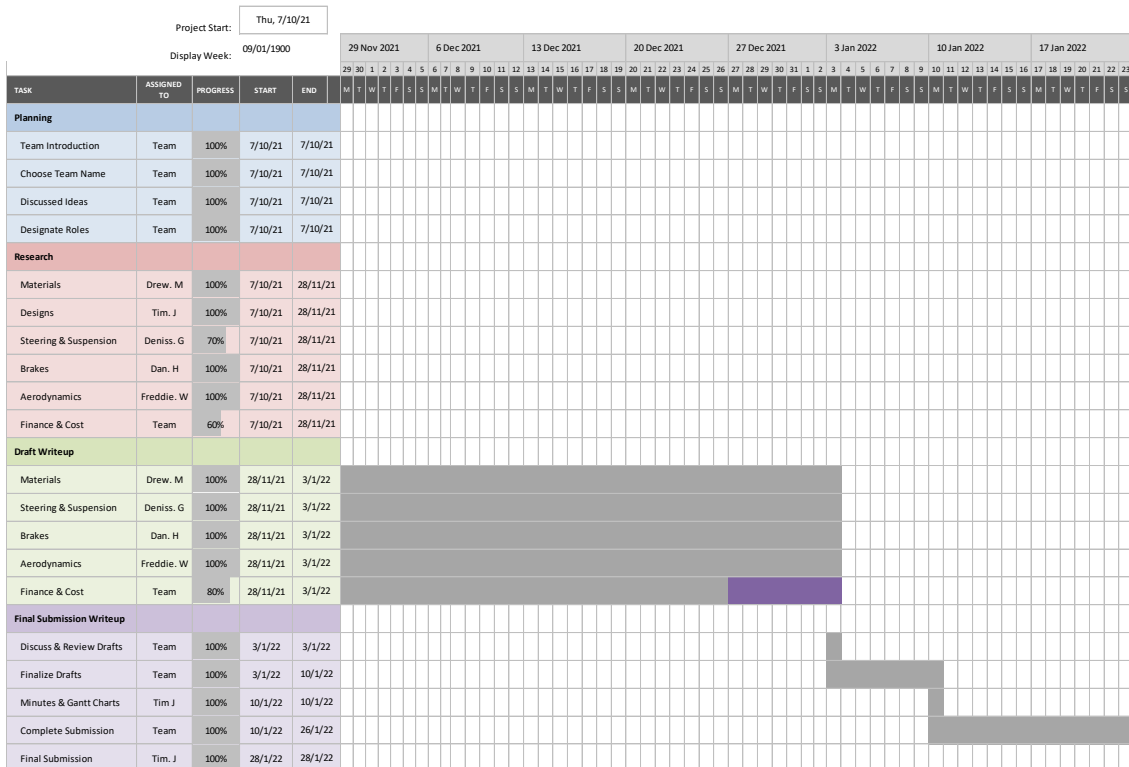
2 Gantt Chart

Table 1 & 2 Gantt Chart – Week 1-8; 8-16

Group D (Soapbox)



Group D (Soapbox)



3 Meeting Minutes

3.1 Meeting 1

Group D (MercedeDAS) Meeting Minutes

Meeting 1 – October 7, 2021

Attendees: Daniel Hannis, Daniel Oneata, Deniss Gavrilovs, Drew Malcolm, Freddie Watkins, Tim James

1:04pm Members joined a meeting over Microsoft Teams.

1:06pm Members introduce themselves and talk about their interests

1:12pm Team name is discussed, ideas presented, team vote on their favourite choice

1:20pm Roles are discussed and narrowed down with each member being assigned a research role.

- Daniel Hannis – Brakes
- Daniel. Oneata – Finance & Cost
- Deniss. Gavrilovs – Steering & Suspension
- Drew Malcolm – Materials
- Freddie Watkins - Aerodynamics
- Tim James – Design, Minutes & Team Manager

1:40pm Tasks are set out for the Team to complete before the next meeting.

- Each team member is to research their area and look at ideas and systems used for soap boxes.
- To choose systems that we may implement into our 3 designs ranging from Low, Medium & High budget. (Budget not set at this time)

1:58pm Team members confirm they know the next task to be completed

1:59pm Meeting concludes.

3.2 Meeting 2

Group D (MercedeDAS) Meeting Minutes

Meeting 2 – October 28, 2021

Attendees: Daniel Hannis, Deniss Gavrilovs, Drew Malcolm, Freddie Watkins, Tim James

1:24pm Members joined a meeting over Microsoft Teams.

1:28pm Each team member goes through their research and talks about their choices and why they've chosen them, in alphabetical order.

1:46pm Team then narrows down on which systems to consider into our designs for both cost & effectiveness purposes such as:

- Braking System
- Steering & Suspension including wheels
- Materials for Chassis & Aerodynamics

2:01pm Team then discusses the next stage of the assignment, writing a draft for each of the sections & including some designs implementing the chosen systems.

2:10pm Team concludes on plan to draft a write-up of all research completed for the next meeting.

2:14pm Meeting concludes.

3.3 Meeting 3

Group D (MercedeDAS) Meeting Minutes

Meeting 3 – November 3, 2021

Attendees: Daniel Hannis, Drew Malcolm, Freddie Watkins, Tim James

1:04 pm Members joined a meeting over Microsoft Teams.

1:11 pm Team members share screens and show their draft write ups for each section of their research. Ideas shared & improvements are implemented with notes.

1:39pm Team members decide next plan of action is to create the final write up for each of their sections for submission. This includes:

- Gantt Chart
- Meeting Minutes
- Drawings of Systems and components

1:54pm Team finalise details to include in final report

2:00pm Meeting concludes

4 Research

4.1 Steering & Suspension

For steering we have decided as a group to use a steering column which connects the steering wheel to the steering mechanism. The steering wheel will be directly connected to the axle. We will use a rack and pinion mechanism for simplicity and reliability (Figure 1). Some more advantages are that the rack and pinion steering mechanism is affordable and easily put together which will help us in keeping costs down, another advantage is that it is a compact system therefore making it easier to fit into our cart. The pinion gear will need to be tested with different sizes to ensure that the steering is not too sensitive which would be a disadvantage for our cart. Another disadvantage is that there is no mechanical advantage such as in power steering vehicles. Even though this is a disadvantage, our cart would be lightweight enough for this to not be a problem.

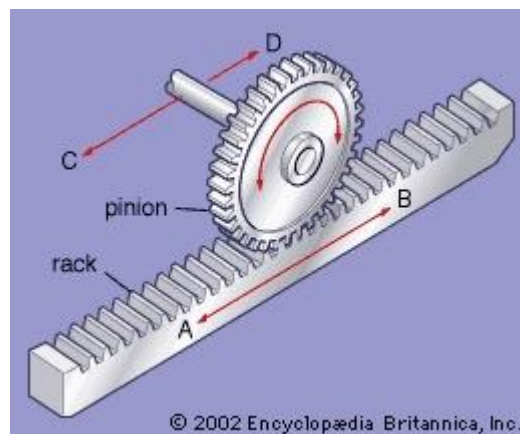


Figure 1

For suspension we have decided as a group to keep it minimal yet practical, therefore choosing a wishbone and shock absorber setup (Figure 2). This will help us reduce body roll within our cart as well as keep the cart stable over bumps and jumps. Some disadvantages would be that it adds weight to the cart which in turn may reduce speed and acceleration. Another disadvantage would be that it is complex and therefore more expensive. We have chosen this suspension system and deemed it to be the best for our cart because it adds stability and reduces body roll which is our objective for suspension components.



Figure 2

4.2 Brakes

Rim brakes, disc systems do sufficient braking due to low pressure such as being a non-motor light vehicle.

If using bike forks then the problem is solved as the forks already have brake mounts fitted, if using stub axles, it can be harder. A Disc bracket would be the obvious choice here but can be difficult with 20-inch wheels finding compatible disks. The alternate to this is to make a bracket to hold the rim brakes. This could be tricky as the bracket will need to be strong enough to not bend under braking.

Rim brakes are also an option that work in the dry but in wet they're not so good.

To get solid brakes all around you need brake calliper's due to their improved braking performance compared to that of rim brakes you find on bicycles. We have decided to connect a set of brake calipers to the front wheels with a hand lever attached to the steering wheel. Over the course of a soap box race this should suffice as it is of a shorter distance, however if this were to be a continuous race, we would look at options including a foot pedal due to fatigue.

Driver should use cadence braking (pump braking) like an ABS module using modulated braking to reduce overheating on the brakes the driver should do this manually to reduce overheating of the brakes as the force on the brakes will be severe at decent speed.

If we have cable operated brakes as such bikes do with you can apply more force with foot pedals than with your hands, an idea for higher speeds and possibly safer too.

If we have a hand brake lever it must be mounted on the steering wheel so you can steer and brake at same time if we do not have foot brake pedals, this is so you can't take any hands off the steering wheel as this will likely lead to a crash.

Design 1: For the first design we are using rim brakes which are pads pushing against the bike wheel using friction to slow it down. This is not just on and off unlike other designs this is a can be gradual pressure or full on if needed to help with cornering if needed and when is needed. Through this it will be lightweight but with good braking pressure to enable the driver to use the brakes like an ABS module with pump braking or full on if needed.

Design 2 + 3: For these designs we have decided to use brake calipers as a more expensive and less budget friendly way of this. With brake callipers it will engage against the tyres and brake easier with safety. Brake callipers do way more compared to design 1. With this on a soapbox the weight distribution will need to be evened out for when we hit a bit of a bump then we will not be unsettled to one side or back/front heavy. This will help with brake lines for more powerful braking compared to design 1 and when tighter corners come encourage later braking, possibly improving overall time.

4.3 Aerodynamics

Aerodynamics

Aerodynamics (aero) is an important area to cover when designing anything that will be used for racing / motorsport. This is because the aero properties of a vehicle can impact areas such as the air resistance it faces at speed, downforce, braking, drag and many others as well as which areas of the vehicle these affect.

For our project soapbox, we have agreed that our main designs will be based around the styling of a Formula 1 car. This is because F1 cars are designed to have large amounts of downforce at high speed while minimising drag. This allows them to take corners at higher speeds as the downforce produced creates a higher area of pressure above the car, forcing it against the track and increasing grip.

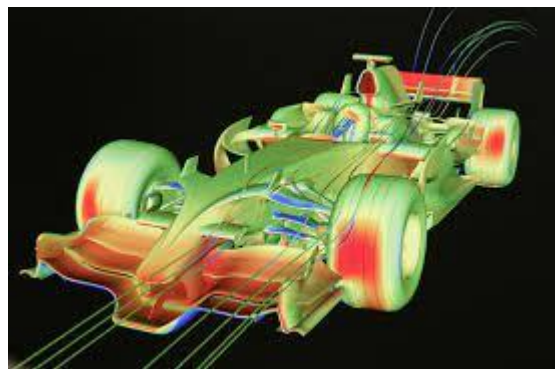


Figure 3

The image (figure 3) above demonstrates these properties as the red areas shown are areas of higher pressure. The two obvious places are on the front and rear of the car as while they increase drag, they create downforce above the wheels of the car.

What we will likely implement into our designs

- Body panels made from a lightweight, affordable material such as aluminium or wood to keep airflow around the car smooth, consistent and non-turbulent.
- A spoiler above the rear axle, made from a light material in order to create downforce on the rear of the car and keep the centre of gravity low. (This will help to reduce oversteer which is common in soapbox racing)
- A small splitter at the front of the car to help reduce drag and introduce downforce to the front axle.
- Canards located near the front wheels to increase stability and downforce.
- A low-down design for the car, as this will help decrease air pressure underneath the car as well as lower the centre of gravity and reduce body roll as well as increase stability at higher speeds.

Design 1

As our first design is built with a lower budget in mind, we will likely implement the cheaper and more cost-effective methods of improving its aerodynamics. This will likely include cheaper and more accessible materials such as cardboard and repurposed wood. The execution for this will likely be simpler and cost-friendly in comparison to the other designs.

Materials such as cardboard or repurposed wood are the best solution for this as they can typically retain their shape well, are very lightweight and very low cost. These materials however can weaken and rot when exposed to bad weather conditions. For this design we will use cardboard due to its low cost, availability and ease to work with. We will be implementing cardboard into the car by cutting it to shape and using it as the main bodywork of the car to reduce drag and turbulence. We will also use cardboard as the floor of the car to reduce turbulence underneath where low-pressure is ideal.

Design 2

Our second design allows for a slightly higher budget, meaning we can implement a more effective system using higher quality materials. The best material to use for this is plywood as it comes at a good value for money and provides a lot more strength and durability due to its cross-grain design. It's also a relatively easy material to work with, however it can rot and decay overtime.

We will be using plywood as the main body panels and floor panel for this design as they will help reduce drag and turbulence, while also adding a certain degree of chassis rigidity at the same time. We will also use plywood to help aid downforce across both axles, this will be done by adding a small splitter in front of the front wheels and a spoiler above the rear wheels. This F1 inspired design should help keep the airflow around the car more consistent and introduce some downforce, which in theory should increase the handling and performance.

Design 3

For the third design, we have allowed for a much higher budget allowing for more expensive materials and refined components. This means that we can implement materials such as fibreglass, sheet aluminium or other composites. For this we have decided to use fibreglass as it can be moulded to a desired shape relatively easily, while maintaining a good level of strength and being extremely lightweight compared to the other options.

We will use fibreglass for creating the body panels for the car, including the floor panels, side of the car, and the aero devices i.e., front splitter, canards, rear spoiler and wheel arches. This material and design setup will be much more effective due to its strength, weight, durability and resistance to different weather conditions.

4.4 Materials

Chassis:

There are 3 ideas of materials that we could use for the chassis which could give different advantages. The first idea is small steel tubing. This is because it provides a lot of strength meaning that if the soap box does crash it will keep the driver very safe and it will maintain its shape meaning that we will be able to continue the race. The only downside to this is that even though it is small it is still steel which is a heavy material meaning that it will slow down the kart and make it harder to brake and turn.

The next material is plywood. This material was chosen as it is a lightweight material that can provide some good strength for its density meaning that the kart will be easier to control for the driver, but it is not as strong as the first and third material meaning it may not be able to support the rest of the parts of the kart under extensive situations. The final material that has been chosen for the chassis is carbon fibre as it is one of the strongest materials that is still lightweight making it very suitable for something that must be quick. Although there are many downsides to as it, as it would be the hardest material to use as we would have to mould every piece.

It is also very expensive and can't be repaired if there is damage, which makes it quite unsuitable if testing must be run on it as it would use all of our budget.

Body:

There is a selection of different materials that we could use for the body of the kart with majority being within our budget. These materials are easy to work/shape which is essential we will be making aerodynamic parts which can be complicated to make and require intricate detail.

The first material that the group suggested was cardboard as we must work around a budget and it is a very cheap material to get meaning that if parts break, they can easily be made again. Another advantage of this like some of the other materials that we have suggested is that it will be easy to put a design onto it. There are also many disadvantages to this material, the main one being that it is very weak compared to the other suggestions and could break even under air resistance.

The next suggestion was fibre glass as it is a material that is used in quite a few low-level motorsports as it can be easily moulded into any shape needed which is a perfect fit, but the moulding process takes a long time and will also take a lot of working as we would have to make many layers of it and different curves if we wanted to make complex aero. The final material that is within budget and could work is plywood. This has been chosen as it provides a lot of strength for the density meaning that a thin sheet could be used and wouldn't break to air resistance. The biggest downside to this material is that it's very hard to shape and cut as it is cross grained.

4.5 Cost

4.5.1 Design 1

- Chassis – Steel Tubing £133 (Including excess for chassis and crash structure)
- Steering – Tie rod pinion steering £79 (Drive shafts & Rods including column)
- Suspension - £0 (Design 1 excluded Suspension)
- Brakes – £45
- Aerodynamics – Cardboard (Free)

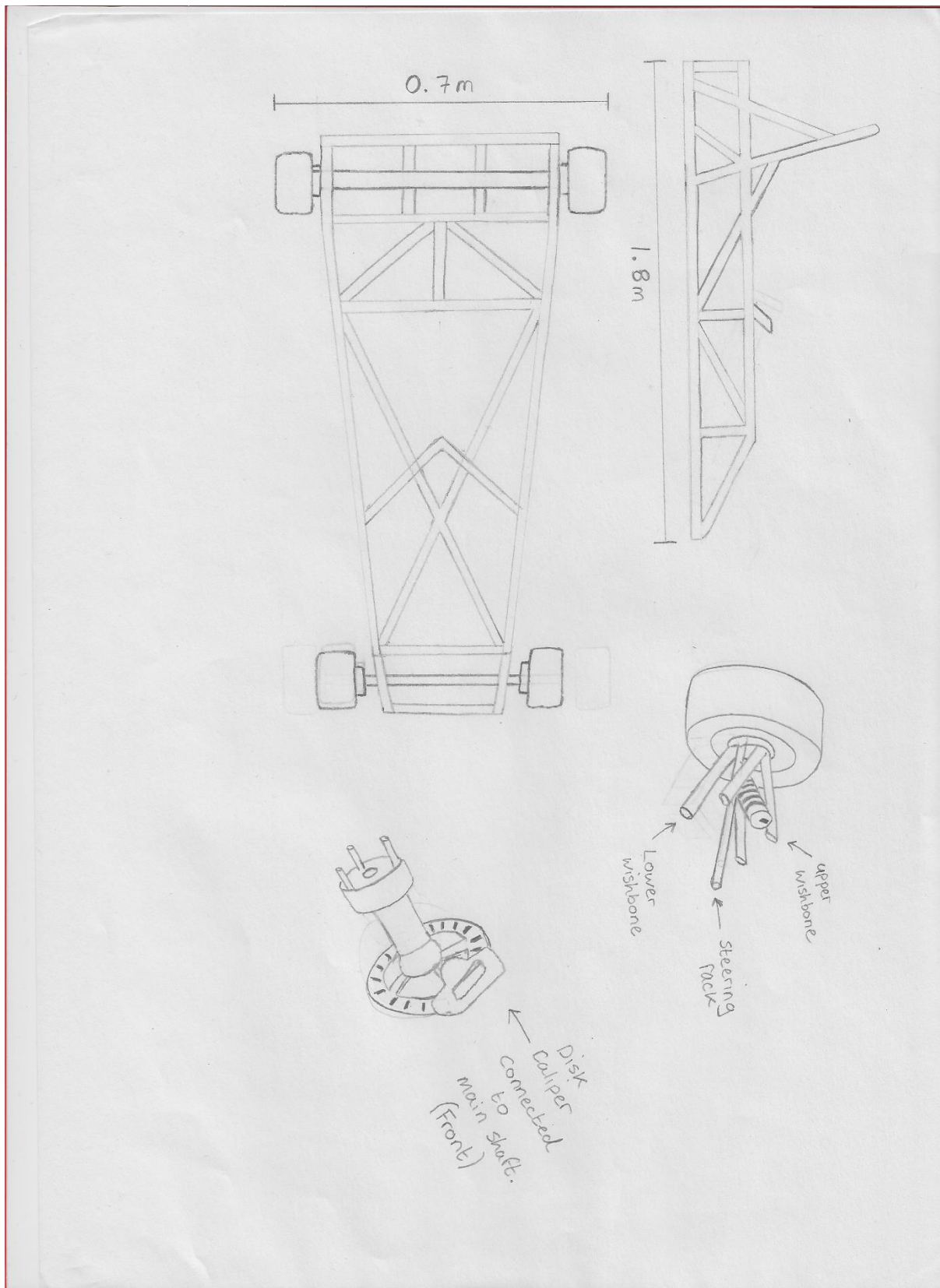
4.5.2 Design 2

- Chassis – Steel Tubing £133 (Including excess for chassis)
- Steering – Pinion Steering £122 (Drive shaft kit with rods & columns including tie rods)
- Suspension – £25 (Coilover shocks)
- Brakes – £45 (Brake hubs including disks & hand lever)
- Aerodynamics – Plywood £45 (includes excess for underfloor & panels)

4.5.3 Design 3

- Chassis – Steel Tubing £133 (Including excess for chassis)
- Steering – Prop Shaft
- Suspension – £42 (Double Wishbone suspension including Coilovers)
- Brakes – £50 (Calipers included with hub and brake disks)
- Aerodynamics – Fibre Glass £300 (Including items needed to create moulds for panels)

4.6 Design



5 Conclusion

We decided against design 1 due to it lacking a suspension which could be a critical component depending on the surface and steering requirements necessary on the course. The simplistic build would have been easier to assemble and cost a fraction of the second and third designs however would be much more susceptible to damage and poor pace.

Design 3 although it fit within the higher end of our budget it was disregarded due to the complexity of incorporating some of the systems such as the suspension setup and aerodynamics produced from fibre glass. If this design were to be involved in an accident it would be too costly to repair.

We have concluded Design 2 would best fit our requirements as the systems we have chosen for each area would cost less and be easier to implement into our chassis designs and require less time to build. If it were to receive any damage during the course, it would require less money and resource to repair.

6 References

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