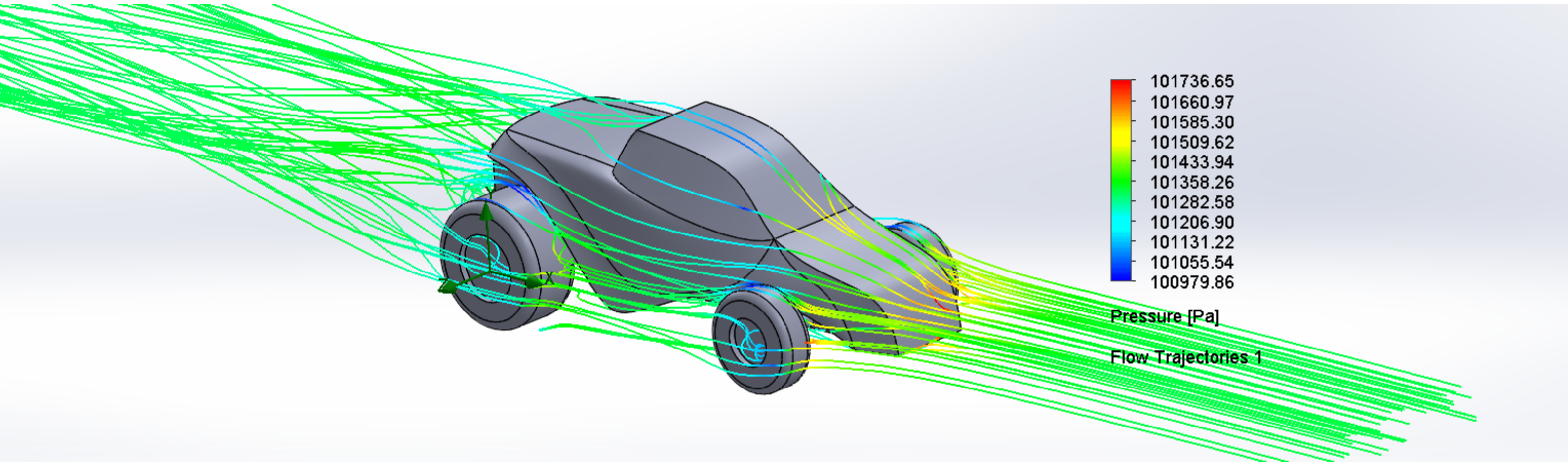
Thermofluids Case Study Report

Vehicle Aerodynamics



Ciara Bates

Design Summary

The chosen vehicle type for this report is battle cars. These cars are based on sports cars, but with the design modified to be more capable for off-road use. They include features like fender flares and large lifted wheels with big tyres. This type of vehicle became popularised due to video games like Rocket League. The chosen design is based off one of the most popular cars in the game, Octane. The shape has been simplified and made more aerodynamic by taking away some of the sticking out features that is on the original. This will also make it simpler and more possible to model flow in Solidworks.

Sketches

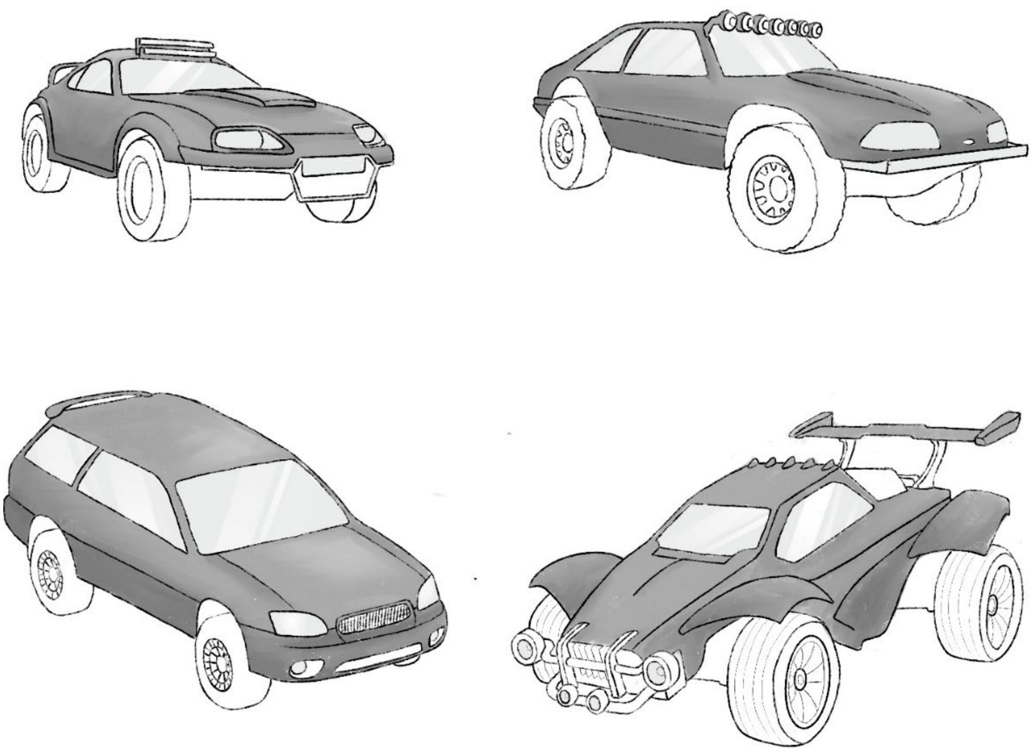


Figure 1 – four initial concept sketches

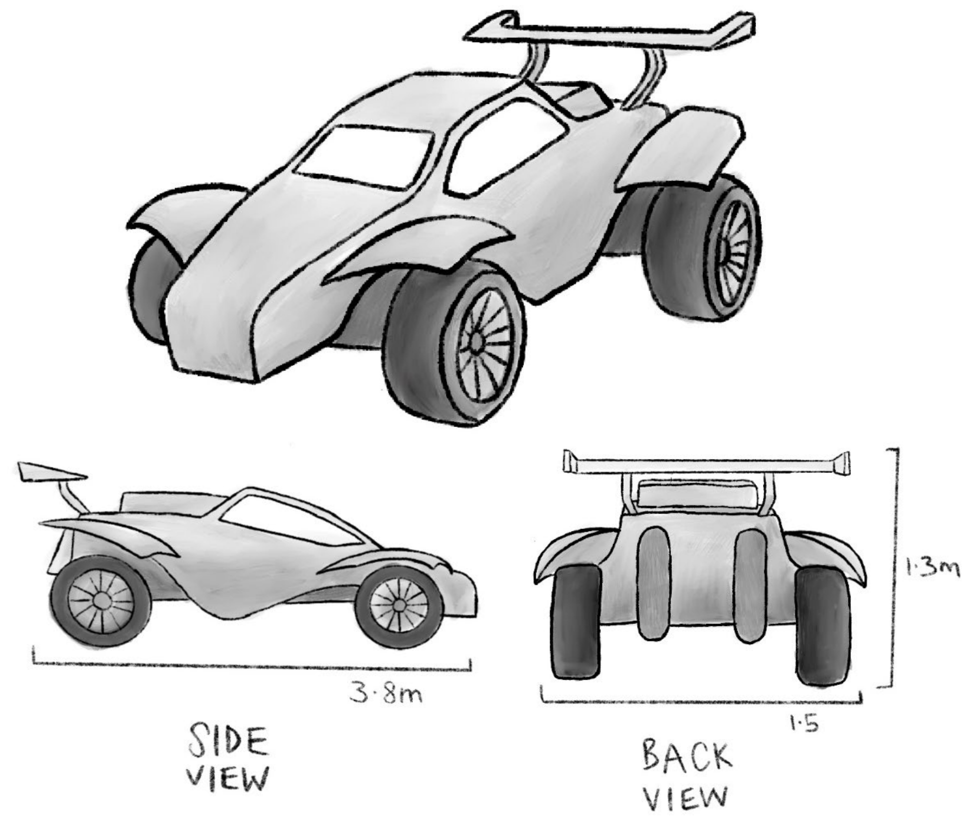


Figure 2 – chosen simplified concept sketches

Solidworks Modelling

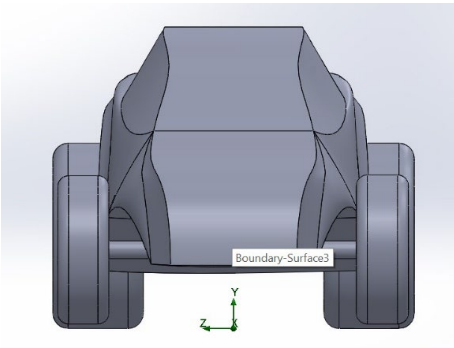


Figure 3 – front view

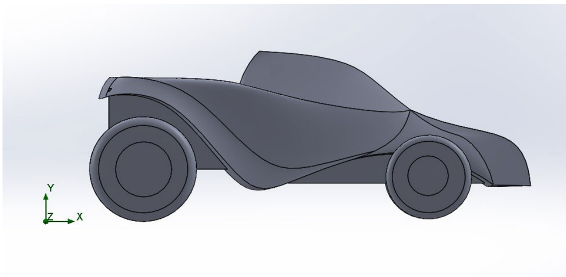


Figure 4 – side view

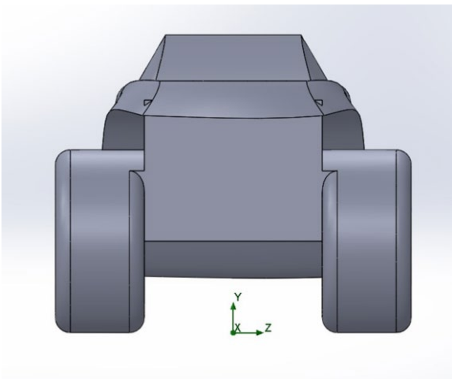


Figure 5 – rear view

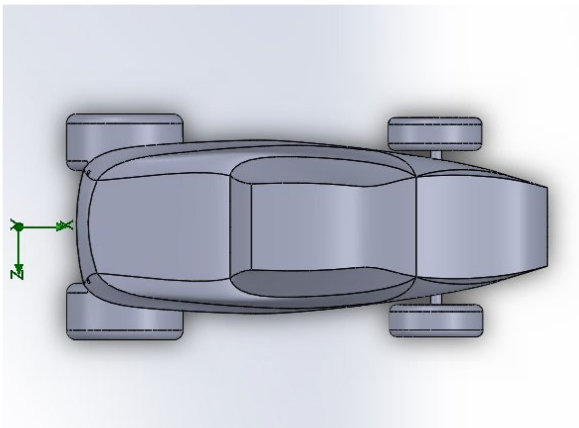


Figure 6 – top view

CFD Modelling

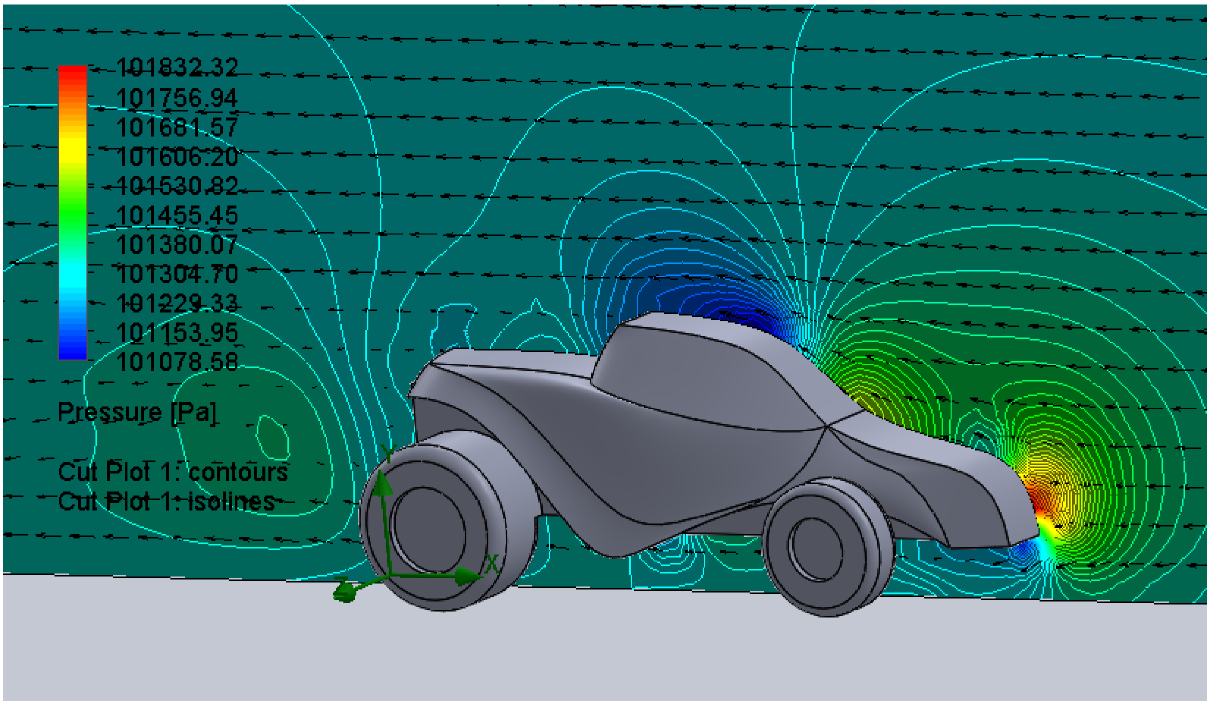


Figure 7 - pressure distribution in 2D

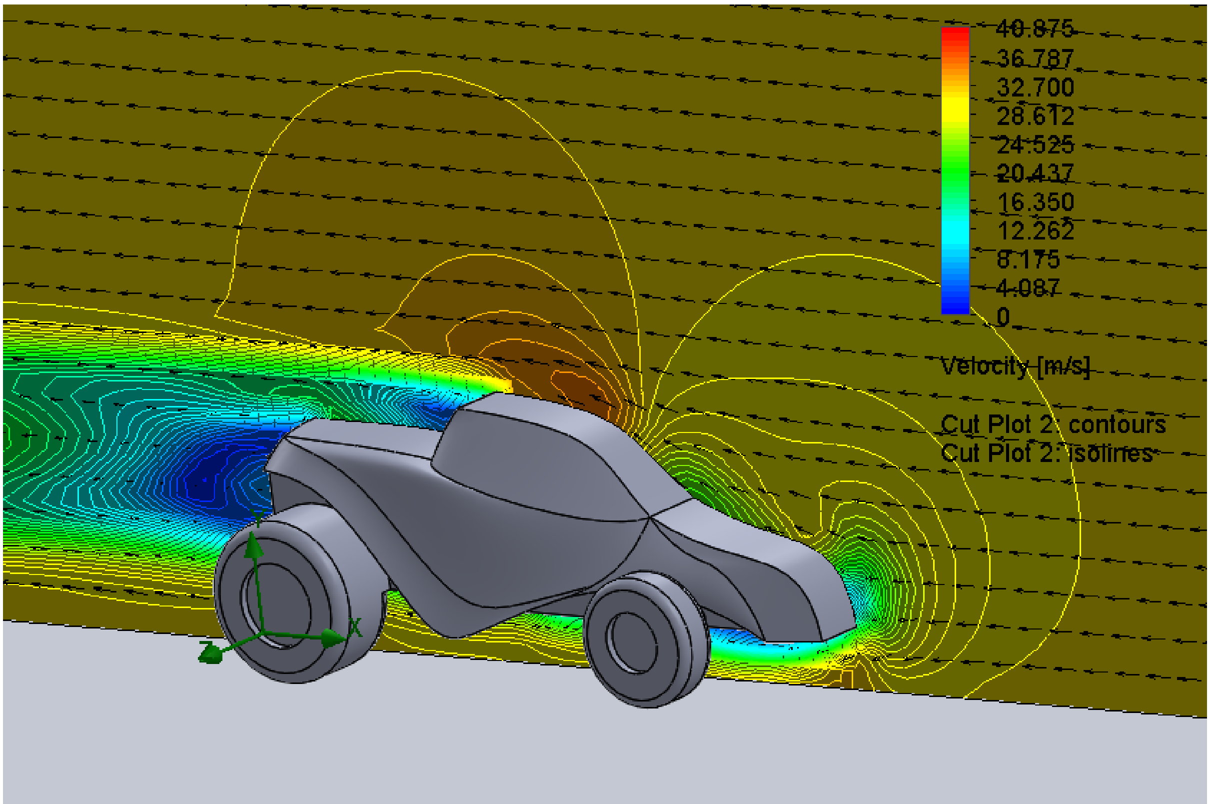


Figure 8 – velocity distribution in 2D

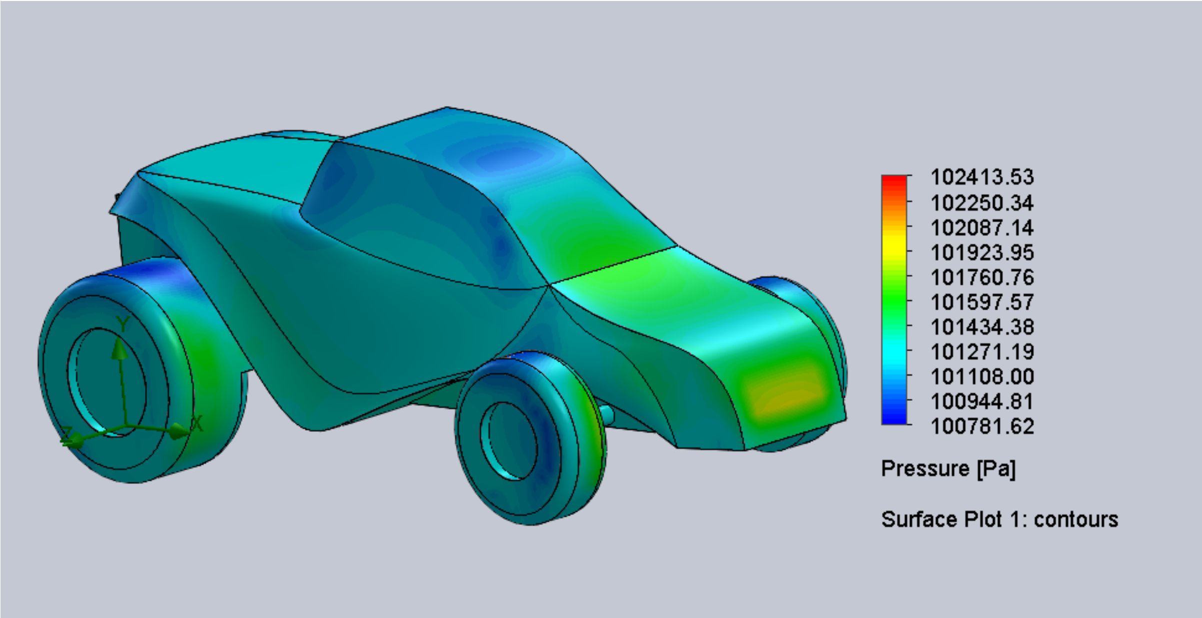


Figure 9 – pressure distribution over the surface of the vehicle

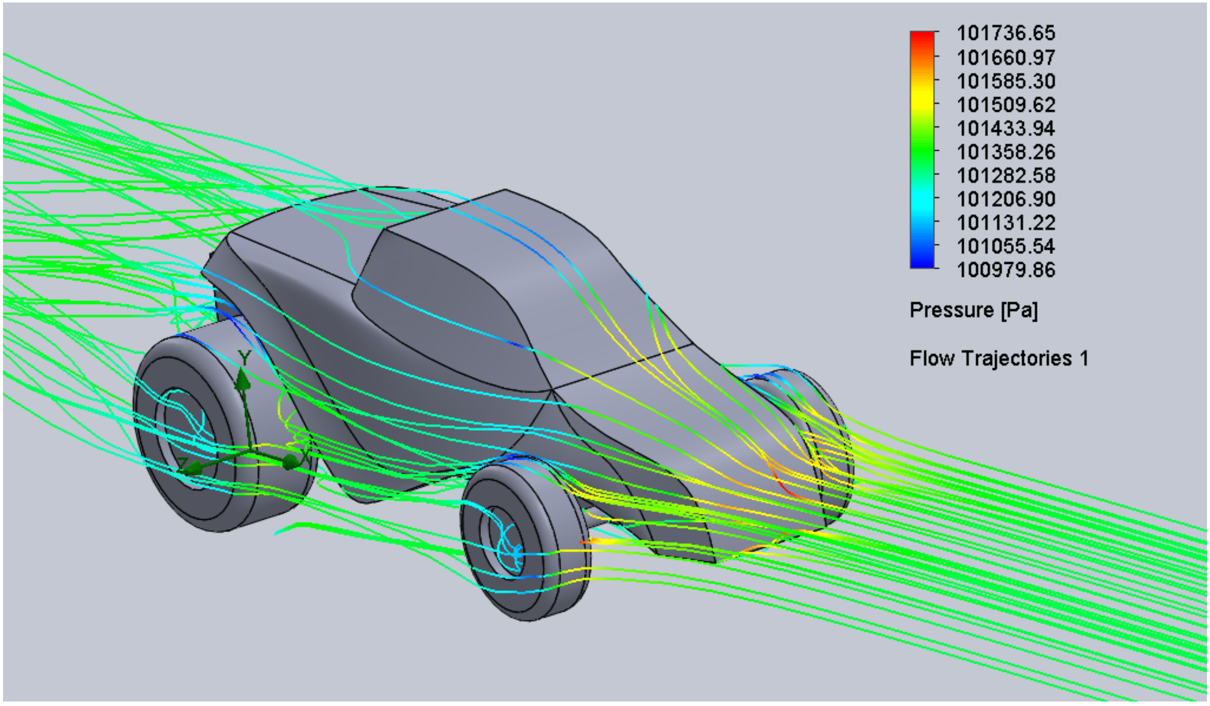


Figure 10 – flow trajectories in 3D

Summary of CFD Results

	Unit	Value
Velocity (average)	[m/s]	-31.1281
Drag Force	[N]	-380.779
Lift force	[N]	202.184
Drag Coefficient	[No Unit]	0.371424

Wind Tunnel Data Analysis

Wind tunnel data for a typical sports car can be compared to the CFD results for that same car, as this should be the most like the battle car design, although this one was tested at a much smaller scale, so the drag force is much smaller. Irregularities between the CFD tool and real-world testing can be evaluated.

<table>
<tr><th></th><th>Value for CFD</th><th>Value for wind tunnel</th><th>% difference</th><th>Reason for the difference</th></tr>
<tr><td>Velocity (average)</td><td>30.833 m/s</td><td>30.552 m/s</td><td>0.91%</td><td>This difference is negligible. The speed of the air flow in the tunnel can be kept very uniform.</td></tr>
<tr><td>Drag Force</td><td>0.983 N</td><td>1.316 N</td><td>25.3 %</td><td rowspan="2">The drag force and drag co-efficient for the wind tunnel is significantly higher than the CFD. This may be because the surfaces in real life will be much rougher, increasing drag. It is possible that the 3D-printed model didn’t have a very smooth surface due to its layers.</td></tr>
<tr><td>Drag Coefficient</td><td>0.272</td><td>0.37</td><td>36 %</td></tr>
</table>

How can the design be improved?

The drag coefficient of the vehicle is within a normal range, but to further reduce drag, the car should be designed to create a less dramatic pressure differential, as high pressure at the front and low pressure at the back pushes the car in opposite direction to its movement. This can be done by reducing the angle of the front surface of the car so that air flow doesn't collide as directly.

The performance of the car could also be improved by adding features that generate more downforce. Downforce is needed to increase lateral grip so the car stays on the ground and allows for faster cornering speeds. This is very important for the Battle Car architype, as they must be agile and move at high speeds.

Downforce can be generated in several ways:

1. **Wing at the back of the car**
   This wing must be an air foil shape. The air follows the shape of the curve due to the Coanda effect. The air the moves over the longer curve will move faster. Using Bernoulli's principle, a fast-moving fluid has a lower pressure than a slow-moving fluid. This air moves more faster under the wing and slower on top of the wing. This creates a pressure difference that pushes the car downwards.

2. **Splitter at the front of the car**
   This increases the amount of high pressure air going over the car, generating down force.

3. **Vortex generators at the back window**
   These keep the flow attached to the back of the car so that air goes through the rear wing to generate downforce.

4. **Side skirts**
   The purpose of side skirts is to block the high-pressure air on top of the car moving under the car where the pressure is lower, as keeping a large pressure difference creates downforce.