RESEARCH AND INITIAL DESIGN

The main factors that would affect the performance of our car would be:

- Magnitude of resistive forces (drag, friction)
- Magnitude of thrust
- Weight

However, seeing as the thrust force would be beyond our control (due to the regulation CO_2 cartridge), our main focuses when designing would be minimising the resistive forces acting on the body of the car, the wheels (especially between wheels and axels), as well as its weight.

$$F = ma$$

Minimising weight would give a greater acceleration

$$F_D = \frac{1}{2}\rho\upsilon^2 C_D A$$

Lower drag coefficient and frontal area would minimise drag force

$$F_f = \mu mg^*$$

Lower coefficient of friction and lower mass would minimise friction force

* Applies as the track is level

Sensitivity testing conducted on an excel simulation showed that the main factor contributing to lap time was the weight of our car. Minimising weight would therefore be our main consideration when designing the car. To keep it as close to the 50g weight limit as possible, we decided to engineer the car so that it was under-weight, later using a ballast system to bring it to exactly 50g when manufacturing.

We decided to set ourselves a target for a maximum lap time of 1.1s and worked out that in order to achieve this, provided our car was 50g, the drag coefficient had to be below 0.13. This then gave us a reference point, to assess the success of our aerodynamic design, when running virtual tests, as it meant we had a specific numerical value to work towards, and compare against.

We first broke down the design of our car into individual components and considered various designs for each. However, it was also important to constantly kept in mind how each component would fit into the bigger picture, as one design choice made in one specific area might significantly alter airflow around other areas too.

F1 Car Component:	F1 in Schools Application:
<u>FRONT WING</u> - First component to meet oncoming airflow → vital to the car's aerodynamic performance - Adds stability - Cascade of aerofoils generate downforce, whilst minimising drag - Directs airflow around the rest of the car, specifically the front wheels (reducing wake)	- Focus on maximising stability, whilst minimising wheel wake and drag; applying the concept of a cascade to better control the airflow - Aerofoils of a small camber placed at a low angle of attack
<u>REAR WING</u> - Main purpose is to generate downforce - Angle of attack of aerofoils can be changed to reduce downforce and drag (e.g., on straights)	- Focus on stability, whilst minimising on trailing drag, optimising the interaction between CO_2 stream and the air flowing off the rear of the car
<u>NOSE</u> - Supports front wing and provides a smooth transition to the main body - Narrow to minimise frontal area - Increases airflow around and underneath the car - Absorbs energy in case of a collision	- Our nose would be as narrow and streamlined as possible - Increasing airflow underneath the car generates downforce without creating too much drag
<u>ENDPLATES</u> - Fixed to the end of the wings to stop the net movement of air down a pressure gradient around a wing and creating drag through unwanted 'wing-tip vortices'	- Front endplates deflect as much air as possible away from front wheels to minimise wake - Regulations restrict ability to extend the rear wing down and control rear tyre wake

KEY PRINCIPLES

The Coandă Effect

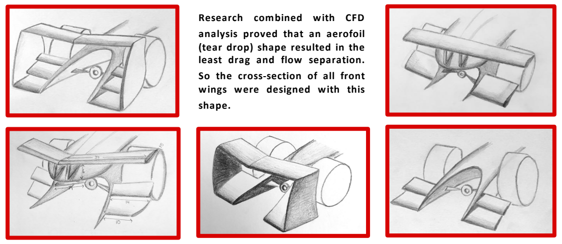
Describes the tendency of a stream of fluid, which comes into contact with a curved surface, to follow the curvature of that surface, even once surface itself moves away from the initial direction. This would prove useful when designing our car, as using smooth curves in our design would help to avoid flow separation and would also be useful in flow channels, where we could use the principle to direct airflow around the wheels, reducing drag.

Bernoulli's principle

States that as the speed of a moving fluid increases, the pressure decreases, (due to laws of conservation of energy and mass). Knowing about this would help us to combat things such as the 'Ground Effect', where a reduction in area for air to flow through, for example between the underlying body and the track, would result in accelerated airflow underneath the car. This would reduce the pressure, resulting in the car being pulled down towards the track, which would be a negative effect as it would reduce the thrust force contributing to its linear speed.

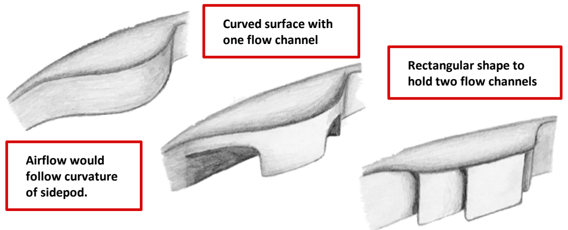
NOSE

Although we created several different sketches of concepts for the nose, a few key features were consistent across the designs. The first was a hollow centre, to reduce frontal area and allow air to flow through the main channel under the car. This also helped to combat the 'Ground Effect' (due to Bernoulli's Principle), which would 'pull' the front of the car down towards the track. The second feature was a series of aerofoils in front of the wheels, aimed at directing the airflow over and around them, reducing drag. The front wing was also mounted on the nose and was designed with an aerofoil cross-section and our front wing designs also tended to have a dihedral shape, to cleanly 'slice' through oncoming airflow.



Research combined with CFD analysis proved that an aerofoil (tear drop) shape resulted in the least drag and flow separation. So the cross-section of all front wings were designed with this shape.

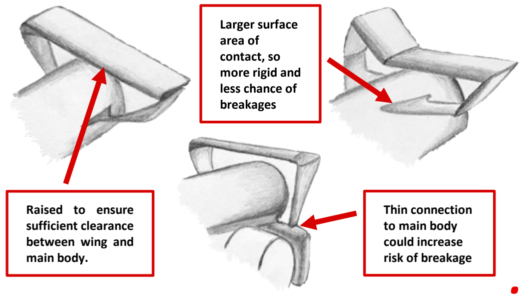
SIDE PODS



Side pods were necessary in order to accommodate the virtual cargo, however, we decided to incorporate flow channels to maximise the performance of the car. These allowed us to guide air out and around the rear wheels, by using the Coandā effect, which would reduce drag, as well as reduce the frontal area and minimise weight. We came up with two main designs, one with a curved shape (housing one flow channel) and one with a more rectangular shape (housing two channels). We suspected that one wide, curved channel would perform better than two, more narrow channels, with a more rectangular surface, but ultimately decided to physically test both designs for confirmation.

REAR WING

The main aim of our rear wing would be stability, so we would not be placing aerofoils at the same high angle of attack used in real F1 cars, as we did not require the same levels of downforce. This is because the track would be straight (so no need for extreme grip) and because the CO_2 cartridge would add a lot of weight to the rear of the car anyway, so no extra force would be needed to keep the rear end down. To conform with the technical regulations, the support structures could only be located at either end of the wing, so we designed two support systems, one extending downwards and the other attached directly to the body. We ultimately went with the latter, as we thought it would perform better aerodynamically, as well as be more compact, durable and easy to attach.



COMPLETE CARS

We came up with two distinct designs to take forward and realise on CAD. We wanted these designs to be very different to one another, so that we could physically test as many different design concepts as possible in our two manufactured prototypes.