F1 in Schools
STEM Challenge

PHOENIX

Design and Engineer Portfolio

Introduction

The most important aspects of the F1™ in Schools Stem Challenge is the design of the car with which the team wishes to participate in the competition and has high hopes of winning is the design.

Our team, Team Phoenix has one lead designer, Master Mirza Mohammad Jafar, Designer engineer, and one assistant designer, Master Mohammad Ali Khan, Manufacturing engineer, who have put there intense effort on making a design that has a mix of both artistic as well as scientific characteristics. Our team Manager, Master Abhishek Behoroy, also helped us in coming up with ideas to accompany our car design with.

Our former team member, Mistress Iqra, and our Graphic Designer, Master Ruddhraksh, analyzed our designs carefully and hence came up came up with further ideas to improve the design.

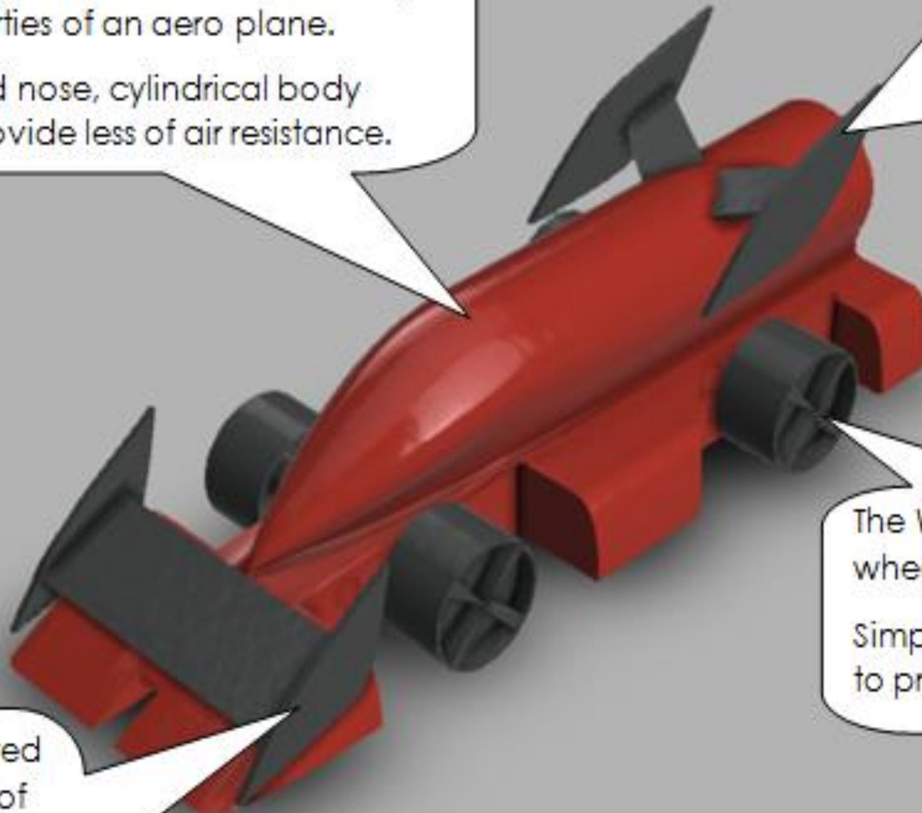
It can be said that our design is a mixed effort of all the team members and each member has played a crucial role in the development of car. So here is our final design, the Finix:

Our Workplace

We did most of our works at our respective homes as we had divided the work among us equally. We were connected to each other through Discord. We opened screen shares and let our teammates comment on our work and hence we always had a second opinion. The designing work has mostly been in our school computer laboratory, under the supervision of Mr. Sharif, Lab Manager.

The Car Body: Inspired by the aerodynamic phenomenon of a teardrop and the properties of an aero plane.

It has a pointed nose, cylindrical body targeted to provide less of air resistance.



The Spoilers (Back wing): Inspired by the streamlined body of a tear drop.

Designed to 'spoil' unfavourable air movement across a body of the vehicle in motion, usually described

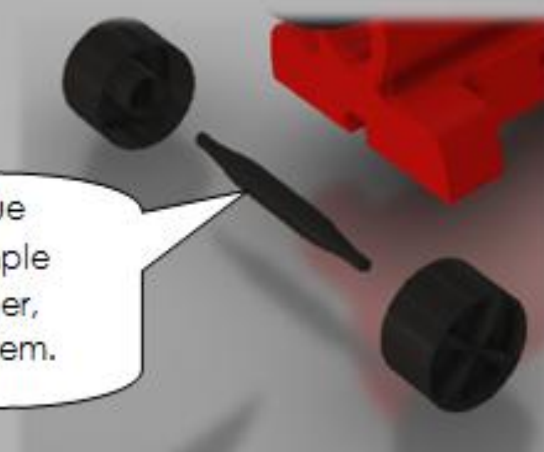
The Wheels: Inspired by BMW wheels.

Simple and aesthetic design to provide the car with style.

The front wing: Inspired by a real front wing of a fully fledged F1 car.

It has been designed to cut though air providing the car with lesser air resistance

The Axle: it is a combination of both oblique cylinder and right cylinder and offers a simple path for bearings and wheels to go together, providing a simple but effective wheel system.



What makes a car fast?

To understand the variables that affect the straight-line performance of an F1 car, we need to have an appreciation of physics, the forces that propel the car and the reactive forces that slow it down. We undertook an analysis of these forces to develop design concepts. We considered the following forces and the extent to which they could be controlled by our design:

#The thrust that propels the car forward, and where it is applied

#The reactive drag force

#Skin friction and rolling resistance.

By knowing the parts of the that we can change and the we cannot, Mohammad and jafar focused on important changes that could be made.

These factors were divided as :

1) Dependent Variables (cannot be controlled)
- Track setup
- Space
- Atmospheric conditions
- Starting mechanism variation
- Canister alterations

2) Independent variables (can be controlled)
- Structural design of car
- Aero-dynamic design of car
- Quality of manufacture
- Overall car weight
- Reaction time
- Wheel designs
- Final car assembly

Thrust

The thrust that propels the car originates from the expulsion of CO_2 from the CO_2 canister. Whilst there is a degree of variability between canisters, the amount of thrust is not a variable that can be controlled by the team. Thrust is a function of mass and acceleration. The lighter the car, the greater its acceleration and the greater its terminal velocity when the canister expires to propel it to the finish line. To convert the full thrust into forward motion, the thrust must be directed through the car's centre of gravity. If the thrust is applied above the centre of gravity of the car, a moment is created which would result in a down-force on the front wheels or up-force on the rear wheels. The further the thrust is away from the centre of gravity, the less efficient the transfer of thrust into forward motion. Using the CO_2 'Canister Sound Endurance Test' and the estimated distance the car travels before it runs out of gas.

Drag Force

Drag force is the single most reactive force that resists forward motion in an F1 car. Drag force is a function of air density and the car's drag coefficient, cross sectional area and its velocity.

- Air density is not a variable that can be controlled by the team and in an air conditioned environment should be constant for all teams at the competition.
- Car drag coefficient is highly dependable on the aerodynamics of the car. To reduce drag coefficient, our design aimed to copy the properties of a teardrop, which has a drag coefficient of 0.04. 678-

Rolling Resistance

Rolling resistance is a function of the weight of the car, friction between the wheels and the track and bearing resistance. For the running surface of the wheels, we selected highly polished aluminium. Our wheels have been designed using polymer-steel bearings which are very efficient and have very low bearing resistance. In addition, rolling resistance is increased by imperfections in the track that may cause the car to bounce and use energy from its forward motion. To minimise rolling resistance, suspension has been integrated into the wheel design to help absorb imperfections in the track and provide a smooth forward motion.

Skin Friction

Skin friction is a function of air density and the car's surface finish and 'wetted area'. Surface roughness was minimised by selecting a high quality paint finish and thin, smooth sponsor's logo transfers using Decal stickers. Wetted area is minimised by its aerodynamics, its size, minimising changes in body shape and maximising the size of edge fillets.

The Wheel System

The Bearing

A Quick Overview of the bearing we ordered from https://robu.in/ to accompany our wheel system:

QUICK OVERVIEW

- Inner Diameter (ID): 3 mm
- Outer Diameter (OD): 9 mm
- Width (mm): 5
- Weight (gm): 6 (for 4 Pcs.)

The Axle

The axle of our wheel system looks like a combination of both oblique cylinder and right cylinder

The Wheel

We got our wheels and axles 3d printed from one of CMS branches CMS Rajajipuram and hence, we thank CMS Rajajipuram for cooperating and with us.

Development

We did not have enough time to develop a complex but effective wheel design so we went with a simple but effective design. The axle fits into the bearing and the bearing in turn fits in the wheel.

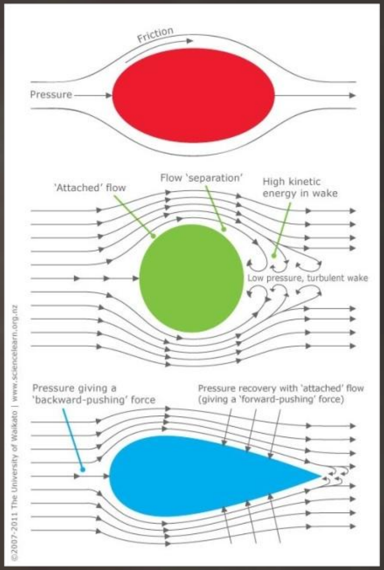
The Wings

The Spoiler (back wing)

A spoiler is an automotive aerodynamic device whose intended design function is to 'spoil' unfavourable air movement across a body of a vehicle in motion, usually described as turbulence or drag. The spoiler has a very simple design. It fits into the body through the slits made on it. It is targeted to give the car more resistance against the drag.

The Front wing

The front wing (or the main plane) is suspended from the nose and runs along the entire length of the Formula One car. To this main plane, adjustable flaps are attached and at the ends of the main plane, the endplates are attached. The front wing design is also very simple. It too, just like the spoiler, attaches to the main body through slits. It is targeted to give the car more resistance against the drag.



The Teardrop Theory

The perfect teardrop shape has the lowest coefficient of friction of any shape (0.04). This means that for a constant cross sectional area, the tear drop would have the lowest drag force. We analyzed what makes the teardrop efficient and tried to adopt those features on our car. We studied about the teardrop on different websites and acquired as much information as possible and this is what we learned:

- The curved nose produced limited pressure points where the object first hits the air, and there was almost no wake behind the pointy tail;
- The smooth curves on the side of the object created minimal turbulence and demonstrated by constant velocity lines almost parallel to each other; and
- Reducing diameter of the object to its pointy tail trained the streamlines back behind the object so they did not separate away from its side.

This was the most important inspiration for each component of the car.

3D printing

We got all our 3D components printed from CMS Rajajipuram. This was so because there was a 3d printer present there and no other branch of CMS could provide us help the parts that we got printed were:

- The spoiler (back wing)
- The front wing
- The wheels
- The axles

We researched over the different filaments which could be used to make these parts and these were:

- PetG
- PLA
- ABS

In the end we decided over PLA for it was easily available and offered the best quality for its price. This was because:

Properties*	ABS	PLA
Tensile Strength**	27 MPa	37 MPa
Elongation	3.5 - 50%	6%
Flexural Modulus	2.1 - 7.6 GPa	4 GPa
Density	1.0 - 1.4 g/cm³	1.3 g/cm³
Melting Point	N/A (amorphous)	173 °C
Biodegradable	No	Yes, under the correct conditions
Glass Transition Temperature	105 °C	60 °C
Spool Price*** (1kg, 1.75mm, black)	$USD 21.99	$USD 22.99
Common Products	LEGO, electronic housings	Cups, plastic bags, cutlery

*Sourced from MakeItFrom**Sourced from Optimatter for a test specimen with 100% infill, 0.2mm layer height printed in a linear pattern*** Sourced from Amazon ABS & PLA

What is a CNC machine?

CNC (Computer Numerical Control) machining refers to a manufacturing process that involves the use computers to control machine parts. CNC machining has been adopted in almost all industries, including small-scale roadside workshops and repair shops.

Everyone involved in manufacturing should take advantage of what this technology can do for their company. For instance, CNC machines:

- Have a high degree of automation that lowers a company's labour intensity.
- Achieve a more precise level of production that produces good product consistency exponentially faster.
- Have multi-axis linkage that allows you to attain complex processing of the prototype machining.

So, some uses CNC machines are:

- Metal Removal Industries:

CNC machines are extremely useful in metal removal industries such as automotive industries, aerospace industries, and in making jewellery. This technology removes excess metal from raw materials to attain desired end product. CNC machines can also be used to create shaped products in the manufacturing industries, which may include threaded, rounded, rectangular, square, or even three-dimensional products.

- Industries for fabricating metals:

There are several industries that require thin metal plates such as steel plates, to create end products. Several metal fabrication tasks such as drilling precision holes, flame or plasma cutting, welding and shearing have been made easier with CNC machines. There are several industries for fabricating metals that would benefit from CNC machines, for instance:

1)Electronics: Computers and motherboards have brains with millions of tiny parts that must be made with precision.

2)Firearms: CNC machines are used to create barrels, ammunition clips, pins, triggers, and several components of the gun.