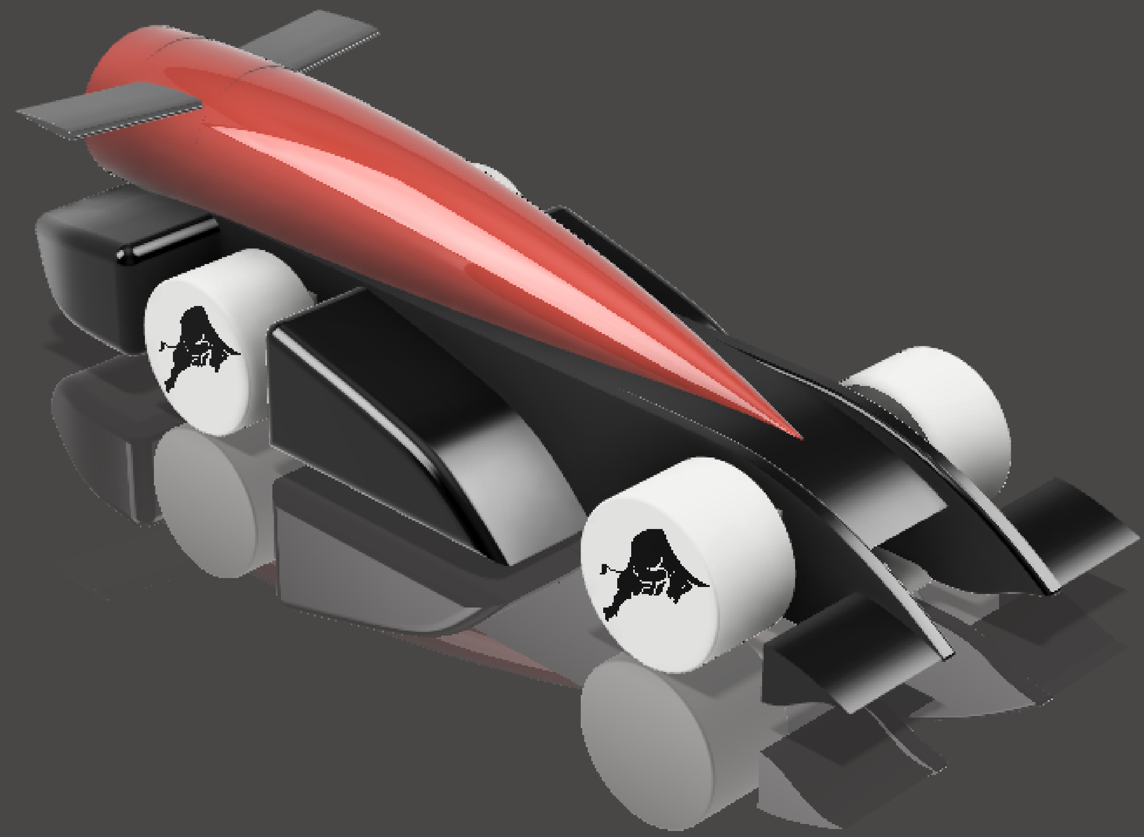
TEAM MATADORS

DESIGN & ENGINEERING PORTFOLIO



"Dazzle them with your Speed.
Baffle them with your Bull."

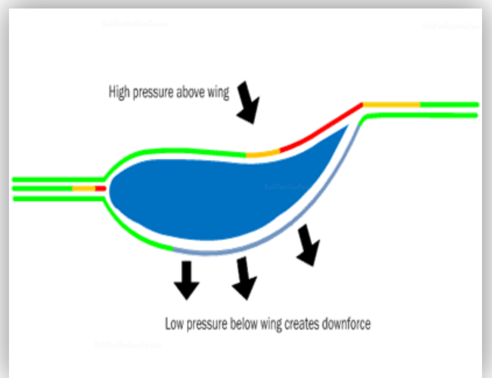
Lift
When the CO_2 exits from the CO_2 canister, as the car moves forward with the acceleration it receives, there is an upward force generated which in conventional terms is referred to lift. It acts through the centre of pressure of the object and is directed perpendicular to the flow direction.

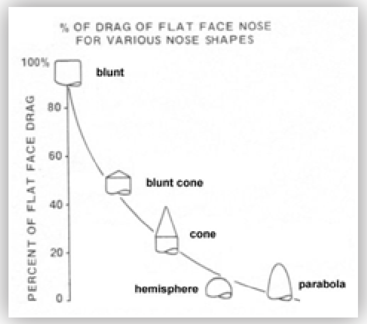
Body Shape
A horizontally- declined teardrop- shape causes the air to flow in patterns or streamlines. Converting a turbulent flow to an absolute laminar flow in real conditions is a relatively difficult task, however, this eddying formation manifests a reduction in the downstream pressure on the moving object and is a principal source of drag.

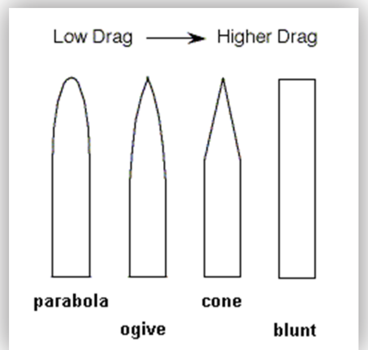
Drag Coefficient
The drag coefficient of an automobile impacts the way the automobile passes through the surrounding air. Aerodynamic drag increases with the square of speed; therefore it becomes critically important at higher speeds

Skin Friction
Being a viscous fluid, air molecules exert a pressure on one another and a layer of air attaches itself to the body of the moving car which exerts frictional force upon the vehicle. To reduce this effect, protrusions such as appropriate gaps and hinges can be incorporated in the car body.

	MITIGATION MECHANISM	Refer to Concept Car No.
Lift	Experimenting the angles of front and rear wing	2, 6
Body Shape	Tapering end to overcome vortices	8, 5
Drag Coefficient	Minimizing frontal area and converging body	1
Skin Friction	Protrusions like hinges	10







INSPIRATION
(1) Mercedes F1 W07 HybridA revolutionary car launched in 2016, with which Mercedes defended its driver's and constructor's championship double which had mini-revolutions in evolving from its predecessor (Figure -1)

(2) Red Bull Racing-Tag Heuer RB12Another 2016 car whose front wing gave us the base for experimenting and trying something new (Figure -2)

(3) McLaren-Mercedes MP4-29 A car of 2014 which had a rear wing with an angle perfect to cut the air (Figure-3)

(4) Haack series: Unlike all of the nose cone shapes above, the Haack series shapes are not constructed from geometric figures. The shapes are instead mathematically derived for the purpose of minimizing drag.

(5) The NACA duct brings air into a vehicle with minimal increase in drag. The NACA duct or NACA scoop is a common form of low-drag intake design, and when properly implemented, it allows fluid to be drawn into an internal duct, often for cooling purposes, with a minimal disturbance to the flow

(6) The Venturi effect is the reduction in fluid pressure that results when a fluid flows through a constricted section (or choke) of a pipe

(7) Bernoulli's principle
Bernoulli's principle states that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy.

(8) Maragoni Effect
The Marangoni effect takes place when there is a gradient of surface tension at the interface between two phases – in most situations, a liquid-gas interface. The surface tension typically changes due to variations in solute concentration, surfactant concentration, and temperature variations along the interface.


Figure - 1


Figure - 2

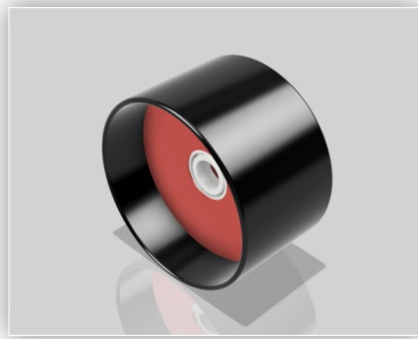

Figure - 3

Inspiration	Refer to Concept Car No.
Mercedes F1 W07 Hybrid	8
McLaren-Mercedes MP4-29	6
Red Bull Racing-Tag Heuer RB12	2,8,9
Haack series	4,5
NACA duct	1,3,4,
Venturi effect	6,7,8
Bernoulli's principle	
Maragoni Effect	5,6,9

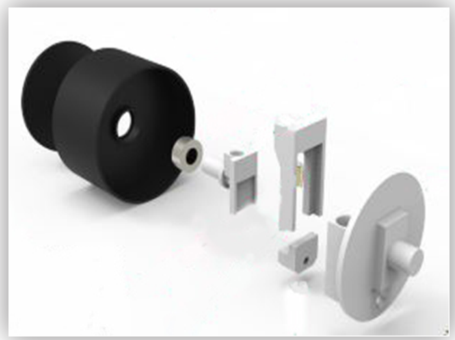
Wheels

For the initial wheel support structure the team had concept choices

Wheels



Wheels with bearings



Wheels with bearings and suspensions

Axle

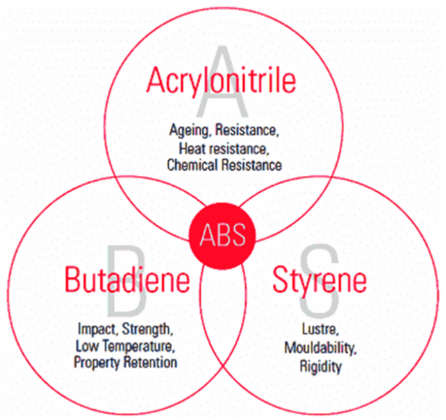
We chose to use bearings without using suspensions. The structure had non-rotating axle with the inner race of the bearing in contact with it. It was the motion of the outer race that facilitated in the wheel rotation. Such a system was chosen to minimize the energy dissipated in frictional activity.

Suspensions

Suspension fitted to the front wheels must be so arranged that its response results only from changes in load applied to the front wheels, and likewise for the rear wheels. Since, the main purpose of suspensions is to absorb the imperfections causing bouncing, we decided to find a substitute instead-in form of material.

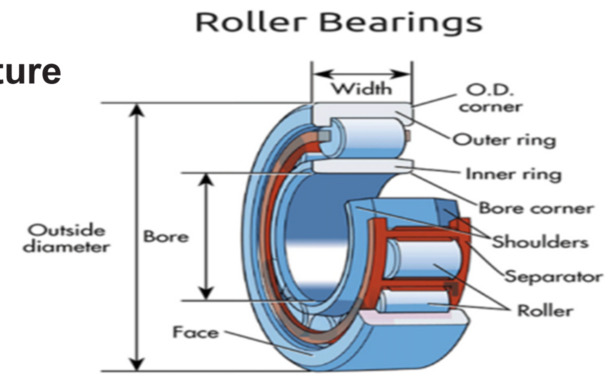
Material Composition

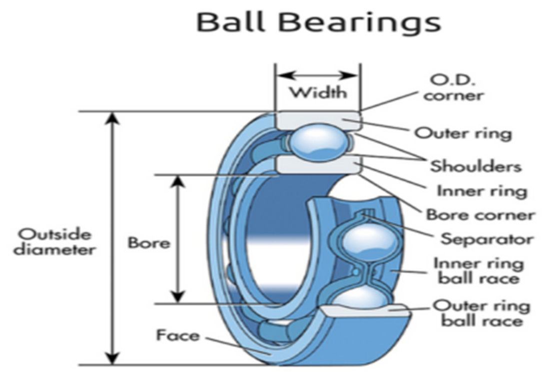
The wheel rim is manufactured of ABS plastic. Due to higher flexural modulus and high machinability, the material served the purpose. Furthermore, the shock-absorbing properties of the material performed the function of suspensions, as mentioned above. As a result , the requirement of a complex suspension-based structure was eliminated, reducing the mass.



Bearings

1. Structure





Ball bearings make use of hard spherical balls that can handle both radial as well as thrust loads. The load is transmitted from the outer race to balls and further to the inner race. Because the bearings are spherical, very less surface area is in contact. Since thrust is inversely proportional to area, the bearings get deformed when the load is high.

In roller bearings, the roller is, as the name suggests, cylindrical. As a result, the contact between the load and inner race is a straight line. Therefore there is a larger surface that is in contact with the load. Applying the same relation between thrust and area, we infer that roller bearings can withhold greater load.

Since our car had a very small mass, ball bearings were suitable for the purpose. Further, ball bearings can handle some misalignment of the inner and outer races. Besides reducing rotational friction, they also support radial and axial load.

(2) Material Composition

We could either use fully-ceramic or hybrid ceramic (contains stainless steel) bearings. For obtaining less mass we chose upon the former.

a) Balls: The hardened spherical balls of our ball bearings are made of silicon nitride. Since silicon nitride ball bearings are harder than metal, this reduces contact with the bearing track. This results in 80% less friction, 3 to 10 times longer lifetime, 80% higher speed, 60% less weight, the ability to operate with lubrication starvation, higher corrosion resistance and higher operation temperature, as compared to traditional metal bearings.

b) Outer surface: This surface is made of ZrO2 (Zirconium Dioxide). The compound is easily polished to finer surface finishes. Further its frictional behavior is such that it provides rolling friction while minimizing the energy lost against friction

(3) Rating

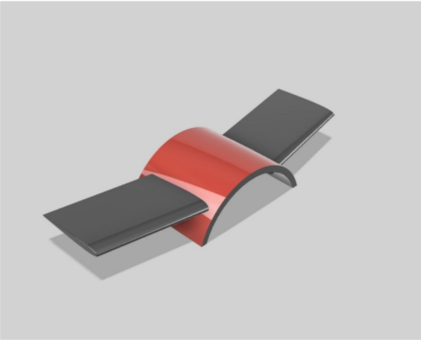
The ball bearings ABEC rating system includes grade 1,2,3,5,7 and 9. The higher the rating, higher the tolerances are, making a more precision part. For the wheel to function at high RPM less tolerance and high precision is required. For our purpose, ABEC 7 was appropriate, since the diameter of our wheel was 26 giving an average RPM of

1. The front wing of the car is designed to benefit in the following ways:

a) We decided to remove a joint structure in the nosecone, between the right and left protrusions as we demanded for inward air flow, and keeping an unwanted structure in the middle further increased the surface area, thus increasing the drag. It also was hampering the inward air flow at the same time increasing the skin friction.

b) The front wing is made at an angle as the complete flow of air below it, would lead to a lift in the car and a complete flow upwards would lead to downforce, both hampering the car.

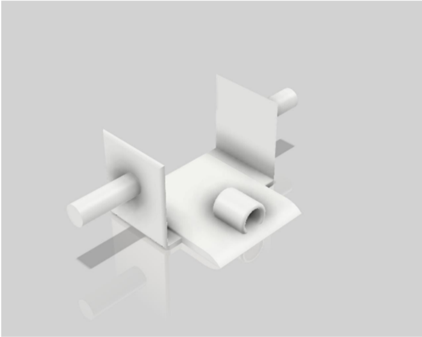
2. The rear wing of the car has been given full tear drop shape. This is the best possible shape which can be given, to reduce the skin friction and easily cut through the wind.
This particular design of the rear wing also ensures minimum turbulence behind the car, guaranteeing a faster car.
Keeping the aerofoil at this angle prevented formation of eddied, as found in experimental testing.

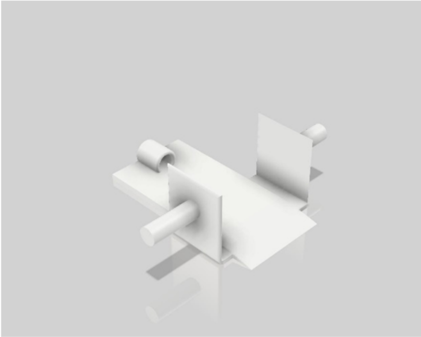


3.Our tether guides were designed such that they were integrated with the wheel support structure. A separate system was not developed for this. This aided us in various aspects:

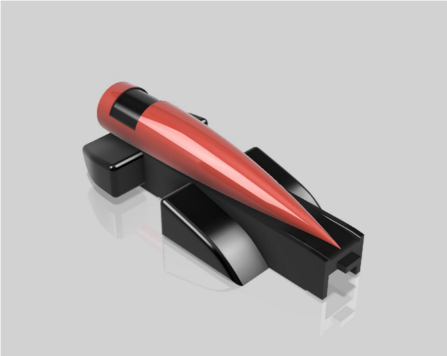
a) We did not have to attach this separately, making the structure from below as smooth as possible, thus reducing the skin friction.

b) This also reduced the mass of the car as the assembling of one part was integrated with the structure.





4. Side support structures: The front side support structures are made with an elevation from the front.
This ensures that the wind flowing above and below the wheels flows smoothly over this structure, avoiding the residual volume of air which can accumulate due the 3mm gap between the wheel and the structure.
The back side support structures are made slightly higher than the base, this ensures that the air which accumulates between the structure and the wheel smoothly goes from over and below the structure, instead of going only from below or above, increasing drag and lift respectively.
The structure above the cuboid has a smooth curve throughout which helps in cutting the wind smoothly, giving a smooth run.

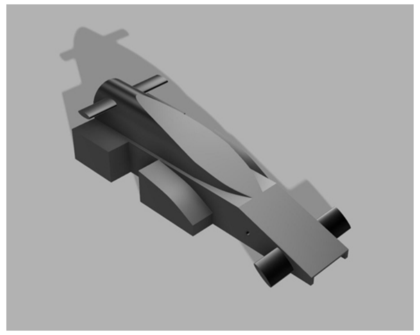


Cause	Risk	Quality
No support could be made within 15mm behind the front wheel.	Side skirt could help reduce the drag, couldn't be made.	We changed the position of the side support structure and designed it to get the same advantage, within the regulations.
The top end could not be tapered due to the presence of the CO_2 Cannister.	This meant having a streamlined shape which ultimately increased the drag	Instead of disrupting the streamlined shape of our main body, we used this ideal shape in our back support structure, which ultimately helped in reduction of drag.
A distance of 120mm had to be there between the front and back tether guide.	This resulted in elongating between both the wheel support structures, thus having greater surface area and the more friction.	The tether guides were integrated with the wheel support structure.

"Dazzle them with your Speed. Baffle them with your Bull."

(1) Concept car 1

This was the first developed car by the team.



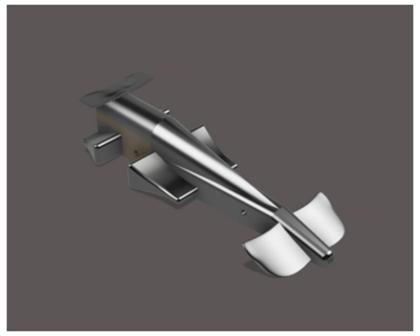
(1) Extremely primitive as compared to others, its main drawback is its highly exposed surface area which caused unwanted increase in surface pressure.

(2) Bulkiness of the car increased its mass, which set back the speed significantly, since the car runs on pressure canister, rather than engine.

Conclusion: The increased frontal surface surged the surface area.

Inspiration: NACA Duct

(2) Concept car 2



The front wing of Concept Car 2 presents

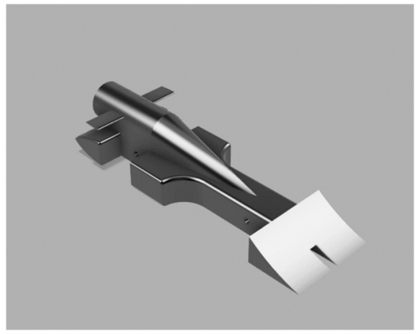
- more of a flat front instead of a streamlined shape,
- high angle of inclination of the front wing also played a role in increasing the drag as well as hampering the airflow over the car, and banging the wind on the wheels and
- The protruding structure between the wings increased the surface area in the front.

The rear end caused the air to swirl around, creating vortices which further created a low air pressure zone, thus pulling the car backwards.

Conclusion: The increased drag and creation of vortices hampered the speed of the car, thus slowing it down.

Inspiration: Red Bull Racing-Tag Heuer

(3) Concept Car 3



The front wing of this car however, streamlined, presented a large surface area.

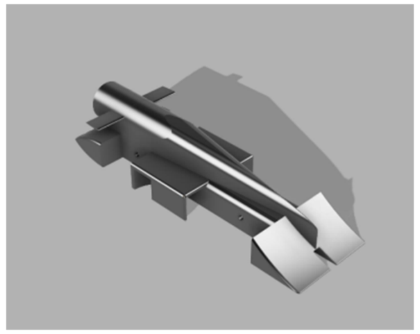
The front wing also turned out to be heavy, with a weight of –g, increasing the overall weight of the car to 70g.

It furthermore was violating one of the regulations which specified the thickness of the front wing.

Conclusion: The increased weight of the car and the front wing's surface area and thickness resulted in a slow pace.

Inspiration: NACA Duct

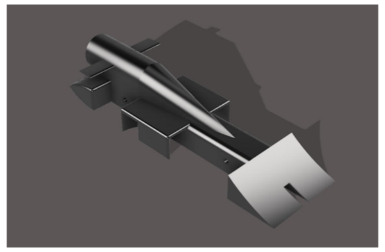
(4) Concept car 4



The front wing of the car is streamlined, which leads to a smooth airflow, however the hollowness of side support structure, led to the rebounding of air in various directions in the side support structure itself, thus making the car unstable.

Further, the development of the elevated and pointed nose cone resulted in the deviation of air which further resulted in taking up of energy, and the energy needed to move the fluid aside reduces the remaining energy available to move the object forward.

Inspiration:NACA Duct, Haack series

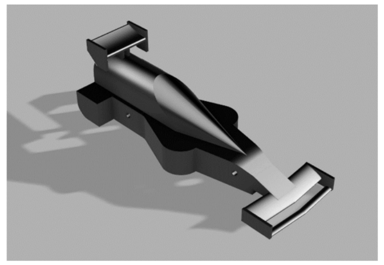


(5) Concept car 5

Similarly, in this car structure the hollow side support structures make the car unstable and heaviness of the front wing makes the car slow.

Inspiration: Haack series, Maragoni effect

(6) Concept car 6



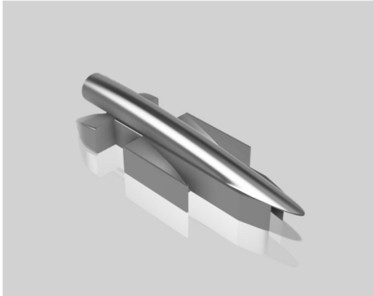
This car turned out to be very bulky, thus making it slow at the very beginning.

Side support structures were made as walls, thus they did not deflect the air, rather struck through it, having a great impact on the car.

The height of the rear wing further increased the turbulence.

Inspiration:Mc Laren Mercedes MP4-29

(7) Concept car 7



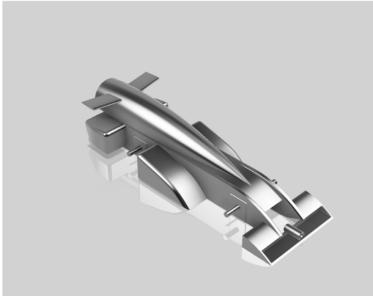
(1) The cartridge chamber along with the main body, though aerodynamic in configuration, was to narrow. According to our calculations an estimated 17N of force is exerted during the launch. This force might be capable to separate the main body and damage it.

(2) Side support structures could not be CNC routed due to their complex structure. Attaching the parts following 3D printing would decrease the stability and make it prone to damage.

Conclusion: The car was subjected to risk of breaking after manufacturing due to its complexity.

iInspiration: Venturi Effect

(8) Concept Car 8

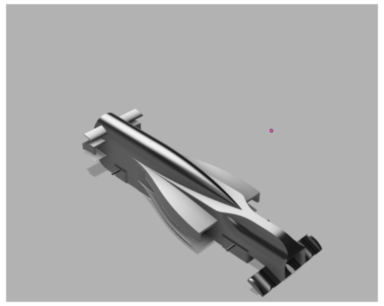


(1) The front wing was a pressure amplifier. Since the car had an inward airflow, a direct pressure was to be exerted on the wings. Reducing the area led to an inverse increase in pressure

Conclusion: The car body was accepted with a final change in front wing design.

Inspiration:Red BullRacing- Tag Heuer

(9) Concept Car 9



(1) The side support structure did not allow a straight passage of air flow. Since it was enclosed on the side, it would cause multiple reflections of the air which would move in an irregular path after bouncing off the surface.

(2) Protrusion like free-surface gaps around the canister housing increased the skin friction.

Conclusion: The air-flow is best manipulated by deflection rather than restriction.

Inspiration: Red Bull Racing- Tag Heuer, Maragoni effect

CAM

Formaking the 3D model of our car we used a CAD (Computer Aided Designing) software Fusion 360 which is provided by Autodesk to students. We made different sketches and used the extrude tool to transform our 2d sketches to make simple 3d models. And for the complex structures we used tools like:

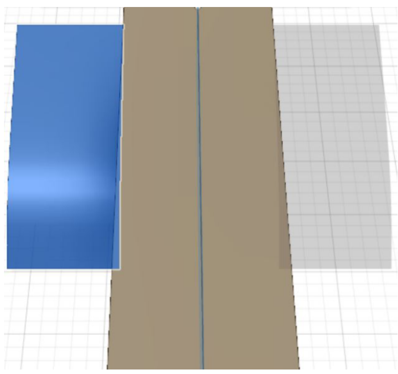
a. 3D: loft, sculpt
b. 2D:mirror, fit point spline,

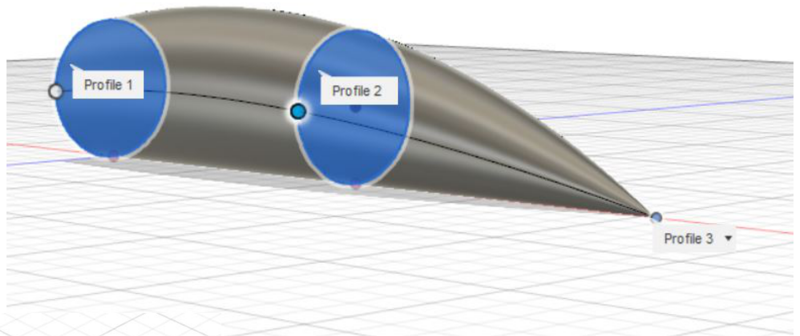
3D Modelling
For making the canister housing in our design we used the loft tool to create the perfect curve. Using this tool, we created a cylindrical structure around the CO2 chamber and then a tangential ogive like main body structure was made.

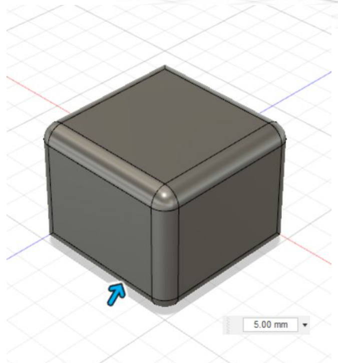
We made each part separately for example the body, canister housing, and the side structures were made separately and then combine tool was used at the end to join them so that changes could be incorporated quickly during our team discussions.
Fillets were applied to almost all the edges of the car. Especially in the wheels support structures to make them more aerodynamic.

2D Sketches
To create sketches at odd places we used the construction tools like offset plane and plane at an angle to first create a plane for our sketches and then make whatever sketches are required to be made.

Mirror Sketch tool was used to maintain symmetry and reduce time consumption, so that one half of the car could be replicated at the other end.

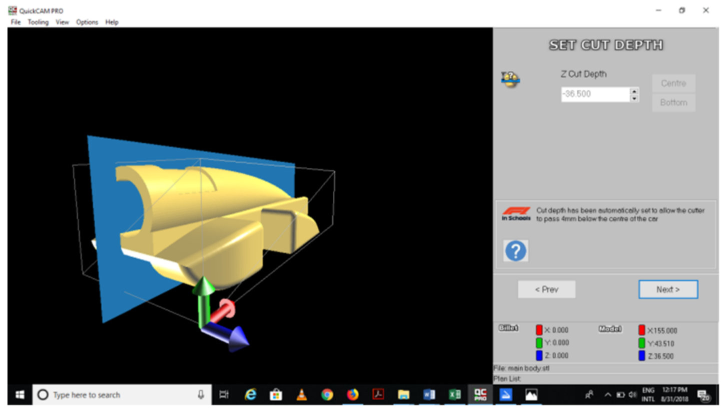




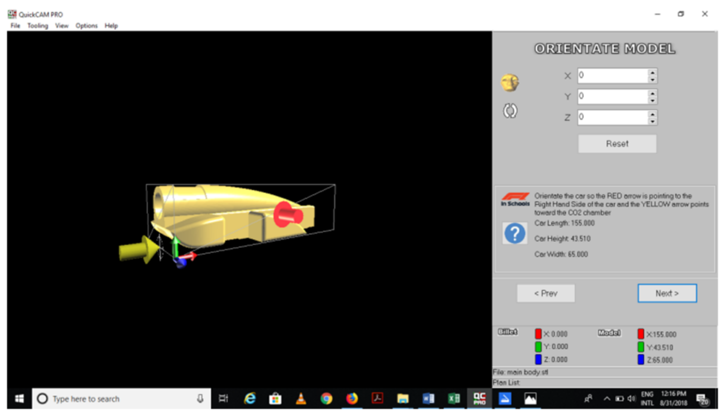


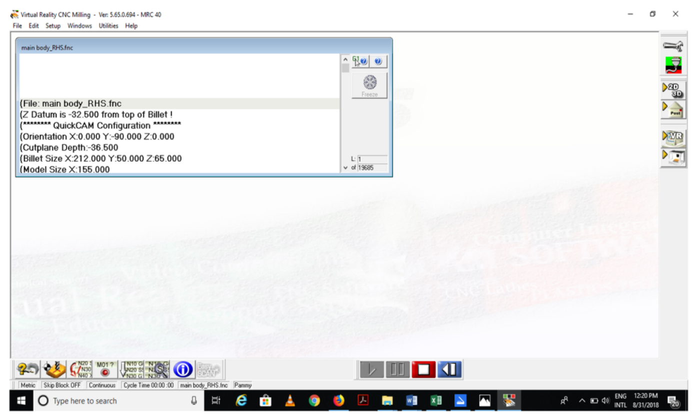
CAM
The 3D model of our car was manufactured using CAM (Computer Aided Manufacturing) Softwares called Quick CAM Pro and VR Milling. Quick CAM Pro was used to turn our design into a string of G-codes. Car Wizard Manufactures our car virtually at first and then it is connected to our CNC router ,Denford MRC40, which is a 3 axis router which manufactures on X,Y and Z Axis.

Drawbacks
1. We used the CAD software fusion 360 for making the 3d model of our car. Fusion 360 exports a low quality STL file which ruins the quality of the car manufactured. We exported a high quality STL file to make sure that we get a high quality finish of our car.
2. Quick CAM Pro manufactures the car by dividing it into two parts, the left half and the right half of the car. Our CNC router first cuts the right half and then the left half. This creates a ridge problem as the Left half is not always identical to the right half of the car. To overcome this problem, we changed the coordinates of the left half to ensure that we get the perfect finish for our car.
3. Earlier, we used the software VR milling for the manufacturing of our car but our design was too complex to be uploaded to this software as it first had to make a mesh of the design which was difficult for it. Car Wizard software, the latest version of VR milling, came just in time which made it easier for us to upload the design to the software and make a better mesh for manufacturing our car.



4. We wanted to ensure that our wheels were perfectly round and smooth to reduce the friction. Our 3d printer gave us a smooth surface but it was not enough. So to make sure the surface of our wheels was very smooth, we used a CNC lathe machine. A CNC lathe machine is ideal for making objects with curved surfaces but it is very expensive so to reduce the expenditure and make sure that we got the smooth surface as well, we 3D printed a wheel of a bigger radius and we CNC lathed it to get the smooth surface and the desirable size.

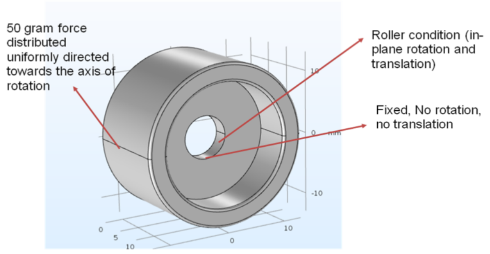




Testing And Simulations

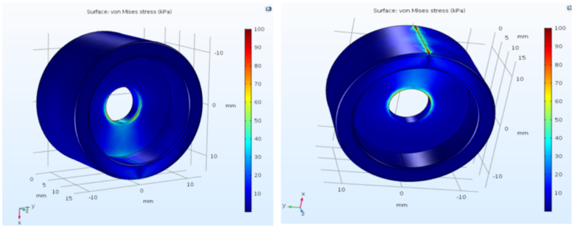
Wheels

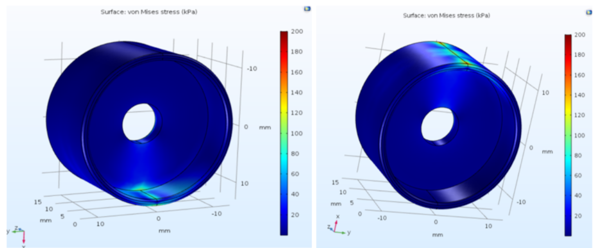
	Property	Name	Value	Unit
☑	Density	rho	1.05*1000	kg/m³
☑	Poisson's ratio	nu	0.35	1
☑	Young's modulus	E	2.05E9	Pa



Material fails when the stress is greater than yield stress of material. For ABS it is around 40MPa.
For testing the boundary conditions, Tetrahedral mesh elements were used with quadratic shape function.

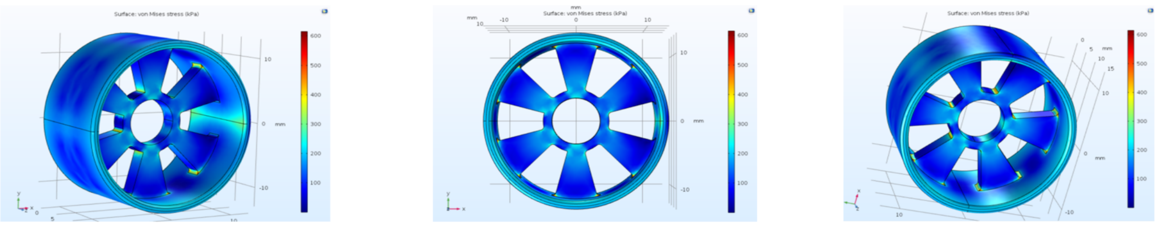
Analysis 1
The initial wheel was thick and bulky. The stresses were too low (max ~100 kPa) and were concentrated around the area of applied force. The initial mass was 4.126g and the maximum stress was around 100KPa, that is 0.25% of Yield Stress.





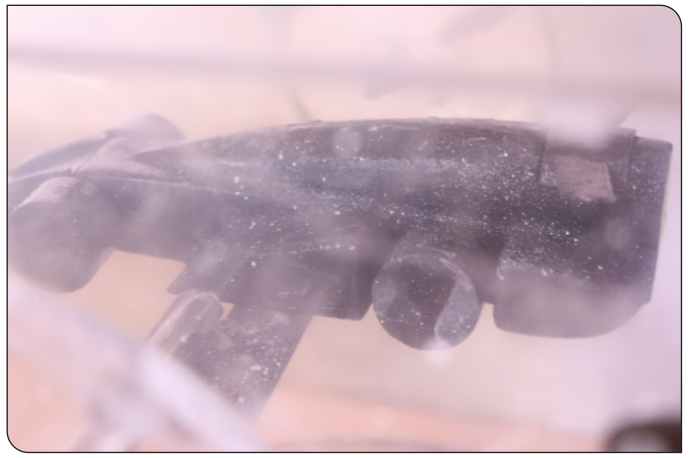
Analysis 2
Decreasing the thickness of the wheel outer walls to 1.2mm reduced the mass without allowing the material to yield. The new mass was 2.508g, that is around 40% improvement. Maximum Stress was around 200KPa, about 0.5% Stress Yield.

Analysis 3
By creating wheel spokes, Maximum stress was moved from outside surface of the wheel to the inner body. It distributed force more evenly throughout the wheel. The mass obtained was 2.0296g, that is approximately 50% improvement. The increase in Stress was about 600%.



Conclusion
Since the stress increases and the mass decreases , we chose against wheel with spokes even though they provided the most stable structure, which we dealt with bearingss. As a result, we chose to make a wheel with reduced outer walls (Analysis 2) and withhout spokes (Analysis 3).

Oil Flow Aerodynamic Testing
The team collaborated with Amity group of Education whose aerospace department let us experimentally test our car through Oil flow tunnels. In such a set up, surface oil flows will indicate the boundary of a flow separation since the oil cannot penetrate the separation boundary. Because of the variation in skin friction between a laminar and a turbulent boundary layer, surface oil treated with naphthalene can be used to determine the transition point on a model. Oil downstream of the transition point will be swept away.



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The following were the results of the aerodynamic test:

(1) In this experimental testing, the visualization of oil flow over the main ogive was laminar and the smooth curves created minimal turbulence.

(2) Some eddies were formed creating vortices as the oil flowed over the rear wing. The angle had to be, thus, manipulated in the upwards direction.

(3) The front wing directed the flow towards the center, increasing the pressure. The front wing's width was subsequently increased in our final design to deflect the flow.

Manufacturing

3D Printing
3D printing being an additive process resulted in no waste of material, contradictory to the process of CNC routing because with 3D printing, parts are built layer by layer. As a result, we only use the ad hoc amount of material needed to build our car's components. Adopting against subtractive manufacturing also served the purpose of our SDGs and CSR.

Material
For the printing of front and rare aerofoils, we short-listed two materials based on their physical properties, namely acetal and ABS.

Material	Acetal	ABS plastic
Coefficient of friction	0.2	0.5
Tensile Strength	10,000 psi	6500 psi
Density	1.42 gm/ cm3	1.06 gm/cm3
Cost (per gram)	₹1.5	₹ (VIVAAN DEDEGA)

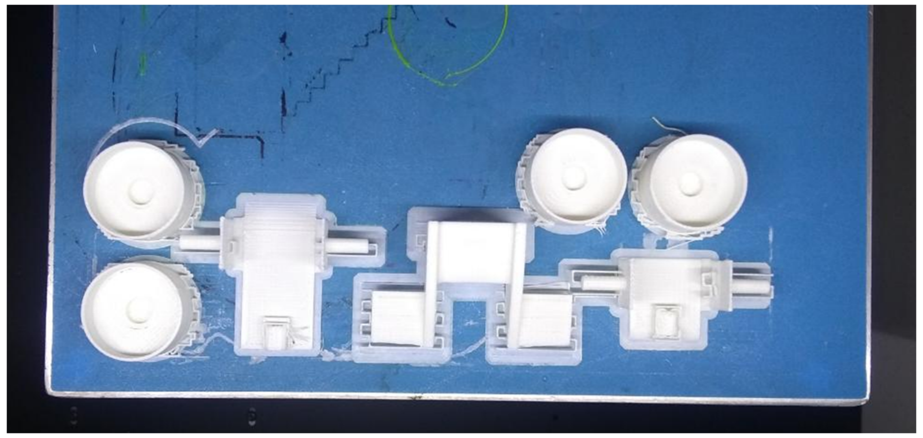
ACETAL (Polyoxymethylene)

Advantages
- Acetal was considered because due to higher flexural modulus and high machinability, the material served the purpose.
- Furthermore, the shock-absorbing properties of thee material performed the function of suspensions, as mentioned above
- Further, the frictional behavior helped decrease the energy dissipated while providing enough to roll the body instead of sliding

Why Did We Not Choose It?
Acetal has low adhesive properties. Since, the 3D printing involves layer by layer formation, the structural strength of aerofoil parts was extremely unstable. The very process of manufacturing couldn't be completed as the layer didn't stick together properly and it couldn't last the physical stress of even one race when placed in a wind tunnel with minimal wind speed. Even when extreme heat was supplied to strengthen the structure, it again solidified and flaked part at room temperature.

ABS Plastic

Advantages
- The clear advantage ABS plastic had was its comparatively low density with respect to Acetal which significantly reduced our weight.
- The cost of ABS plastic was considerably lower than Acetal and it was more easily available locally.
- Manufacturers had more advantages dealing with ABS plastic rather than Acetal due to its better adhesive properties which made it easier for us to deal with on-hand problems during manufacturing.



CNC ROUTING
CNC routing being a subtractive process, had some restrictions to its manufacturing capabilities, in comparison to 3D Printing. We checked for the possibility and viability of manufacturing which resulted in elimination of some of our car designs

In concept car 7, even though the design cleared all regulation checks conducted by us, the problem arose in manufacturing as the car required a 5-axis machine to cut the car and the 3-axis machine could not find the required positioning to cut the car.

Our team searched for 5 axis CNC Routers in and around Delhi, however during manufacturing it was found out that these machines were used only for heavy metals, and the material used for our block which is polyurethane was a light metal for these processes, thus making it susceptible to breaking.
In our final car, we paid heed to the manufacturing limitation and changed the design in which majority of the external parts were printed and only the inherent main body was routed, but during testing, the car showed significant loss of speed and after 15 minutes of testing in the smoke tunnels, broke down as the connection between side support structure and the main body was very low as compared to them being CNC routed together and having uniform bonding strength due to them being in continuation with each other.

There were also some problems with the coding when new designs were tried so in collaboration with the manufacturer, we substituted, on some controllers, plain english language descriptions for the cryptic NC programming languages "M" and "g" code which greatly simplified our work and increased the its efficiency.

CALCULATIONS

Thrust released by pressurized canister

F = u (dm/dt) __ (2)
Where u is relative velocity of air expelled
And (dm/dt) is rate of expelling that is mass expelled per second

Solving (dm/dt)
Mass (m) = volume (v) x density of (( )
R m = area of nozzle (a) x distance (x) x ([Rvolume = area x distance]
R m = a(x
Differentiating both sides with respect to time
dm/dt = d(a(x)/dt
R dm/dt = (a) (() (dx/dt) [R a and (remain constant over passage of time]
R **dm/dt = (a) (u) (•)** __ (1) [R dx/dt = u]

Putting (1) in (2)

F = (u) (u) (a) (()
R **F = (u)^2 (•) (a)** __ (3)
F= (154m/s)^2 (1560 kg/m^3)(59.4 x 10^{-6} m^2)
F= 14.27 N

Moment of inertia
Let us take dx as a small element of the part taken and let dm be its mass.
$R_W^W W^2 WW$ [Moment of Inertia of Continuous Mass Distributions]
$R_W^W W.WWW^2$ [Mass= Volume x Density]

$$\pi_W^W \frac{W}{W}.WWW^2$$

$R_W^{W}\frac{W}{W}.2WWWWW.WW$ [Volume= Length x Breadth x Height]

$\frac{W}{W}.$ $2W.W\, R_W^W W^3.WW$[Mass, Volume and Width are constant]

$\frac{W}{W}.2(.W\ {}^{W}\frac{W^4}{W^4}$

$\frac{W}{W}.2(.W \left[\frac{W^4}{4}\ \pi\ \frac{W^4}{4}\right[$

$\frac{W}{W.W^2.W\pi W.W^2.W}.\ 2(\ W\left[\frac{W^4}{4}\ \pi\ \frac{W^4}{4}\right[$

$$\frac{2W}{(W^2\ \pi\ W^2)}\left[\frac{W^4}{4}\ \pi\ \frac{W^4}{4}\right[$$

Total Moment of Inertia= Sum of Moment of Inertia of its parts = Moment of bearing + Moment of Outer Wheel

Moment of Bearing

$\frac{2]}{]^2]\quad 2}\ \frac{]^4}{4}\quad \frac{]^4}{4}$ Nm

$\frac{2-0.00025}{0.35^2\quad 0.2^2}\ \frac{0.35^4}{4}\quad \frac{0.2^4}{4}$ Nm

$\frac{0.0005}{0.1225\quad 0.04}\ \frac{0.01500625}{4}\quad \frac{0.0016}{4}$ Nm

$\frac{0.0005}{0.0825}\ \frac{0.01340625}{4}$ Nm

$\frac{0.0005}{0.0825}[0.00335156]$Nm

0.000020312484848Nm

20.31μNm

Moment of Outer Wheel

$\frac{2]}{]^2]\quad 2}\ \frac{]^4}{4}\quad \frac{]^4}{4}$ kg m^2

$\frac{2-3.893}{1.3^2\quad 0.35^2}\ \frac{1.3^4}{4}\quad \frac{0.35^4}{4}$ kg m^2

$\frac{7.786}{1.5675}\ \frac{2.8561}{4}\quad \frac{0.01500625}{4}$ kg m^2

$\frac{7.786}{1.5675}[0.71027344]$kg m^2

3.52803125 kg m^2

3528031.25 μkg m^2

Sum total= 3528051.56 μkg m^2

3.528031.25 Nm

Torque= Moment* Angular acceleration

= Moment* Acceleration*radius

= Moment* Force/mass* radius

= (3.52 Nm)(14.27N/0.058 Kg)(0.013 m)

= 11.25 Nm

Power= torque* rpm/5252

ANALYSIS:

1. The initial calculation of the torque was imperative as it was required in further calculations.
2. Since the power was constant in our case, it was inferred that a lower torque would result in higher RPM. After testing the wheel with the least torque was chosen to yield highest RPM.
3. In linear mechanics, mass which is the measure of inertia is inversely proportional to acceleration for a constant force. Applying logic in rotational mechanics, less moment of inertia yielded higher acceleration.

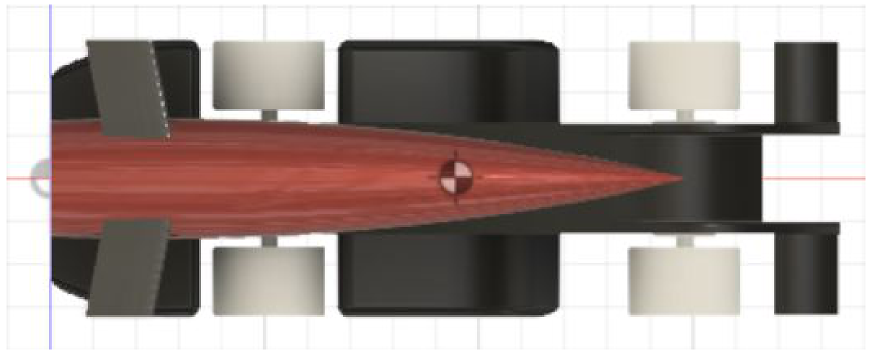
When two objects are acted on by the same torque, the object with the larger moment of inertia has the smaller acceleration.
The moment of inertia of an object depends on the mass of the object, and on how this mass is distributed with respect to the axis of rotation. The farther the bulk of the mass is from the axis of rotation, the greater is the rotational inertia of the object as mentioned in Leonard Euler'sTheoria Motus CorporumSolidorumseuRigidorum

Angular Momentum is a vector quantity that is a measure of the rotational momentum of a rotating body or system, that is equal in classical physics to the product of the angular velocity of the body or system and its moment of inertia with respect to the rotation axis, and that is directed along the rotation axis

Force is directly proportional to the rate of change of momentumor Force is directly proportional to mass time the rate of change of velocity or Force is directly proportional to velocity times the rate of change of mass

Equation of Continuity
The product of area of cross section and the speed remains same at all points of a tube of flow. This is called as the equation of continuity and expresses the law of conservation of mass in fluid mechanics.

Center of Gravity (CoG)



Aim: aerofoils and body parts were made of different materials with masses, an analysis test was conducted to find the center of gravity using Autodesk Fusion 360.

Results: The CoG coincided with the virtual cargo part, maing the car stable resulting in minimum torque.

Woodtech Polyester
The block used to manufacture the car is of the material Polyurethane.

- After the finishing of the car we decided to use woodtech polyester which basically helped us three specific areas of the car:

- **Glass finishing-**This reduced the skin friction of the car, which would enable a smooth run on the track and also less impact on the car.
- **High heat resistance-** Polyurethane adversely gets affected from sunlight giving its direct relation to the heat provided by it. Also, during the race the heat provided by the kinetic energy is also compensated by this material.
- **High Scratch Resistance-** The scratch resistance property enabled the durability of the car for a number of races. This turned out to be highly useful during the transportation of the car and causing unnecessary scratches further increasing the friction during the car.

Aquadur Dent Filler
One of the most important aspects of the race is deacceleration of the car. This further presents us with the problem, which is the impact with which the car stops, creating a possibility of dents on the car. This possibility also arises in the transportation of the car from India to Singapore.
To avoid this we researched upon Aquadur Dent Filler. It had the following benefits:

- It can be applied on the interior as well as exterior of the surface. This provided extra protection to the car.
- It provides extraordinary toughness to the block.
- Both of these aspects made the car more durable. It made sure that the car runs manyraces and is able to withstand the impact of deacceleration without much damage.

Adhesives
The adhesive used had to be chosen keeping in mind the various properties of this block. For polyurethane we researched that cyanoacrylates were the best adhesive to be used.
Provided that we were using thermoset polyurethane it was advised to use ‘Fevikwik’ which is a type of cyanoacrylate. Fevikwik provides a strong and fast adhesive nature and dries within seconds.
Loctite quick set 404 is another cyanoacrylate. Plastics being one of its main substrate meant that the cure speed for bonding was more and strong. Due to better compatibility with polyurethane, as found experimentally, we chose Loctite 404. This was also considered to compensate with the weight, if the weight of the car turns out to be less than the ideal weight.

Epolac Epoxy Two Pack

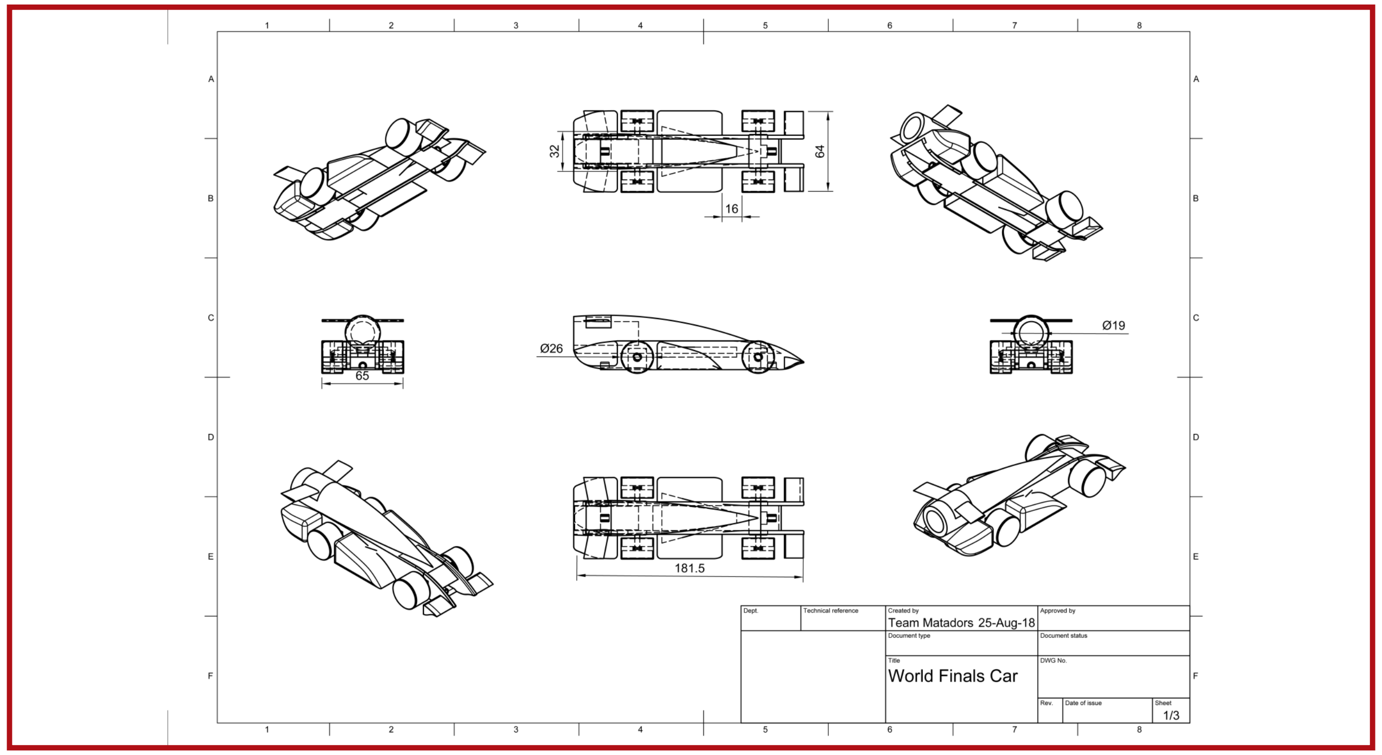
We decided to use Epolac Epoxy Two Pack at the end for two reasons:

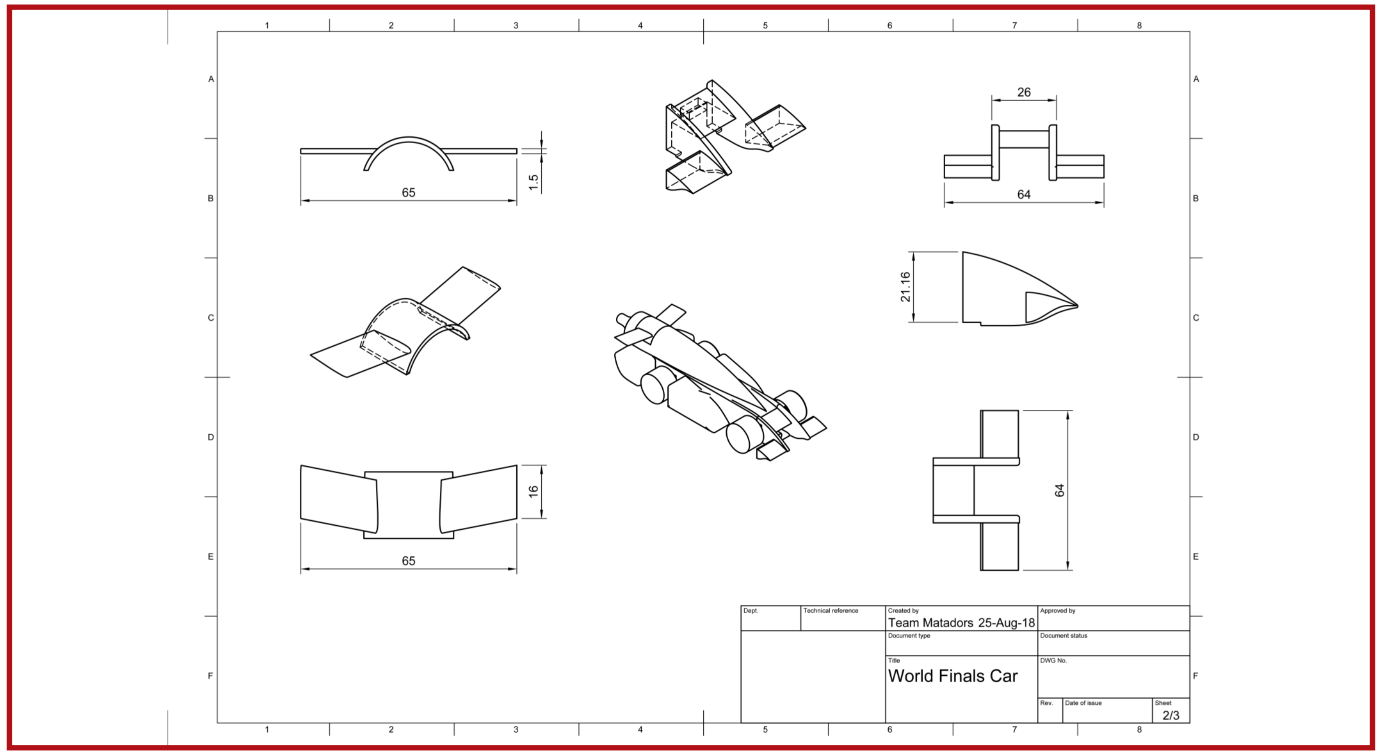
1. It did not increase the weight of the car.It gives a film thickness of 75- 100 microns in a single coat.
2. It gave higher resistance to chemical solvents. This was highly useful after the manufacturing of the car. After the manufacturing of the car, its storing in various places at our school and houses and also during transportation did not hamper its quality.
3. This material is highly useful in coastal environments. Coastal environments present a very humid surrounding and the presence of humidity may bring a variation in the foam hardness. Thus, use of this specific material, protects our car from humidity and moisture present in Sentosa.

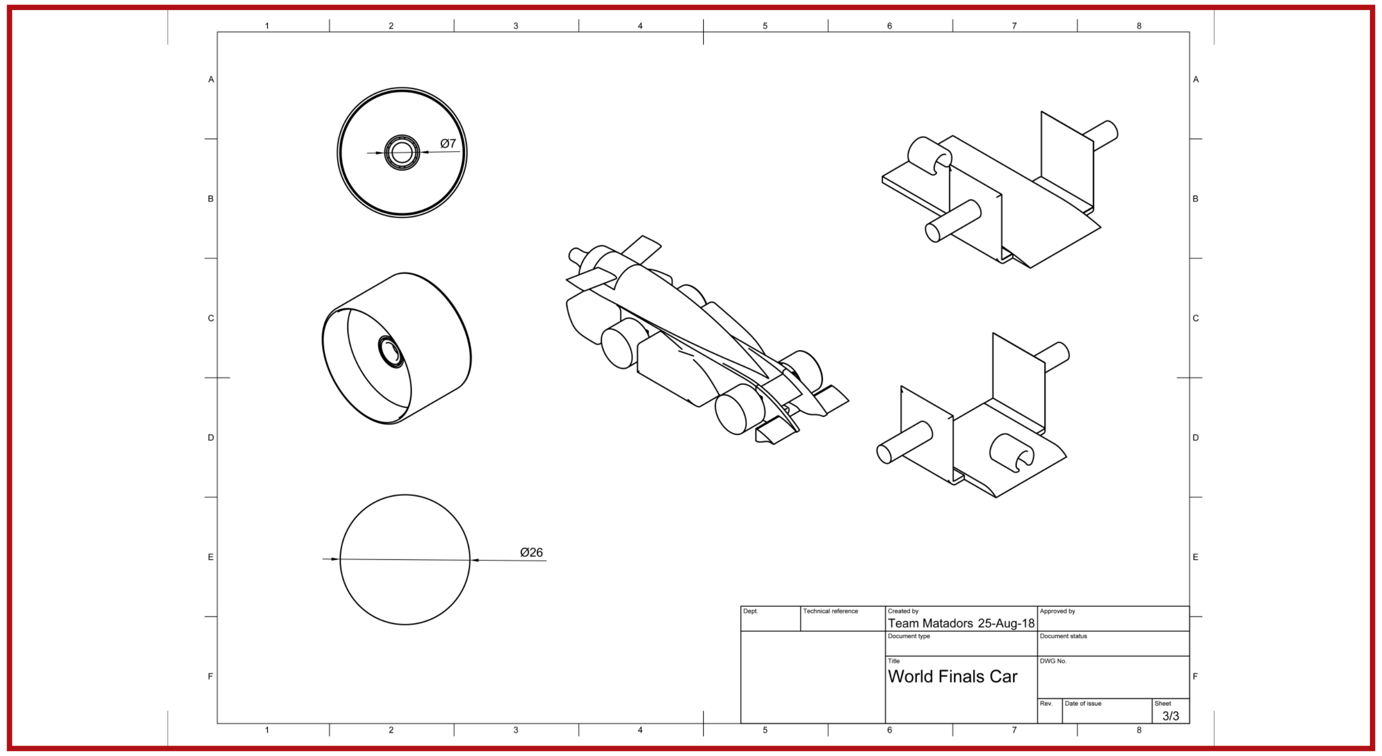
Sanding
The grit size of sandpaper is usually stated as a number that is inversely related to the particle size. A small number such as 20 or 40 indicates a coarse grit, while a large number such as 1500 indicates a fine grit. The lowest grit sizes range from 40 to 60. This **workhorse paper**, used by us, is perfect for shaping or removing a lot of material at a quick pace.

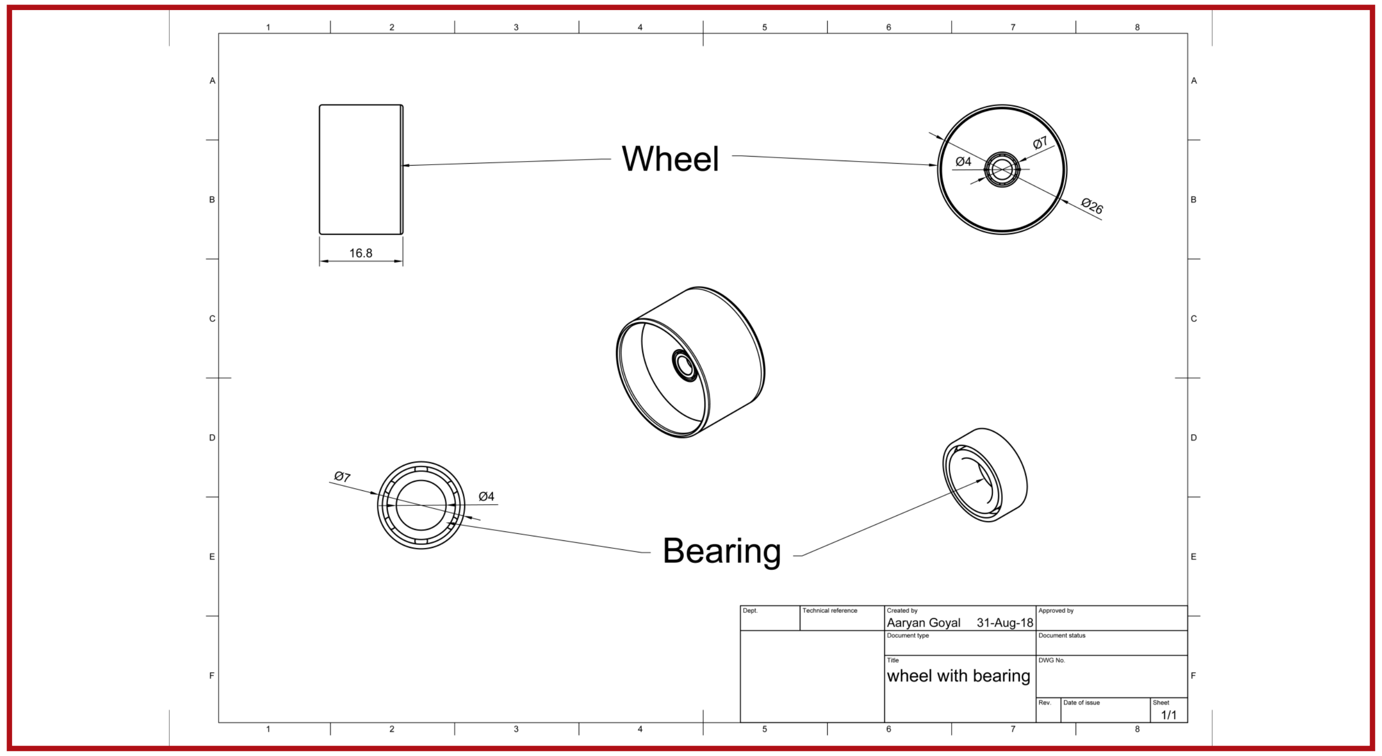
Assembly of the Car

After manufacturing of the car, its sanding was done to fine the parts of the car, according to our required needs.
It was followed by making the car hollow manually by the wood craftsperson. This was done by using the appropriate size blade. Further fining of the car was done to remove the scratches. This time the process of sanding was done by taking a wood piece with a width of the hollow structure inside and wrapping a sand paper paper around it, and sanding against it. This guaranteed the fining in all the directions in an efficient manner.
Subsequently, Loctite 404 was used for its adhesive properties and the parts were stuck and left to dry.
At the end, Epolac epoxy coating was applied on the car, in the shades of our team colour.


32
64
16
Ø26
Ø19
65
181.5
Team Matadors 25-Aug-18
World Finals Car
1/3


65
1.5
26
64
21.16
16
65
64
Team Matadors 25-Aug-18
World Finals Car
2/3


Ø7
Ø26
Team Matadors 25-Aug-18
World Finals Car
3/3


Wheel
16.8
Ø4
Ø7
Ø26
Ø7
Ø4
Bearing
Aaryan Goyal 31-Aug-18
wheel with bearing
1/1