ENGINEERING
PORTFOLIO

ELECTRONIC INTERCONNECT ENGINEERING

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INTRODUCTION

TECHNICAL GUIDENCE

Since Rocket Squad one is a pioneering Formula Pakistan team from Pakistan, we had no prior experience in such competitions. To support us, our school assigned mentors from NUST University to guide our team. Through this collaboration, we received expert technical guidance from NUST's Formula Student teams, who have extensive experience in designing and manufacturing formula-style cars for competitive events. Their mentorship provided us with valuable insights into engineering design, material selection, and manufacturing processes, enabling our team to make informed decisions and enhance the overall performance and reliability of our car.

PORJECT OBJECTIVES

MASS:

Our car was light so it could speed easily and handle well. We made sure to remove any unnecessary weight to make our car robust and fast. This made it easier for us to control our car on the circuit and perform well in races.

COST:

Cost management was a crucial aspect of our project. We considered costs for all materials and production methods. Utilizing quality, economical parts allowed us to manage expenses effectively, ensuring we didn't overspend on performance-related areas.

RULE COMPLIANCY:

Each and every element of it was checked to ensure it was in accordance with Formula Pakistan rulebook. This helped to ensure our car is safe, legal, and competitive throughout. Another reason to follow the rules is to ensure our car will certainly qualify through the technical inspections.

DESIGN:

The design of the car was done with considerations for aerodynamics and stability. The car was designed using CAD simulations, allowing us to optimize it for airflow and stability. The design aimed at ensuring the car looks aesthetic and is technically correct as per the judges' requirements.

PERFORMANCE & RACE:

Performance and race readiness were central to our project. Fine tuning the exact design through testing and optimization, we got just the right lightness distribution, rolling resistance, and all other aerodynamics such that the car was fast, stable, and competitive on the track.

MANUFACTURING:

Our goal is to make a design which not only complete rule compliancy requirmnet but also easy to manufacture as the foam material is very weak.

RESEARCH & DESIGN PROCESS

The Research & Design Process formed the foundation of our team's approach to building a competitive car. We began by thoroughly studying the competition rules, technical regulations, and performance criteria to ensure that our design would meet all required standards. This step helped us identify key areas of focus, including speed optimization, stability, and energy efficiency.

Our team then conducted extensive research on aerodynamics, materials, and wheel designs, comparing different approaches to determine the most effective solutions. This included analyzing existing designs, consulting STEM resources, and simulating potential performance outcomes using mathematical models.

The design phase involved multiple iterations, where sketches, CAD models, and simulations were refined based on predicted performance and practical feasibility. Each design choice was carefully evaluated for its impact on weight distribution, launch efficiency, and overall race performance.

Collaboration played a vital role during this process, as team members with expertise in aerodynamics, mechanics, graphics, and project management contributed to a well-rounded and optimized design. Through this structured approach, we ensured that our car design was both innovative and technically sound, ready for prototyping and testing.

Auto CAD SOFTWARE(REJECT)

We didn't use AutoCAD because SolidWorks was more suitable for our project. AutoCAD is primarily used for 2D design, whereas our main requirement was 3D modeling and car part design. Additionally, learning AutoCAD and understanding its complex commands is time-consuming. We chose a simple, user-friendly software to create designs quickly and accurately. Therefore, SolidWorks was more efficient and convenient for our needs.

AUTODESK
AutoCAD

SOFTWARE USED

SolidWorks is a very versatile software for 3D designing, which helps to generate a complex design very quickly and accurately. It has very powerful functionalities for designing, simulating, and assembling. This makes the designing task very efficient for us. We use it to translate our concepts into tangible models and improve them. It minimizes errors and gives us the desired output and it is also easy to use.

WHY WE USED SOLIDWORKS?

We used SolidWorks for designing our formula pakistan car because it is a powerful and industry-standard CAD software that allows precise 3D modeling, accurate dimensions, and easy design modifications. SolidWorks enabled us to create complex aerodynamic shapes, analyze assemblies, and ensure proper fit of all components before manufacturing. Its simulation and visualization features helped us evaluate design feasibility, weight optimization, and structural integrity while saving time and reducing errors. This made SolidWorks an ideal choice for developing a competition-ready car that meets Formula Pakistan regulations.

SOLIDWORKS

RESEARCH AND DEVELOPEMENT

AERODYNAMIC SYSTEM

Aerodynamics is also critical in an Formula Pakistan car because it reduces drag and enables a car to attain high speeds. A well-designed aerodynamic system ensures that a streamlined flow of air is accomplished.

Front Wing

The front wing is a strategically placed aerodynamic component designed to facilitate smooth airflow around the vehicle's nose, adhering to Formula Pakistan regulations for optimal performance and safety.

REAR WING

The rear wing controls airflow, improving stability and aerodynamic efficiency, and adheres to Formula Pakistan regulations.

AIRFOIL

Airfoils enhance speed, stability, and downforce by controlling airflow, improving grip, reducing lift, and improving traction, cornering, and overall vehicle dynamics for increased speed.

AIRFOILS UNDER CONSIDERATION

- NACA 0010
- NACA 4412
- NACA 2412

AIRFOIL REJECTION FOR FRONT AND REAR WING (NACA 0010)

We eliminated the NACA 0010 airfoil due to its ineffectiveness at low Reynolds numbers. Symmetric profiles like NACA 0010 produce higher drag and lower lift-to-drag efficiency compared to optimized airfoils, resulting in reduced downforce and performance.

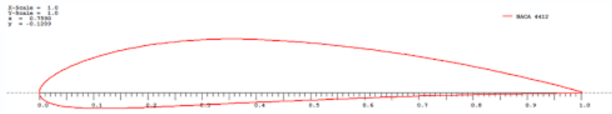
AIRFOIL REJECTION FOR FRONT AND REAR WING (NACA 4412)

We didn't select the NACA 4412 airfoil because it generated too much drag. While it offered good lift, our main challenge was minimizing drag, not maximizing lift. We needed a faster airfoil with less drag.

AIRFOIL SELECTION FOR FRONT AND REAR WING (NACA 2412)

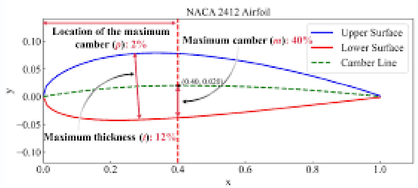
For our car, we selected the NACA 2421 airfoil for the front and rear wings because of its excellent aerodynamic properties. The airfoil's cambered shape produces moderate lift, creating slight downforce that enhances straight-line stability without causing a substantial increase in drag. This ensures the car maintains speed and control on the track. Furthermore, its straightforward geometry facilitates accurate manufacturing, enabling us to optimize performance while adhering to Formula Pakistan's technical regulations.

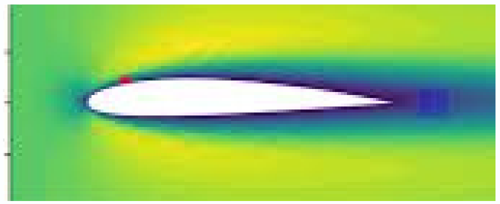
NACA 4412



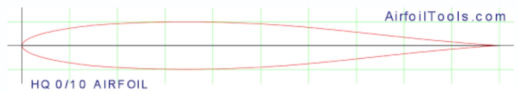
NACA 2412

m p t





NACA 0100



INERTIA AND WHEEL DESIGNING

INERTIA

Inertia is an object's resistance to changes in motion, directly linked to its mass. In our car, this is most noticeable during launch, stemming from both the chassis' linear inertia and the wheels' rotational inertia. Increased mass hinders acceleration, while heavier, larger wheels amplify rotational inertia. Our team, through analysis and simulations, recognized vehicle mass as a key performance factor. We thus focused on a lightweight design, adhering to regulations, by optimizing materials and geometry. This reduced inertia, leading to faster starts and improved overall race performance, solidifying mass optimization as a core engineering goal. The optimization process involved several key strategies.

Design Optimization:

* Streamlined the car's bodywork to reduce drag and improve airflow.
* Used computational fluid dynamics (CFD) simulations to analyze and refine the aerodynamic design.
* Optimized the suspension system for efficient energy transfer and optimal handling.

Material Selection:

* Employed lightweight yet high-strength materials like carbon fiber and aluminum alloys.
* Carefully selected materials for each component, considering strength-to-weight ratio and cost.

ROTATIONAL DYNAMICS

Rotational dynamics describes how objects behave when rotating and the forces they encounter. In our car, the wheels' rotational inertia significantly impacts acceleration and launch efficiency. The mass distribution around the wheel dictates the torque needed to rotate it, making reducing rim mass and optimizing overall weight distribution a top priority. Through careful design considerations, we minimized rotational resistance, improved acceleration, and enhanced overall track performance.

TIRES

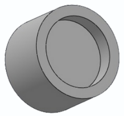
In our Car project, we decided to design and manufacture our own wheels, even though we could purchase standard wheels from the competition, Formula Pakistan. The main reason for designing and manufacturing our own wheels is to reduce the weight of our car and thus enhance its performance. We can design and produce our wheels in a way that allows us to choose the material we prefer and optimize it to achieve maximum strength with minimal weight. Additionally, we can design our wheels just as we design our car, tailored to our specific design and requirements.

WHEEL DESIGN AND PERFORMANCE OPTIMIZATION

This wheel was specifically conceptualized and used in our F1 in Schools vehicle in order to obtain the best performance levels with the help of the best combinations of low mass, strength, and stability. This streamlined design of the wheels ensures lower frictional resistance when it moves over the wheels, thereby allowing it to easily cover the path of the track. In addition to this, this particular design of wheels provides stability while moving in motion, which plays an important role in keeping it moving at the same speed in the straight path of the track.

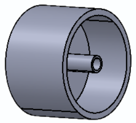
REASON FOR REJECTION OF THIS DESIGN

We did not choose this wheel due to it having too much mass and also being slightly too large for our F1 in Schools racing car. This makes it more difficult for it to accelerate, as it would have to work against the mass of both itself and the wheel.



REASON FOR SELECTION OF THIS DESIGN

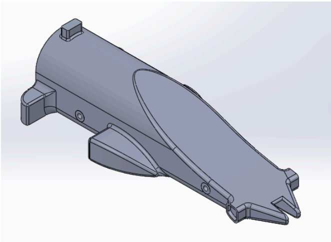
The reason for choosing this wheel is that it had a lower mass and an ideal diameter, which helped in reducing the overall weight and rotational inertia of the wheel to enable the car to accelerate faster and utilize the energy more efficiently during the race.



DEVELOPMENT OF CAR

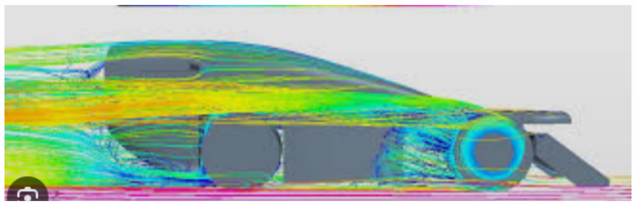
DESIGN CONCEPT:

The car's design concept was developed around our team's performance and speed goals. We created initial sketches and 3D models while considering aerodynamics, stability, and weight distribution. The design was kept simple, efficient, and fully compliant with competition rules to ensure the car was fast, stable, and controllable on the track.



AERODYNAMICS:

The aerodynamic features that characterize this particular automobile are largely accounted for under Streamlining and Downforce Management. These features include a wedge-shaped nose and a teardrop-shaped body that are designed to reduce resistance due to frontage and sustain attached flow. Through the use and application of a nose-shaped inlet that pierces through the air and a rear wing that creates downward force, this particular automobile is designed to promote fast speed-sustaining acceleration and grip during cornering.Finally, other features such as wheel fairings and sidepods are responsible for managing air turbulence around wheel wells. Their purpose is to sustain a smooth flow of air moving towards the rear, hence promoting acceleration and grip during cornering.



MATERIAL SELECTION:

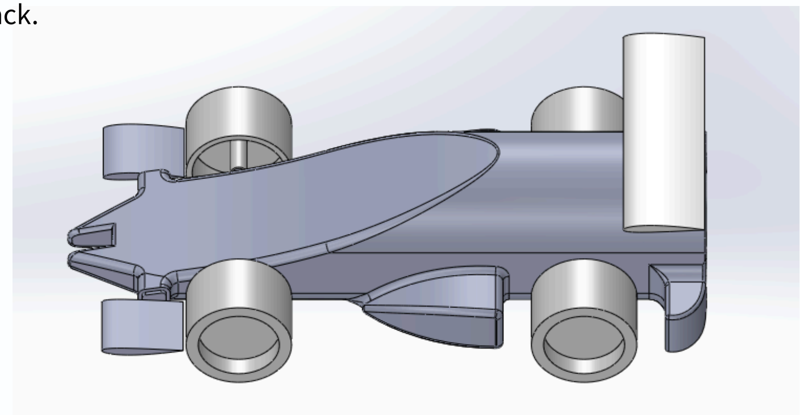
The wheels' materials were carefully selected to achieve a balance between strength, weight, and cost. ABS was chosen as the primary material due to its durability and high impact resistance. Despite being lightweight, ABS provides sufficient rigidity and stability for improved speed and control. This ensured compliance with competition rules while maximizing overall performance.

ABS Material

PLA material

CAD MODELING:

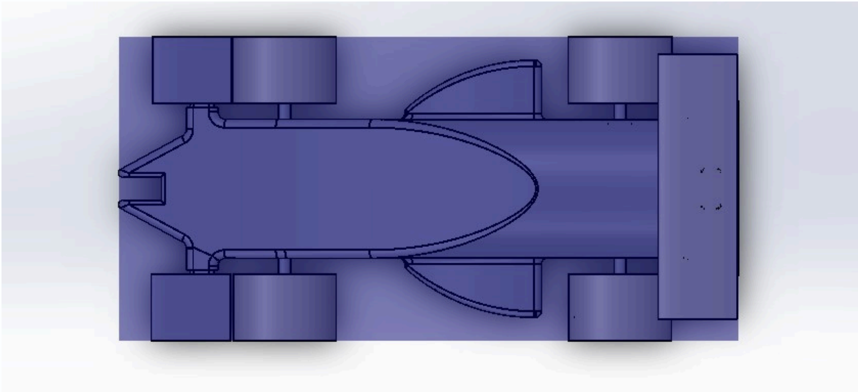
The car's design concept was developed around our team's performance and speed goals. We created initial sketches and 3D models while considering aerodynamics, stability, and weight distribution. The design was kept simple, efficient, and fully compliant with competition rules to ensure the car was fast, stable, and controllable on the track.



MANUFACTURING OF CAR

CAR BODY

We chose CNC machining for manufacturing our formula Pakistan car because CNC machines operate on three axes, which allows highly precise and controlled material removal. This process ensures excellent dimensional accuracy, smooth surface finish, and consistent quality, which are critical for aerodynamic performance. CNC machining produces stronger and more reliable parts from solid material, reducing the risk of deformation and inaccuracies that can occur in 3D printing. Due to its high accuracy, repeatability, and professional manufacturing standards, CNC machining is the most suitable method for producing our competition car.

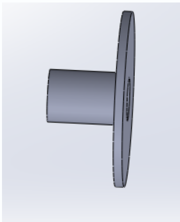


WHEEL SUPPORT SYSTEM

We are using bushes in our wheel support system to reduce friction and allow smooth rotation of the wheels, which improves speed and efficiency. The bushes are made from ABS material, providing good strength, durability, and resistance to wear. By 3D printing them, we achieved precise geometry and consistent fit, ensuring reliable performance while keeping the system lightweight. This setup helps our Formula Pakistan car run smoothly and maintain better control on the track.

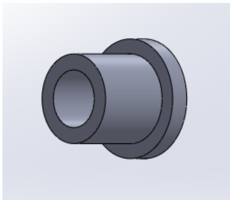
REASON FOR REJECTION OF THIS DESIGN

The initial bush was rejected due to its small outer diameter and 2.5 mm inner diameter, which resulted in poor fit and weak support. This caused instability and improper load distribution, so a better design was selected.



REASON FOR SELECTION OF THIS BUSHES

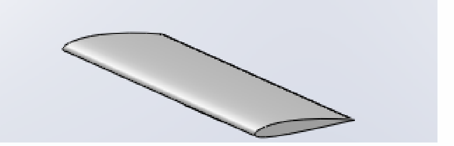
Bushes were used in the wheel support system to reduce friction and ensure smooth wheel rotation. The increased bush diameter improved load distribution, stability, and durability, minimizing wear and enhancing overall performance.

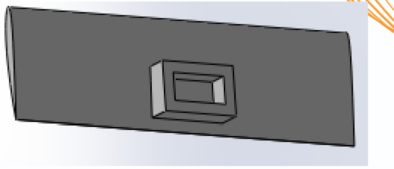


MANUFACTURING OF CAR

WINGS

We are using 2412 airfoil wings for both the front and rear of our car because they provide a good balance of downforce and low drag, which helps improve stability and speed on the track. The wings are made from ABS material, giving them strength, durability, and resistance to deformation under stress. Using the same wing design for front and rear also simplifies manufacturing while ensuring consistent aerodynamic performance for our Formula Pakistan car.

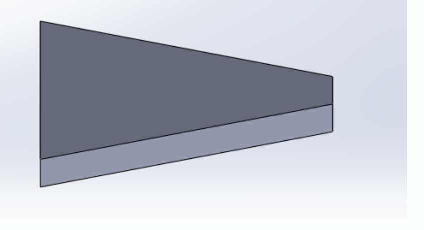


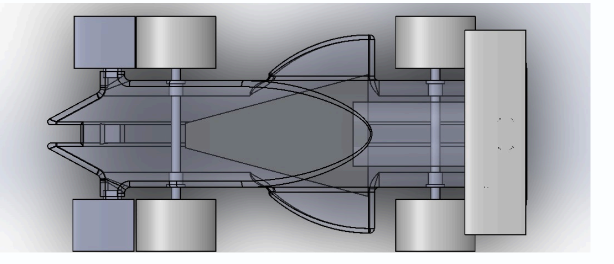


We used NACA 2412 airfoil wings on our car because they provide a better lift-to-drag ratio, improving stability and traction. Being a cambered airfoil, NACA 2412 generates effective downforce even at low speeds. This helps the car stay stable during turns and high-speed motion. We rejected NACA 0010 because it is a symmetric airfoil and produces less downforce. Overall, NACA 2412 was more suitable for maximizing the car's performance.

VIRTUAL CARGO

We use virtual cargo in our car to simulate extra weight during testing.
It allows us to see how the car behaves under different loading conditions without physically adding heavy components.
By using virtual cargo, we can test stability, handling, and performance more safely and efficiently.
This method saves time and reduces the risk of damaging the car during trials.
Overall, virtual cargo helps us optimize the car's design for real-world conditions while keeping testing practical and safe.





We placed the virtual cargo at the center of the car to simulate the weight distribution accurately.
This helped us understand how the car would perform under load and maintain balance.
However, we faced problems while setting it up, as the cargo system was overflowing from the body.
We had to carefully adjust and secure it to ensure proper placement without affecting the car's structure.

SEPERATE PARTS OF CAR

BUSHES

Bushes absorb shocks and vibrations from the track, making the ride smoother. They help maintain control and driver comfort.

REAR WING

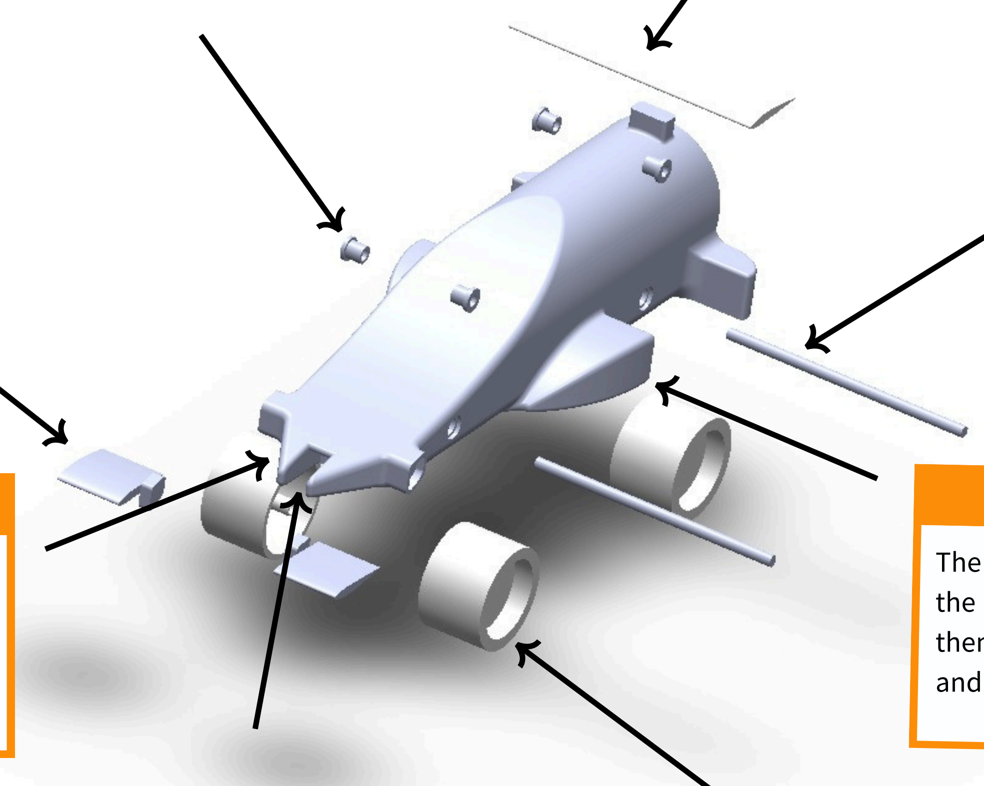
The rear wing creates downforce that presses the car to the ground, improving traction at high speeds. It is essential for balance and safe cornering.

FRONT WING

The front wing directs airflow downwards to increase grip and improve steering. It helps keep the car stable and controllable during the race.

AXLE

The axle connects the wheels to the car and transfers power to them. It enables wheel rotation and movement of the car.



NOSECONE

The nosecone shapes airflow to reduce air resistance and increase speed. It also helps balance the car and maintain control.

SIDE PODS

The axle connects the wheels to the car and transfers power to them. It enables wheel rotation and movement of the car.

TETHER LINE SLOT

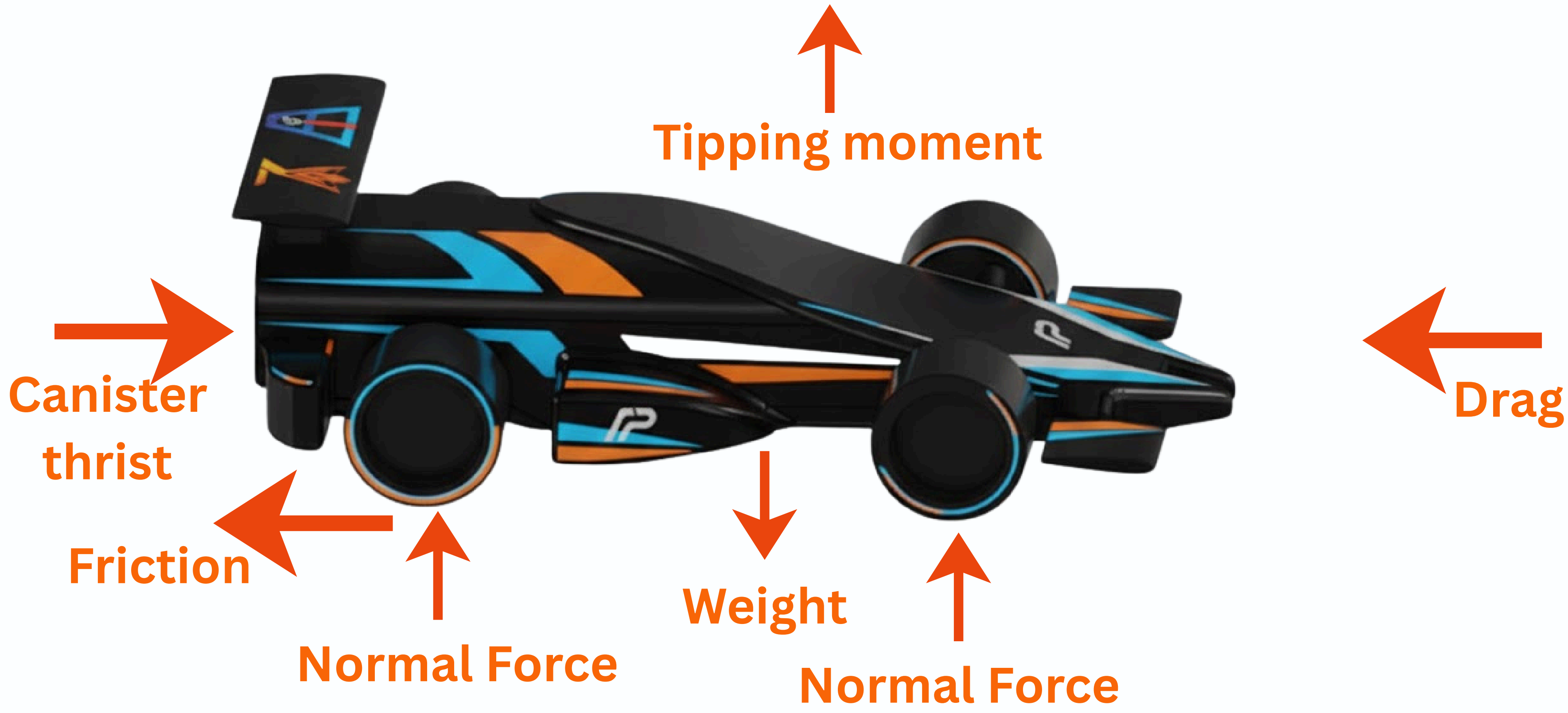
A tether line guide was used to reduce friction and energy loss, ensuring smooth and efficient tether movement during runs.

WHEEL

Wheels provide grip and allow the car to move by touching the ground. Good wheels improve speed and safety.

Free Body Digram

These Forces applying on Our Car



ROCKET SQUAD

THANK YOU