

Comparative Analysis of F1 2026 Front Wing Designs

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1. Abstract

This report presents a comparative analysis of three different front wing designs for the 2026 Formula One season. The study aims to enhance understanding of the aerodynamic performance of F1 front wings and improve related design and simulation skills. Three concepts were modelled: one sourced from existing online designs, and two based on concepts from the FIA. Using SolidWorks 2017 for design and ANSYS Student for simulations, each design was analysed following FIA testing guidelines. Computational Fluid Dynamics (CFD) simulations were conducted to determine lift and drag coefficients and visualize pressure distribution and airflow velocity. The results indicated that the FIA concepts performed significantly better, with drag coefficients ranging from 0.4 to 0.28 and lift coefficients from -1.6 to -2.3. Challenges were encountered during the design phase, particularly in understanding initial design principles.

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3. Introduction

3.1 Background Information

The aerodynamic performance of Formula One cars is crucial for achieving high speeds and maintaining stability on the track. One of the most important components in this regard is the front wing, which plays a key role in producing downforce and managing turbulent air. Understanding the aerodynamics of front wings is essential for designing competitive F1 cars.

3.2 Purpose of the Study

This project aims to further my understanding of the aerodynamic performance of F1 front wings and improve my design and simulation skills. By modelling and analysing three different front wing designs for the 2026 Formula One season, I seek to identify the most effective design in terms of lift and drag coefficients.

3.3 Scope of the Report

The report covers the modelling and analysis of three front wing designs: one sourced from existing online designs, and two based on concepts from the FIA, they can be seen in figures 1 and 2 . The study follows FIA guidelines and utilises FEA/CFD simulations to evaluate the aerodynamic performance of each design.



Figure 1 – Design idea 2



Figure 2 – Design idea 3

4. Literature Review

4.1 Importance of Front Wing Design

The front wing of a Formula One car is a critical component for aerodynamic performance. It is the first element to interact with the airflow, making it essential for generating downforce and managing turbulent air. The design of the front wing significantly impacts the overall stability and speed of the car [1].

4.2 Historical Development

Aerodynamics has been a key consideration in Formula One car design since the 1950s. The introduction of wings in the late 1960s marked a significant shift, emphasizing the importance of downforce in racing performance [2]. Over the years, front wing designs have evolved to optimize aerodynamic efficiency and comply with changing regulations [1].

4.3 Computational Fluid Dynamics (CFD) in F1

CFD has become an indispensable tool in the design and analysis of F1 car components. It allows engineers to simulate airflow and predict the aerodynamic performance of different designs without the need for costly prototypes [3]. Studies have shown that CFD can accurately predict lift and drag coefficients, helping teams refine their designs for optimal performance [3].

4.4 Recent Studies and Findings

Recent research has focused on optimizing front wing designs to balance downforce and drag. For example, a study on the 2022 front wing design used CFD and Finite Element Analysis to assess aerodynamic loads and structural behavior [1]. Another study compared front wing designs from 2018 and 2019, finding significant improvements in lift and drag coefficients with the newer design [3].

4.5 Challenges in Front Wing Design

Designing an effective front wing involves addressing various challenges, such as managing airflow around the tires and minimizing drag. Engineers must also consider structural integrity to prevent deformation under high aerodynamic loads [1]. These challenges require a combination of advanced simulation tools and innovative design strategies [2].

4.6 Future Directions

Future research in front wing design aims to further optimize aerodynamic performance while adhering to regulatory constraints. This includes exploring new materials and configurations to enhance rigidity and reduce weight [1]. Continuous advancements in CFD and other simulation technologies will play a crucial role in these efforts [3].

5. Methodology

5.1 Design Process

The design process for the front wing models was guided by the FIA 2026 Formula 1 Technical Regulations (Issue 8 - 2024-06-24) [4]. These regulations provided detailed guidelines and rules for the design. The maximum length of the front wing was set at 1800mm. SolidWorks 2017 was used to create the 3D models of the front wing designs.

5.2 Simulation Setup

5.2.1 FEA Setup:

1. **Material definition:** Ensure to assign PAN Carbon Fibre to the whole body.
2. **Geometry Import:** The front wing geometry was imported into the FEA environment.
3. **Mesh Creation:** A mesh was created for the front wing.
4. **Force Application:** A force of 100kg was applied to the ends of the flaps. This can be seen in practice in figure 6.
5. **Deflection Analysis:** The deflection results were analysed to assess structural integrity.

5.2.2 CFD Simulation Setup:

1. **Geometry Import:** The front wing geometry was imported into the simulation.
2. **Enclosure Creation:** An enclosure was created with a ride height of 35mm (0.03m). Can be seen in figure 3.
3. **Boolean Subtraction:** A Boolean subtraction operation was performed, with the enclosure as the target body and the front wing part as the tool body.
4. **Mesh Creation:** A mesh was generated with an element size of 1000mm, resulting in approximately 90,000 elements. The maximum number of elements was limited to 105,000 due to the constraints of the student version of ANSYS. Seen in figure 4.
5. **Named Selections:** Named selections were added to ensure zone names matched.
6. **Mesh Check:** The mesh was checked for accuracy and consistency.
7. **Model Setup:** The k-epsilon model was set to realizable.
8. **Materials:** Default materials were set to air and aluminium.
9. **Boundary Conditions:** Inlet velocity was set at 80 m/s. Seen in figure 5.
10. **Reference Values:** Reference values were computed from the inlet and the solid body.
11. **Methods:** Spatial discretization was set to second order upwind for all methods.
12. **Report Definitions:** Lift and drag report definitions were created.
13. **Initialization:** Hybrid initialization was performed.
14. **Iterations:** 100 iterations were run.
15. **Contour Visualization:** Pressure contours were created on the body with 15 contours.
16. **Streamlines:** Streamlines were generated from the inlet to visualize air velocity, using 1000 lines.

| Details of Enclosure1 | |
|---|-----------------|
| Enclosure | Enclosure1 |
| Shape | Box |
| Number of Planes | 0 |
| Cushion | Non-Uniform |
| <input type="checkbox"/> FD1, Cushion +X value (>0) | 0.75 m |
| <input type="checkbox"/> FD2, Cushion +Y value (>0) | 0.5 m |
| <input type="checkbox"/> FD3, Cushion +Z value (>0) | 0.5 m |
| <input type="checkbox"/> FD4, Cushion -X value (>0) | 0.5 m |
| <input type="checkbox"/> FD5, Cushion -Y value (>0) | 0.03 m |
| <input type="checkbox"/> FD6, Cushion -Z value (>0) | 0.5 m |
| Target Bodies | Selected Bodies |
| Bodies | 1 |
| Merge Parts? | No |
| Export Enclosure | Yes |

Figure 3 – Enclosure setup for CFD analysis

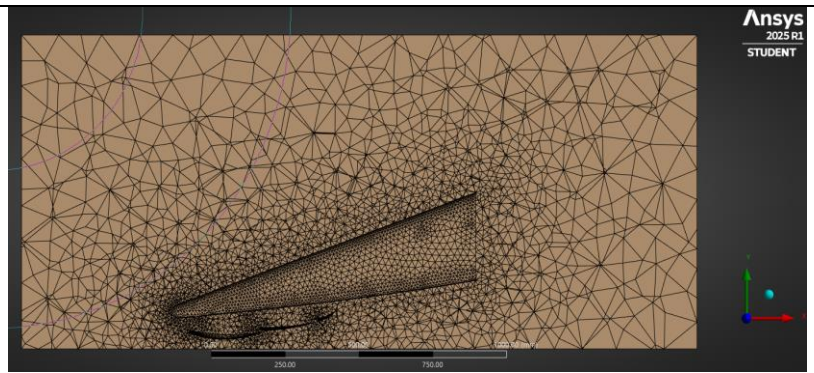


Figure 4 – Mesh setup for CFD analysis

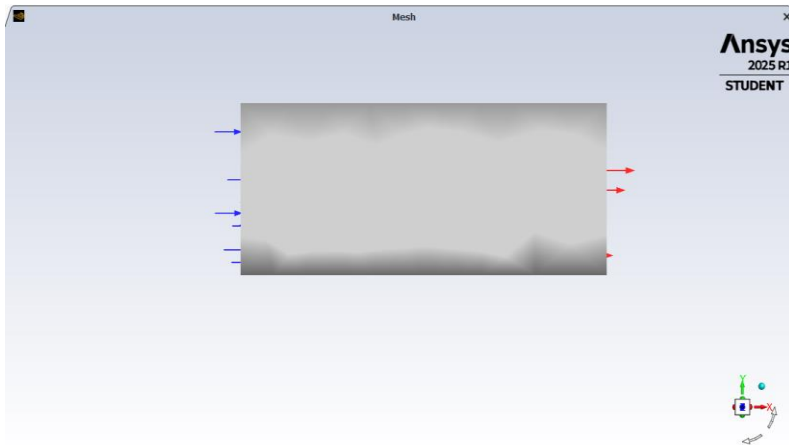


Figure 5 – Setup of boundary conditions

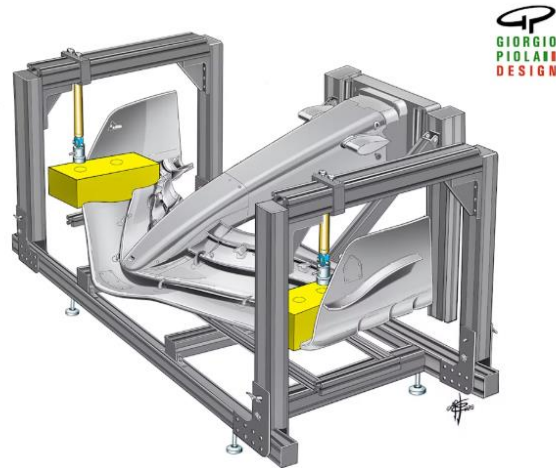


Figure 6 – FIA testing setup for Front wing deformation

5.3 Materials and Specifications

Typical front wing designs utilised PAN-based carbon fibre due to its favourable properties:

1. **Density:** Approximately 1.75 g/cm³.
2. **Melting Point:** Decomposes before melting.
3. **Young's Modulus:** Approximately 230-240 GPa.
4. **Tensile Strength:** Approximately 3.5-4.0 GPa.
5. **Elongation at Break:** Around 1.5-2.0%.
6. **Thermal Conductivity:** Approximately 10-20 W/m·K.
7. **Coefficient of Thermal Expansion:** Approximately -0.5 to 0.7 μm/m·K.
8. **Water Absorption:** Negligible.
9. **Dielectric Constant:** Around 1.5-2.0 at 1 kHz. [\[5\]](#)[\[6\]](#)[\[7\]](#)

5.4 Validation and Verification

The accuracy of the simulations was validated by comparing the results with existing data and benchmarks. Realistic results were obtained, confirming the reliability of the simulation setup and methods used. The FEA results were compared to the legal limit of deflection.

6. Results

6.1 FEA Results

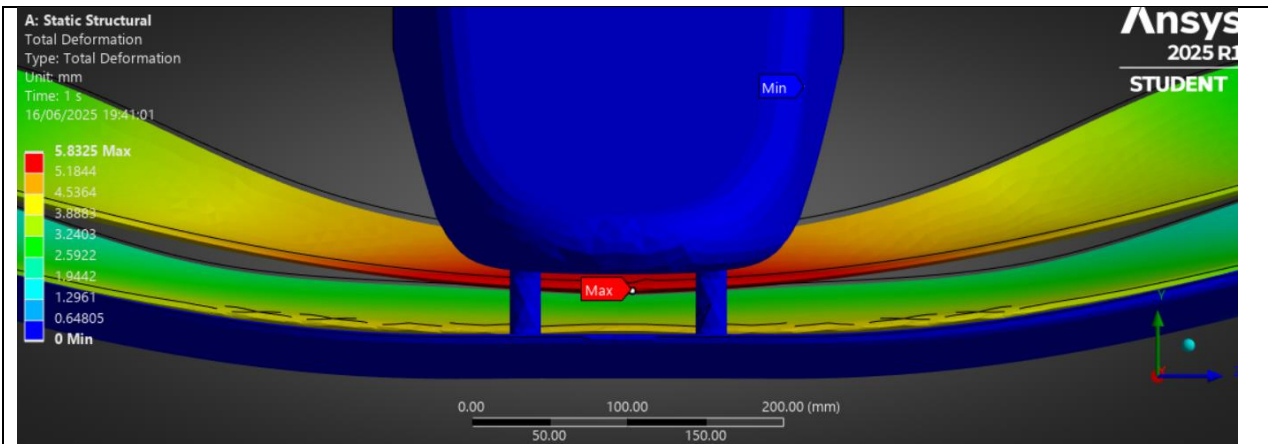


Figure 7 – Front View showing position of max deformation

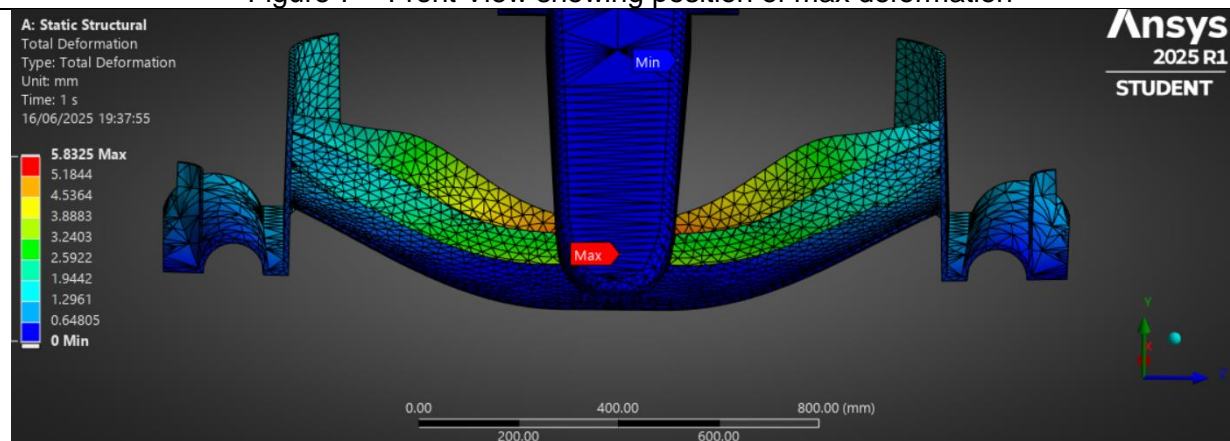


Figure 8 – Front view showing overall deformation

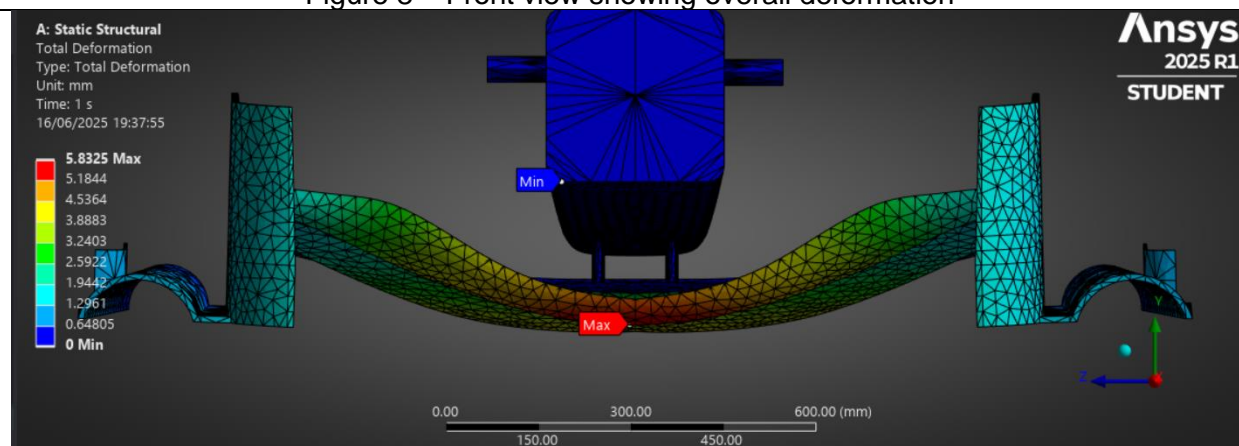
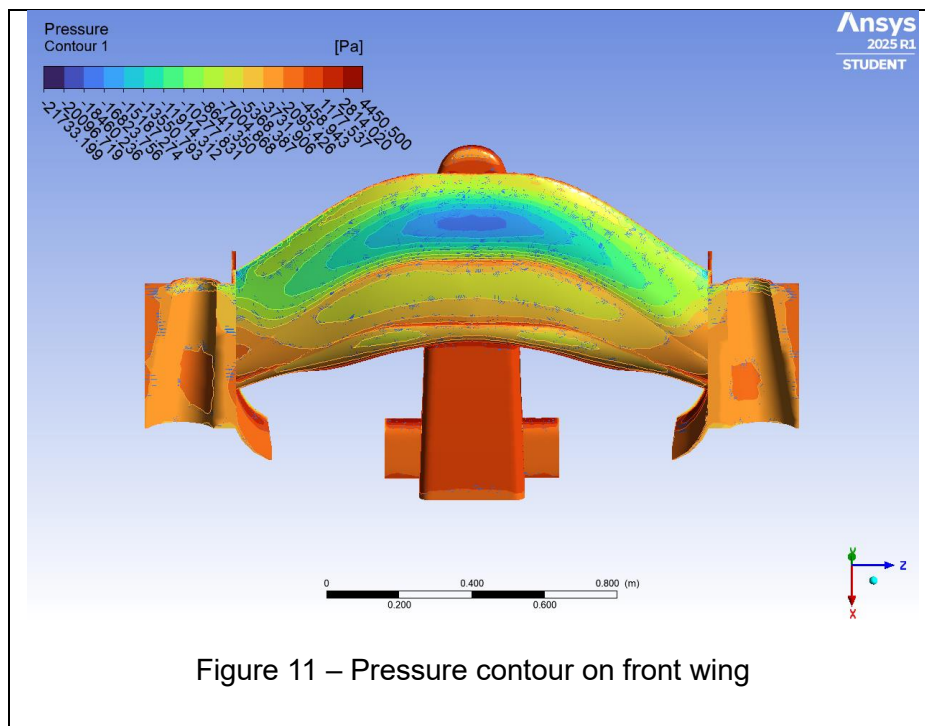
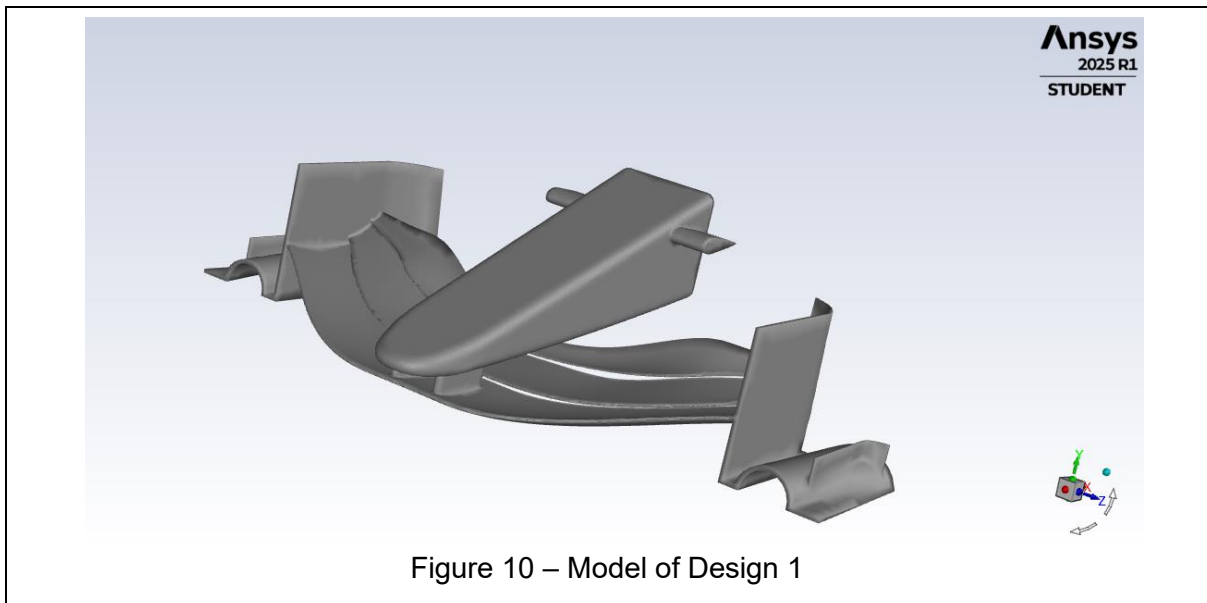


Figure 9 – Rear view showing overall deformation

6.2 Design 1



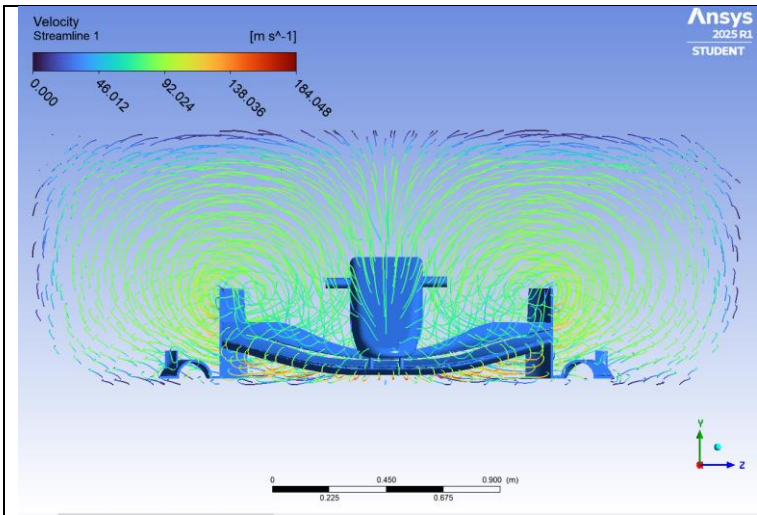


Figure 12 – Velocity of surrounding air (head on view)

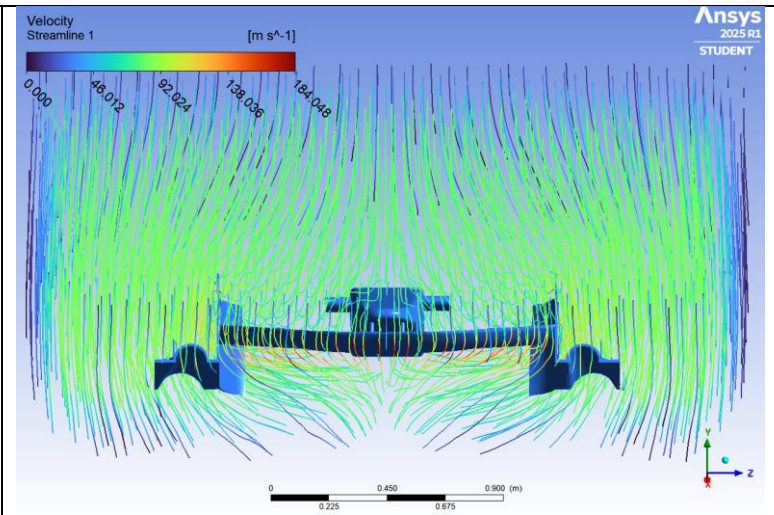


Figure 13 – Velocity of surrounding air (under side view)

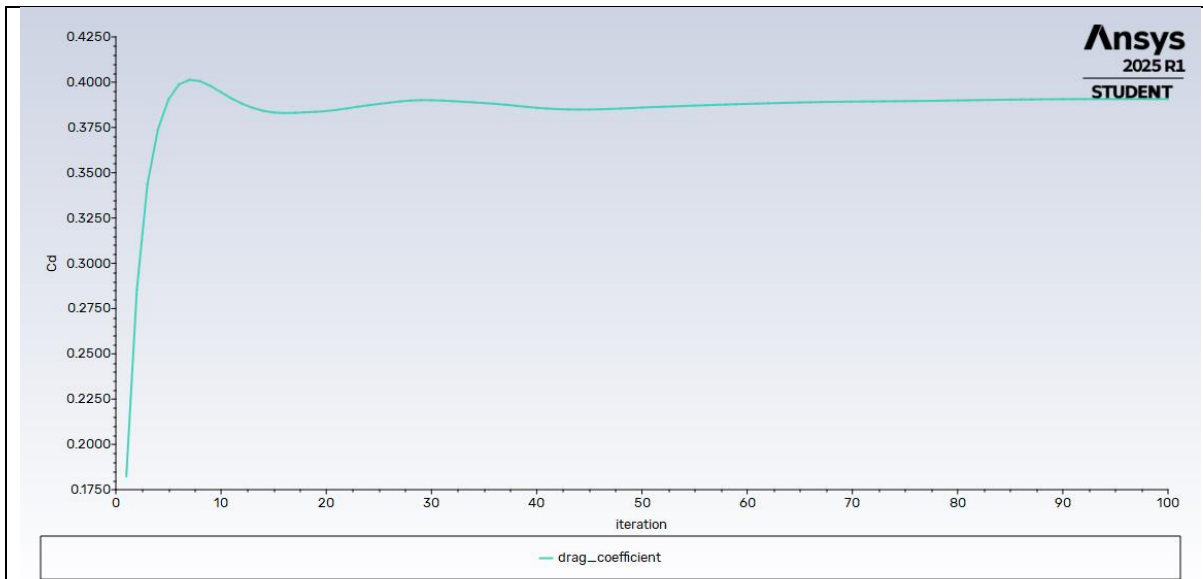


Figure 14 – Drag Coefficient Result for Design 1

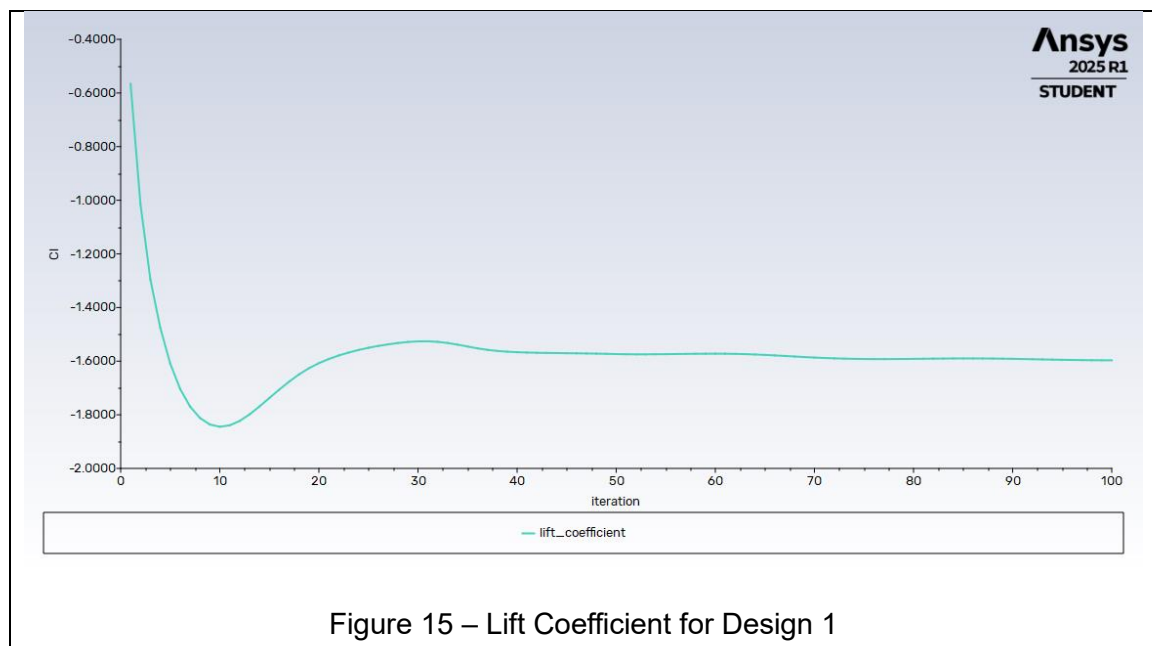
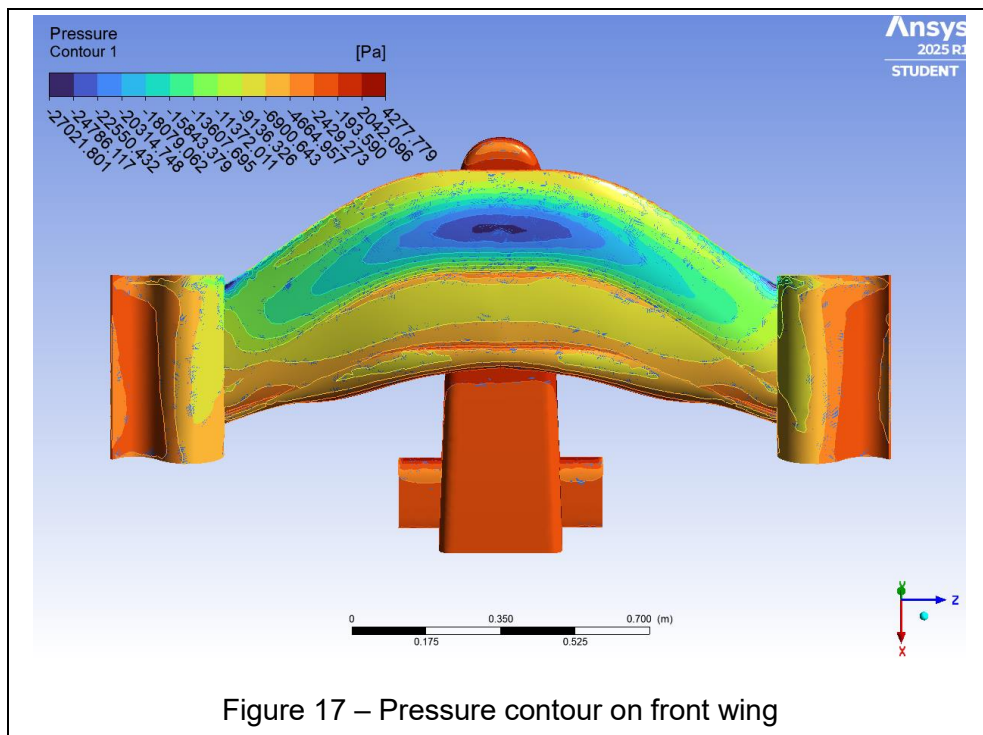
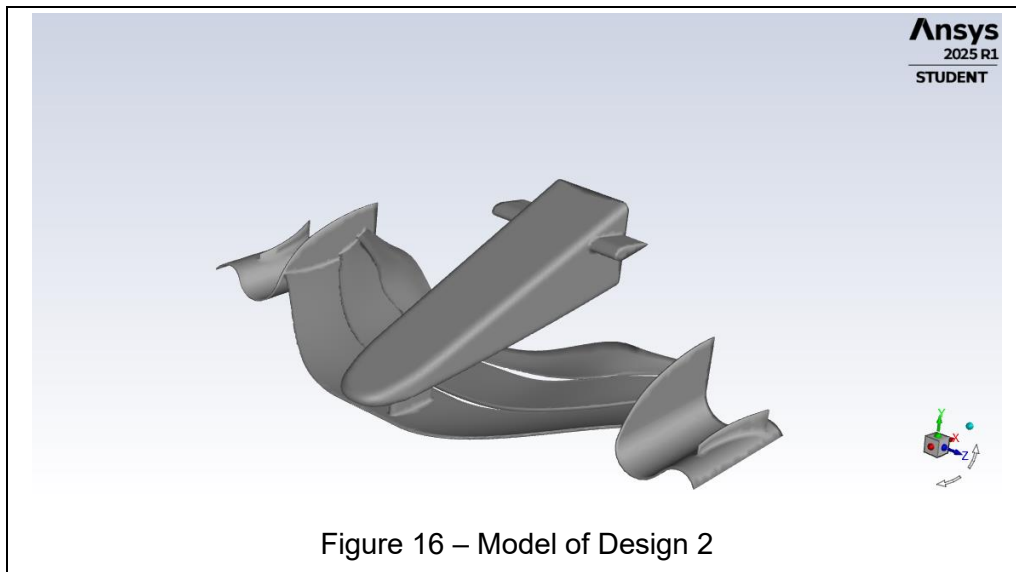


Figure 15 – Lift Coefficient for Design 1

6.3 Design 2



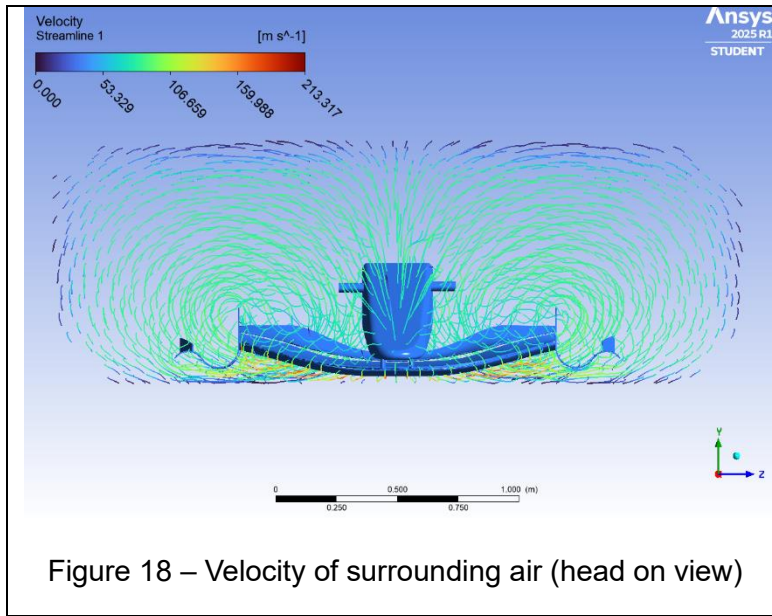


Figure 18 – Velocity of surrounding air (head on view)

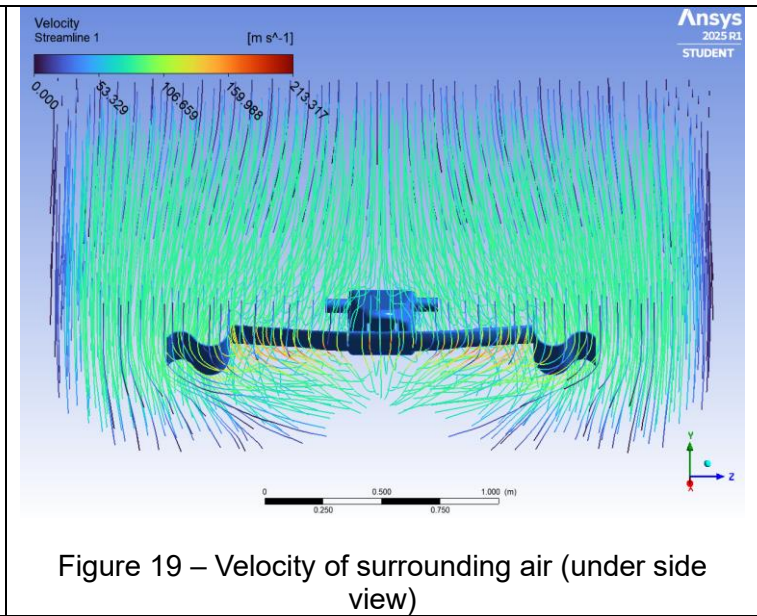


Figure 19 – Velocity of surrounding air (under side view)

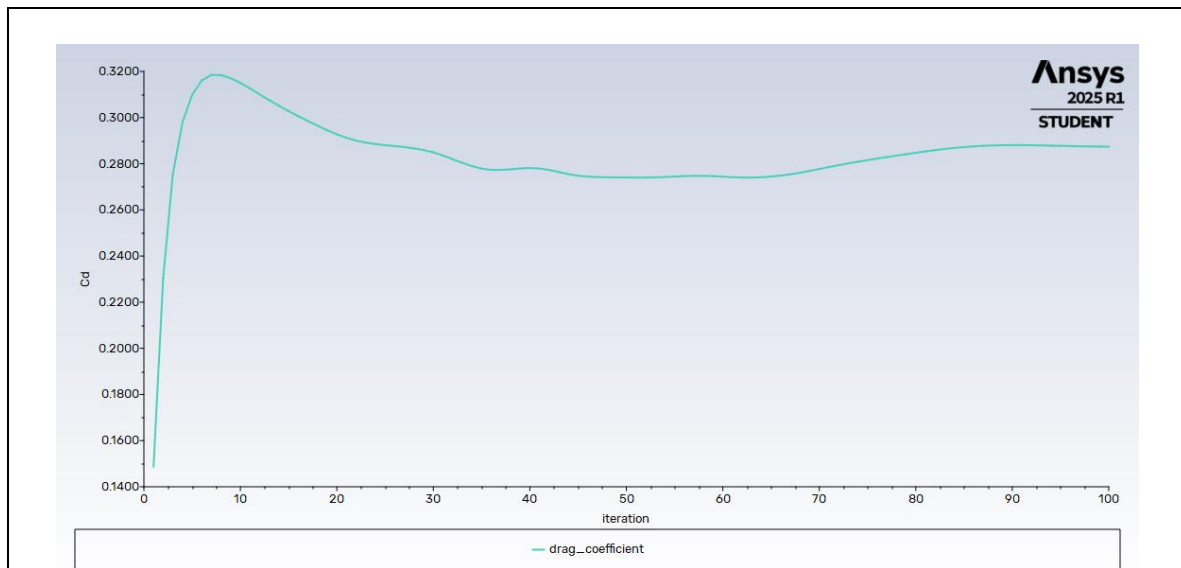


Figure 20 – Drag Coefficient Result for Design 2

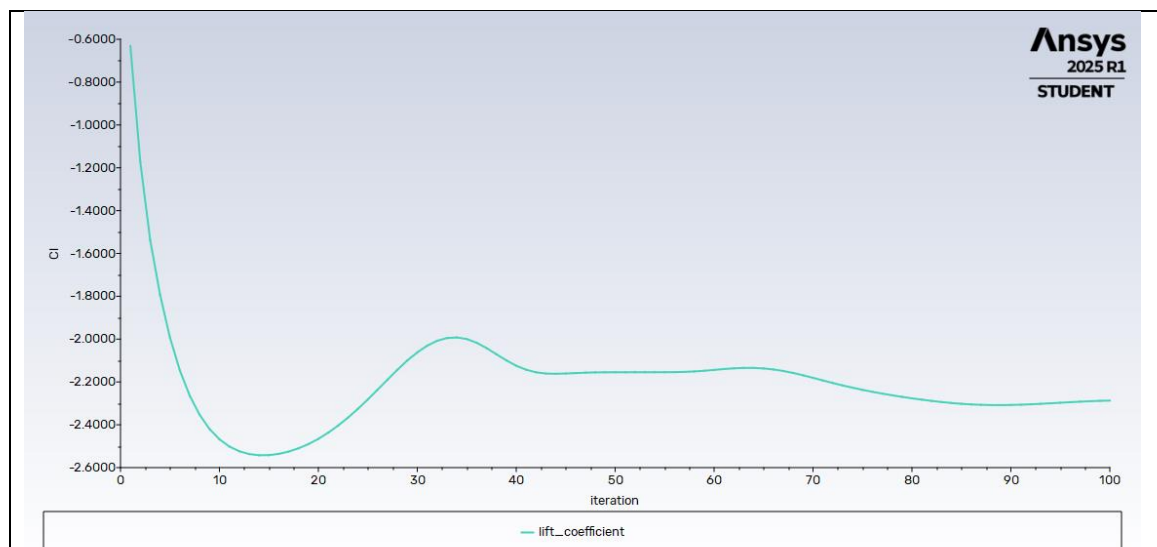


Figure 21 – Lift Coefficient for Design 2

6.4 Design 3

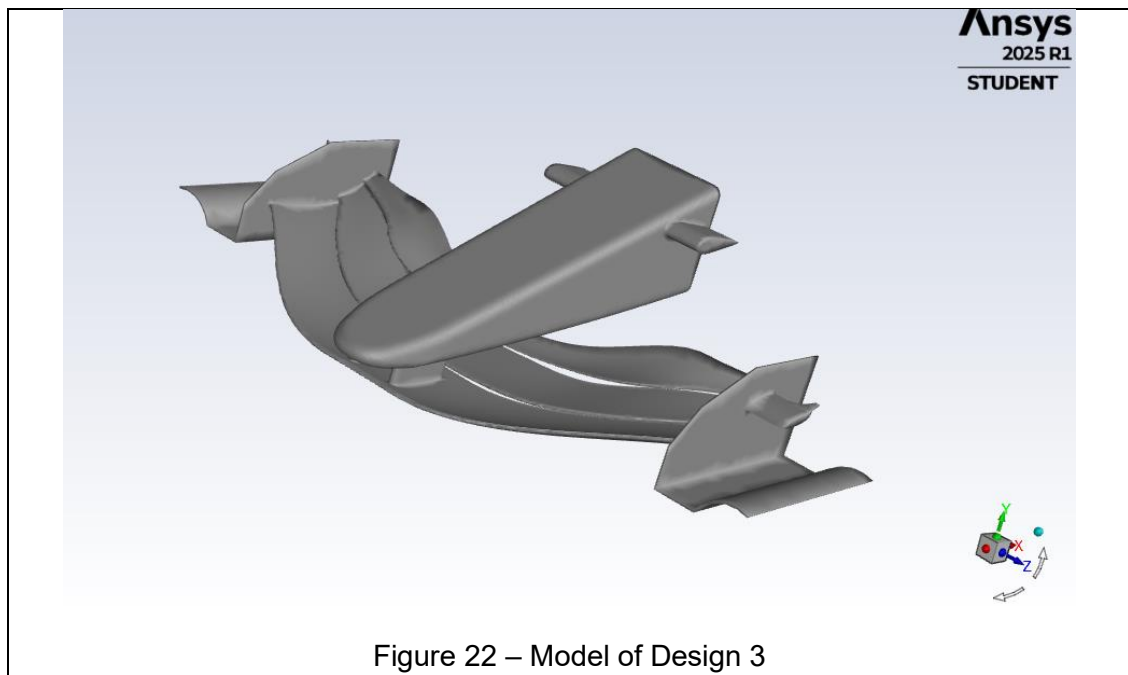


Figure 22 – Model of Design 3

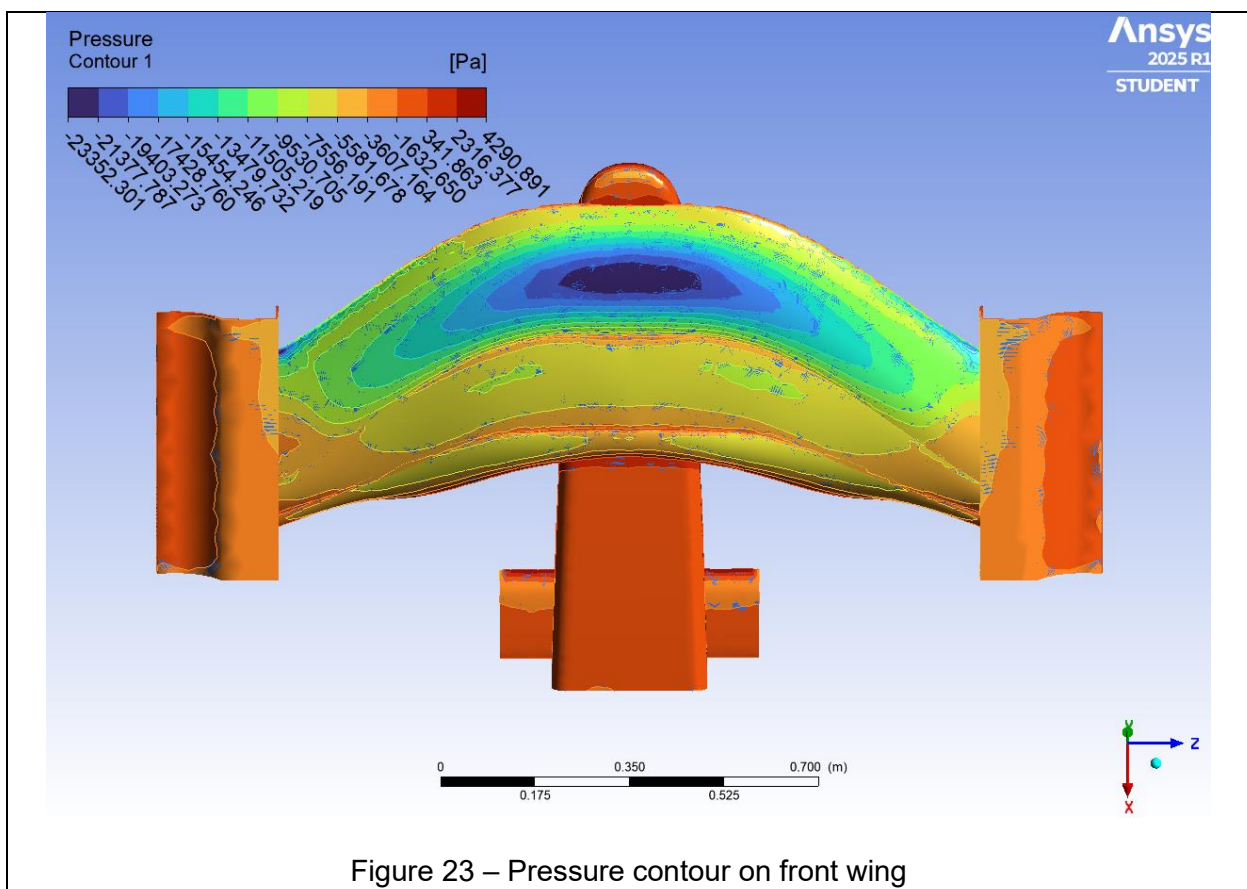


Figure 23 – Pressure contour on front wing

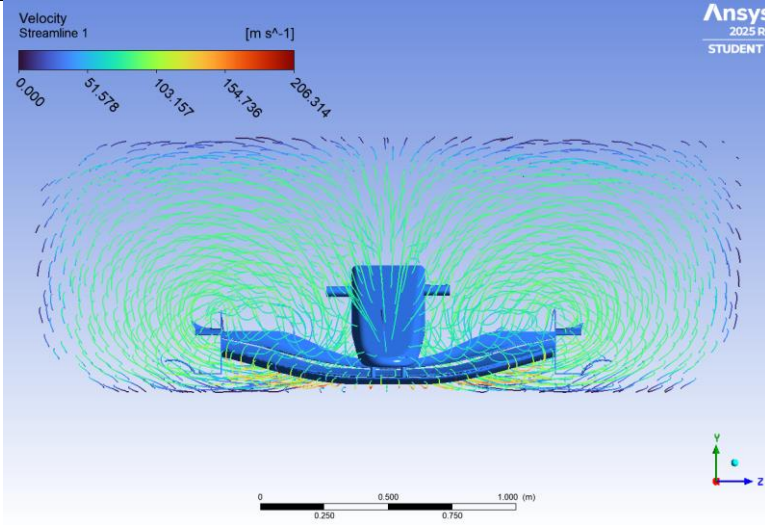


Figure 24 – Velocity of surrounding air (head on view)

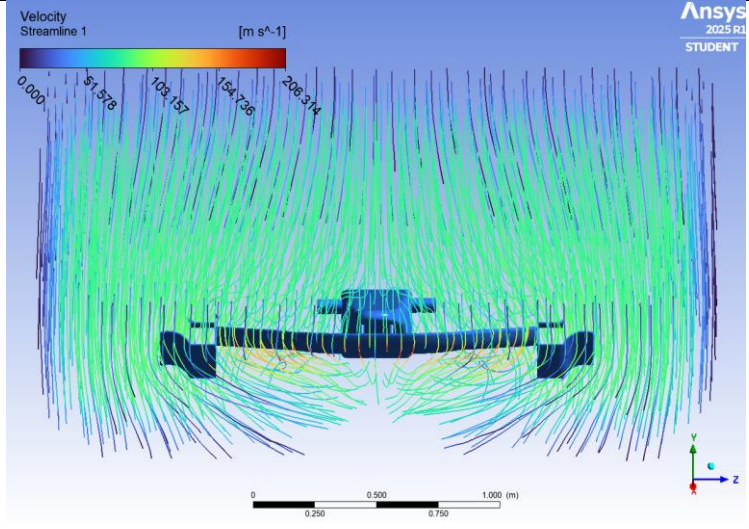


Figure 25 – Velocity of surrounding air (under side view)

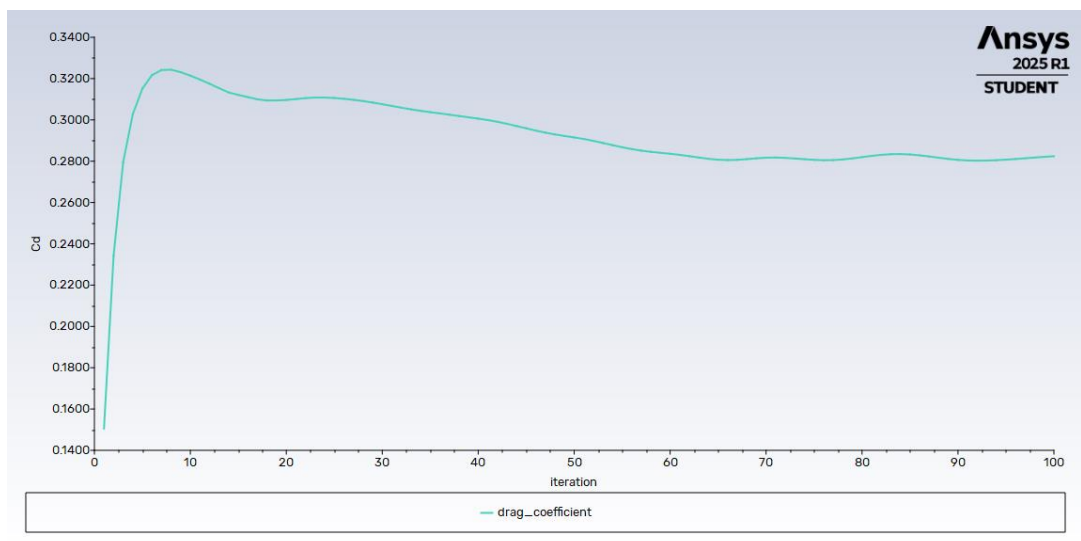


Figure 26 – Drag Coefficient Result for Design 3

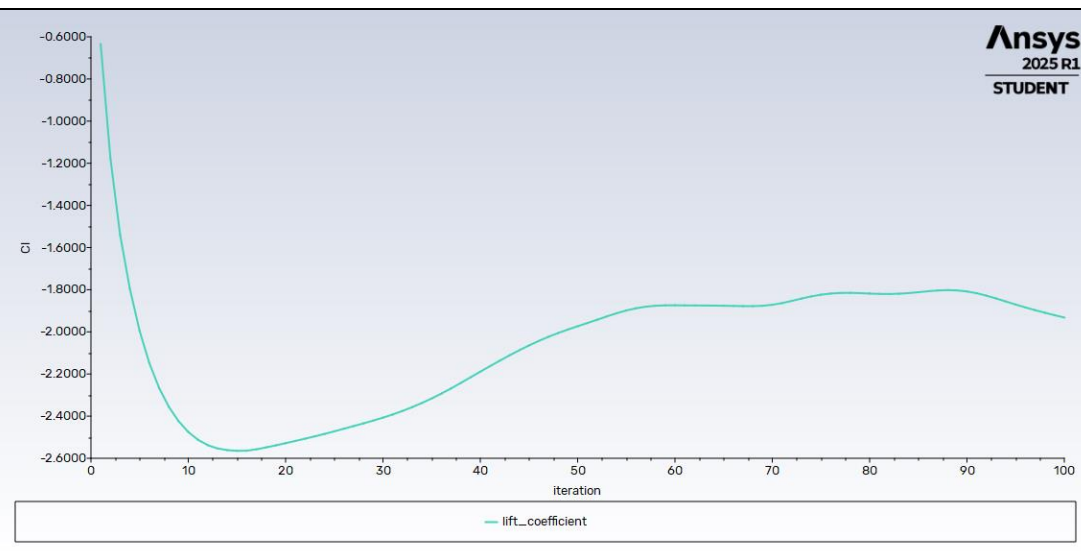


Figure 27 – Lift Coefficient for Design 3

7. Discussion

7.1 Overview

The analysis of the three front wing designs for the 2026 Formula One season involved detailed CFD simulations and FEA to determine the aerodynamic performance and structural integrity of each design. The results were evaluated based on lift and drag coefficients, pressure distribution, and airflow velocity.

The Finite Element Analysis (FEA) results reveal important details about the structural behaviour under applied loads. The maximum deformation observed is approximately 5.8 mm. The analysis highlights specific areas of peak deformation, which are crucial for identifying potential failure points and areas needing reinforcement. The peak deformation seen on figures 7 to 9 is focussed on the back of the wing more specifically on the third flap.

| Design number | Drag Coefficient | Lift Coefficient |
|---------------|------------------|------------------|
| 1 | 0.4 | -1.6 |
| 2 | 0.29 | -2.3 |
| 3 | 0.28 | -1.93 |

Design 1

- **Pressure Contour:** The pressure contour on the front wing of Design 1 (Figure 11) shows a distribution with higher pressure on the leading edge and lower pressure on the trailing edge. This indicates effective downforce generation.
- **Velocity of Surrounding Air:** The velocity vector fields (Figures 12 and 13) reveal smooth airflow over the wing, with some turbulence at the trailing edge.
- **Drag Coefficient:** The drag coefficient for Design 1 (Figure 14) fluctuates but remains within a range around 0.4, that suggests moderate aerodynamic efficiency.
- **Lift Coefficient:** The lift coefficient for Design 1 (Figure 15) is approximately -1.6. This indicates effective downforce generation.

Design 2

- **Pressure Contour:** The pressure contour on the front wing of Design 2 (Figure 17) shows a more uniform distribution compared to Design 1, with a clear gradient from high to low pressure. This suggests improved downforce and stability.
- **Velocity of Surrounding Air:** The velocity vector fields (Figures 18 and 19) indicate smoother airflow with less turbulence, particularly on the underside of the wing.
- **Drag Coefficient:** The drag coefficient for Design 2 (Figure 20) is 0.29, lower than that of Design 1, indicating better aerodynamic performance.
- **Lift Coefficient:** The lift coefficient for Design 2 (Figure 21) is approximately -2.3. This indicates effective downforce generation with improved stability compared to Design 1.

Design 3

- **Pressure Contour:** The pressure contour on the front wing of Design 3 (Figure 23) shows a similar distribution to Design 2, with high pressure on the leading edge and low pressure on the trailing edge. This suggests effective downforce generation.
- **Velocity of Surrounding Air:** The velocity vector fields (Figures 24 and 25) indicate very smooth airflow with minimal turbulence, suggesting excellent aerodynamic efficiency.
- **Drag Coefficient:** The drag coefficient for Design 3 (Figure 26) is the lowest among the three designs at 0.28, indicating superior aerodynamic performance.
- **Lift Coefficient:** The lift coefficient for Design 3 (Figure 27) is -1.93, this shows effective downforce generation, contributing to the overall stability and performance of the design.

7.2 Comparative Analysis

- **Lift and Drag Coefficients:** Design 2 and Design 3, based on FIA concepts respectively, performed significantly better than Design 1. The drag coefficients ranged from 0.4 to 0.28, and the lift coefficients ranged from -1.6 to -2.3. Design 3 had the lowest drag coefficient, making it the most aerodynamically efficient. Whereas Design 2 had the lowest lift coefficient, making it the best for downforce generation.
- **Pressure Distribution:** Both Design 2 and Design 3 showed more uniform pressure distribution, which is crucial for maintaining stability and generating consistent downforce.
- **Airflow Velocity:** The velocity vector fields for Design 2 and Design 3 indicated smoother airflow with less turbulence, particularly on the underside of the wing. This contributes to their superior aerodynamic performance.

7.3 Implications

The findings suggest that the FIA concept offers significant advantages in terms of aerodynamic efficiency and stability. The lower drag coefficients and smoother airflow indicate that these designs are better suited for high-speed performance and stability on the track.

8. Conclusion

This study aimed to enhance understanding of the aerodynamic performance of F1 front wings and improve related design and simulation skills by analysing three different front wing designs for the 2026 Formula One season. The designs were evaluated using CFD simulations and FEA, following FIA guidelines and rules, to determine lift and drag coefficients, pressure distribution, and airflow velocity.

The results indicated that the FIA concept performed significantly better than the online-sourced design. The drag coefficients ranged from 0.4 to 0.28, and the lift coefficients ranged from -1.6 to -2.3. Design 3 exhibited the lowest drag coefficient, making it the most aerodynamically efficient, whereas Design 2 had the lowest lift coefficient, therefore making it the best for high downforce. Both Design 2 and Design 3 showed more uniform pressure distribution and smoother airflow, contributing to their superior aerodynamic performance.

Challenges were encountered during the design phase, particularly in understanding initial design principles. However, reviewing various models and pictures provided an initial understanding that helped overcome these challenges. The simulations were limited by the constraints of the student version of ANSYS, which restricted the number of elements in the mesh.

The findings suggest that the FIA concept (Design 2 and 3) offer significant advantages in terms of aerodynamic efficiency and stability. The lower drag coefficients and smoother airflow indicate that these designs are better suited for high-speed performance and stability on the track.

The FEA results further underscore significant findings regarding our structural analysis. The maximum recorded deformation is approximately 5.8mm, with critical areas experiencing peak deformations identified. Addressing these high-deformation zones through design optimization and material selection can enhance overall structural integrity.

Future work will focus on optimizing the front wing design to further improve aerodynamic performance. This could involve refining the geometry and conducting more detailed simulations with higher mesh resolutions. By improving design and simulation skills, this project contributes to the ongoing development of competitive F1 car designs.

9. References

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7. J. Cao, W. Zhao, and S. Gao, "Properties and Structure of In Situ Transformed PAN-Based Carbon Fibers," *Materials*, vol. 11, no. 6, pp. 1017–1017, Jun. 2018, [Properties and Structure of In Situ Transformed PAN-Based Carbon Fibers](#) (accessed Jun. 18, 2025).

10. Appendices

Appendix A – [F1 Tech: How an F1 Front Wing Works: A Comprehensive Guide - F1 BLAST - Home of F1 news and stories](#)

Appendix B – [fia 2026 formula 1 technical regulations issue 8 - 2024-06-24.pdf](#)

Appendix C – [How Low Are F1 Cars? \(Ride Height Explained\) - FLOW RACERS](#)

Appendix D – [Bing Videos](#)

NOTE:

Please refer to SolidWorks drawings and models for more dimensional information and the Ansys workbench files for more simulation information

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