F1 Car Downforce

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Introduction:

Downforce, called also negative lift, has a remarkable importance in Formula One (F1). The downward pressure keeps the car in control and stable, as it is glued to the track. The racing cars take sharp corners at high speed as this force contributes to creating enough aerodynamic grip.

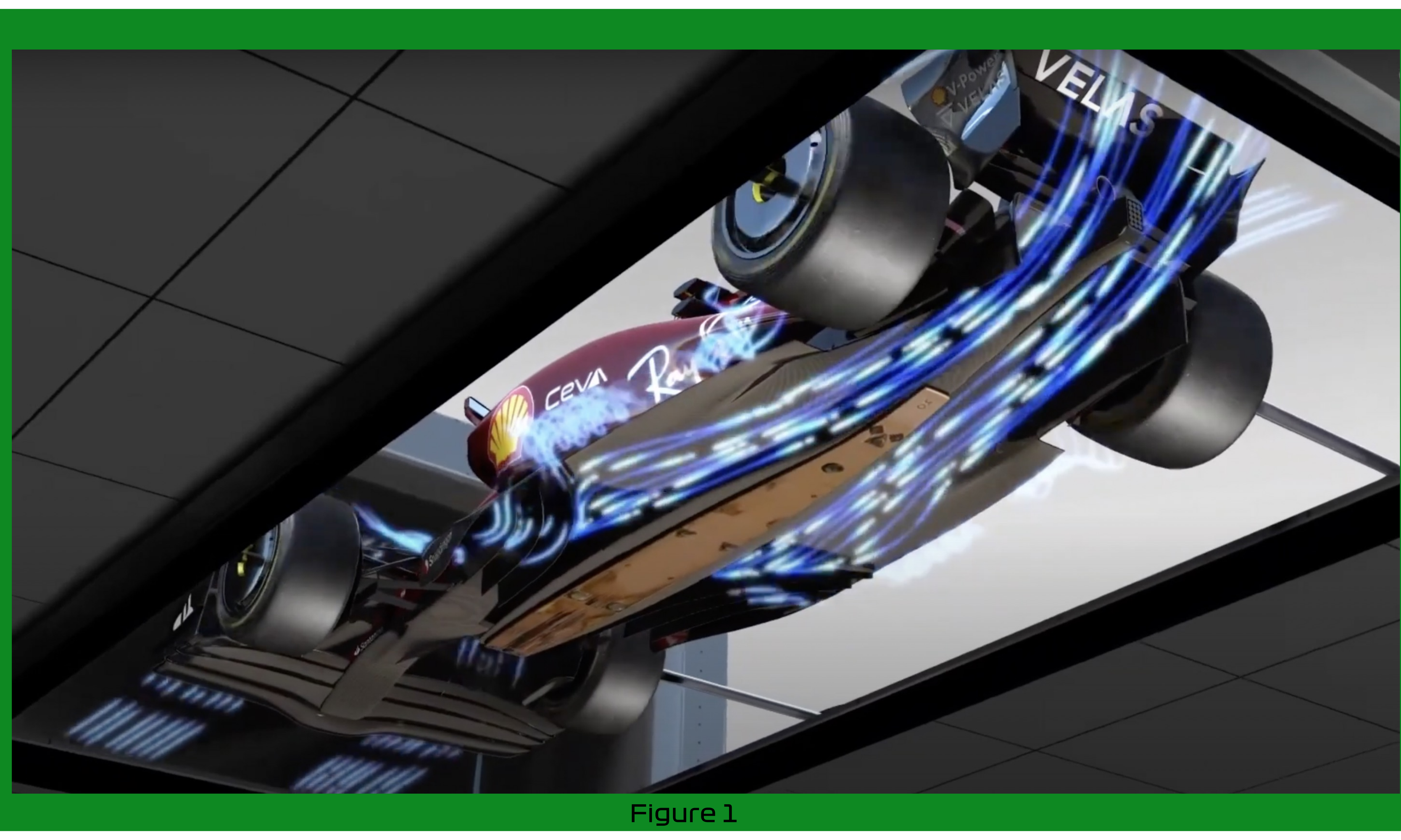

Figure 1

Newton's 3rd Law

Newton's third law of motion states that for every action, there is an equal and opposite reaction. In the case of a Formula 1 car, the downforce generated by the car is a result of the interaction between the car and the air around it. When a Formula 1 car moves through the air, it creates a disturbance in the air molecules around it. This disturbance creates a force on the car, which is equal and opposite to the force created by the car on the air. This force is known as aerodynamic downforce. The amount of downforce generated by a Formula 1 car is dependent on several factors, but the shape of the car plays a crucial role. The most amount of downforce is generated by the splitters, canards, vortexes and especially the front wings.

Aircrafts wings & F1 car wings

The front wings used in F1 cars were inspired on aircrafts. Aeroplanes wings generate lift in order to take off, due to the airflow passing over the wings. This creates a low pressure above the wing and high pressure underneath the wing, resulting in a upwards force of lift. F1 reverses this principle, generating a lower pressure underneath the wing and a higher pressure above the wing that generates downforce. In fact, the F1 wings can be simply imagined as an inverted aircraft wing.

Figure 2

To explain how wings produce lift and downforce effect, Bernoulli's principle is useful:

Bernoulli's principle

$$P + \frac{1}{2}\rho u^2 + \rho g h = const$$

P: Pressure
ρ: Air density
u: Velocity
h: Height
g: Gravitational field strength

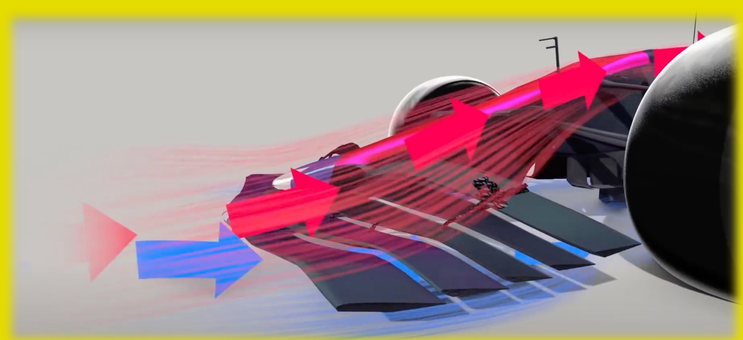

Figure 3

- Important assumption: The airflow is not turbulent

Formula of Downforce

Downforce: $\frac{1}{2} CIAV^2$

Cl: Coefficient of lift
A: Frontal area
V: Object velocity

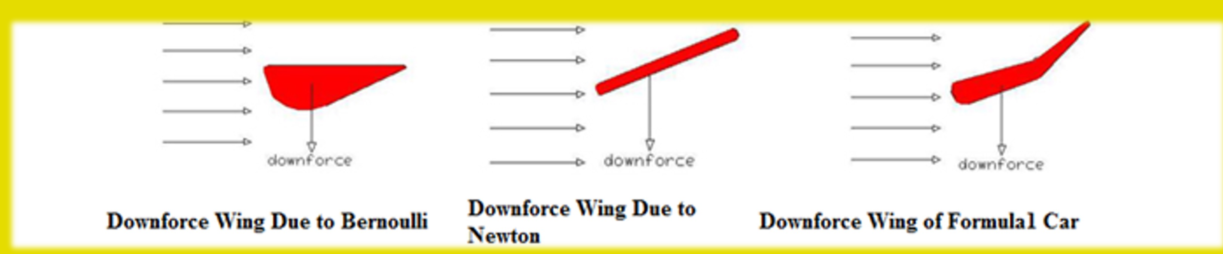

Figure 4

Newton's 2nd Law and Downforce relation

Increasing the weight of the car, leads to more downforce but this would slow down the car. This can be explained by Newton's 2nd law:

$F = ma \rightarrow$ F: driving force; m: mass of the car; a: is the acceleration, or change in motion of the car

Therefore, if the weight of the car is increased, the downforce would also increase but this would slow down the car.

- Improves car balance & stability at high speeds during cornering

- Reduces acceleration and top speed
- Decreases car's agility and responsiveness
- Reduces tires' lifespan as they are more consumed

Conclusion

The balance between speed in the corners and speed in the straights it's crucial in F1. Downforce enables higher speeds in corners but a lower speed on straight lines. Therefore, it is important to balance out these factors that can impact the car's overall performance and handling. Ultimately, the optimal weight for an F1 car will depend on a range of factors, including the characteristics of the track, the weather conditions, and the individual strengths and weaknesses of the car and its driver.

https://www.youtube.com/watch?v=ZFEzMKYjShc
https://www.formula1-dictionary.net/aerodynamics_of_f1.html
https://thegsaljournal.com/2020/06/28/aerodynamics-in-formula-1/
https://f1chronicle.com/understanding-formula-1-formula-1-technology/
https://f1chronicle.com/how-do-formula-1-cars-generate-downforce-f1-tech/
https://www.youtube.com/watch?v=edZycMFeEkU
https://www.youtube.com/watch?v=UbDPmvg1OXU
http://www.f1now.co.uk/the-bernoulli-effect/
shorturl.at/tDFS3
https://www.youtube.com/watch?v=qXKQezyI2Oo
shorturl.at/dxABT
http://www.lcs-fast.com/elemental/
shorturl.at/iEFY9
https://www.youtube.com/watch?v=V1iUJThaeqQ

References