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How Formula 1 teams use science, engineering, data, and strategy to win races

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ABSTRACT

Formula 1 is not just about fast cars and brave drivers. It is one of the most scientific sports in the world. Every race is affected by physics, engineering, mathematics, data, weather, tyres, fuel, brakes, aerodynamics, and human decision-making. A Formula 1 car wins not only because it has a powerful engine, but because the team understands how to control air, heat, grip, speed, and time.

This research paper explains the science behind winning in Formula 1 in extremely simple language. It studies how aerodynamics helps a car stick to the track, how tires decide race pace, how brakes handle extreme heat, how hybrid power units provide speed, and how teams use data to make race decisions. It also explains why the driver's body and mind are important. A driver must handle high G-forces, pressure, fatigue, and split-second decisions.

The paper finds that winning in Formula 1 is not caused by one single factor. It is the result of many small advantages working together. A few tenths of a second per lap can decide a race. In Formula 1, science is not just part of winning. Science is the reason winning is possible.

Keywords: Formula 1, aerodynamics, tires, downforce, braking, racing strategy, engineering, data analysis, physics

INTRODUCTION

Formula 1 looks simple when we watch it on television. Cars go around a track, drivers overtake each other, and the fastest car wins. But the reality is much deeper. Formula 1 is a mix of sport, science, engineering, mathematics, technology, and human courage.

A Formula 1 car is not just a car. It is more like a moving science experiment. Every part of it is designed for speed. The front wing, rear wing, floor, tires, brakes, engine, steering wheel, and even small air openings on the car all have a purpose.

In a normal road car, the main goal is comfort and safety. In a Formula 1 car, the goal is to go as fast as possible while still staying under control. This is very difficult because speed creates problems. The faster a car goes, the more air pushes against it. The tires become hot. The brakes

become extremely hot. The driver's body feels huge forces. The team must make the right strategy at the right time.

Winning in Formula 1 is not only about pressing the accelerator. It is about answering many scientific questions:

How can the car go faster in corners?
How can the tires last longer?
When should the driver pit?
How much downforce does the car need?
How can the brakes stay at the right temperature?
How can the driver save energy and still attack?
How can the team use data better than others?

Formula 1 uses aerodynamics, tire science, hybrid engine technology, braking systems, computer data, and race strategy. The sport has also changed with new technical rules. Formula 1 explains that modern power units use hybrid technology, and the sport is moving toward sustainable fuel blends and new technical systems (Formula 1, 2026a). The 2026 regulations also introduced active aerodynamics, where the wings can adjust depending on whether the car is cornering or driving on a straight (Formula 1, 2026b).

This paper explains the science behind Formula 1 winning in simple words so that even someone who does not love science can understand why this sport is so advanced.

RESEARCH QUESTION

How do science, engineering, data, and strategy help Formula 1 teams win races?

The aim of this paper is to explain the main scientific ideas behind Formula 1 in very simple language.

This paper will study:

1. How aerodynamics helps cars go faster.
2. Why tires are so important in Formula 1.
3. How brakes work under extreme heat.
4. How hybrid power units create speed.
5. How teams use data and race strategy.
6. Why the driver's body and mind matter.
7. Why winning in Formula 1 depends on many small details.

SCIENTIFIC THEORY

1. What Is Formula 1?

Formula 1, or F1, is the highest level of single-seater motor racing. The cars are designed to be extremely fast, but they must also follow strict rules. These rules control things like car size, engine type, aerodynamics, tires, safety, and race procedures.

Each Formula 1 team has two drivers. The team builds and develops the car, while the drivers race it. But a Formula 1 team is not just made of drivers. It includes engineers, mechanics, strategists, data scientists, designers, tire experts, aerodynamicists, fitness trainers, and many more people.

A race is not won only on Sunday. It is prepared for months in factories, simulators, wind tunnels, and computer models.

2. The Main Science Behind F1

The main scientific areas in Formula 1 are:

Scientific Area	Simple Meaning in F1
Aerodynamics	How air moves around the car
Tyre science	How rubber gives grip and loses performance
Mechanics	How the car moves, turns, and brakes
Thermodynamics	How heat affects tires, brakes, and engines
Data science	How teams use numbers to make decisions
Human biology	How the driver's body handles force and pressure
Strategy	How timing and decisions win or lose races

A Formula 1 car is successful when all these areas work together.

1. Aerodynamics: The Science of Air

What Is Aerodynamics?

Aerodynamics means the study of how air moves around objects. In Formula 1, air is extremely important because the car is moving very fast. At high speed, air can either help the car or slow it down.

There are two important aerodynamic words in Formula 1:

Downforce and Drag

Downforce is the force that pushes the car down into the track. It gives the tires more grip. More grip means the car can go faster through corners.

Drag is air resistance. It slows the car down on straights.

So, F1 teams face a big problem:

They want **more downforce** for corners.
But they want **less drag** for straights.

This is like wanting shoes that are sticky when you turn but slippery when you run straight. The perfect car must balance both.

Why Downforce Helps Winning

When a car turns a corner, it wants to slide outward. Downforce pushes the car down, helping the tyres stay connected to the track. This allows the driver to take corners at higher speed.

Without enough downforce, the car slides.
With too much drag, the car becomes slow on straights.

So engineers must choose the best setup for each track. A track like Monaco needs more downforce because it has many slow corners. A track like Monza needs less drag because it has long straights.

Formula 1 has used systems such as DRS, or Drag Reduction System, to reduce drag on straights. DRS opens a flap in the rear wing, helping the car go faster in certain zones (Formula 1, 2023). In the 2026 regulations, active aerodynamics allow wing angles to change more generally between straights and corners (Formula 1, 2026b).

2. Tires: The Only Part Touching the Road

Why Tires Matter So Much

Tires are one of the most important parts of a Formula 1 car because they are the only part touching the track. The engine may be powerful, and the aerodynamics may be clever, but if the tires do not grip, the car cannot use that power.

Tires decide:

How fast the car can turn.
How quickly it can brake.
How well it can accelerate.
How long can the car stay fast before needing a pit stop.

Formula 1 tires are supplied by Pirelli. Pirelli provides different dry tire compounds, from harder to softer rubber. Softer tires usually give more grip but wear out faster. Harder tires usually last longer but may be slower (Formula 1, n.d.-a; Pirelli, n.d.).

Simple Tire Example

Imagine two types of erasers.
A soft eraser grips the paper more, but it also wears away quickly.
A hard eraser lasts longer, but it may not grip as strongly.
F1 tires work in a similar way.

A **soft tire** is faster but may not last long.
A **hard tire** lasts longer but may not be as fast.
This creates race strategy. A team must decide whether to use faster tires and stop more often, or slower tires and stop less often.

Tire Temperature

Tires also need to be at the right temperature. If they are too cold, they do not grip well. If they are too hot, they wear out quickly.

This is why drivers weave behind the safety car. They are not showing off. They are trying to keep heat in the tires.

Winning in F1 often depends on keeping tires in the perfect temperature window.

3. Brakes: Turning Speed Into Heat

Why Braking Is Science

Formula 1 cars are not only fast because they accelerate quickly. They are also fast because they brake extremely late.

A normal driver brakes early before a corner. An F1 driver brakes much later, slows down very quickly, turns, and then accelerates again. This saves time.

But braking creates heat. When the car slows down, its motion energy turns into heat energy. This heat goes into the brakes.

F1 brakes use carbon materials and work at extremely high temperatures. Brembo explains that carbon braking systems need a proper operating range and can lose performance if they are too cold (Brembo, n.d.-a). Formula 1 has also explained that F1 carbon brakes can reach extremely high temperatures, especially at heavy braking circuits such as Canada (Formula 1, 2015).

Simple Braking Example

Imagine rubbing your hands together.
If you rub slowly, they become a little warm.
If you rub very fast, they become hot.

Brakes work in a similar way. When brake materials rub together at high speed, they produce heat. In Formula 1, this heat is extreme.
The difficult part is keeping brakes in the right range.
Too cold = not enough braking power.
Too hot = brakes wear out or lose performance.
So teams design brake ducts to control airflow and cooling. Even braking is not just about the driver pressing a pedal. It is science, heat, materials, and control.

4. Power Unit: The Science of Speed

What Is a Power Unit?

In Formula 1, people do not just say "engine." They often say **power unit** because the system includes more than a normal engine.

A modern F1 power unit includes a combustion engine and hybrid electric systems. The combustion engine burns fuel. The electric systems recover and use energy. Formula 1 explains that new power unit rules make the hybrid element more important and also connect to sustainable fuel use (Formula 1, 2026a).

In simple words:

The fuel engine gives power.
The electric system adds extra power.
Energy recovery captures energy that would otherwise be wasted.

Energy Recovery

When a car brakes, some energy is normally lost as heat. In hybrid F1 systems, part of the energy can be recovered and reused.

This is similar to charging a battery while slowing down.

The car then uses that stored energy later to go faster.

This makes F1 not only about power, but also about energy management. A driver and team must decide when to use energy, when to save it, and when to attack.

5. Data: The Invisible Race

What Is Telemetry?

Telemetry means data sent from the car to the team. During a race, the car sends information to engineers. This can include speed, tyre temperature, brake temperature, engine performance, fuel use, and many other details.

Catapult explains that F1 telemetry captures and sends data such as speed, tyre pressure, engine performance, and fuel consumption, helping teams understand how the car is performing in real time (Catapult, 2024).

This means there are actually two races happening:

The race we see on TV.
The data race happening on computers.

Why Data Helps Teams Win

Data helps teams answer questions like:

Are the tyres overheating?
Is the driver losing time in one corner?
Should the driver pit now?
Is another driver faster on fresh tyres?
Is rain coming?
Can the car finish the race safely?

A driver may feel something in the car, but the engineers can see the numbers. The best teams combine driver feeling with computer data.

Methodology

This paper uses a secondary research approach. This means it is based on existing information from Formula 1 sources, tyre information, braking-system sources, and explanations of racing technology.

The approach has four parts.

First, the paper explains the basic science behind Formula 1 in simple language.

Second, it studies the main areas that affect winning: aerodynamics, tyres, brakes, power units, data, strategy, and driver performance.

Third, it uses simple examples and basic calculations to show how small differences can change a race result.

Fourth, it discusses why Formula 1 is not just a driving competition, but a scientific and technological competition.

This method is useful for a high school research paper because Formula 1 is very advanced, but its main ideas can still be explained simply.

Calculations

1. Small Time Differences Matter

In Formula 1, a difference of 0.2 seconds per lap can be huge.
Let us imagine two drivers:
Driver A is 0.2 seconds faster per lap than Driver B.
The race has 50 laps.
So: **0.2 × 50 = 10 seconds**
This means Driver A can finish 10 seconds ahead just by being two-tenths of a second faster every lap.
That is why F1 teams care about tiny improvements. A new front wing, better tire temperature, or cleaner pit stop can change the race.

2. Tire Strategy Example

Imagine a driver has two choices.
Option 1: Stay on old tires.
Lap time = 1 minute 35 seconds.
Option 2: Pit for new tires.
Pit stop loss = 22 seconds.
New tire lap time = 1 minute 32 seconds.
New tires are 3 seconds faster per lap.
To recover the 22 seconds lost in the pit stop:
22 ÷ 3 = 7.33 laps
So after about 8 laps, the new tires can make up the pit stop time.
This is why teams calculate carefully. A pit stop is not just changing tires. It is a math decision.

3. Undercut Example

An undercut happens when a driver pits before a rival and uses fresh tires to go faster. Formula 1 explains the undercut as passing a rival by pitting earlier and using the fresh-tire out-lap to beat the rival's old-tire in-lap (Formula 1, 2021).
Simple example:
Driver A stays out on old tires and does a lap in 1:35.
Driver B pits and comes out on fresh tires, then does a lap in 1:32.
Driver B gains 3 seconds.
If Driver A pits one lap later and loses time, Driver B may come out ahead.
This is why race strategy can win a race even if the car is not the fastest.

4. Downforce and Drag Example

Imagine a car has more downforce.
It gains 0.4 seconds in corners.
But because of extra drag, it loses 0.2 seconds on straights.
Net gain: **0.4 − 0.2 = 0.2 seconds**
That setup is useful.

But on another track:
It gains 0.2 seconds in corners.
It loses 0.5 seconds on straights.
Net result: **0.2 − 0.5 = −0.3 seconds**
That setup is bad.
This is why teams do not use the same setup at every race. Each track needs a different balance.

5. Pit Stop Time Example

Imagine one team does a pit stop in 2.4 seconds.
Another team does it in 3.1 seconds.
Difference: **3.1 − 2.4 = 0.7 seconds**
This sounds tiny, but in F1, 0.7 seconds can be the difference between coming out ahead of another car or getting stuck behind it.

Results

1. Winning Is Not About One Thing

The biggest finding is that Formula 1 races are not won by only the fastest driver or only the strongest engine. Winning happens when many areas work together.
A winning car needs:
Good aerodynamics.
Good tire management.
Strong braking.
Efficient power.
Accurate data.
Smart strategy.
A calm and skilled driver.

2. Aerodynamics Helps Cars Corner Faster

Aerodynamics is one of the most important parts of F1. Downforce helps the car grip the track, while drag slows it down. The best teams find the right balance.

3. Tires Can Decide the Race

Tires are not just black circles on the car. They are a major part of race performance. A team can lose a race if the tires overheat, wear out, or are used at the wrong time.

4. Brakes Must Be Hot, but Not Too Hot

F1 brakes work under extreme heat. They must be warm enough to work properly but not so hot that they lose performance. This makes braking a science of temperature control.

5. Strategy Is Mathematics in Action

Pit stops, tire choices, undercuts, overcuts, and safety car decisions are all based on calculations. A race can be won by making the right decision at the right second.

6. Data Has Changed Racing

Modern F1 teams use huge amounts of data. Engineers study information from the car in real time. This helps teams make faster and smarter choices during a race.

7. The Driver Still Matters

Even with technology, the driver is still very important. The driver must feel the car, manage tires, brake at the right time, handle pressure, and make quick decisions.

Discussion

Formula 1 is one of the best examples of science in real life. Many students think science is only found in textbooks, labs, or exams. But Formula 1 shows that science is also found in speed, competition, sport, and technology.

The most important idea in Formula 1 is balance.

A car needs downforce, but not too much drag.
Tires need heat, but not too much heat.
Brakes need temperature, but not overheating.
The driver must attack, but not destroy the tires.
The team must take risks but not make reckless decisions.

This balance is what makes Formula 1 difficult.

A normal person watching a race may think the fastest car should always win. But in reality, the fastest car may lose if the strategy is wrong. A driver may be leading the race but lose because the tires wear out. Another driver may win because they pit at the perfect time.

This is why Formula 1 is often called a team sport. The driver is the most visible person, but hundreds of people help create the result.

The driver's body is also part of science. F1 drivers face G-forces when braking and cornering. Mercedes-AMG Petronas explains that lateral G-forces push drivers sideways in corners, and the number of Gs describes how much force the driver feels (Mercedes-AMG Petronas Formula One Team, n.d.).

This means drivers need strong neck muscles, good fitness, fast reactions, and mental focus. They are not just sitting in a car. They are athletes controlling a machine at extreme speed.

Formula 1 also shows the importance of data. In school, students often ask why mathematics matters. F1 gives a clear answer. Teams use numbers to decide race strategy, tire life, fuel use, lap times, and car setup. A few numbers can change the race.

For example, if new tires are three seconds faster per lap, the team calculates whether the pit stop is worth it. If rain comes in six minutes, the team must decide whether to pit now or wait. If a driver is stuck behind another car, the team must decide whether to try an undercut.

This is mathematics under pressure.

The future of Formula 1 will likely become even more scientific. Active aerodynamics, sustainable fuels, hybrid power units, artificial intelligence, simulation tools, and better data systems will continue to shape the sport. But human creativity will still matter. Engineers must design clever cars. Strategists must make brave calls. Drivers must perform under pressure.

Formula 1 proves that science is not boring. It is fast, loud, risky, and exciting.

Conclusion

Formula 1 is not just a racing sport. It is a science competition at high speed. Every race is affected by physics, engineering, mathematics, data, weather, and human skill.

This paper found that winning in Formula 1 depends on many scientific factors. Aerodynamics helps the car stick to the track. Tires decide grip and race pace. Brakes turn speed into heat. Hybrid power units manage energy. Data helps teams make decisions. Strategy turns numbers into results. The driver brings everything together through skill, courage, and focus.

The most important lesson is that small details matter. In Formula 1, one-tenth of a second can change everything. One wrong pit stop can lose a race. One tire choice can change the result. One brave overtake can create victory.

Formula 1 teaches that winning is not luck. It is preparation, science, teamwork, and decision-making.

In simple words, Formula 1 is where physics becomes speed.

Limitations

This paper has some limitations.

First, it explains Formula 1 science in very simple language, so it does not include advanced physics equations.

Second, calculations are basic examples. Real Formula 1 teams use much more complex computer models.

Third, Formula 1 technology changes often because the rules keep changing.

Fourth, the paper does not study one specific race in full detail.

Fifth, some team data is secret, so the public cannot know every detail about how teams make decisions.

Even with these limitations, the paper shows the main science behind Formula 1 winning in a way that is easy for students to understand.

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