Name: _____ Date: _____

Downforce, Drag and the Rulebook

Reading level 13 · 1879 words

In a wind tunnel the car does not move. A scale model sits still while the road moves beneath it and fans pull air over it, which gives the same relative motion between car, road and air that a real car meets on the track. Imani, an aerodynamicist at a Formula 1 team, watches the readings climb as she chases two forces that pull against each other: how hard the air presses the car down, and how much that push slows it. Track testing is so limited in modern Formula 1 that the tunnel is a vital tool. Her time in it is limited too, because the amount a team receives depends on where it finished in the championship, and finishing higher earns less.

NASA's equations show why the two forces are linked. Lift depends on the density of the air, the square of the velocity, a lift coefficient and the wing area, and drag has the same form. A wing turns the air one way and the force acts the other way, so a wing set to throw air upward is pushed down. A team's guide to its 2022 car says that at about 150 kilometers per hour the car makes as much downforce as it weighs. At top speed the figure is probably three or four times as much. By our arithmetic, doubling 150 to 300 multiplies downforce by four. At the 330 kilometers per hour Formula 1 gives for the approach to Monza's first corner, the square law gives nearer five. So three or four is a rough figure, not a measurement, and teams change their wings for fast tracks.

Downforce is not free, and it is not equally useful everywhere. More of it holds the car to the road in corners, but on a straight the price is drag, so teams adjust their wings to suit each track, changing the front wing angle or the depth and angle of the rear flap to set the level. Slow corners matter most, because the cars spend so much of a lap at low and medium speed that the biggest lap time is lost there. Thin air changes the bargain again. In Mexico the altitude means low air density. Density is a term in both equations, so even a team's maximum-downforce wing gives downforce like Monza's, along with the highest top speeds of the season.

For 2026 the FIA changed the bargain by letting the wings move. The flaps on the front and rear wings each have two fixed positions, called Corner Mode and Straight Mode, and the rules say the change between them may take no more than 400 milliseconds. On the straights the FIA marks, the driver can open the flaps to cut drag, and in corners they close to keep downforce. The FIA said downforce had been reduced by 30 percent and drag by 55 percent for the new cars, but those are design figures from a 2024 announcement and not measured race results. The rules also require that if the front-wing system fails it returns to Corner Mode. In principle, one car can now serve both sides of Imani's tradeoff within a single lap.

All of that force reaches the road through the tires. The tire problem has not changed since 1950: how do you get the most grip without wearing the rubber out too fast or too soon? Pirelli's answer is a ladder of compounds. For 2026 there are five dry ones, from C1, the hardest, to C5, the softest, and Pirelli dropped a sixth because its lap-time gap to the C5 was too small to matter. Wear shows up as degradation. One form is graining, in which stress breaks the surface into microcracks that leave peaks and troughs on the tread and cut grip in corners and under braking and acceleration. The rules turn all this into strategy, because in a dry race each driver must use two specifications of dry tire or be disqualified.

The other limit is energy. For 2026 the electric motor that drives the rear wheels grows from 120 kilowatts to 350, and the goal is to lift electricity from about 20 percent of the power unit's output to about 50. Braking can recover up to 8.5 megajoules a lap, twice the old limit. By our arithmetic, spending all 8.5 megajoules at 350 kilowatts would last about 24 seconds. That is a thought experiment, though: the rules also keep the battery's charge swing to 4 megajoules and cut the electric power as speed rises, so when the energy is used matters as much as how much there is. The heat-recovery unit that harnessed exhaust gases was deleted, partly because in 18 years road-car makers had not adopted the technology. All teams now use advanced sustainable fuel.

A rule book decides what a car is, so a new one rebuilds the cars. The hybrid power units ran for twelve years from 2014. In 2018 the halo arrived, and the minimum weight rose by five or six kilograms, depending on the report, to make room for it. For 2022, F1 announced a rise of about 5 percent, from 752 kilograms to 790, partly because of stronger structures and heavier tires. A team's 2022 guide gives 795 for the cars that raced. By 2025 the minimum was 800. For 2026 it is 768, and the tires are narrower. The FIA's rule actually gives the minimum mass as 724 kilograms (726 in qualifying) plus the nominal weight of the tires, so the headline number includes the rubber.

Closer racing is the first of two stated aims of the aerodynamic rules. The FIA's text says to promote it by minimizing the aerodynamic loss when one car follows another. Ground effect, outlawed at the end of 1982, returned in 2022 as shaped underfloor tunnels. F1's research said older cars lost 35 percent of their downforce about 20 meters behind another car and 47 percent at about 10 meters. It said the 2022 design would cut those losses to 4 and 18 percent. A magazine report on F1's own graph gave 14 percent against 45 at one car length, so even F1's figures differ. Neither is a race result. FIA simulations reported in November 2025 gave about 5 percent loss at 20 meters for the original 2022 cars but about 20 percent for the 2025 cars, so most of the gain was gone. For 2026 the tunnels gave way to a flatter floor.

A second rule limits what a team can buy. The cost cap began in 2021 at 145 million dollars, fell to 140 million in 2022 and 135 million in 2023, and is 215 million for 2026, before a yearly adjustment for inflation. Before it, spending was unregulated, which let richer teams buy the

best people and technology. F1 says the rise is roughly neutral, because costs that were once outside the cap, such as annual depreciation, now count inside it. Some things stay excluded, including legal, HR, finance and marketing costs, driver pay, and the three highest-paid staff. The cap sets a ceiling on spending that relates directly to the car's performance, not on how well that money is spent. A separate cap on power-unit makers is 190 million dollars for 2026.

Points tell their own history of rule changes. The first World Championship race, at Silverstone on May 13, 1950, took 70 laps and nearly two and a quarter hours, while a race today generally ends within two. That year the points scale was 8-6-4-3-2, and since 2010 the top ten score from 25 down to one, with a few more points for the top eight in a sprint. The 2010 change had a reason, because under the old scale only two points separated first from second. Other ideas were tried and dropped. Double points for the last race were used in 2014 and removed from the 2015 rule book, and a fastest-lap bonus point returned in 2019 before it was removed after 2024.

Safety rules read like a list of answers. After the 1994 San Marino Grand Prix, where two drivers died, the FIA analyzed circuits by computer and found 27 high-risk corners. Car changes later removed 15 of them, and by 1996 track changes had cut the list to two. A 1998 rule gave a driver 10 seconds to leave the cockpit, and the 2026 test is a different one, 7 seconds to remove the steering wheel and get out, with the halo overhead. The head-and-neck device called HANS was approved in 2001, first raced in 2002 and made mandatory in 2003. The Virtual Safety Car followed a fatal accident at the 2014 Japanese Grand Prix and was introduced in 2015, setting a minimum time for each lap.

The halo shows how a safety rule is argued over and tested. It was chosen, delayed in mid-2016 to 2018 for more research, and then made standard, and every one is made to an FIA standard by a designated maker. Regulation text quoted by formula1.com in 2021, and a separate engineering report on the 2018 rules, both give a 116 kilonewton downward load, about 12 metric tons by our arithmetic. It must be held at least 5 seconds with no failure. One report from the halo's launch gave 125 kilonewtons, so the sources differ, or the report may describe a different test. It costs weight and slows escape, and its supporters still say it stops some very rare but very real risks. After a 2022 crash the FIA strengthened roll hoops for 2024, and the 2026 rules require the top of the roll hoop to support a 20 g vertical impact.

The sprint is the first argument. It is a 100-kilometer race of about 30 minutes, about a third of a Grand Prix, with no mandatory pit stop. F1 holds six sprint weekends in 2026 and says the format guarantees meaningful action every day, with points or grid position at stake. Critics disagree. F1 introduced sprints in 2021, when only the top three scored, and had revised the format every year through 2023. That year, after the new format's first sprint in Baku, drivers' reviews were mixed and the fans' reaction was lukewarm. By October one team boss said the races lacked drama and put strict limits on car changes. F1 itself calls the format a young and evolving concept, still a learning exercise, so both sides are describing something real.

DRS is the second. From 2011 to 2025 it was a rear-wing flap that cut drag when a driver was within one second. It divided opinion: some felt it made artificial drive-by passes, while others believed it saved F1 from processional races. Now it is gone. DRS existed to make up on the straight for the downforce a following car loses in the corners, and Overtake Mode does the same job another way. The wings that open on straights are available to every car, inside the zones the FIA marks on each track, whether or not it is close behind another. A driver within about one second at the detection point, nominally the final corner, gets extra electrical energy for the next lap. Imani switches off the fans. In the tunnel the road slows, and the model sits still again.

Questions

1. Why does doubling a car's speed matter so much for downforce?

A. Downforce depends on the square of the speed
B. Downforce stops once a car passes 150 km/h
C. Faster cars have thicker air

2. Why did Pirelli drop its sixth dry compound for 2026?

A. It was too expensive
B. Its lap-time gap to the softest compound was too small to matter
C. The rules banned it

3. In the screen on energy, "about 24 seconds" is

A. a rule from the FIA
B. a measured lap time
C. the book's own arithmetic from two sourced figures

4. In the tire screen, "degradation" most nearly means

A. a steady loss of performance from wear
B. a ban on certain tires
C. a faster compound

5. What do the two sets of downforce-loss figures in the closer-racing screen have in common?

A. Both were measured in 2022 races
B. Both are race results
C. Both are design or research figures, not race results

6. Which was NOT part of the 2026 power unit changes in the energy screen?

A. Electric power up from 120 to 350 kilowatts
B. A larger V12 engine
C. Sustainable fuel

Words to know

downforce: downward air push
coefficient: scaling number
degradation: wearing down
graining: surface cracking
megajoules: energy units

Answer key: Downforce, Drag and the Rulebook

1. A. Downforce depends on the square of the speed
2. B. Its lap-time gap to the softest compound was too small to matter
3. C. the book's own arithmetic from two sourced figures
4. A. a steady loss of performance from wear
5. C. Both are design or research figures, not race results
6. B. A larger V12 engine