forces involved in Automobile Racing

Key Concepts

- Acceleration
- Centripetal force
- Friction
- Inertia
- Trade-off
- Air resistance
- Downforce
- Force
- Gravity

More about Force

In simple terms, a force is any push or pull. There are numerous types of forces that we encounter every day. We can analyze many of these forces through examples taken from automobile racing.

An unbalanced force will cause acceleration and make an object increase or decrease its speed. When two forces equally oppose each other, we say they are balanced. A balanced force does not cause acceleration. Think of a tug of war: If the forces from opposite teams are equal or balanced, neither team moves.

A car sitting on the racetrack has forces on it, but they are balanced. Look at the picture of the soapbox derby car [Soap Box Derby Car, 1939 ID# THF69252]. The force of gravity pulls down on the car while an equal force from the track pushes up. The forces are balanced, and the car remains stationary. If the soapbox derby car were on a hill, the downward force would be greater than the upward force and the car would accelerate down the hill. Before a race begins, a race car's engine has not yet started to provide a forward force, and the car remains at rest, like these drag racing cars [Official Start of First NHRA Drag Racing Meet, Great Bend, Kansas, 1955 ID# THF34472].

In order to get a car to move, there must be an unbalanced force. Look at this race car which has gone off the track. [Three Men Pushing a Barber-Warnock Special Race Car Off the Track at Indianapolis Motor Speedway, probably 1924 ID# THF68328] Notice that it takes several people to accelerate the car by pushing it. A large force is needed to overcome friction, a backwards force opposing motion, and a simple method of getting the car to the starting line is simply to push it, overcoming the friction between the tires and the track.

Forces on Larger Cars

It takes a lot of force to accelerate a large car. In one of the earliest race cars – the Sweepstakes built by Henry Ford – the motor was extremely large to provide a lot of force. The motor and the rest of the car were massive. This early car raced at only about 60 miles per hour. [Composite Image Depicting Henry Ford and Spider Huff Driving the Sweepstakes Racer at Grosse Pointe Racetrack, 1901 ID# THF24696] The Sweepstakes was effective in its day because other cars were also very heavy. Note the difference between the Sweepstakes and the 1960 Slingshot Dragster drag race car [Buck & Thompson Class D Slingshot Dragster, 1960 ID# THF36041]. The Slingshot Dragster has a smaller engine than the Sweepstakes but is much lighter, so it can go faster. In most races today, all the race cars are required to have the same mass in order to keep the races competitive.

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Centripetal Force

Another force involved in racing is centripetal force. When a car is traveling in a circle or on a curve, centripetal force pulls the car back toward the center of the circle or curve. Some racetracks are banked to push the car back toward the center. The banked turn helps provide centripetal force.

Most people think that when a car is traveling around a curve, the car is being forced out of the circle. Actually, the car naturally moves straight. Newton's first law states that a body in motion remains in motion unless acted upon by an outside force. To keep a car on a curved track, an inward force, toward the center, must be applied to the car to keep it on the track. Try to analyze the unusual accident in this photo [Damaged Race Car After a Racing Accident, 1905-1915 ID# THF12446].

Note that the car has crashed through the fence. Look back at the track in the upper left. You can see that the car should have gone around a left-hand curve, but it obviously didn't make the curve. For a race car to stay on the track around a curve, there must be an inward force. The tires pushing against the road or pavement should provide the inward force to keep the car in a circle; they did not provide enough force this time.

Tire Forces

Tires are very important in racing and have evolved over the years. Look at the tires on the Ford Thunderbird NASCAR-style car. [Ford Thunderbird NASCAR Winston Cup Race Car Driven by Bill Elliott, 1987 (aerial view ID# THF69260)] Note the large tires, designed to grip the road. Race cars can go through several tires during a long race because friction between the tires and the pavement wears tires out rapidly.

Other Problems

Look at the picture of Henry Ford and his friend Spider Huff, with Ford in the driver's seat [Henry Ford Driving the 999 Race Car Against Harkness at Grosse Pointe Racetrack, 1903 ID# THF23024]. Note the man sitting on the running board on the left side of the car. Imagine sitting on the small running board, racing and bouncing down the road at 60 miles per hour. What do you think the man on the running board is doing?

Newton's first law says that an object in motion (in this case, the car) will continue in motion unless acted upon by a force. When the driver makes a left-hand turn, the race car actually tends to go straight. The grip of the tires on the track provides force to turn the car. But early cars were not stable. The bottom of the car, where the tires are located, turned, while the heavy top of the car tried to keep going straight. These cars tended to roll over while turning.

So why did the rider ride on the left side? Most races are on oval tracks and run counterclockwise, so the drivers are constantly turning left around curves. Since the early race cars on these tracks could not corner very fast without rolling over to the right, the rider provided extra weight, or a downforce, on the left side of the car to balance the car and keep it from rolling over.

The running-board rider on these early race cars also served another purpose. Can you guess what it is? The rider watched the engine to make certain that it was running properly. He could warn the driver to slow down if there was an engine or gear problem, and if needed, he could actually oil the motor while racing.

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In modern race cars, on-board computers monitor the entire system; the computers send information back to the engineers in the pits so that necessary adjustments can be made to the race cars during pit stops. Compare what you may have seen happening in a modern pit stop with this picture of an older pit stop during a car race [Barber-Warnock Special Race Car in Pit at Indianapolis Motor Speedway, 1924 ID# THF68329].

Center of Gravity

The weight of modern race cars is very low to the ground; they have what is called a low center of gravity. The center of gravity is the average center of all the weight. If their center of gravity is too high, cars can tip over while going around sharp turns. Lowering the center of gravity or weight helps keep cars from rolling over.

Drag Force, or Wind Resistance Force

A large force in racing is wind resistance, or drag. At high rates of speed, the air pushing against the front of the car produces great force opposing the race car's forward speed.

Innovators are constantly redesigning cars to cut down on wind resistance by shaping the front of the car. Look at Willys Gasser, 1958 (front view ID# THF69394) and (side view ID# THF69391). The shape of this car would certainly cause a great amount of air resistance, requiring the car to push the air. The force of the air against the car would slow the Gasser's acceleration and speed. To decrease the air resistance from its large, flat front, the top of the Gasser was chopped off and lowered.

Notice the difference between the shape of the Gasser and the Ford Thunderbird [Ford Thunderbird NASCAR Winston Cup Race Car Driven by Bill Elliott, 1987 (aerial view) ID# THF69260]. The front of the Gasser pushed a lot of air, but the Thunderbird has a sloped front that allows air to pass over the top of the car with less resisting force.

When the Gasser's owner, George Montgomery, finally retired the Willys, he replaced it with a modified Mustang that was much lower and had better aerodynamics.