Lesson 5
Ground Effects, Innovations and Safety in Automobile Racing

Main Idea

Science, physics and engineering principles help explain ground effects and safety innovations in automobile racing.

Key Concepts

– Aerodynamics
– Airfoil
– Air resistance
– Bernoulli's principle
– Downforce
– Force
– Ground effects
– Pressure
– Relative motion
– Roll bar
– Safety features

Materials

– Computers with access to the Internet; digital projector and screen (preferred) OR printed handouts of Background Information Sheet, Student Activity Sheet and digitized artifacts' images and descriptions
– Background Information Sheet for Students 5A: Ground Effects, Innovations and Safety in Automobile Racing
– Student Activity Sheet 5B: Ground Effects and Safety Innovations in Automobile Racing
– Answer Key 5B: Ground Effects and Safety Innovations in Automobile Racing

Duration 1 class period (45 minutes)

Racing Oral History Interviews

– Jim Dilamarter: Getting Downforce and Pushing Air

Digitized Artifacts
from the Collections of **The Henry Ford**

Lesson 5 Ground Effects, Innovations and Safety in Automobile Racing

– March 84C Race Car, 1984
(aerial view ID# THF69371)
(side view ID# THF69368)
– Willys Gasser, 1958 (front view ID# THF69394)
– Ford Thunderbird NASCAR Winston Cup Race Car Driven by Bill Elliott, 1987
(aerial view ID# THF69260)
– Henry Ford Driving the 999 Race Car Against Harkness at Grosse Pointe Racetrack, 1903
ID# THF23024
– Start of the Indianapolis 500 Race, 1937
ID# THF68313
– Lyn St. James Suited Up in Race Car, Giving a Thumbs-Up, 2008 ID# THF58671

Continued…

Instructional Sequence

1. Engagement

Ask the students what they know about wind resistance in cars. Ask them if they know how air moving over a car can be used to help the car actually go faster.

2. Exploring Ground Effects and Innovations in Automobile Racing

Distribute Background Information Sheet for Students 5A: Ground Effects, Innovations and Safety in Automobile Racing. If possible, access this online so that students can view the digitized artifacts embedded and hyperlinked in the Background Information Sheet. (See the Background Information for Teachers section below for additional information on Bernoulli's principle and the digitized artifact images.)

Use the Background Information Sheet to review, read and discuss with students the question for analysis, concepts and information about Ground Effects, Innovations and Safety in Automobile Racing.

Encourage students to make their own observations, ask questions and offer other examples from life that illustrate these concepts and principles.

3. Background Information for Teachers

Bernoulli's principle is the overriding concept that makes an airplane stay in the air or makes a race car stay on the track. In an airplane wing, the surface on top of the wing is longer than the bottom surface due to differences in their curves. The faster-traveling air over the longer surface causes lower pressure on the top of the wing, while the bottom of the wing is subject to comparatively higher pressure. This creates a force upward that moves from high pressure to low pressure, and it is this force, caused by pressure difference, that keeps the airplane in flight.

Ask your students if they play baseball or softball and know what causes a baseball or softball to curve in its trajectory. Actually, it's the spin that the pitcher puts on the ball that makes it curve. The side of the ball spinning into wind has slower moving air flowing past it. The side of the ball spinning away from the direction of the throw has a faster moving air flowing past it, setting up a drop in pressure from the side of the slower-moving air to the side of the faster-moving air. The drop in pressure causes a force in that direction and the ball curves with the pressure.

Continued…

Lesson 5 Ground Effects, Innovations and Safety in Automobile Racing Continued

- March 84C Race Car, 1984 (aerial view ID# THF69371). This Texaco Star race car illustrates the airfoils that produce downforce for greater traction in the corners. This picture shows a side view of the race car and its airfoil. Notice the shape of the airfoil, which has a longer surface on the bottom of the wing and a shorter surface on the top. The air traveling over both surfaces gets from front to back in the same time; therefore the air that travels over the longer underside must travel faster than the air that travels over the top side. The faster-moving air causes a drop in pressure underneath the airfoil, and since a force is created toward a drop in pressure, a downforce is created. The downforce will cause greater traction on the track and allow the car to go faster around the curves without skidding off the track. In most races, these airfoils are not allowed because they allow race cars to travel at a higher speed than is considered safe on some race-tracks.
- Willys Gasser, 1958 (front view ID# THF69394). The Willys "Gasser" is a drag race car from the 1950s and 1960s that has a flat nose. The flat surface pushes back on the incoming air and decreases the car's ability to accelerate. To minimize this liability, the top of this car was actually chopped off and lowered to decrease the surface of the flat front.
- Ford Thunderbird NASCAR Winston Cup Race Car Driven by Bill Elliott, 1987 (aerial view ID# THF69260). The red #9 Ford Thunderbird NASCAR-style race car illustrates a front end that slopes for better aerodynamics. The air can ride easily over the top of the car, allowing the Thunderbird to cut through the air resistance.
- Henry Ford Driving the 999 Race Car Against Harkness at Grosse Pointe Racetrack, 1903 ID# THF23024. The picture of this early race car shows a rider on the side of the car. Needless to say, these early race cars were not built for safety.
- Start of the Indianapolis 500 Race, 1937 ID# THF68313. This start of the Indianapolis 500 shows many cars with open tops.
- Lyn St. James Suited Up in Race Car, Giving a Thumbs-Up, 2008 ID# THF58671. This illustration shows how the interiors of modern race cars are different those of older race cars. Identify all the safety features shown in the picture.

Assessment

Assign Student Activity Worksheet 5B: Ground Effects and Safety Innovations in Automobile Racing to assess students' learning and understanding.

ground effects, innovations and safety in Automobile Racing

Question for Analysis

What are the technologies and innovations behind ground effects and safety features in automobile racing?

Introduction

Of the many special innovations and concepts developed over automobile-racing history, most involve science and physics principles that have been expanded and further developed in engineering race cars. Many of these innovations and concepts are used today in our passenger cars.

Concepts

Aerodynamics

The way the shape of an object affects the flow of air over, around or under it.

Airfoil

A winglike device on a race car that creates downforce as the air flows over it.

Air resistance

The force created by the air when it pushes back against an object's motion.

Bernoulli's principle

Air moving faster over the longer path on a wing will cause a decrease in pressure, resulting in a force in the direction of the decrease in pressure.

Downforce

The aerodynamic force on a car that pushes it downward, resulting in better traction.

Force

Any push or pull.

Ground effects

The effects from aerodynamic designs on the underside of a race car, which create a vacuum.

Pressure

Force divided by area.

Relative motion

The comparison of the movement of one object with the movement of another object.

Roll bar

A heavy metal tube or bar wrapped over the driver in a race car; the roll bar prevents the roof from crushing the driver during a rollover.

Safety features

In an automobile, things that make the car safer or that make racing safer.

Oral History Interviews

Watch the following oral history interviews to understand how race car builders work toward innovating new ways to go faster. Al Unser, Sr. also talks about the need for teamwork in order to accomplish any goal.

Racing Oral History Interviews

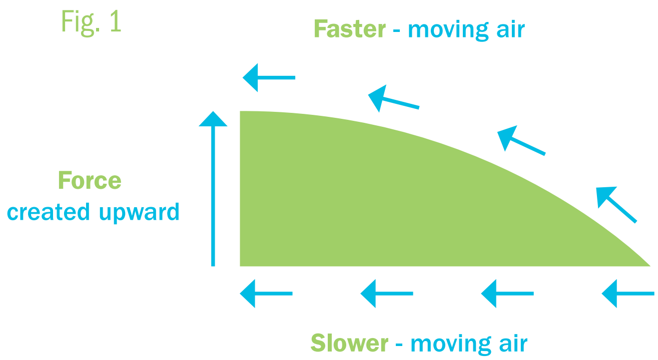
– Jim Dilamarter: Getting Downforce and Pushing Air

Airflow

Race car designs can manipulate the motion of air around the cars through aerodynamics. A ground effect results from an aerodynamic design on the underside of a race car, which creates a vacuum.

One of the most interesting aspects of automobile racing involves Bernoulli's principle. Fast-moving air causes a drop in air pressure and a force in the direction of the pressure drop. If you look at a wing of an airplane, you will see the top of the wing has a longer surface than does the bottom of the wing (see Fig.1). The air has to travel faster over the longer, upper surface. The faster moving air produces a drop in pressure, giving the bottom of the wing comparatively higher pressure, and there will be a force created from the pressure difference. The resulting force will push or lift the wing upward.

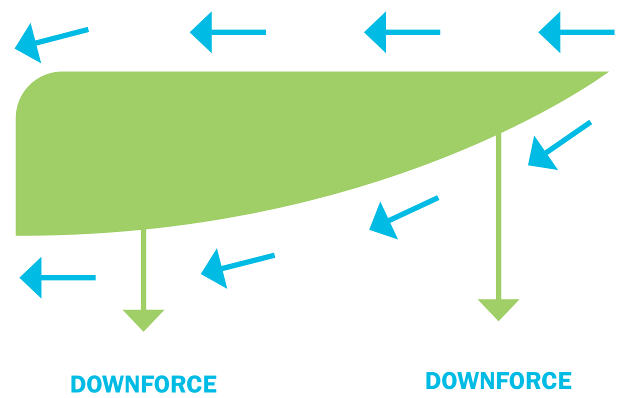
Fig. 1



Airfoils

Race car engineers have used Bernoulli's principle to make winglike objects called airfoils. The "wing" of the airfoil is turned upside down, so that the longer surface is on the bottom. The airfoil is attached to either the front or the back of the car to push down on it and gain better traction. Look at the airfoil on the Texaco Star race car [March 84C Race Car, 1984 (aerial view ID# THF69371)]. The winglike airfoils are attached to the nose of the car and the rear of the car. As the air passes over the airfoil, the pressure difference caused by the air moving faster below the airfoil than above it produces a downforce (see Fig. 2).

Fig. 2



Downforces

The fronts of race cars (and of passenger cars) are slanted downward, not to take advantage of Bernoulli's principle, but simply to allow air to pass over the car without pushing on the front of the car. Notice the front of the red #9 Ford Thunderbird [Ford Thunderbird NASCAR Winston Cup Race Car Driven by Bill Elliott, 1987 (aerial view ID# THF69260)}. The front of the Thunderbird is slanted forward. The forward slant allows two advantages. First, the air rides over the top of the car without pushing straight back against the car so that there is less force opposing the car's motion. Second, there is a downward force on the front of the race car allowing the tires to grip better and the car to corner faster. When the air hits the front of a race car that has a low front and then continues over the top of the car, the air actually pushes down on the front of the car to give better traction (see Fig. 3). Notice the low front on this Thunderbird; it causes the oncoming air to push down on the front of the car.

Fig. 3

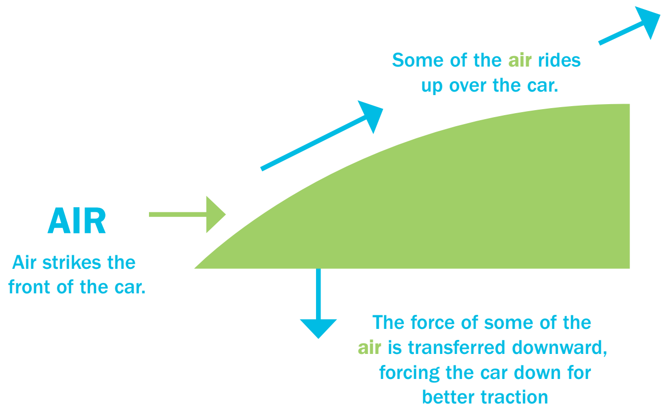
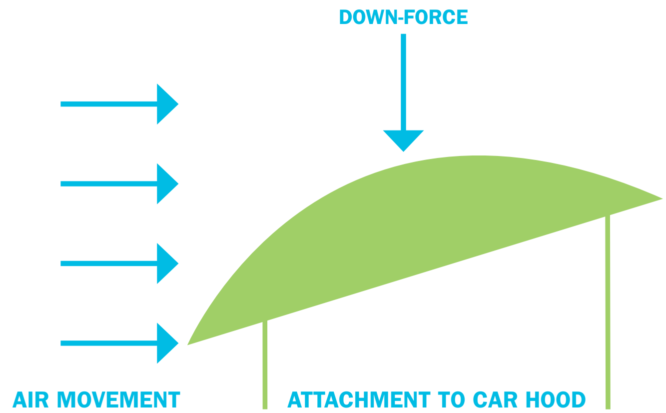


Fig. 4



Sometimes the airfoil itself is tilted so that the airfoil transfers force directly downward to the car. When the air strikes the tilted airfoil, there are two forces produced. Not only is Bernoulli's principle in effect, but the tilt of the airfoil causes a transfer of the force downward. The angle of the airfoil can be adjusted for different racing conditions. If the track has more straight sections, the foil is kept level with the track. If there is a lot of cornering, the foil is tilted to produce more downforce. Notice the airfoils on the 1984 March 84C-Cosworth Indianapolis race car [March 84C Race Car, 1984 (aerial view ID# THF69371)].

Notice how the air moves. The air strikes the front of the airfoil, which is slanted down. The angle of the air against the foil causes a push, or force, downward. The airfoil is attached to the hood and therefore forces the car downward onto the track, allowing greater traction for cornering (see Fig. 4).

There is a drawback to using the airfoil angled downward – it increases the force against the front of the car and slows it down. This presents a trade-off: The car gains cornering ability but loses overall straightaway speed. An airfoil angled downward would only be useful on tracks with short straightaways and a higher percentage of curves.

Safety

Race car designs are always being improved to allow the race cars to travel faster and more safely. The cars have roll bars to strengthen the roof during a rollover. The driver wears a 5-point seat belt that totally and securely straps him or her in. The driver wears fireproof clothing and fireproof gloves. Many safety features that are designed for race cars are later adapted for passenger cars

ground effects, innovations and safety in Automobile Racing

Name

1. Draw a sketch that illustrates Bernoulli's principle by drawing an airfoil and then sketching and labeling the air movement and the resulting forces as you imagine them.

2. Look at these pictures of early races: Henry Ford Driving the 999 Race Car Against Harkness at Grosse Pointe Racetrack, 1903 ID# THF23024 and Start of the Indianapolis 500 Race, 1937 ID# THF68313. Compare them with these images of more modern race cars: Lyn St. James Suited Up in Race Car, Giving a Thumbs-Up, 2008 ID# THF58671 and March 84C Race Car, 1984 (side view ID# THF69368).

   Use these pictures and your studies to make a list of 10 items below that includes safety issues in the older race cars and safety features of the more modern race cars.

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

ground effects, innovations and safety in Automobile Racing

1. Draw a sketch that illustrates Bernoulli's principle by drawing an airfoil and then sketching and labeling the air movement and the resulting forces as you imagine them.

   See the explanation and figure on Background Information Sheet 4A for a sample drawing that illustrates Bernoulli's principle.

2. Look at these pictures of early races: Henry Ford Driving the 999 Race Car Against Harkness at Grosse Pointe Racetrack, 1903 ID# THF23024 and Start of the Indianapolis 500 Race, 1937 ID# THF68313. Compare them with these images of more modern race cars: Lyn St. James Suited Up in Race Car, Giving a Thumbs-Up, 2008 ID# THF58671 and March 84C Race Car, 1984 (side view ID# THF69368).

   Use these pictures and your studies to make a list of 10 items below that includes safety issues in the older race cars and safety features of the more modern race cars.

   There are numerous possible answers; here are some of them:

Some safety issues in the older race cars:

1. *Notice the rider on the running board. Notice everything that might happen to him, such as falling off, bumping and getting hit by another car, etc.*
2. *Notice that few of the drivers or riders are wearing a helmet.*
3. *Notice that there are no roll bars.*
4. *There is very little back on the seat to protect the driver's back.*
5. *There are no seat belts in the older cars.*
6. *There is no windshield, so objects can get in drivers' eyes.*

Some safety features of the more modern race cars:

7. *Notice the fire-resistant suit.*
8. *Notice the fire-resistant gloves.*
9. *Notice the high back on the driver's seat to protect the driver's back.*
10. *Notice all the cushioning in the car.*
11. *Notice the 5-point safety belt.*
12. *Notice the strength in all the bars above the driver; these bars hold up the roof during a rollover.*
13. *Notice the driver's helmet.*
14. *Notice the eye shield.*
15. *Notice that the entire seat tends to wrap around the driver.*