

Lesson 2

Newton's Three Laws and Racing

Main Idea

Newton's three laws of motion – the law of inertia, $F=ma$ and action and reaction – can be illustrated with examples from automobile racing.

Key Concepts

- Acceleration
- Air resistance
- Force
- Friction
- Inertia
- Mass
- Momentum
- Relative motion
- Speed
- Velocity

Digitized Artifacts

from the Collections of **The Henry Ford**

Lesson 2 Newton's Three Laws and Racing

- [Willys Gasser, 1958](#) (side view ID# THF69391)
- [Lyn St. James Suited Up in Race Car, Giving a Thumbs-Up, 2008](#) ID# THF58671
- [Start of the Indianapolis 500 Race, 1937](#) ID# THF68313
- [Three Men Pushing a Barber-Warnock Special Race Car Off the Track at Indianapolis Motor Speedway, probably 1924](#) ID# THF68328

- [Official Start of First NHRA Drag Racing Meet, Great Bend, Kansas, 1955](#) ID# THF34472
- [March 84C Race Car, 1984](#) (cockpit view ID# THF69363)
- [Ford Thunderbird NASCAR Winston Cup Race Car Driven by Bill Elliott, 1987](#) ID# THF69258
- [Buck & Thompson Class D Slingshot Dragster, 1960](#) ID# THF36041
- [Race Car "999" Built by Henry Ford, 1902](#) ID# THF70568
- [Damaged Race Car After a Racing Accident, 1905-1915](#) ID# THF12446

Racing Oral History Interviews

- Jim Hall: [Safety Rules](#)
- Jim Hall: [Engineer to Go Faster](#)

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 2A: Newton's Three Laws and Racing
- Student Activity Sheet 2B: Newton's Three Laws
- Answer Key 2B: Newton's Three Laws

Duration 1-2 class periods (45 minutes each)

Continued...

Lesson 2 Newton's Three Laws and Racing Continued

Instructional Sequence

1 Looking for Laws of Motion in Automobile Racing

Distribute Background Information Sheet for Students 2A: Newton's Three Laws and Racing. If possible, access this sheet online so that students can view the digitized artifacts embedded and hyperlinked in the Background Information Sheet. Instruct students to listen to the racing oral history interviews and examine the digitized artifacts. (See the Background Information for Teachers section below for additional information on the digitized artifacts.)

Use the Background Information Sheet to review, read and discuss with students the questions for analysis, concepts, and information about Isaac Newton and his laws of motion as they apply to automobile racing.

Encourage students to make their own observations, ask questions and offer other examples from life that illustrate Newton's laws of motion.

2 Background Information for Teachers

Additional information on the digitized artifacts is provided below to supplement what is offered on the website and to assist your students in the completion of the Background Information Sheet and Student Activity Worksheet.

- [March 84C Race Car, 1984](#)
(cockpit view ID# THF69363)

Notice the wide tires, designed for better grip in the turning. The front and rear wings generate downforce to help the car hold the road. The bodywork under the car, called the side pods, is carefully shaped to create lower pressure under the car than above, which pulls the car down tighter to the road.

- [Buck & Thompson Class D Slingshot Dragster, 1960](#)
ID# THF36041

Dragsters are designed to do one thing – cover a quarter-mile from a standing start as quickly as possible. This car contains no extra weight – nothing that does not contribute to that goal. This chassis was actually built from a kit, and the entire car was built and raced by two young men from Rockford, Illinois – Bob Thompson and Sam Buck.

- [Willys Gasser, 1958](#) (side view ID# THF69391)

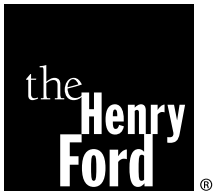
Cars like this were enormously popular for drag racing in the 1950s and 1960s. In the 1930s, Willys were small, lightweight economy cars with excellent acceleration and were a favorite of drag racers.

- [Damaged Race Car After a Racing Accident, 1905-1915](#) ID# THF12446

Automobile racing has always been a dangerous sport for both drivers and fans. Sometimes things go terribly wrong. Here, the car has crashed through the fence when it continued in a somewhat straight line instead of making the left-hand turn. Look back behind the fence to see that the car did not make the curve. This is an example of Newton's first law. It could also represent Newton's second law, as there was not enough force between the tires and the track to cause the car to accelerate around the curve.

Assessment

Assign students Student Activity Worksheet 2B: Newton's Three Laws to assess learning and understanding.



Newton's three laws and Racing

Questions for Analysis

- What are Newton's laws of motion?
- How do Newton's laws of motion apply to automobile racing today?

Key Concepts

Acceleration

The rate at which an object's velocity changes;
 $a = \Delta v / \Delta t$.

Air resistance

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

Force

Any push or pull.

Friction

The opposing force between two objects that are in contact with and moving against each other.

Inertia

An object's tendency to resist any changes in motion.

Mass

The amount of matter in an object.

Momentum

The combined mass and velocity of an object, or mass times velocity.

Safety features

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

Speed

The distance an object travels divided by the time it takes to travel the distance.

Velocity

The speed of an object, including its direction.

Weight

The force of gravity pulling on an object. Weight equals mass times the acceleration due to gravity.

Background

Isaac Newton was an English physicist and mathematician who lived from 1642 to 1727. He worked in many areas of physics, but he is primarily known for his three laws of motion. These laws of motion can help us describe the speed, acceleration, thrills and dangers of automobile racing.

Continued...

Racing Oral History Interviews

Listen to Jim Hall talk about changing force and changing how fast cars will go. He also discusses how he works within the rules and yet still tries to find ways to make his car go faster.

- Jim Hall: [Safety Rules](#)
- Jim Hall: [Engineer to Go Faster](#)

Newton's First Law – The Law of Inertia

Newton's first law is called the law of inertia. Inertia is the resistance to change in motion. Newton's first law states that a body at rest remains at rest and that a body in motion remains in motion unless acted upon by an outside force. This law means that once we start moving, we continue moving.

In everyday life, we exhibit inertia because we tend to keep doing what we are already doing. When we are up, we like to stay up. If we are sitting or sleeping, we like to stay sitting or sleeping.

If a car is standing still without the motor running, the car will remain there. Look at the picture of the drag race car sitting in front of *Henry Ford Museum*. [[Willys Gasser, 1958](#) (side view ID# THF69391)] As long as the engine is not started and no one pushes this car, it will remain where it is.

If a driver starts the engine and pushes the accelerator, the motor produces a force that moves the car forward. The driver and passengers feel as though they are thrown or pushed backwards, but actually the car goes forward and the driver and passengers remain where they are. When the car accelerates forward and the car seats hit them in their backs, they feel as though they are being thrown backwards.

Newton's first law can also be seen in a car that is stationary and gets hit in the rear end. The driver feels as if he or she flies backwards, but actually the car is pushed forward, leaving the driver behind.

There are many safety features designed to protect race car drivers. Race cars have high-backed seats so that when the drivers accelerate forward, their entire body goes forward with the car. Look at the picture of the inside of Lyn St. James's race car with its tall car seats.

[[Lyn St. James Suited Up in Race Car, Giving a Thumbs-Up, 2008](#) ID# THF58671] Racecar drivers' heads do not snap back because they are up against a tall seat. In your family car, your car's head rests and seats keep you from feeling as though you are thrown backwards.

Once race cars reach a high rate of speed, they continue at the high rate of speed, according to Newton's first law. [[Start of the Indianapolis 500 Race, 1937](#) ID# THF68313] If there is a crash and the car is stopped by an outside force (for example, another car or a wall), the driver keeps on going. Safety belts help slow the driver to prevent him or her from flying out of the car or from hitting the front windshield. In a passenger car, air bags slow the driver and passenger.

In a modern race car, the race car safety belts are called 5-point belts. They go around both shoulders as well as around the waist and down to the center of the front of the seat, and they attach at 5 points. Modern race drivers also use a HANS Device, which wraps around the driver's neck to help protect his or her neck from flying side to side. Five-point belts and HANS Devices help protect race car drivers from the effects of Newton's first law.

Continued...

Look at the picture of an Indy race car. [March 84C Race Car, 1984 (cockpit view ID# THF69363)] In serious auto racing accidents, especially those that involve Indy-style cars (called open wheel race cars), many pieces of the car fly off. Why is it actually good that parts fly off the race car? Rather than the energy going into the driver, the kinetic energy can be dissipated in the flying parts. Roll bars are also used to prevent the car from crushing around the driver.

Newton's Second Law – $F = ma$

Newton's second law can be stated mathematically as force equals mass times velocity, written as $F = ma$. An unbalanced force will create acceleration. The greater is the force, the greater will be the acceleration. The greater the mass, the less the acceleration. Thus a car with larger mass will accelerate more slowly.

What do car builders and engineers do to increase acceleration and speed? Race car designers and innovators aim for the most powerful engine possible, for more force and acceleration. The designers also want to make the car lighter so that the car has better acceleration and speed. Most races regulate engine size, so designers or car builders cannot put too large an engine in their race car. Therefore, race car builders try to make cars lighter where possible, by using aluminum or plastic rather than steel, which is heavier. Many wheel rims are made from lightweight magnesium to decrease mass in the car.

Look how light the 1960 Slingshot dragster looks. [Buck & Thompson Class D Slingshot Dragster, 1960 ID# THF36041] The Slingshot car is very light. It is designed and built for drag racing, where the track is straight and only a quarter-mile long.

Notice the 1902 Ford 999 race car built by Henry Ford. [Race Car "999" Built by Henry Ford, 1902 ID# THF70568] The 999 car had a large, 1,150-cubic-inch engine to provide a large force to make it accelerate and go fast. Notice how heavy the 999 car is; its weight slows it down.

Newton's Third Law – Action and Reaction

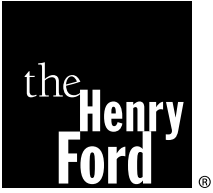
Newton's third law states that for every action in one direction, there is an equal and opposite reaction. Another way to state the third law is for every force in one direction, there is an equal and opposite force in the other direction.

When a race car accelerates, the motor and engine transfer force to the tires, which push backwards against the pavement. The pavement or track pushes back on the race car. Because forces cause objects to accelerate, the car moves forward. When two forces push against each other, the lighter object moves farther and faster.

Thus the car moves rather than the track. If there is gravel or dirt on the track, then the track does move, in a way: You see the gravel or dirt fly back as the car goes forward.

There are numerous examples of action and reaction in everyday situations. When a jet is flying, the engine forces hot gas out in one direction and the jet flies in the opposite direction. A swimmer pulls water backward to propel forward. A bullet is shot out of a gun in one direction and the gun recoils in the opposite direction.

Sometimes motion is expressed by the term momentum. The momentum of an object, such as a race car, is the combination of its mass and its velocity. When two objects push against each other, they go in opposite directions, and the momentum in one direction equals the momentum in the other direction.



Newton's three laws

Name _____

1. In the space below, state Newton's first law in your own words. List three examples of Newton's first law:

2. In the space below, state Newton's second law in your own words. List three examples of Newton's second law.

3. In the space below, state Newton's third law in your own words. List three examples of Newton's third law.

4. For each statement below, write 1st, 2nd or 3rd, according to which law of motion the statement best represents:

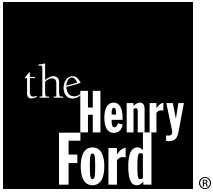
A _____ You place a can of cola on the dashboard in front of you. When the car accelerates forward, the cola dumps on your lap.

B _____ You are standing on a skateboard. You jump off the skateboard in one direction, and the skateboard goes flying in the opposite direction.

C _____ A car is stuck in snow. One person can't get the car moving, but with the help of three friends, the car can be pushed out of the snow.

D _____ When you are swimming, you pull your hand back through the water and then you go forward.

E _____ Once a space shuttle reaches orbit, it just continues in orbit without any more propulsion.



Newton's three laws

1. In the space below, state Newton's first law in your own words. List three examples of Newton's first law:

Newton's first law is called the law of inertia. The law states that a body at rest remains at rest and a body in motion remains in motion unless acted upon by an outside force.

Examples can include any example of an object remaining in motion or remaining at rest, such as:

- A** *A race car waiting to start a race will remain still.*
- B** *Once a race car is moving, it keeps on moving.*
- C** *When a person is in a car and the car suddenly brakes or stops, the passenger keeps on going unless a seat belt or air bag restrains him or her.*

2. In the space below, state Newton's second law in your own words. List three examples of Newton's second law.

Newton's second law is $F = ma$ or Force = mass times acceleration. An unbalanced force produces acceleration. The acceleration is proportional to the force and inverse to the mass.

Examples include any statement about larger forces producing more acceleration or less massive objects accelerating faster, such as:

- A** *A large engine will accelerate a car faster than a small engine.*
- B** *The more massive a car, the slower it will accelerate.*
- C** *Several people can push a car more easily than one person can.*

3. In the space below, state Newton's third law in your own words. List three examples of Newton's third law.

Newton's third law concerns action and reaction. It states that for every action in one direction, there is an equal and opposite reaction. The third law can be stated that for every force in one direction, there is an equal force in the opposite direction.

Examples include any in which one object propels in one direction and another object propels in the opposite direction, such as:

- A When a cannon ball is shot forward, the cannon recoils.*
- B When you push against a wall, the wall pushes back against you.*
- C In order to throw a baseball or softball forward, your feet must push back against the ground. If you are wearing flat shoes on wet grass, your feet will slip when you try to throw any object.*

4. For each statement below, write 1st, 2nd or 3rd, according to which law of motion the statement best represents:

A 1st You place a can of cola on the dashboard in front of you. When the car accelerates forward, the cola dumps on your lap.

B 3rd You are standing on a skateboard. You jump off the skateboard in one direction, and the skateboard goes flying in the opposite direction.

C 2nd A car is stuck in snow. One person can't get the car moving, but with the help of three friends, the car can be pushed out of the snow.

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E 1st Once a space shuttle reaches orbit, it just continues in orbit without any more propulsion.