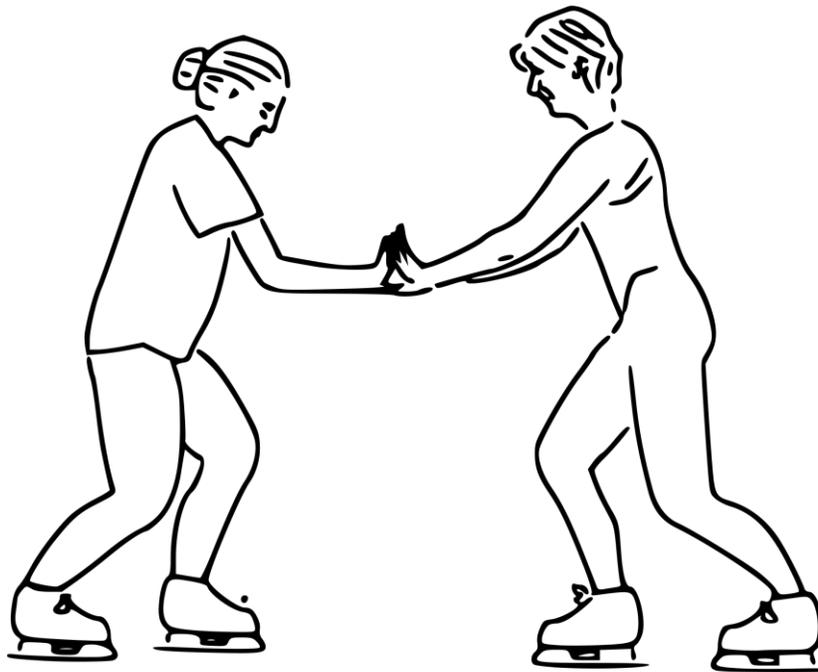


# Demoing through Newton's Laws of Motion

**Subject Area(s):** Physics, Physical Science  
**Associated Unit:** None  
**Lesson:** Demoing through Newton's Laws

**Header** Insert Image 1 here, centered



**Image 1**

**ADA Description:** Two skaters pushing against each other show Newton's Third Law of Motion

**Caption:** None

**Image file:** forces\_title.jpg

**Source/Rights:** Copyright © 2006 Benjamin Crowell – Wikimedia Commons  
[http://upload.wikimedia.org/wikipedia/commons/thumb/b/b2/Skaters\\_showing\\_newtons\\_third\\_law.svg/2000px-Skaters\\_showing\\_newtons\\_third\\_law.svg.png](http://upload.wikimedia.org/wikipedia/commons/thumb/b/b2/Skaters_showing_newtons_third_law.svg/2000px-Skaters_showing_newtons_third_law.svg.png)

**Grade Level** 9 (9-12)  
**Lesson #** 1 of 1  
**Lesson Dependency** None  
**Time Required:** 90 minutes (including associated activity)

**Summary:**

Isaac Newton’s three laws of motion are not only important to student’s understanding of physics, but provide the basis for engineering phenomena throughout our society. In this lesson, students will learn about these three laws of motion and their applications through the lesson discussion and associated activity. Using the student’s interest in Harry Potter, the lesson begins by explaining Newton’s Laws and how they govern the world around us like the Fundamental Law of Magic in Harry Potter. The students will then complete the associated activity before reconvening as a class and discussing and understanding engineering applications of these laws based on the activity completed.

**Engineering Connection:**

Newton’s laws are the basis for engineering, movement and the interaction that engineers and scientist have to think about in every design and idea. Understanding how these laws work, just like any scientific law, is the first step in being able to apply it to engineering problems. While rockets are clear examples of these laws, once these laws are understood they can be applied to a multitude of problems relating to mechanical engineering (brake system in cars), electrical engineering (accelerometer), and civil engineering (sediment transport).

**Engineering Category:**

1. Relating science and/or math concept(s) to engineering

**Keywords**

newton, force, acceleration, accelerometer, sediment transport, brakes, momentum, thrust, drag

**Educational Standards:**

International Technology and Engineering Educators Association (ITEEA) Standards

ITEEA, Standard 5, Grades 9-12, I. With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making.

ITEEA, Standard 11, Grades 9-12, N. Identify criteria and constraints and determine how these will affect the design process.

Texas Essential Knowledge and Skills (TEKS)

*Grade 9-12 [2010] - §112.39 Physics*

(2) Scientific processes. The student uses a systematic approach to answer scientific laboratory and field investigative questions. The student is expected to: (C) know that scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well-established

and highly-reliable explanations, but may be subject to change as new areas of science and new technologies are developed;

(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to: (D) explain the impacts of the scientific contributions of a variety of historical and contemporary scientists on scientific thought and society;

(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to: (E) research and describe the connections between physics and future careers;

### **Pre-Requisite Knowledge**

Basic understanding of velocity, acceleration, and mass. Law of Conservation of Momentum

### **Learning Objectives (For Lesson and Associated Activity)**

After this lesson, students should be able to:

- Describe the first step in research/engineering process
- Define Newton's First, Second, and Third Law of Motion
- Be able to demonstrate each law
- Describe one application related to engineering for each law

### **Introduction / Motivation**

(Show a scene from Harry Potter or read from the Harry Potter series a discussion of the law that governs the world of magic).

Do we have laws like that in our world? Have a few students respond and make sure to encourage them to think of rules/laws in the world of physics. If you are on a skateboard and you run into a curb, what happens? Why? If you push your textbook, what will happen? And if you run into someone on skates, why will they move in the opposite direction at a similar speed? These are all questions we are going to answer today using a set of three basic laws: Newton's Laws of Motion!

Read with me the three laws we will be learning about today. (Write on board) Newton's First Law of Motion: An object at rest stays at rest and an object moving at a constant velocity continues at that velocity unless acted upon by a net force. Newton's Second Law of Motion: Force equals mass times acceleration. Newton's Third Law of Motion: For every action there is an equal and opposite reaction.

While we talk and demonstration these laws today, we will understand why these laws are important when you drive to school, when you play video games, and when you go to the beach. For engineers the first step in creating and understanding these different phenomena is to understand the laws that govern the world they are working in: the world of motion in physics. The world is defined by Newton's Laws of Motion. Now, repeat the Newton's Laws of Motion again with me so we can begin understanding and demonstrating these laws.

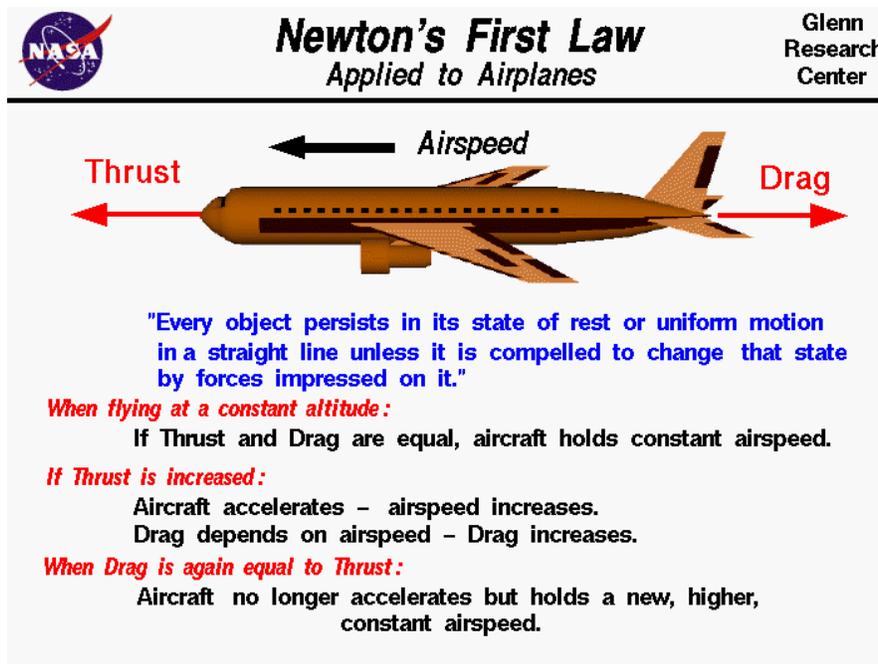
Complete Associated Activity and use Lesson Background & Concepts for Teachers for the discussion to follow the activity. Use the attached PowerPoint for the discussion.

## Lesson Background & Concepts for Teachers

### Newton’s First Law of Motion:

Newton’s First Law of Motion states that an object at rest stays at rest and an object moving at a constant velocity continues at that velocity unless acted upon by a net force. When a weight is balanced on top of an empty can, the weight is at rest and will stay at rest (though it is much heavier than the empty can). Similarly, when the weight is in motion, it will stay in motion which is why it crushes the can. As seen in Image 2, we notice this phenomenon in the movement of a plane. A plane will move at a constant velocity but there are two forces that are constantly trying to change that. The thrust (cause by the engine) acts as a force on an airplane that can increase the velocity while the drag (caused by wind resistance) acts as a force on an airplane that can decrease the velocity [1]. When they are equal, the plan stays in a constant state of motion.

Image Insert Image 2 here, centered



**Image 2**

**ADA Description:** From the Glenn Research Center is Newton’s First Law applied to airplanes for the purpose of high school and college student education.

**Caption:** Newton’s First Law (Applied to Airplanes)

**Image file:** Newtons\_first\_plane.jpg

**Source/Rights:** Copyright © 2010 Tom Benson (NASA)

<http://www.grc.nasa.gov/WWW/k-12/airplane/Images/newton1.gif>

In order to change an object either from rest or from constant velocity, a force must act on it. This is why cars need brakes. While it would be nice to be able to wish your car to stop, a force must be applied to the car in order to slow down and stop at the right time unlike what is seen in Image 3. Image 3 does show Newton’s First Law of Motion. The tree is at rest and it wants to stay at rest!

Image Insert Image 3 here, left justified



**Image 3**

**ADA Description:** Two skaters pushing against each other show Newton’s Third Law of Motion

**Caption:** None

**Image file:** car\_crash.jpg

**Source/Rights:** Copyright © 2005 Thue (WikiCommons)

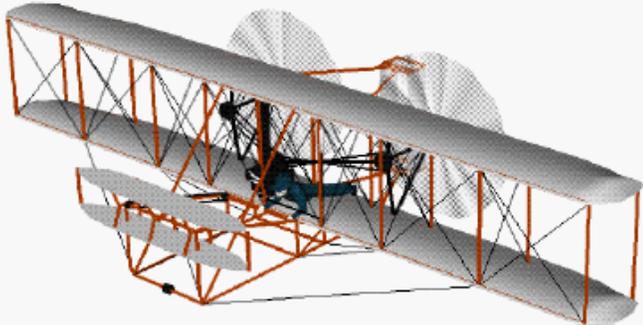
[http://upload.wikimedia.org/wikipedia/commons/e/e1/Car\\_crash\\_1.jpg](http://upload.wikimedia.org/wikipedia/commons/e/e1/Car_crash_1.jpg)

Brake pads are a component of a disk brake system that is used to grind and slow its motion. As a car moves along the roadway, it is maintaining a constant velocity; however, when a red light is observed ahead, the car must change that constant velocity (slow down) by exerting a force on the car. The brake pads (and system) produce this force through friction. [2]

Newton’s Second Law of Motion:

Newton’s Second Law of Motion states that force equals mass times acceleration (Image 3). Force is dependent on the change in velocity and therefore causes a change in velocity and a change in velocity causes a force. [3] It has both a magnitude and direction.

Image **Insert Image 4 here, centered**



 **Newton’s Second Law**  
*Definitions* Glenn  
Research  
Center

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**Differential Form:** Force = change of momentum with change of time  $F = \frac{d(mv)}{dt}$

**With mass constant:** Force = mass X acceleration  $F = m a$

**or:** Force = mass X change in velocity with time  $F = \frac{m (V_1 - V_0)}{(t_1 - t_0)}$

*Force, acceleration, momentum and velocity are all vector quantities.*  
Each has both a magnitude and a direction.

**Image 4**

**ADA Description:** From the Glenn Research Center is Newton’s Second Law definition for the purpose of high school and college student education.

**Caption:** Newton’s First Law (Applied to Airplanes)

**Image file:** Newtons\_second\_plane.gif

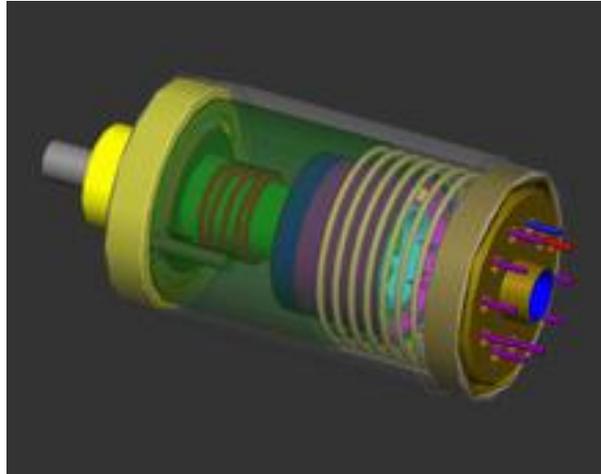
**Source/Rights:** Copyright © 2010 Tom Benson (NASA)

<http://wright.nasa.gov/airplane/Images/newton2.gif>

This principle can be found in your phone [6] and in a Wii remote. Inside both of these devices is something called an accelerometer. An accelerometer is a device that measures acceleration. Based on the discussion of Newton’s Second Law of Motion, in order to find the acceleration we must know the force and mass of an object. This is demonstrated with the Ball in a Box (see associated activity). When the ball is in the box (at rest), the force being applied

to the bottom of the box is due to gravity. Due to relative motion, when you move the box quickly to the right, the ball makes contact with the left side of the box causing a force. Accelerometer works the exact same way; however, unlike in this case, an accelerometer has sensors that measure the force applied [4]. Because the mass is also known, the acceleration is determined and relayed to the Wii unit so that it knows where to move the character or pointer. Accelerometers (Image 5) are used many other areas including vehicle, biological migration tracking, and health monitoring [5].

Image **Insert Image 5 here, left justified (next to beginning of accelerometer discussion)**



**Image 5**

**ADA Description:** From the Glenn Research Center is Newton’s Second Law definition for the purpose of high school and college student education.

**Caption:** Newton’s First Law (Applied to Airplanes)

**Image file:** Newtons\_first\_plane.jpg

**Source/Rights:** Copyright © 2010 Tom Benson (NASA)

<http://www.grc.nasa.gov/WWW/k-12/airplane/Images/newton1.gif>

*Newton’s Third Law of Motion:*

Newton’s Third Law of Motion states that for every action there is an equal and opposite reaction (Image 6). When an engine thrusts forward, flow of a fluid like air is pushed with an equal force back.

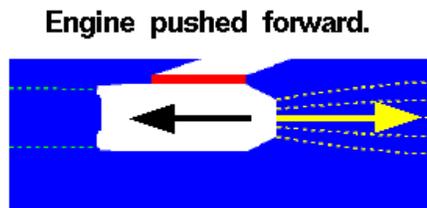
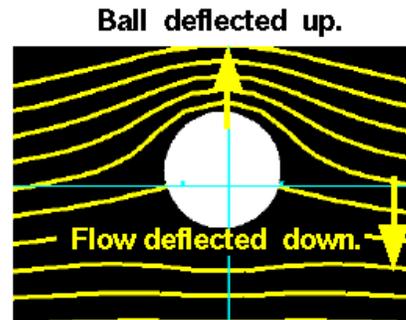
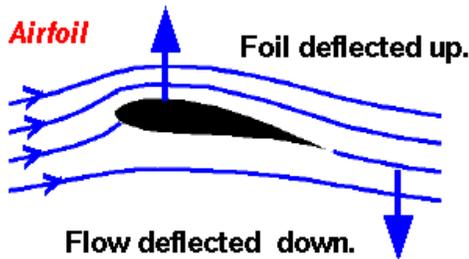
Image **Insert Image 6 here, centered**



## Newton’s Third Law Applied to Aerodynamics

Glenn  
Research  
Center

For every action, there is an equal and opposite re-action.



*Spinning Ball*

Image 6

**ADA Description:** From the Glenn Research Center is Newton’s Third Law applied to aerodynamics for the purpose of high school and college student education.

**Caption:** Newton’s Third Law (Applied to Aerodynamics)

**Image file:** Newtons\_third\_aerodynamics.gif

**Source/Rights:** Copyright © 2010 Tom Benson (NASA)

<http://www.grc.nasa.gov/WWW/k-12/airplane/Images/newton3.gif>

Similarly, Bouncing Balls (see associated activity) demonstrates this principle through the law of conservation of momentum (collision). When each ball individually is dropped it, it bounces a certain height depending on how much air is in the ball. When they are drop with the tennis ball on top of the basketball, the momentum of the balls combined is transferred from the floor to the basketball then to the tennis ball cause the tennis ball to fly significantly higher.

This same principle is used by geologist and civil engineers to understand the movement sediment. Sediment Transport is the movement of sediment due to forces from gravity and water. The collision of sand particles must follow the same rules and laws as the tennis ball and basketball. Grain sizes can range from millimeters to inches in diameter causing smaller particles to move faster in a collision. This interaction is modeled through computer programs that start with these governing equations for Newton’s Laws of Motion.

### Vocabulary / Definitions

Word	Definition
Newton’s First Law of Motion	An object at rest stays at rest and an object moving at a constant velocity continues at that velocity unless acted upon by a net force.
Newton’s Second Law of Motion	Force equals mass times acceleration
Newton’s Third Law of Motion	For every action there is an equal and opposite reaction.
Brake Pads	A component of a disk brake that is used to grind and slow its motion
Accelerometer	A device that measures acceleration
Sediment Transport	The movement of sediment due to forces from gravity and water.

### Associated Activities

Demonstrating Newton’s Laws of Motion

### Lesson Closure

Use the background information presented above to discuss the finding is the associated activity and how Newton’s Laws of Motion are present in each demonstration and engineering example. Have students updated their worksheet if need in a different color pen or pencil. (Use this as your post-lesson assessment).

Before engineers or scientist can discover new ideas and invent new applications, the laws that govern these problems must be understood and demonstrated. Today we did that with Newton’s Laws of Motion and learn how they are already being applied.

### Assessment

#### Pre-Lesson Assessment

Use the discussion questions built into the introduction to assess the student’s current level of understanding regarding Newton’s laws and how understanding governing laws are the first step in the engineering process.

#### Lesson-Embedded Assessment

See Associated Activity

#### Post-Lesson Assessment

Use Associated Activity Worksheet and discussion following the Associated Activity as the post-lesson assessment (Lesson Closure).

### Lesson Extension Activities

Activity: Demolishing Newton’s Laws: Where Newton’s Laws of Motion Don’t Apply  
(Currently Being Written)

### Additional Multimedia Support

Harry Potter: video clip of laws discussion and destruction scene (Book reading could also be used instead)

## References

[1] Benson, Tom. “Newton’s First Law: Applied to Planes”. <http://www.grc.nasa.gov/WWW/k-12/airplane/newton1.html> NASA (2010). Accessed December 12, 2012.

[2] Deaton, Jamie P., “How Brake Pads Work” <http://auto.howstuffworks.com/auto-parts/brakes/brake-parts/brake-pads.htm>. HowStuffWorks, Inc. (1998-2012) Accessed December 12, 2012.

[3] Benson, Tom. “Newton’s Second Law: Definitions” <http://wright.nasa.gov/airplane/newton2.html>. NASA (2010). Accessed December 12, 2012.

[4] Starlino. “A guide to using IMU(Accelerometer and Gyroscope Devices) in Embedded Applications”. [http://www.starlino.com/imu\\_guide.html](http://www.starlino.com/imu_guide.html) . Starlino Electronics (2010). Accessed December 12, 2012.

[5] “Accelerometer”. <http://en.wikipedia.org/wiki/Accelerometer>. Accessed December 12, 2012.

## Attachments

### Other

None

### Redirect URL

None

### Contributors

Daniel W. Burlson

### Copyright

### Supporting Program

National Science Foundation AWARD # 0840889, GK-12 Program at the University of Houston: Innovations in Nanotechnology and Nanosciences using a Knowledge, Applications, Research, and Technology (KART) Approach