Demonstrating Newton's Laws of Motion

Subject Area(s): Physics, Physical Science

Associated Unit

Associated Lesson: Demoing Through Newton's Laws of Motion

Activity Title : Demonstrating Newton's Laws of Motion

Insert Header Here (Centered)

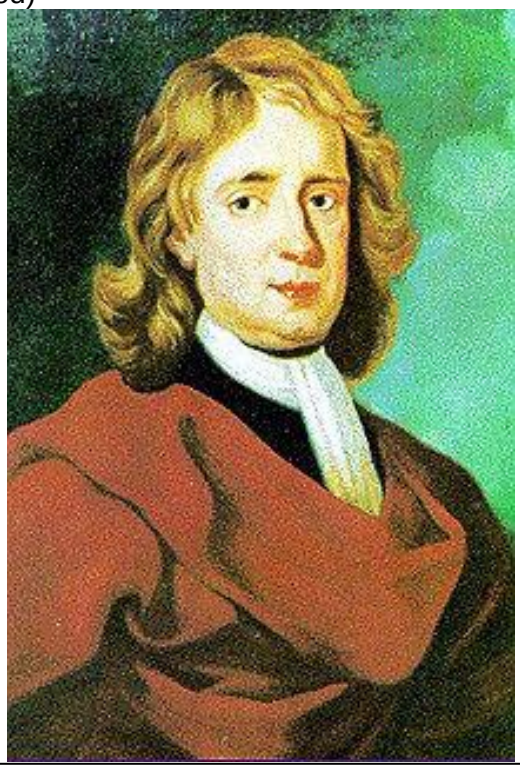

Image 1
Image file: isaac_newton.jpg
ADA Description: An image of a contemporary painting of Sir Isaac Newton
Source/Rights: Copyright © 2005 Wikimedia Commons
http://upload.wikimedia.org/wikipedia/commons/2/21/Isaac-newton_1.jpg

Grade Level: 9 (9-12)

Activity Dependency: See associated lesson

Time Required: 45 Minutes

Group Size: 6

Expendable Cost per Group: US $2

Summary:

The goal of this activity is to provide an understanding of Newton's laws through a series of demonstration (3 total). Students are given the material and procedure and are encouraged to answer hypothesize, record results, and make real world connections to the demonstrations they perform.

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. 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's Law, motion, force, accelerometer, acceleration, sediment transport, brakes

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
Conservation of momentum, understanding of Newton's Laws of Motion, relative motion

Learning Objectives
After this activity, students should be able to:

- Describe the first step in research/engineering process
- Identify which of Newton's Laws applies to each demonstration
- Identify one example of how this law is important in engineering and design

Materials List

The material list below is the total needed for one attempt at each demonstration. The material list should be multiplied appropriately depending on how many times the demonstration is done

Demonstration (Station) #1 – Weighing Down A Can

- One soda can (empty)
- 10 lb weight
- Brake Pad

Demonstration (Station) #2 – Ball in a Box

- Box (clear with closable top)
- Tennis ball
- String
- Duct tape
- Wii remote
- Rubber Band

Demonstration (Station) #3 – Bouncing Balls

- 1 Basketball
- 1 tennis balls
- Water
- Sand (large and variety of grain size)
- Plastic tub

Introduction / Motivation

The first step in any engineering design is to understand what you are working with and be able to demonstrate these laws. When researchers and engineers begin creating model to understand how fluid flows in a river or how to design the most efficient car or airplane, the first step is to write down the governing equations and principles. What laws or principles did we just discuss? (See Associated Lesson). You are going to take the first step in the engineering design process and present your understanding of Newton's Laws of Motion by doing demonstrations that use the three laws.

Vocabulary / Definitions (Note: Same as Associated Lesson)

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 a its motion
Accelerometer	A device that measures acceleration
Sediment Transport	The movement of sediment due to forces from gravity and water.

Background

If it is not already visible from the associated lesson, write down each of Newton's Laws of Motion so that the students can refer to it or have them refer to their notes from the associated lesson. All the background information is covered in the associated lesson (Demoing Through Newton's Laws)

Procedure:

Before the Activity (Setup)

1) Gather materials for each demonstration and place in different areas in the classroom
2) For demonstration #1:
   a) Place the weight on a sturdy table and the empty cans and brake pad in a bin or bag next to the table.
3) For Demonstration #2
   a) Wrap the rubber band around the tennis ball.
   b) Take the string loop it underneath the rubber band.
   c) Make the length of the string allows the ball to barely touch the bottom of the box.
   d) Use duct tape to hold down the string outside the box so that it is hanging inside the box and just touch the bottom.
4) For Demonstration #3
   a) Place balls in bag or on table for students to grab
   b) In a plastic tub (or sink if available), Place sand (1-inch thick) over half of the area and put water (1/2 inch thick) in the other area.
5) Make copies of the procedural documents for each station and place one at each demonstration area
6) Make copies of the worksheet and distribute as students enter the room.

As an entire class:

1. Split the class into three groups.
2. Explain that each station has 15 minutes then will rotate to the next station.
3. Explain the rotation. Station 1 goes to Station 2. Station 2 goes to Station 3. Station 3 goes to Station 1.

4. Make sure to record the necessary information on the worksheet at each station for a discussion at the end of the class. It is important for each group to identify each of newton's laws that are present for each demonstration.

Station #1: Weighing Down a Can

Insert Image #2 here (left justified next to procedure for this station)

Image 2

Image file: brake_pad.jpg

ADA Description: This is an image shows how a brake pad works.

Source/Rights: Copyright © 2010 Amm105 at WikiCommons
http://upload.wikimedia.org/wikipedia/commons/7/76/Brake_pads.JPG

Caption: Using the concept presented in the state, brake pads help your car stop or slow down.

1. What will happen when you place the weight on top of an empty can? Answer question on worksheet.
2. Place an empty can on the table.
3. Carefully balance the weight on top of the can.
4. Record what happen. Which of Newton's laws applies? Answer question on worksheet.
5. What will happen if you drop the weight on top of an empty can? Answer question on worksheet.
6. Place an empty can on the table.
7. Hold the weight directly over the can about two feet high.
8. Drop the weight
9. Record what happen. Which of Newton's laws applies? Answer question on worksheet.
10. Look at the brake pad (Image 2). How does the law presented in this demonstration relate to how a brake pad works? Answer question on worksheet.
11. Place crushed can in recycling and return items to original location.

Station #2: Ball in a Box

Insert Image #3 here (left justified next to procedure for this station)

Image 3

Image file: wii_remote.jpg

ADA Description: This is an image of a wii remote that uses an accelerometer.

Source/Rights: Copyright © 2012 Daniel Burleson, NSF GK-12 Program, College of Engineering, University of Houston

Caption: Similar to a ball suspended in a box, a Wii remote uses an accelerometer to measure the acceleration of your motions with a Wii console.

1. With the box sitting still on the table, what is the ball exerting on the bottom of the box? Answer question on worksheet.
2. What will happen to the hanging tennis if you move the box quickly to the right? Answer question on your worksheet.
3. Pick up the box and hold it waist high.
4. Allow the ball to become steady then quickly move the box to the right.
5. What did the ball exhibit on the side of the box? Which of Newton's laws applies? Answer on worksheet.
6. What will happen to ball if you drop the box? Answer question on worksheet.
7. Pick up the box and hold as high as you can away from your body.
8. Drop the box.
9. Record what happens. Which of Newton's laws applies? Answer on worksheet.
10. Look at the Wii remote. This same principle is used in this remote. How do you think it is used? Answer question on worksheet
11. Return all items to their original location.

Station #3: Bouncing Balls

Insert Image #4 here (left justified next to procedure for this station)

Image 4

Image file: shoreline.jpg

ADA Description: This is an image of the Long Beach Harbor in April, 1998.

Caption: The interaction or collision of particles is very important in their movement. Sediment transport along the coast is determined by how these particles force are transferred between the sediment particles themselves and with external forces from water movement.

1. Take the basketball and hold it at waist height. How high will the basketball bounce back up? Which of Newton's laws apply to this interaction? Answer question on worksheet.
2. Drop the basketball and record an estimate of the height it bounced back up.
3. Take the tennis ball and hold it waist height. How high will the tennis ball bounce back up? Which of Newton's laws apply to this interaction? Answer on your worksheet.
4. Drop the tennis ball and record an estimate of the height it bounced back up.
5. Have one person hold the basketball at his or her waist and have another person hold the tennis ball directly top of the basketball. How high will each ball bounce? Answer question on your worksheet.
6. Drop the balls simultaneously and estimate the height that each ball bounces back.
7. Explain why you believe you got these results.
8. Look at the sand and water setup in the bin at this station.
9. What will happen to the sand if you cause wave action in the water? How do Newton's laws work in this case? Answer question on worksheet.
10. Have someone calmly splash the water to cause waves to form like you would see in Image 4.
11. Record what happens to the sand on your worksheet. Make sure to state how this relates to Newton's laws of motion.
12. Return all items to their original location.

Attachments

Procedure_demonstration_1_.doc
Procedure_demonstration_1_.pdf
Procedure_demonstration_2_.doc
Procedure_demonstration_2_.pdf
Procedure_demonstration_3_.doc
Procedure_demonstration_3_.pdf
Worksheet_demonstrate_newtons_laws.doc
Worksheet_demonstrate_newtons_laws.pdf

Safety Issues
Make sure students are careful when dropping the weight on the can so that it does not fly off the table and hit someone.

Troubleshooting Tips

Investigating Questions
Investigating questions are included throughout the procedure and on the worksheet give. Refer to the procedure for each demonstration for investigating questions.

Assessment

Pre-Activity Assessment
See Associated Lesson
Activity Embedded Assessment
The questions included in each demonstration are used to assess the students understanding of newton's laws and their ability recognize these laws.
Post-Activity Assessment
See Associated Lesson

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

Activity Scaling
- For lower grades, the demonstrations can be done as a class for the sake of time and to use the collective knowledge of all students.
- For upper grades, have the students create an additional demonstration and example for each of newton's law. Encourage them to come up with something that clearly uses all three laws.

Additional Multimedia Support
None

References
None

Other

Redirect URL

Contributors
Daniel W. Burleson

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

Classroom Testing Information

Demonstration (Station) #1
Weighing Down a Can

1. What will happen when you place the weight on top of an empty can? Answer question on your worksheet.

2. Place an empty can on the table.

3. Carefully balance the weight on top of the can.

4. Record what happens. Which of Newton's laws applies? Answer question on worksheet.

5. What will happen if you drop the weight on top of an empty can? Answer question on your worksheet.

6. Place an empty can on the table.

7. Hold the weight directly over the can about two feet high.

8. Drop the weight

9. Record what happen. Which of Newton's laws applies? Answer question on worksheet.

10. Look at the brake pad. How does the law presented in this demonstration relate to how a brake pad works? Answer question on worksheet.

11. Place crushed can in recycling and return other items to original location.

Demonstration (Station) #2
Ball in a Box

1. With the box sitting still on the table, what is the ball exerting on the bottom of the box? Answer question on worksheet.

2. What will happen to the hanging ball if you move the box quickly to the right? Answer question on worksheet.

3. Pick up the box and hold it waist high.

4. Allow the ball to become steady then quickly move the box to the right.

5. What did the ball exhibit on the side of the box? Which of Newton's laws applies? Answer question on worksheet.

6. What will happen to ball if you drop the box? Answer question on worksheet.

7. Pick up the box and hold it as high as you can away from your body.

8. Drop the box.

9. Record what happens. Which of Newton's laws applies? Answer question on worksheet.

10. Look at the Wii remote. This same principle is used in this remote. How do you think it is used? Answer question on worksheet.

11. Return all items to their original location.

Demonstration (Station) #3
Bouncing Balls

1. Take the basketball and hold it at waist height. How high will the basketball bounce back up? Which of Newton's laws apply to this interaction? Answer question on worksheet.

2. Drop the basketball and record an estimate of the height it bounced back up.

3. Take the tennis ball and hold it waist height. How high will the tennis ball bounce back up? Which of Newton's laws apply to this interaction? Answer question on worksheet.

4. Drop the tennis ball and record an estimate of the height it bounced back up.

5. Have one person hold the basketball at his or her waist and have another person hold the tennis ball directly top of the basketball. How high will each ball bounce? Answer question on worksheet.

6. Drop the balls simultaneously and estimate the height that each ball bounces back.

7. Record what happens. Why? Answer question on worksheet.
8. Look at the sand and water setup in the bin at this station.

9. What will happen to the sand if you cause wave action in the water? How do Newton's laws work in this case? Answer question on worksheet.

10. Have someone calmly splash the water to cause waves to form.

11. Record what happens to the sand on your worksheet. How does Newton's laws of motion apply to this? Answer questions on worksheet.

12. Return all items to their original location.

Demonstration (Station #1): Weighing Down a Can

1. What will happen when you place the weight on top of the empty can?

2. What actually happened?

3. Which of Newton's Laws of Motion applies to this case?

4. What will happen when you drop the weight on top of the empty can?

5. What actually happened?

6. Which of Newton's Laws of Motion applies to this demonstration?

7. How does the law presented in this demonstration relate to how a brake pad works?

Demonstration (Station #2): Ball in a Box

1. With the box sitting still on the table, what is the ball exerting on the bottom of the box?

2. What will happen to the hanging ball if you move the box quickly to the right?

3. What actually happened?

4. What did the ball exert on the side of the box?

5. Which of Newton's Laws of Motion applies to this demonstration?

6. What will happen to the hanging tennis ball if you drop the box from head high?

7. What actually happened?

8. Which of Newton's Laws of Motion applies to this case?

9. How do you think this same principle works for a Wii remote?

Demonstration (Station #3): Bouncing Balls

1. How high will the basketball bounce when you drop it at waist high?

2. Which of Newton's Laws of Motion apply to this interaction?

3. How high will the tennis bounce when you drop it from waist high?

4. Which of Newton's Laws of Motion apply to this interaction

5. How high will each ball bounce if they are drop together with the tennis ball on top?

6. What actually happened?

7. What did the ball exert on the side of the box?

8. Which of Newton's Laws of Motion applies to this case?

9. What happens to the sand due to the wave action and which how does this relate to the bouncing balls (use Newton's Laws)?