Overview

In this three-part activity, students explore Newton’s three Laws of Motion that govern all bodies in motion, from toy cars to spacecraft in orbit around Earth. Each part (experiment) focuses on a separate Law of Motion, progressing through them in order (First, Second, Third). It requires minimal materials that are easy to obtain. A handout walks students through each of the experiments.

Gravity is one of the fundamental concepts of Physics. It is an abstract concept which can’t be explained without the help of activities. Students in the middle grades need to have a solid idea of gravity and its influences on our daily lives. Usually, children find the concept of gravity a bit confusing as it provides little scope for activity. In this lesson, students will compare the effects of gravity on various objects.

Objectives

In the course of completing this lesson, students should:

• Recognize how different forces (particularly gravity) act on objects
• Identify how Newton’s Laws of Motion can be illustrated in everyday life
• Detect patterns that illustrate some of the universal characteristics of forces

Physical Science

Space Science

Time Required

90 minutes

Standards Addressed

If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object’s motion.

An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.
Background & Connection to the ISS

Newton's Laws of Motion not only govern forces on Earth but also on the International Space Station. In fact, the microgravity environment of the ISS showcases the Laws of Motion in ways that are difficult to replicate on Earth. Because the ISS is in a constant state of free-fall, it simulates a weightless environment (thus it's a microgravity environment). By seeing how each of the Laws of Motion plays out on Earth, students are likely to better understand how the ISS's microgravity environment is different, as well as how a microgravity environment affects other forces — particularly in ways that contribute to the unique research that scientists conduct on the ISS.

Materials Required
(per group)

- 10 Washers
- Pin
- Pencil
- Balloon
- Flexible drinking straw
- Tape
- 2 meter sticks
- Books
- Toy Car (Matchbox, Hot Wheel size)
Activity Steps

1. Before students begin their experiments in this activity, help them tap into prior experiences with the Laws of Motion by asking:
   - **If a soccer ball is kicked in an open field, why does it eventually stop no matter how hard it is kicked?** (Students might come up with forces like friction or gravity acting against the movement of the ball. If they don't come up with gravity, ask students what gravity is and which way the force pulls compared to the direction of the force applied to the soccer ball.)
   - **What if a soccer ball is kicked on the moon where there’s much less gravitational force, would the ball travel a longer distance or shorter distance? Why?** (Students should get this, particularly if gravity came up in the first question – it is weaker, so the force acting against the soccer ball is much weaker/less.)
   - **Have the students imagine they have a slingshot and two stones — one the size and weight of a golf ball and the other the size and weight of an 8-pound shot put. If each one is shot separately using the same slingshot and pulled back an equal distance, which would travel the greater distance? Why?** (Chances are students will correctly believe that the golf ball-sized stone will travel a greater distance — likely because it's not so heavy. If necessary, try to guide students to the fact that the force acting on both objects is equal.) Watch the multimedia definition for the term mass in the Learn the Lingo section of the CASIS Academy website (www.casisacademy.org).
   - **Who was Sir Isaac Newton?** (Students are likely to know that he “invented” gravity or came up with the theory! There is no need to go much deeper than that.)

2. Divide the class into pairs/groups based on the number of materials available for experiments and the space available.

3. Distribute the handout *Much More Interesting Than an Apple on the Head*, setting up the activity. Read the introduction as a class. Ask students if they thought the apple hit Sir Isaac Newton on the head (which may have come up in Step 1.)

4. Guide and instruct students through the experiments. The handout should have all of the information they need. Check in on each group periodically.

5. Give the class updates on when they should be moving from one experiment to the next. The first should take roughly 5 minutes; the second should take 10 – 12 minutes; the third should take 5 – 7 minutes.

6. After students have completed the three experiments, discuss the experiences with students. As part of the discussion, ask students to come up with questions the experiments raise — especially any questions that begin with “Why” or “How.”

7. Have students end the lesson by writing a paragraph on which of the three laws they would like to test in experiments in a microgravity environment. They should identify the law and provide at least one reason why they would want to perform tests in microgravity.
Extensions & Modifications

• To incorporate a more explicit connection to the International Space Station, begin the lesson by watching the ISS Tour Video [www.casisacademy.org]. Use that as a springboard to discussing how forces act differently on Earth than they do in space. Ask students to identify some specific differences.

• To extend the lesson as a class and/or for student who are interested in microgravity research on the ISS, investigate the Student Spaceflight Experiments Program (SSEP). This website: http://ssep.ncesse.org provides background and points out opportunities to design real-life microgravity experiments for the ISS.

• It may be messy, but it will be fun to try the “pull the tablecloth” trick as a way to illustrate Newton’s First Law.

• For the Newton’s Race experiment, have students adjust the angle of the meter sticks to determine if they discover any patterns between the slope and the distance the cars travel with different masses.

• Expand the last step of the lesson to be more than a paragraph.

• To abridge the lesson, have groups of students complete one experiment (covering all three among the groups) and report the results back to the class.

Attribution

Adapted from *Newton’s Challenge*, written by Tracy Trimpe at sciencespot.net, http://sciencespot.net/Pages/classphys.html#Anchor9
Much More Interesting Than an Apple on the Head

Famously, an apple inspired Sir Isaac Newton to formulate his theory of gravitation. At the time in the mid 1660s, plain old Isaac Newton (Queen Anne knighted him nearly 40 years later) was in a garden where he witnessed apples falling from a tree. Though it’s fun to imagine the idea for gravity literally hitting him on the head, apparently that’s just myth! But an apple falling to the ground helped Newton piece together some ideas that he had been developing — ideas that ended up being his Law of Universal Gravity and other concepts that we take for granted today.

Did you know that Sir Isaac Newton developed three Laws of Motion? (He wasn’t, like ... “I gave thee the theory of gravity, so now my work is done. I shall rest on my laurels.”) They’re “laws” in the sense that they “govern” the forces of motion. Today, those laws will be explored through three different experiments. (Yes, each experiment goes with a different Law of Motion.)

**Wacky Washers**

*An object at rest stays at rest or an object in motion stays in motion unless acted upon by an external force.*

— Newton’s First Law of Motion

1. To prepare for this experiment, stack 4 washers, one on top of the other, to form a tower of washers. Place the stack of washers on top of a textbook or on the floor.

2. Aim another washer at the bottom of the stack of four washers and give it a good hard flick with your finger or hand. What happens?

3. Flick a stack of two washers into a stack of four washers. What happens?

4. Flick a stack of four washers into a stack of four washers. What happens?

5. Explain your observations in terms of Newton’s 1st Law.
Newton’s Race

An applied force on an object equals the rate of change of its momentum over a period of time.

— Newton’s Second Law of Motion

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<th># of Washers</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Average Distance</th>
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1. Set up a ramp using meter sticks and several books. Place one end of the ramp on the books and line up the other end with a piece of masking tape on the floor.

2. Place the toy car at the top of the meter stick and roll it down the ramp. Use a meter stick to measure how far the vehicle rolls. Repeat this step two more times (for a total of three trials), entering the results in the table (the Race Record) above.

3. Add five washers to the top of the toy car and repeat the process from Step 2 (including 3 trials). Record the measurements in the chart. Be sure all the washers remain on the vehicle!

4. Add five more washers (for a total of 10) to the vehicle and repeat the process from Step 2 (including 3 trials). Record the measurements in the chart. Be sure all the washers remain on the vehicle!

5. Answer the following questions:
   - How does increasing mass (adding more washers) affect the force of objects in motion (the distance the vehicle rolls)? Explain your answer using data from the chart.
   - What would happen if fifteen washers were added to the car? Predict how far the car would roll.
   - Explain the results of the experiment in terms of Newton’s 2nd Law.
Balloon Rally
For every action, there is an equal and opposite reaction. — Newton's Third Law of Motion

1. Attach a balloon to the end of a flexible straw with tape. (Choose the end that is furthest away from the bend.)

2. Push a straight pin through the straw about halfway between the balloon and the bend in the straw. Fasten the pin in the eraser of a pencil.

3. Blow up the balloon and bend the straw to a 90° angle before allowing the air to escape. What happens?

4. Blow up the balloon and bend the straw to a 45° angle before allowing the air to escape. What happens?

5. Blow up the balloon, but leave the straw straight (180° angle). Release the air in the balloon. What happens?

6. Remove the pin and hold on to the straw as the balloon is blown up. Release the straw. What happens?

7. Explain your observations in terms of Newton's 3rd Law.