National Aeronautics and Space Administration

Christa's Lost Lessons

Newton's Laws

Grade: 6-8

For more of Christa's lessons and accompanying videos filmed in orbit, visit www.challenger.org/christa.

www.nasa.gov

Newton's Laws

Background Guide

Grade Level:
6th-8th

Suggested Time:
Two 50-60 minute class periods

Standards:

- MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Background: Newton's Laws

- First Law: An object in motion stays in motion unless an unbalanced force acts upon it.
- Second Law: Force is equal to the mass of an object times its acceleration (F=ma).
- Third Law: For every force acting on an object, that object exerts an equal force in the opposite direction on the first object.

Essential Questions

- Do Newton's Laws apply in microgravity?
- How does microgravity help us to understand Newton's Laws on Earth?

Objective

- Demonstrate Newton's Laws in Earth's gravity compared to microgravity.

Materials

- Pen/Pencil
- Newton's Laws Video (linked)
- Tennis ball
- Other types of balls in pairs (e.g. two marbles, two golf balls, two more tennis balls, etc.)
- Sand or flour
- Small bins (shoebox size)
- Assorted objects such as rocks, marbles, toy cars, small books, wooden blocks, wads of paper, etc.
- Masking or painter's tape
- Foot-long ruler
- Stopwatch

Teacher Preparation

For the teacher-led "Engage" activity, draw a table on the board as shown on the next page.

The student-led activity is designed to be carried out in three separate stations. Students should rotate through each station to test each law. You may wish to set up multiple versions of each station so students can work in smaller groups. However, be sure there is plenty of room at each station for crashes and messes!

At station one, create a challenging path for your students to roll a tennis ball through. Students will use a ruler to change the direction of the tennis

ball. To create the path, use two parallel lines of tape, but make the path zig-zag and mark the starting and ending locations. The narrower and more erratic the path, the more challenging the student activity will be! The station requires a tennis ball, a ruler and a stopwatch.

At station two, fill two shoebox-sized boxes halfway with sand or flour. You may want to put paper/plastic bags under them for easy clean-up. Provide students with multiple types of balls to drop into the sand/flour, but be sure you have at least two of each object (i.e. two golf balls, large marbles, etc.) at each station. You will also use these materials briefly for your "Engage" opening demonstration.

At station three, gather several different objects such as balls, toy cars, books, etc. If desired, you can have students gather materials from around the classroom on their own.

PROCEDURE

Engage (15 min)

Materials Needed: Box filled halfway with sand or flour, balls to drop into box.

Opening Demonstration: Thinking About Forces

1. Before the class begins, create a three-column table similar to the one below on the board.

Verb	What force makes the ball move?	What forces slow the ball down?

2. Pick up a ball. Ask the class to think of all the different ways they could make the ball move (such as throwing, bouncing, hitting, flicking, sliding, dropping, etc.). Record these words in the first column on the board. Be sure the word "drop/dropping" is on the list.
3. Once you've generated a list of action words, ask students to consider the forces that make the ball move. For example, drop a ball into the box of sand/flour. In this case, gravity makes the ball move, so "gravity" should be recorded on the chart. Fill in the chart for the verbs you have listed.
4. Next, ask students to consider the forces that slow the ball down. For example, drop the ball again into the sand/flour and ask students to consider the forces that slowed the ball down. Students should eventually notice the upward force of the sand/flour slowing the ball. Students may also notice that air resistance slows the ball.
5. Explain that over the next two days, students will explore Newton's Laws, which explain how objects and forces interact. Students will explore Newton's Laws on Earth AND see how they apply on the International Space Station.

Explore (15 min)

Materials needed: Newton's Laws video: Find at www.challenger.org/Christa.

Video Viewing:

- At this time, show the designated video associated with the Newton's Laws lesson.
- Students should observe/take notes on their handouts during the video.

Explain (60 min)

Materials needed: Tennis ball, other balls in pairs (e.g. two marbles, two golf balls, two tennis balls, etc.), sand or flour, small bins (shoebox size), assorted objects (e.g. rocks, marbles, toy cars, small books, wooden blocks, wadded paper, etc.), pen/pencil, masking/painter's tape, ruler, stopwatch.

Stations:

- Each station should take about twenty minutes to complete, leaving one minute for transitional time between stations.

- Station 1 – Newton's First Law:
  An object in motion stays in motion unless an unbalanced force acts upon it. Students should time each other pushing the tennis ball down the path marked with tape, using the ruler provided at the station. Students can only hold the top of the ruler with their thumb and fingertips and can only contact the ball with the bottom three inches of the ruler. If the ball rolls outside the path or students use anything other than the ruler to make contact with the ball, the team must start over. The student that moves the ball fastest down the path wins!

- Station 2 – Newton's Second Law:
  Force is equal to the mass of an object multiplied by its acceleration. Have some bins containing sand or flour set up at the station along with some objects of different masses. Drop two objects of different masses (suggestions listed in materials) from the same height at the same time. Notice, the objects will hit the sand or flour at the same time because their acceleration is constant from the force of gravity. According to the law (F=ma), the one with the greater mass will exude more force. This can be seen by the indent made in the sand or flour. Test this out with a few objects. Answer the corresponding questions on the attached worksheets and prepare to move to the next station.

- Station 3 – Newton's Third Law:
  For every force acting on an object, that object exerts an equal force in the opposite direction of the first force. Have a bin with objects for students to choose from (suggestions listed in materials). Have students place one object on the ground. Have them take a second object that can be rolled or slid (ball, small book, etc.) and

roll it toward the still object. Watch the reaction as it hits the object. Have students test out different combinations of objects and observe how the reactions differ. Does rolling a ball at a wooden block have a different reaction than rolling a toy car at it? How so? Answer the corresponding questions on the attached worksheets and prepare to conclude the activity.

Students should return to the groups they were in at the beginning of the activity and prepare for the next portion of the lesson.

Elaborate (20 min)

Materials needed: None.

As a class, discuss the following questions:

- Are Newton's Laws different in space than on Earth?
- Think about the demonstrations Ricky and Serena conducted on the International Space Station. How would they differ if they were conducted on Earth? Why?
- Think about the activities you conducted as a class. How would they differ if they were conducted on the International Space Station? Why?
- Can you think of your own ways to demonstrate:
  - Newton's First Law?
  - Newton's Second Law?
  - Newton's Third Law?

Evaluate (10 min)

Materials needed: Paper, pen/pencil.

Challenge students to answer the following question as an exit ticket:

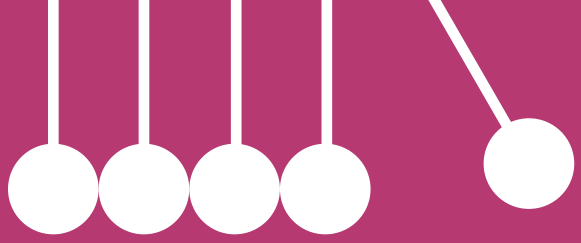
- Describe how each of Newton's Laws are involved in a rocket launching into space.

Your students may note:

- 1st Law: The rocket remains at rest until an unbalanced force (thrust from fuel expelled) acts on the rocket.
- 2nd Law: The more mass the rocket has, the more force is required to launch it into space.
- 3rd Law: As the fuel is being pushed out the back of the rocket, it creates an equal force in the opposite direction of the rocket, causing it to "blast-off!"

To learn more about the science of rocket launches, use this resource:
www.nasa.gov/pdf/153415main_Rockets_How_Rockets_Work.pdf

NEWTON'S LAWS



On the International Space Station: Astronauts Ricky Arnold and Serena Auñón-Chancellor are going to perform an experiment that teaches you about Newton's Laws on the International Space Station. Write down your observations and answer the questions as you watch the video.

1. Write down Newton's First Law of Motion.

_____

_____

2. Describe what happened to the ball of candies Serena pushed down the module.

_____

_____

_____

3. How does the movement of the ball in the module differ from what would happen if you pushed a ball on Earth?

_____

_____

_____

4. Write down Newton's Second Law of Motion.

_____

_____

5. Which accelerates more down the module: the bag filled with bubble wrap, or the bag filled with water? Why?

_____

_____

_____

6. How do astronauts determine the mass of an object in space?

_____

_____

_____

7. Write down Newton's Third Law of Motion.

_____

_____

8. Serena applies force to a bag filled with water and a bag filled with bubble wrap. Which bag applies a stronger force to Serena? How can you tell?

_____

_____

_____

NASA Astronauts Ricky Arnold and Serena Auñón-Chancellor demonstrate Newton's Third Law on the International Space Station.

NEWTON'S LAWS

Today, you'll have the opportunity to explore Newton's Laws before learning about how they work on the International Space Station. You will learn about Newton's Laws by conducting three activities at three different stations. Follow the directions and answer the questions as you go along.

Station One: Newton's First Law

At this station, you will be exploring Newton's First Law with a challenge! You will push a tennis ball down the path marked in tape. But... you can only use the ruler to push the ball! The fastest down the path wins the challenge. Here are some rules:

- You can only hold the top of the ruler with your thumb and fingertips (fig. 1).
- You can only contact the ball using the bottom three inches of the ruler (fig. 2).

Have fun challenging one another, then answer the following questions:

1. What forces are acting on the tennis ball at the starting line, before it is moving? Are these forces balanced? How do you know?

_____

_____

2. How did you get the ball moving? Were forces balanced when you hit the ball down the path? How do you know?

_____

_____

3. What did you need to do to change the direction of the ball and stop the ball? Were forces balanced when changing directions or stopping the ball? How do you know?

_____

_____

fig. 1

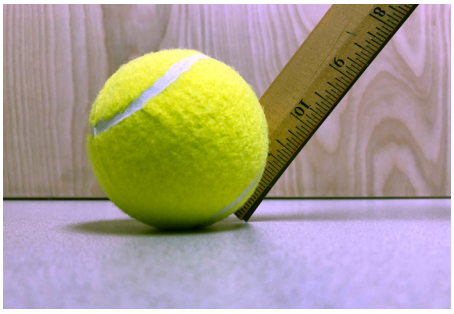


fig. 2

NEWTON'S LAWS

Station Two: Newton's Second Law

At this station, you will be exploring Newton's Second Law. Follow the directions below and answer the corresponding questions.

1. At your table, you have bins filled with sand or flour and some objects that have different masses. Pick up two different objects and hold them in your hands. Can you tell which one has more mass by doing this? Which object has more mass? _____
2. Hold two of the objects at the same height. Have a classmate count, and on the count of three, drop them at the same time. Observe what happens.

   _____

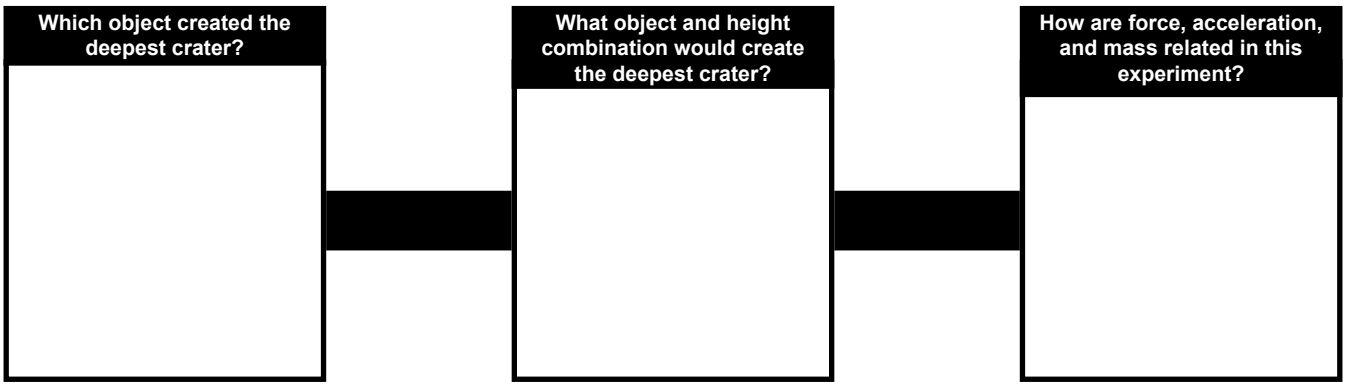
   _____
3. Take your objects out of the bin. Observe the crater created by your object. What do you notice about the difference in the craters? Why do you think they are different?

   _____

   _____
4. Flatten out the sand or flour in the bins. Select two of the same type of object. Drop one from a higher level and one from a lower level. Does this make a difference in the size and/or depth of the craters? Why do you think the height makes a difference?

   _____

   _____
5. Fill out the graphic organizer below.



Clean up your station and prepare to rotate.

NEWTON'S LAWS

Station Three: Newton's Third Law

At this station, you will be exploring Newton's Third Law. Follow the directions below and answer the corresponding questions.

1. At your station, you have several assorted objects. Set one of the objects on the ground. Take another object and slide it or roll it toward the object you set on the ground so that it collides. Describe what happened to both objects.

_____

_____

2. Reset your original object on the ground. Choose a different object and roll/slide it at your object on the ground. Describe what happened to both objects. Was the reaction different? If so, what changed and why do you think it changed?

_____

_____

3. Repeat this process using the objects you used in step 2. This time, roll the object more quickly. Record your observations and answer the questions in the graphic organizer below.

Record what happened to both objects. You can draw a diagram or write them down.	**Describe how an increase in one object's speed changed the reaction.**

Clean up your station and prepare to rotate.

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