Forces in Motion

Students learn about Newton's Laws of Motion. Through a series of experiments, students explore Newton's Third Law of Motion in greater depth.

Grade Level: 5th-8th

Phenomena:
Engaging in experiments can help us further understand Newton's Laws.

Objectives:
- Students will describe force.
- Students will define Newton's Third Law of Motion and connect the definition to real life examples.
- Students will conduct experiments to explore Newton's Third Law of Motion

Materials:
- Balloon rocket set up: string, drinking straw, balloon, tape
- 6 pennies for each pair of students
- 2 rulers for each pair of students
- Image of Sir Isaac Newton
- Student worksheets
- At least 3 balloons
- Close-pins to keep air inside balloon
- Double-sided tape
- Newton's cradle -if available

Appendixes:
- Image of Sir Isaac Newton: Page 7
- Student worksheet: Pages 8-9

Time Considerations:
Preparations: 10-15 minutes
Lesson Time: 55-65 minutes
Introduction: 10 minutes
Activity 1: 5 minutes
Activity 2: 10 minutes
Activity 3: 15-20 minutes
Activity 4: 10 minutes
Conclusion: 5-10 minutes

Related Lesson Plans:

Nevada Outdoor School . org

Next Generation Science Standards

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.

Science and Engineering Practices (SEP):
Planning and Carrying out Investigations.

Disciplinary Core Ideas:
Forces and Motion

Crosscutting Concepts:
Stability and Change

Excellence in Environmental Education Guidelines

Strand 2.1—The Earth as a Physical System
C) Learners begin to grasp formal concepts related to energy by focusing on energy transfer and transformations. They are able to make connections among phenomena such as light, heat, magnetism, electricity and the motion of objects.

Background

Sir Isaac Newton was one of the greatest scientists and mathematicians that ever lived. Newton was born in England on December 25, 1643. While in college, Newton, like most good scientists, wrote his ideas in a journal. In his journal, Newton wrote about his observations of what he coined as the three laws of motion. Newton also had ideas about gravity, the diffraction of light and forces. Sir Isaac Newton's accomplishments laid the foundations for modern science.

Newton's Three Laws of Motion are extremely important to the sciences, specifically physics. The first law states: an object at rest will remain at rest unless acted on by an unbalanced force; an object in motion continues in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

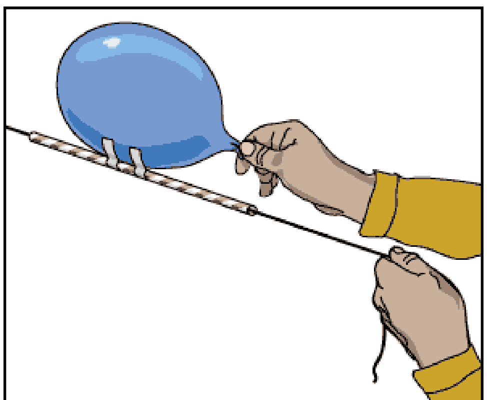
Newton's second law states: acceleration is produced when a force acts on a mass; the greater the mass of the object being accelerated the greater the amount of force needed to accelerate the object. Heavier objects require more force to move the same distance as lighter objects. The second law also gives us an exact relationship between force, mass, and acceleration. This relationship can be seen in the mathematical equation: F=M x A Where F= force, M= mass, A= acceleration.

Newton's third law of motion states: For every action there is an equal and opposite re-action. This means that for every force there is a reaction force that is equal, but opposite in direction. Whenever an object pushes another object it gets pushed back in the opposite direction with the same amount of force. For Newton's third law of motion there are action-reaction pairs. You might know that Earth orbits the sun because a gravitational force acts between them. Which is greater: The gravitational force of the sun on Earth or the gravitational force of Earth on the sun? If you thought they were exactly the same, you're right! The sun's gravitational force acting on Earth is an action. Newton's third law reaction is Earth's gravitational force acting on the sun. Earth's gravitational force on the sun and the sun's gravitational force on Earth are an action-reaction pair (TeacherTECH).

Preparation

Gather all needed materials.

For the balloon rocket set up you will need a drinking straw, long piece of string, balloon, tape, and two chairs. Thread the string through the straw. Tape one end of the string to the leg of a chair. Tape the other end to the back of another chair and push them apart to create tension. The string will form the path of the rocket.
For the balloon rocket procedure blow up the balloon and hold the end so the air does not escape. Tape the balloon to the straw lengthwise so that the balloon can propel the straw. Move the balloon to one end of the string and release (Cislunar Aerospace, Inc.).



Balloon rocket setup

Doing the Activity

Introduction:
Write the word "force" on the board. Ask students to raise their hands if they think they can explain what a force is.

Ask the students to keep the question, what is a force, in mind as you do the first activity.

Ask the students to sit in their seat with their best posture– straight back, legs at a right angle with their feet flat on the ground and hands in their lap.

Once everyone is sitting correctly, ask the students to try to stand up without leaning or losing their good posture. Can they do it? If so, ask the student to demonstrate.

Now, ask the students to sit back down with the same posture as before, and then ask them to stand up and think about how they were able to stand up.

Ask a few students how they were able to stand up? (most will say push off the ground with their feet, push off their armrests with their hands, etc)

After the students have given you their explanations, write "push" on the board.

Next, have the students sit down in their chairs, facing a partner. Tell the students to again sit with good posture. Explain to the students that they can help each other up, but they should do this again without leaning or losing their good posture. Students should reach out to grab each other's hands and help pull each other up; write the word "pull" on the board (Wetzel, D.).

Now, ask the students again: what is a force? Hopefully more students will raise their hands this time.

Give the students the definition of force: a force is a push or a pull that gives an object energy to do work or move. For example, in order to move, in this case stand up, we need a push or a pull.

Put a picture of Sir. Isaac Newton on the board. Ask the students if anyone knows who the man is? Explain who he is and that he has three laws of motion.
Talk about how Sir. Isaac Newton lived a long time ago, from the 1600's to 1700's. It is amazing that we still use the same laws he came up with so long ago.


Sir Isaac Newton

Introduce Newton's Three Laws of Motion to the students.

Newton's first law - Law of Inertia: objects at rest tend to stay at rest, objects in motion tend to stay in motion unless acted upon by an external force.

Newton's second law gives us a formula telling us how much force is needed to move or stop an object. This formula is: $F = M \times A$. The greater the mass, the greater the force needed to move an object. The force needed to accelerate an object equals the mass of the object multiplied by its acceleration.

Students know this law even if they don't know the exact words. Objects with more mass require more force to move a certain distance than objects with less mass. Use objects from the classroom to demonstrate this. Or give examples the students will be able to relate to. For example, it is easier to kick a soccer ball across a field than a bowling ball because the soccer ball has less mass.

Explain to the students that they are going to be discovering Newton's third law in the remainder of the lesson.

Activity 1: Two Balloons
Hold up two balloons, one of which has less air than the other. These balloons should not be tied.

Ask the students what the difference between the two balloons are? (one is bigger and has more air in it than the other).

Discuss with students what will happen when you let go of an untied balloon. Then ask which balloonswill fly through the air longer.

The students should tell you that the larger balloon with more air will fly through the air for a longer time than the smaller balloon with less air. Find out! Let the balloons go and ask students if they were right.

Activity 2: Balloon Rocket
Direct students' attention to the balloon rocket setup. Explain to the students that as a class you are going to do an experiment, and as scientists, we must remember how important it is to be accurate, precise and make observations. When doing this experiment, we will be using the steps of the scientific method.

1.*Question:* can we make the balloon shoot up the string?
2.*Hypothesis:* ask the students to make educated guesses about what they think will happen.
3.*Materials:* list and point out the materials needed to conduct the experiment: balloon, tape, straw, string.
4.*Procedure*: discuss and explain the steps of the experiment as you go through them.

5.*Results:* ask the students to tell you what happened after conducting the experiment.
6.*Conclusions:* ask the students what they think made the balloon shoot up the string? (the air coming out of it) Ask the students if the balloon was not filled with as much air whether it would go a shorter or further distance? (the balloon would not go as far) To demonstrate this, blow up the balloon with less air than it had initially. Let the students observe what happens.

After the demonstration, have students draw a diagram of the balloon rocket setup. Ask the students to draw an arrow in the direction the balloon traveled up the string and an arrow pointing in the direction the air blew out of the balloon. Ask the students how many forces were acting on these balloons; they can refer to how many arrows they drew on their diagram. (two)

Write on the board "forces come in pairs." Explain to the students that the air was acting on the balloon and the balloon was acting on the air.

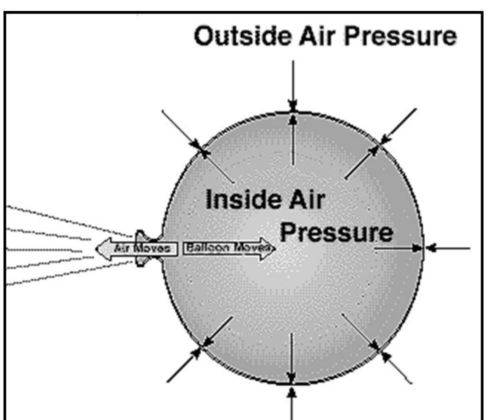


Illustration of balloon rocket

Then ask the students what the relationship is between the two arrows? (they are opposite to each other) Then, explain that forces come in pairs and are opposite in direction to each other.

Activity 3: Penny Flick
Before letting students do the experiment, set clear boundaries - do not throw pennies, be safe, etc. Remind students that they are going to be acting as scientists.

Pass out observation sheets, which include experiment set up instructions. Then model the experiment set up in the front of the room or on the board. Pretend to push one penny, but do not actually let go - you don't want to ruin the results for the students.

Have students think about Newton's third law, the experimental set up and then write their hypothesis on the observation sheet.

Next pass out the materials and allow students to conduct three trials of the initial experiment. Remember to stress the need to do experiments more than once to ensure accurate results. Have them write their observations down on their sheet.
Bring the students back together and ask what they observed. How did the results compare to your hypothesis? Ask if anyone has any idea of why this happened? Write their ideas on the board.

After the students have had time to experiment and observe, tell them to experiment with pushing two pennies into the stack - 2 pennies in– 2 pennies out.


Penny flick

Ask the students to predict what they think will happen if they pushed three pennies in - 3 pennies in– 3 pennies out.

Record these ratios up on the board and then ask students how they would explain the relationship between the input and outputs they observed. (they are equal)

Write this on the board, "forces come in pairs and they are opposite in direction of each other but equal in time and magnitude.

At this point in the lesson go back to the balloon rocket setup. The two forces happened at the same time and with the same amount of force, the force of the air being pushed out of the balloon is equal to the force of the balloon shooting up the string.

Point out that the two forces going in opposite directions are also equal.

Now ask the students what they think Newton's third law is? Based on what they have observed and recorded, ask the students if any of them can wrap up what was learned in the lesson.

Put Newton's third law up on the board, read it aloud and have students write it down: for every action, there is an equal and opposite reaction.

At this point in the lesson, review each part of the third law, relating it to the different steps of the lesson.

Now ask, keeping in mind all the parts of Newton's third law, which one comes first the action or the reaction force?

Listen to the different responses and point to the word equal up on the board.

Remind students that equal means both equal in size and equal in time. So, the answer is that they happen at the same time.

Have students stand up and tell them to jump up in the air, paying attention to how they are doing it. (you bend your knees and push down on the ground to jump)

Explain that at the same time you are pushing down on the ground, the ground is pushing back on you in the opposite direction with the same amount of force.

Activity 4: Investigation
Ask the students to flip over the observation sheet.

On the back of the observation sheet there are three investigation goals.

Remind students that they are scientists and therefore, they should try to achieve the goals with the materials they have.

Tell them that if they finish the goals with more time to spare, they should conduct additional experiments and record their results and observations.

Ask the students if they have any different ideas about why the end pennies will move from the opposite end of the chain?

Write the ideas on the board. Cross out any explanations that no longer make sense with the new knowledge the students have.

Explain the basic idea that for every action there is an equal and opposite reaction. This is why when you push two pennies into the front of the chain, two pennies moved from the end of the chain.

Conclusion

If you have a Newton's Cradle available, ask students to predict what will happen, based on their new knowledge of Newton's Third Law, as you conduct different experiments. For example, what will happen if one ball is pulled back and released? What if two balls are pulled back at the same time?

Assessment

Assess students based on their observations and conclusions on their observation sheets; Students that were able to conduct more experiments than those that were specified, can be assessed on their additional experiments and observations.

Extensions

Ask the students to find other places that Newton's third law can be seen in effect. Have students research and/or demonstrate the First and Second Law of Motion.

Newton's cradle

Ask students to create a public safety announcement about why you should wear your seatbelt.

Vocabulary

Force: in physics, any action that changes the shape or the movement of an object

Mass: in physics, the mass of an object is the amount of physical matter that it contains

Newton's First Law of Motion: If an object is at rest, it will remain at rest unless an outside force acts upon it. If an object is moving, it will continue to move in a straight line at the same speed until an outside force on it.

Newton's Second Law of Motion: The force needed to accelerate an object equals the mass of the object multiplied by its acceleration or the formula: *F= M x A.* Where F = force, M = mass, A = acceleration

Newton's Third Law of Motion: For every action there is an equal and opposite reaction.

Sources

- Cislunar Aerospace, Inc. (1995-2002). *Balloon Jet.* Retrieved Dec. 16, 2011, from K-8 Aeronautics Internet Textbook: http://wings.avkids.com/Curriculums/Forces_Motion/balloonjet_howto.html
- Cislunar Aerospace, Inc. (1995-2002). *Coin Flick.* Retrieved Dec. 16, 2011, from K-8 Aeronautics Internet Textbook: http://wings.avkids.com/Curriculums/Forces_Motion/coinflick_howto.html
-
- TeacherTECH. (1995-2009). *Sir Isaac Newton*. Retrieved Dec. 16, 2011, from http://teachertech.rice.edu/Participants/louviere/Newton/newton.html
- Wetzel, D. (2009, Feb. 23). *Basic Physics in a Bag.* Retrieved Dec. 16, 2011, from Suite 101: http://david-r-wetzel.suite101.com/basic-physics-in-a-bag-a98344
-
-

Images:

- (2011). *Newtons Cradle.* Retrieved Dec. 16, 2011, from OrangeOnions: http://www.orangeonions.com/product/PP0375/Newtons-Cradle.html
- (2011). *Balloon Rocket.* Retrieved Dec. 16, 2011, from http://djackson.myweb.uga.edu/4440/Daily/Handouts/BalloonRocketsInstructions.html
- Cislunar Aerospace, Inc. (1995-2002). *Coin Flick Movies.* Retrieved Dec. 16, 2011, from K-8 Aeronautics Internet Textbook: http://wings.avkids.com/Curriculums/Forces_Motion/coinflick_howto.html
- Kneller, G. (1702). *WG Isaac Newton 8.* Retrieved Dec. 16, 2011, from Juggle: http://www.juggle.com/isaac-newton
- National Aeronautics and Space Administration. (2003). Rocket Principles. In *Rockets: An Educator's Guide with Activities in Science, Mathematics, and Technology.* Retrieved Dec. 16, 2011, from http://www.nasa.gov/pdf/58269main_Rockets.Guide.pdf

Name:____

Experiment Set Up

1. Place two rulers parallel and about an inch and a half apart from one another.
2. Use double sided tape to secure the rulers to your desk.
3. Line five pennies up against the middle of one of the rulers in a straight line.
4. All five pennies **MUST** be touching.
5. Place a sixth penny by itself against the same ruler, about an inch from one end.
6. Hold the ruler so that it is all the way pressed to the table, and now gently push the lone penny in the direction of the penny chain so that it hits the first penny square in the middle.
7. Observe what happens!
8. Repeat the same experiment **AT LEAST** three times to check for reliable results.

Experiment #1

Question

What will happen if you push one penny at a chain of 5 pennies?

Hypothesis

____

____

Observations

Trial One:

Trial Two:

Trial Three:

Name:____

Experiment Set Up

1. Place two rulers parallel and about an inch and a half apart from one another.
2. Use double sided tape to secure the rulers to your desk.
3. Line five pennies up against the middle of one of the rulers in a straight line.
4. All five pennies **MUST** be touching.
5. Place a sixth penny by itself against the same ruler, about an inch from one end.
6. Hold the ruler so that it is all the way pressed to the table, and now gently push the lone penny in the direction of the penny chain so that it hits the first penny square in the middle.
7. Observe what happens!
8. Repeat the same experiment **AT LEAST** three times to check for reliable results.

Experiment #1

Question

What will happen if you push one penny at a chain of 5 pennies?

Hypothesis

____

____

Observations

Trial One:

Trial Two:

Trial Three:

Investigation Goals

1. To discover **two** ways to move the end penny further than it went in the first experiment

2. To discover how to move two pennies from the end of the penny chain significantly farther than the rest

3. Conduct your own experiments—what do you observe?

Investigation Goals

1. To discover **two** ways to move the end penny further than it went in the first experiment

2. To discover how to move two pennies from the end of the penny chain significantly farther than the rest

3. Conduct your own experiments—what do you observe?