THE MYSTERY FORCES (1 Hour)

Addresses NGSS
Level of Difficulty: 2
Grade Range: 3-5

OVERVIEW

In this activity, students will learn that objects do not always have to be touching to exert a force on each other. They will investigate electric, magnetic and gravitational forces and recognize that these types of forces between a pair of objects do not require that the objects be in contact. Students will investigate forces using everyday objects such as magnets, balloons, hair, combs, water, and various types of balls. They will make observations about forces between objects that are not touching.

Topic: **Force and Motion**

Real-World Science Topics

- A look at how various types of forces play a role in everyday activities and objects.
- An examination of technologies and machines that are built around the idea that two objects can exert force on each other without touching.

Objective

After completing this activity, students will be able to recognize that a pair of objects can exert a force on each other without being in contact. They will demonstrate how properties such as size, composition, and distance affect the size of the force between objects. Finally, students will know that electricity, magnetism and gravity are all examples of non-contact forces.

NGSS Three-Dimensions

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-1)	**PS2.B: Types of Interactions** • Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2-3),(3-PS2-4) • The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1)	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1) (3-PS2-3) **Patterns** • Patterns of change can be used to make predictions. (3-PS2-2)

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- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (3-PS2-2)

Background Information

What is force?

Force is a push or pull upon an object resulting from the interaction of two objects. Anytime there is an interaction between two objects, there is force exerted on each of the objects. When the objects no longer interact with each other, the two objects no longer experience the force.

What is non-contact force and what are some examples?

Non-contact force is a force that can exert a push, or pull an object without actually having any physical contact with that object. This happens when force is applied on some object by another object without any interaction or contact between those two objects. In a non-contact force, the force is transmitted over distance. Some refer to these types of forces as "action-at-a-distance forces." Examples of non-contact forces include magnetic, gravitational and electrostatic force.

What is electric, magnetic and gravitational force?

Electric force is the attractive or repulsive interaction that happens between two electrically charged objects. When two charged objects interact, even at a distance, they will always exert a force upon each other. Magnetic force is similar to electric force and, simply defined, is the force exerted between magnetic poles, producing magnetization. Gravitational force is a bit different in that it has nothing to do with charged objects. The size of gravitational force in each situation depends on the mass of the interacting objects and their distances apart. The more massive an object is, the greater the gravitational force. Since gravitational force is inversely proportional to the distance between two interacting objects, more separation distance will result in weaker gravitational forces.

What determines the size of the electric and magnetic forces between two objects?

The sizes of electric and magnetic forces depend on the properties of the matter that makes up the objects, as well as the distance that separates the two objects. For magnetic forces, the size of the force is also dependent of the orientation of the magnets relative to each other.

Key Vocabulary

Force – a push or pull upon an object resulting from the interaction of two objects
Magnetism – a force of attraction or repulsion that acts at a distance due to a magnetic field, which is caused by moving electrically charged particles
Gravity – the force that attracts a body toward the center of the earth, or toward any other physical body having mass
Electric force – the force between two electrically charged objects
Static electricity – the imbalance of electric charges within or on the surface of an object

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Materials Needed for Activity

- Image: Bending Water (see attachment below)
- *Is This Really Happening?* Handout (see attachment below)
- *Investigating Forces* Handout (see attachment below)
- *Object Interactions* Teacher Page (see attachment below)
- *Mystery Forces* Handout (see attachment below)
- *Mystery Forces* Teacher Key (see attachment below)
- Supplies:
    - Assortment of magnets including a least 2 bar magnets
    - String
    - 5 empty soda cans
    - Zip baggie containing with iron or other magnetic objects
    - Ball (soccer, basketball, football, tennis ball, etc.)
    - Balloons
    - Tape
    - Plastic ruler
    - Salt and Pepper
    - Wool or fur cloth
    - Sheets of paper
    - Straws
    - Toy cars (extension activity)
    - Timer (extension activity)

Teacher Preparation

- Make copies of the *Is This Really Happening?* Handout for each student
- Make copies of the *Investigating Forces* Handout for each group of 2 students
- Make copies of the *Mystery Forces* Handout for each group of 2 to 4 students
- Access a projector to show Bending Water image
- Review *Object Interaction*s Teacher Page and have materials available to do demonstrations
- Prep enough materials for the *Investigating Forces* activity (2 to 4 students per group)
- Extension activity: Using tape, mark a start line and a finish line on the floor

STEPS FOR *THE MYSTERY FORCES*

1. **Warm-up Activity:** Distribute a *Is That Really Happening?* Handout to each student. Display the "Bending Water" image so that all students are able to clearly see it. Ask students to record 3 things they notice about what is happening in the picture(s). These should be things they can clearly observe. Next, have students record 2 things they think they know based on their observations. Their two thoughts must be supported by observations they can make in the picture. And finally, ask them to record 1 thing they wonder about after analyzing the picture.

   Have students share out a few observations, inferences, and questions. Facilitate a discussion about what they noticed, what they think, and what they wonder. It is important that this discussion is student-centered with you facilitating and encouraging students to share their thoughts rather than offering your own. At this point, there is no need to answer any of their questions or address whether their thinking is correct or incorrect. These inferences and questions will be revisited at the end of the lesson.

   Some observations my include:
   The water is bending in the second picture.
   There is a black object in the second picture and not in the first.
   The comb is not touching the water.
   There is liquid coming out of the spout in both pictures.

   Some inferences they might make include:
   I think the black object is a comb because of its shape.
   I think the comb is making the water bend because the water in the first picture is not bent but it is in the second picture.
   I think the comb is magnetic because it is pulling the water toward it.
   I think the comb is made out of something special because it is making the water move in the second picture.
   I think there is some kind of wind pushing the water over because combs cannot make water bend.

   Some questions they may have:
   What is the black object made up of?
   Is that water coming out of the spout?
   Is that a special black object?
   How can a comb make water bend like that?
   Is the black object a magnet?
   Would the water still bend if the black object was moved farther away?

   After they share ideas, tell the students that they are going to do some investigative work to see if they can determine what is causing the water in the picture to bend.

   (Alternative Activity: Rather than using the picture, you can actually set up the bending water scenario in your sink. Allow students to observe the running water without the charged comb and then again as you hold the comb close to the stream. The comb should already be charged and ready so they do not see you rubbing the cloth on the comb. Students will then complete the *Is That Really Happening?* Handout.)

2. Ask students to define the term *force* in their own words at the bottom of the *Is That Really Happening?* Handout. Choose several students to share out their definitions. Build on the definitions they provided by explaining that force is a push or pull upon an object resulting from the interaction of two objects. Point out that anytime there is an interaction between two objects, there is a force exerted on each of the objects. When the objects no longer interact with each other, the two objects no longer experience the force.

   Write the terms *contact force*, *gravitational force*, *magnetic force*, and *electric force* on the board.

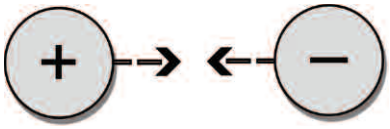
Ask students if they think they have ever experienced any of these types of forces. Discuss with them what each types of force is and how they differ. Explain that contact force is the force exerted on two objects that make contact with each other. Point out that gravitational force is the force that any two objects with mass have on each other. Explain that any object with mass has some gravitational force, but the more massive the object the greater the gravitational force. Earth has a very large gravitational force because it is such a massive object. Explain that magnetic force is the force exerted between magnetic poles, producing magnetization. Finally, explain that electric force is the force that occurs between two electrically charged objects.

Say: Today, we are going to investigate ways that two objects can exert these types of force on each other.

3. Next, pass out the *Investigating Forces* Handout to each student partners. Explain that you will be showing them several examples of two objects interacting with each other. Holding up the handout as reference, explain that they must 1) describe what happens, in the third column, when the two object interacted, 3) in the fourth column, determine if the two objects touch each other during the interaction, and 4) in the fifth column, identify what type of force is exerted.

Demonstrate the 5 interactions outlined on the *Object Interactions* teacher page. After each demonstration, give student partners time to discuss, identify and complete the columns on their handout. Lead a whole group discussion about each interaction. Discuss if there was contact between the object, and what type of force was being exerted.

4. Next, divide the class into groups of 2 to 3 students. Give each group the *Mystery Forces* Handout, as well as supplies for the activity. Read the directions aloud to the students. Before beginning, explain that rubbing a sheet of paper on the straws causes lots of small negatively charged particles to jump from the paper onto the straw. Draw the diagrams below and explain that particles with like charges have a repulsive force while opposite charges have an attractive forcer. These push and pull forces between particles are known as electric force. Allow students to complete the handout independently.



1 positively & 1 negatively charged particle interacting

2 positively charged particles interacting

5. Select a few students to share their findings with the class. Clarify any misconceptions and make sure students understand that not all objects have to touch to exert a force on each other.

6. **Wrap-up Activity:** Revisit the Bending Water Image and the *Is That Really Happening?* Handout. Now that students have had some time to investigate force between two interacting objects, ask them to think about what might be causing the water to bend. Select a few students to share their thoughts about what is happening. Conclude by explaining the situation.

Say: The comb was rubbed with the wool cloth causing many negatively charged particles to jump onto it. This caused the comb to become negatively charged. The water however is somewhat positively charged. This set up an attractive electric force between the comb and the water causing the water to bend toward the comb.

If time allows, give students a chance to ask for clarification on any of their thoughts.

Extension Activity

Set up a hands-free toy car race. Explain to students that they will be racing a toy car from point A to point B. The car with the fastest time wins the race. Let them know that they cannot touch their car after it crosses the start line. Their car can only be moved using a non-contact force such as gravity, magnetism or electrostatic force. Provide students with a variety of materials to design their car. These materials might include balloons, string, tape, magnets, books for ramps, wool cloths, paper clips, rulers, and combs.

Sources

http://www.colorado.edu/physics/2000/waves_particles/wavpart2.html
http://mgs-mager.gsfc.nasa.gov/Kids/magfield.html
http://kids.niehs.nih.gov/explore/pollute/emf.htm

THE MYSTERY FORCES BENDING WATER IMAGE

Before

After

Name:

Date:

Is That Really Happening?

3 Things I Notice	2 Things I Think

1 Thing I Wonder

_____

_____

_____

_____

_____

Investigating Forces

Object 1	Object 2	What happened when the two objects interacted?	Did the two objects touch each other?	Type of force observed?
Ball	Cans			
Magnet 1	Magnet 2			
Magnet	Bag of iron			
Balloon	Can			
Ruler	Salt/Pepper			

Do two objects have to touch to exert a force on each other? _____

What types of force do not require two object touch?

Object Interactions

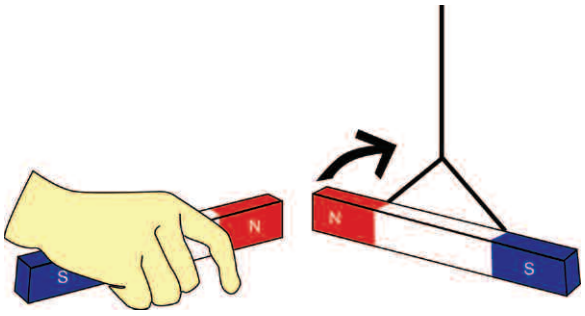
Materials

- 5 empty soda cans
- Ball
- 2 bar magnets
- String
- Balloons
- Plastic ruler
- Salt and pepper
- Wool (or fur) cloth
- Zip baggie
- Iron (or other magnetic) objects
- Overhead projector (optional)

Demonstrations

1. Set up a stack of 4 or 5 empty soda cans. Roll a ball at the cans causing a collision between the ball and the cans.

2. Set up a bar magnet hanging from a string as depicted below. Use a second bar magnet to repel like poles causing the magnet on the string to spin away. The magnets should never touch in the demo.



3. Tape a zip baggie filled with some sort of magnetic objects from the table's edge so that it hangs free. Use a strong bar magnet to attract the magnetic objects in the bag, causing the bag to swing back and forth. Again, the magnet should not actually touch the bag.

4. Hold a ball up in the air and allow it to free fall for a distance. Catch the ball before it makes contact with the ground.

5. Rub a balloon with a piece of wool cloth for several seconds. Turn an empty soda can over on its side. Without touching the can with the balloon, make the can roll using the electrostatic force between the two objects.

6. Pour a bit of salt and pepper on the table (if an overhead projector, pure the salt and pepper on the screen and turn it on so that the silhouette of the salt and pepper is projected on the wall.) Rub a plastic ruler with a piece of wool cloth for several seconds. Hold the ruler close to the salt and pepper causing it to jump and move around. Some may even jump onto the ruler.

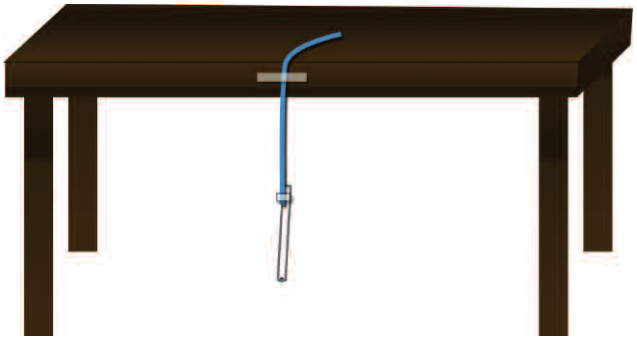
Mystery Forces

Materials

- tape
- 2 straws
- string, about 20cm in length
- sheet of paper

Set up

- Tape one end of the string to one end of a straw.
- Tape the other end of the string to the edge of the table allowing the straw to hang free.



Reminder

- Rubbing the paper against a straw causes negatively charged particles to jump onto the straw from the paper. This causes the straw that has been rubbed to have a negative charge.
- The more you rub the straw against the paper, the more negative particles jump to the straw.

Investigation questions

What happens when you charge up one straw with negative particles and move that straw toward the other? Why do you think this happens?

Does rubbing the one straw for a longer period make a difference in how the two straws interact? Why?

What happens when you charge up both straws with negative particles and move them close to each other? Why do you think this happens?

Do the two straws have to touch to exert a force on each other? _____

What type of force are you observing in this experiment?

_____

Mystery Forces: Key

Materials

- tape
- 2 straws
- string, about 20cm in length
- sheet of paper

Investigation questions

What happens when you charge up one straw with negative particles and move that straw toward the other? Why do you think this happens?

As you move one straw close to the other, the two straws attract and move toward each other. This is because the straw rubbed with the paper has a negative charge and the other straw has a slightly positive charge. Opposite charges have an attractive force.

Does rubbing the one straw for a longer period make a difference in how the two straws interact? Why?

Yes it does make a difference. The attraction seems stronger the longer the straw is rubbed. This is because the longer it is rubbed the more negatively charged it becomes.

What happens when you charge up both straws with negative particles and move them close to each other? Why do you think this happens?

As you move the straws toward each other, they repel and move away from each other. This is because both straws were rubbed with paper causing them to both have a negative charge. Like charges cause the object to have a repulsive force.

Do the two straws have to touch to exert a force on each other? No, they do not have to touch.

What type of force are you observing in this experiment?

Electric force which is a type of non-contact force