Hands-On Flextension: Exploring Electrostatic Force

Overview

This hands-on activity builds on and reinforces students' understanding of forces that act at a distance, with a focus on electrostatic force. Students explore electrostatic forces, prompted by a set of challenges that they try to accomplish. Next, students generate scientific questions based on their observations. Electrostatic force is less predictable and consistent than magnetic force, and investigating it can be both challenging and intriguing. The purpose of this lesson is for students to gain firsthand experience with electrostatic force and to gain experience generating scientific questions based on observations. You might choose to include this Flextension if you would like your students to have more exposure to electrostatic force, and if you would like to challenge your students to explore and ask questions about a challenging type of force.

Recommended Placement: after Lesson 1.5 (including after the homework, reading "Painting with Static Electricity")
Suggested Time Frame: 45 minutes

Next Generation Science Standards (NGSS)

Performance Expectations

- **MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.** [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.]

Performance Expectations (continued)	• **MS-PS2-5: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.** [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.]
Disciplinary Core Ideas	• **PS2.B: Types of Interactions:** ° Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3) ° Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). (MS-PS2-5)
Science and Engineering Practices	• **Practice 1:** Asking Questions and Defining Problems • **Practice 3:** Planning and Carrying Out Investigations
Crosscutting Concepts	• Cause and Effect

Vocabulary

- attract
- electrostatic force
- repel

Materials & Preparation

Materials

For the Class

- Hands-On Flextension copymaster: Exploring Electrostatic Force
- 1 balloon pump*
- 1 large index card*
- marker*
- water*

For Each Group of Four Students

- 1 tray*
- 2 rulers
- 2 large balloons*
- 1 dish towel or similar*
- 1 piece of felt, at least 15 cm x 15 cm*
- 1 piece of faux fur, at least 15 cm x 15 cm*
- 10 foam packing peanuts*
- optional: additional types of cloth*
- optional: glass, acrylic, and/or nylon rods*

For Each Student

- 1 copy of Hands-On Flextension: Exploring Electrostatic Force student sheets

*teacher provided

Preparation

1. **Print Hands-On Flextension copymaster: Exploring Electrostatic Force.** Locate the Hands-On Flextension copymaster: Exploring Electrostatic Force in Digital Resources for *Magnetic Fields* Lesson 1.5. Make one copy of all pages for each student.
2. **Create and post vocabulary card on the classroom wall.** With a marker, write "electrostatic force" in large print on an index card. Post this card on the classroom wall.
3. **Inflate balloons. Inflate two balloons for each group of four students.** Use your mouth or the balloon pump. Alternatively, you could have students inflate the balloons while you are distributing materials.
4. **Moisten dish towels.** For each group of four students, moisten a dish towel. The towel should be damp but not dripping.
5. **Prepare trays of materials.** For each group of four students, place the following materials on a tray:
   - 2 rulers
   - 2 inflated balloons
   - 1 damp dish towel

- 1 piece of faux fur
- 1 piece of felt
- 10 foam packing peanuts
- optional: additional types of cloth
- optional: glass, acrylic, and/or nylon rods

6. **Immediately before the lesson, have on hand the following materials:**
   - student sheets
   - trays of materials

Notes

Additional Materials

Providing additional materials—rods and/or additional types of cloth—will enrich student explorations of electrostatic force, and may result in students producing stronger or more reliable forces, depending on the conditions in the classroom (especially humidity). On the other hand, students should be be able to observe clear evidence of electrostatic force using just a ballon, foam peanuts, and faux fur. Many science supply companies sell sets of rods of various materials for use in exploring electrostatic force. If you only have a few of these sets, you could have pairs pass them around during testing. Small pieces of cloth can be purchased at fabric stores or you can purchase inexpensive used clothing and cut it apart.

Challenges of Conducting Full Investigations

In this lesson, students generate questions about electrostatic force and explore to gather initial evidence about one of their questions. This lesson does not include students planning and conducting full investigations (for example, controlled experiments) because of how difficult it can be to produce a consistent charge. With a second class period, though, you could have students plan and conduct experiments, with the awareness that for many students the results may be unclear or puzzling.

Science Background

A force is a push or a pull that can change the motion of an object. A force can cause an object to change its motion—e.g., start moving, stop moving, or change direction and/or speed. Forces can be contact forces (your foot kicking a ball) or non-touching forces. Non-touching forces include magnetic force, electrostatic force, and gravity. Electrostatic force (also called Coulomb's force) is the push or pull between two objects due to their electric charge. If the charges of the objects are the same (both positive or both negative), the force is repelling; if the charges are opposite, the force is attracting. Like magnetic force, electrostatic force diminishes with distance. The larger the magnitude of the charges on the objects, the greater the electrostatic force. Electrostatic force can be somewhat inconsistent or unpredictable because the amount and type of charge on an object can vary due to many factors, including humidity and contact with other materials.

Instructional Guide

Explore and Activate Prior Knowledge

1. **Discuss the "Painting with Static Electricity" article.** Remind students that they read this article for homework. Call on volunteers to share big ideas from the article and/or questions about the article. Explain that students will investigate the force described in the article—electrostatic force—in class today.
2. **Introduce materials.** Hold up a tray of materials and explain that students will attempt to produce electrostatic forces and will look for evidence of those forces using these materials.
3. **Demonstrate charging a balloon.** Hold up a balloon and rub the faux fur on the balloon. Explain that rubbing a balloon can give it an electric charge. If you have included rods as well, point out that rubbing these with fabric can also give these a charge.
4. **Introduce using the damp dish towel to remove the charge.** Touch the balloon with a damp dish towel and explain that touching something damp can cause the balloon (or rod) to lose its charge. Students should use the damp cloth to "reset" the balloon in between their tests.
5. **Distribute the Exploring Electrostatic Force student sheets and explain procedures for the activity.** Pass student sheets to each student and direct them to Part 1: Electrostatic Challenges. Pairs will work together to try to accomplish the challenges listed, and students will record what they observe. Groups should share the materials on the tray. The rulers will help students measure results.
6. **Emphasize the purpose of the activity.** Explain that the purpose of this activity is for students to explore electrostatic force and to use multiple methods to try to produce it. Attempting to complete the challenges will guide students to make observations. It is possible that some or many pairs will not succeed at every challenge.
7. **Encourage students to try many different ways of testing for forces and offer some hints.** For example, when an object is resting on a surface it takes a stronger force to make it start moving than if the object is in the air. Making an object move upward, against the force of gravity, takes a stronger force than making it move sideways.
8. **Pairs explore electrostatic force, attempt challenges, and record results and observations.** Distribute trays and have pairs begin working. As needed, remind students to record results and observations.
9. **Share observations.** Call on several volunteers to share observations.

Construct New Ideas

10. **Introduce the term *electrostatic force*.** Explain that observations of foam peanuts being attracted or repelled from a distance were evidence of electrostatic force.

    Electrostatic force is the push or pull between two objects due to their electric charge. Rubbing a balloon with fabric can make the balloon electrically charged.

    Point out that the vocabulary word is posted on the classroom wall.

    You can have students record a note about this word and its definition. For example, if students are using a print version, direct them to write it in their student glossaries.

11. **Discuss comparisons to magnetic force.** Remind students that they have mostly been investigating a different force: magnetic force.

    What do you think might be the same about magnetic force and electrostatic force?

    [Both can act at a distance; both can attract or repel; both involve a field.]

    What do you think might be different about magnetic force and electrostatic force?

    [They work with different materials; magnetic force seems more consistent; electrostatic force seems to "wear off"; it is easier to switch between repelling and attracting with magnetic force.]

12. **Highlight the science practice of asking questions.** Explain that students will next focus on asking questions about electrostatic force.

    Asking questions is a key practice in science. Science is about discovering new answers, and you can't have an interesting answer without an interesting question.

13. **Emphasize questions based on observations and unexpected results.**

    Scientists ask questions that are based on observations, especially on observations that are surprising or unexpected.

14. **Emphasize questions that can be investigated using available materials.** Explain that students will focus on questions that can be investigated—at least partly investigated—using the materials available.

    Scientists ask questions that can be investigated. If there is no way to investigate a question it is not very useful. If a question is too broad, for example, "Why does electrostatic force work?," it is not clear how to investigate.

15. **Students generate questions about electrostatic force.** Direct students to Part 2: Questions About Electrostatic Force of the Exploring Electrostatic Force student sheets. Give pairs or groups about five minutes to discuss and list several questions.

16. **Each pair chooses one question.** Explain that each pair will choose one question to begin investigating. Their question should be based on observations, especially unexpected results. It should be a question that they can begin investigating using the materials available. Have students discuss with their partner then circle the question they choose.
17. **Pairs explore to gather initial evidence about their question.** Point out that students will likely not have enough time to get a certain answer to their question. Their goal should be to gather some initial evidence. Give pairs about ten minutes to gather and record evidence.
18. **Share questions and evidence.** Call on pairs to share their questions and the evidence they found. Encourage other students to respond with related evidence, additional questions, or ideas for other ways to investigate.

Exploring Electrostatic Force

Part 1: Electrostatic Challenges

Working with your partner, use the materials on the tray to produce electrostatic forces that can act at a distance. Try to accomplish the four challenges below. It is okay if you don't succeed at all of them. Record your results and your observations.

Challenge	Results	Observations
make a force that attracts an object from as far away as possible	farthest distance apart: 4 cm	Mostly we observed repelling forces. It was hard to get objects to attract.
make a force that repels an object from a starting point as far away as possible	farthest distance apart: 11 cm	It worked best if we held the foam peanut in the air and then let go. You could see it move away from the balloon as it fell.
make an attracting force that attracts as many objects as possible to a balloon (or rod)	number of objects attracted: 1 foam peanut	We tried rubbing peanuts on the balloon. Most repelled, but one was attracted. We could not get more than one to stick to the balloon at a time.
make a repelling force that moves an object as far away as possible	farthest distance moved: 15 cm	We got this result by rubbing the balloon with the faux fur for a long time.

Exploring Electrostatic Force (continued)

Part 2: Questions About Electrostatic Force

Useful questions in science:

- are related to observations, especially unexpected or surprising results.
- can be investigated.

1. Working with your partner or group, list several questions about electrostatic force.

- Which kind of fabric rubbed on the balloon will make the strongest charge?
- Is it always true that repelling electrostatic forces are more common than attracting electrostatic forces?
- Do lighter peanuts (cut in half) get attracted from farther away?
- Does rubbing the balloon for longer always produce a stronger charge?

2. With your partner, choose one of the questions above to begin investigating, and circle that question.

3. With your partner, use the materials on the tray to begin investigating your question. Describe evidence you find.

We found some evidence that more rubbing makes a stronger force. We got the foam peanut to be repelled farther away than ever (13 cm) when we rubbed the balloon for more than a minute. But it only worked that well twice and we tried it six times.

Name: _____ Date: _____

Exploring Electrostatic Force

Part 1: Electrostatic Challenges

Working with your partner, use the materials on the tray to produce electrostatic forces that can act at a distance. Try to accomplish the four challenges below. It is okay if you don't succeed at all of them. Record your results and your observations.

Challenge	Results	Observations
make a force that attracts an object from as far away as possible	farthest distance apart:	
make a force that repels an object from a starting point as far away as possible	farthest distance apart:	
make an attracting force that attracts as many objects as possible to a balloon (or rod)	number of objects attracted:	
make a repelling force that moves an object as far away as possible	farthest distance moved:	

Name: _____ Date: _____

Exploring Electrostatic Force (continued)

Part 2: Questions About Electrostatic Force

Useful questions in science:

- are related to observations, especially unexpected or surprising results.
- can be investigated.

1. Working with your partner or group, list several questions about electrostatic force.

_____

_____

_____

_____

_____

_____

_____

2. With your partner, choose one of the questions above to begin investigating, and circle that question.

3. With your partner, use the materials on the tray to begin investigating your question. Describe evidence you find.

_____

_____

_____

_____

_____