

All Charged Up

Electrostatics

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Grade Level	11th – 12th Grade	**Time Frame**	2-4 class period(s)
Course	Physics	**Duration**	150 minutes

Essential Question

How is static charge generated and how do isolated charges separated by a distance relate to force?

Summary

Students will be able to explain the fundamental concepts involved in electrostatics, such as charge, friction, conservation of charge, laws of attraction, and Coulomb's Law.

Snapshot

Engage

Students watch a short video of a dog that has been charged and write a 20 word Gist statement to describe the physics of what they see in the video.

Explore

Students develop a method to levitate a ring made of grocery bag material using a balloon and paper towel. Students will write a 50-word Gist statement, explaining what happened using their academic vocabulary.

Explain

Students share Gist statements, and the teacher clarifies and formally defines terms and relationships involved in electrostatics including conservation of charge and Coulomb's Law.

Extend

Students apply mathematical relationships to electrostatic problem solving and research additional applications of electrostatics.

Evaluate

Students will explain the process of lightning using academic vocabulary from the lesson.

Standards

ACT College and Career Readiness Standards - Science (6-12)

IOD302: Understand basic scientific terminology
SIN301: Understand the methods used in a simple experiment
SIN503: Determine the experimental conditions that would produce specified results

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS3-5: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Oklahoma Academic Standards (Physics)

PH.PS1.8.DCI.2: The total number of neutrons plus protons does not change in any nuclear process.
PH.PS3.2.DCI.2: That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

Attachments

- Career-Focused Reflection Teacher Guide—All Charged Up.docx
- Career-Focused Reflection Teacher Guide—All Charged Up.pdf
- Career-Focused Reflection—All Charged Up - Spanish.docx
- Career-Focused Reflection—All Charged Up - Spanish.pdf
- Career-Focused Reflection—All Charged Up.docx
- Career-Focused Reflection—All Charged Up.pdf
- Lesson Slides—All Charged Up.pptx
- Practice Problems—All Charged Up - Spanish.docx
- Practice Problems—All Charged Up - Spanish.pdf
- Practice Problems—All Charged Up.docx
- Practice Problems—All Charged Up.pdf
- Teacher Guide Practice Problems—All Charged Up.docx
- Teacher Guide Practice Problems—All Charged Up.pdf

Materials

- Lesson Slides (attached)
- Practice Problems (attached; one per student)
- Teacher Guide Practice Problems (attached; optional)
- Career-Focused Reflection (attached; optional)
- Grocery bags
- Balloons (large, round type works best)
- Scissors
- Paper towels
- Chart Paper
- Markers, colored pencils, crayons, etc.
- Sticky notes

10 minutes

Engage

Teacher's Note: Lesson Preparation

This lesson involves how charge is generated using conservation of charge and how isolated charges separated by a distance interact with one another. Charge is a fundamental unit of matter (variable symbol is q and unit is C for coulomb). The value of a single charge is e = 1.6 x 10-19 C. Total charge of an object is found by multiplying the number of charges by the value of a single charge (q = ne). Objects become charged by the reorientation of electrons. There are several ways of charging objects: friction, induction, and polarization. In this lesson, students are charging bags and balloons using friction. If an object gains electrons it is considered to be negative, and if the object loses electrons it is considered to be positive. While an object gains or loses its electrons, those electrons are transferred to another object, thus conserving charge. When two or more isolated charges are separated by a distance, either an attracting or repelling force exists that is proportional to the product of their charges and inversely proportional to the square of the distance between them (Coulomb's Law). The direction of the force is determined by the charges associated with the objects and its applicable laws of attraction. If the objects have opposite charges they will attract but if their signs are like then they will repel.

Use the attached **Lesson Slides** to facilitate. Display **slide 2** and introduce students to the lesson. Use **slides 3-4** to go over the essential question and lesson objectives. Move to **slide 5** and introduce students to the I Notice, I Wonder instructional strategy. Play the video on **slide 6** and give students time to record their notices and wonders, replay the video if necessary.

Display **slide 7**. Invite students to share out what they noticed and wondered about the video. Ask students if there were any common words or phrases they heard in each other's answers. Record those words or phrases on a piece of chart paper or on the board so that they can refer to it as the lesson progresses. Some terms to listen for are static, charge, friction, electrons, negative, positive, attract, repel, electric field, and force.

Embedded video

https://youtube.com/watch?v=HXJBi7ZQHIo

Possible Student Responses

The dog became statically charged due to the friction between the blanket and the dog's fur. The dog's fur became charged because of the blanket rubbing, like when you shuffle across carpet in your socks then shock someone.

Teacher's Note: Static Electricity

The dog's hair stands up because friction causes a transfer of electrons from the dog to the couch. This leaves the dog with a net positive charge and the couch with a net negative charge. However, the system conserves charge so there was not a net loss or gain of electrons by the system. The system is defined to be a couch and a dog.

30 minutes

Explore

Move to **slide 8** and show students the picture of the levitating ring and balloon. Tell students they have 20 minutes to accomplish the same thing they are seeing in the picture, using a balloon to levitate a ring. Go over the list of supplies they will have to complete the task. Avoid the temptation to tell them how to accomplish the task.

Teacher's Note: Levitating Balloon Process

The easiest way to accomplish the task is to blow up the balloon and cut a ring out of the grocery bag. The ring should only be an inch or two wide. Then, rub the paper towel on the balloon repeatedly in the same direction and do the same thing with the grocery bag ring. Rubbing the bag and the balloon in the same direction will separate the electrons, inducing a charge. Both the ring and the balloon should have the same charge, therefore the objects will repel and the ring will appear to levitate.

Common Student Mistakes

Students may have too big of a strip of bag for the electrostatic force to be large enough to counteract the bag's weight. Students who do charge both objects will have limited success. If a group only charges the balloon, you may ask them to charge the bag in the same way and see if it affects their results. Students will have more success if they rub the paper towel against the bag in one direction only with the bag on a table. The balloon will also need to be rubbed using the paper towel to get the best results, not someone's shirt or head. If students are having limited success, you may want to ask them how they can get the bag to levitate higher. To do this, they should reduce the weight of the bag by making a smaller ring.

Once all of the groups have accomplished the task, display **slide 9** and have a class discussion on how the activity was similar and how it was different from the charged static dog video. Use the questions on the slide to guide the discussion and add to the list of terms from the Engage portion. Some additional terms from the discussion may include repel, charge(d), force, and gravity (weight).

Transition to **slide 10** after the discussion. Introduce students to the Gist instructional strategy. Have students write a 50-word Gist summary incorporating all of the terms listed and explaining the relationships they observed in the activity or video.

Teacher's Note

Students should introduce the idea of a force being present that is at least equal to the bag's weight, because it levitates. They should mention both objects had to be charged in the same way. This means the two objects have like charges and will repel.

30 minutes

Explain

Move through **slides 11–21** to go over the what charge is and how to calculate it.

The laws of attraction state that objects with like charge will repel and charges with opposite charge will attract. Positive and negatives attract while positive-positive or negative-negative interactions will result in repulsion.

Coulomb's Law states that a mutual force of attraction or repulsion exists between any two charges that is directly proportional to the product of their charges and inversely proportional to the square of the distance between them. This is similar to Newton's Universal Law of Gravitation.

Fe = (k q1q2)/r^2 where k is a constant = 9 x 10^9 Nm^2/C^2

Move to **slide 22** and pass out the **Practice Problems** handout to each student. Allow students to work with partners as they work through the practice problems. Before they begin, pass out three cups (a red one, a yellow one, and a green one) to each pair. Explain that they should use these cups to communicate how they are doing on the practice problems. Red means they need help, yellow means they are working without trouble, and green means they have completed the practice problems. Have students use this system as they work through the practice problems.

Use to the provided **Teacher Guide Practice Problems** to support students if they struggle with answering the questions.

Teacher's Note: Additional Practice

For more information about Coulomb's Law and working problems, go to the Physics Classroom: Coulomb's Law website.

Teacher's Note: Practice Answers

Be sure all the correct answers are given to the students by the end of the discussion. Rather than just giving them the answer or having the groups simply state the correct answer when they share, be sure to explain how they got the answer. It may be a good idea to assign a group to answer a problem they have worked incorrectly, just so you can address any misconceptions they may have.

30 minutes

Extend

Put students in groups of three or four and pass out a piece of chart paper to each group. Move to **slide 23** and explain to students that they will be creating a poster about lightning based on the information they learn. On their poster they will need to include a clear answer, drawings or diagrams, and include applicable vocabulary from the lesson.

Teacher's Note: Lightning Resources

There are all kinds of lightning info available online. Students should know that many aspects of lightning remain a mystery. The article How Lightning Works provides some insight on that mystery.

Once groups are done with their posters, move to **slide 24.** Introduce students to the Gallery Walk instructional strategy. Ask students to hang their poster around the room. Inform them that they will be walking around to visit each poster. Explain that to offer feedback, they will be leaving questions on other groups' posters about the information that could improve their poster.

Optional Career-Focused Activity

Pass out a copy of the attached **Career-Focused Reflection** handout. Unhide **slide 25** to show students a video interview with a professional climatologist: *Career-Focused - Climatologist with Monica Maddox*

Embedded video
https://youtube.com/watch?v=Am10w_ksBQg

Invite students to complete the questions on the handout in complete sentences and to show their work in the word problem. Facilitate a discussion surrounding these questions. Then have students flip their paper over and work with a partner to answer the question concerning Columb's law, which a climatologist might use to predict thunderstorms based on climate patterns. Use the attached **Career Focused Reflection Teacher Guide** for reference as needed.

10 minutes

Evaluate

After all the questions are answered, move to **slide 26** and show students the embedded Electroscope Demo ScienceLibrary video. Pause at 0:50. Explain that the device in the video is called an electroscope and it was invented hundreds of years ago to detect charge in objects. The stronger the charge, the greater the reaction of the leaves at the bottom of the device.

Embedded video

https://youtube.com/watch?v=Ngv2OlqFWXU

Move to **slide 27**. Use the Think-Pair-Share strategy with this prompt: "Based on what you've learned so far, explain what is happening and why it's happening." Show the video to the students again, stopping again at 0:50. Invite students to give their answers or their partner's answer to what is happening in the video. Once a few students have answered, play the second half of the video that has the areas of charge labeled.

Optional Differentiation

Additional mathematical practice with Coulomb's Law may be necessary for students to gain fluency. You may want students to build an electroscope using clay/holder, straws, and tape.

Resources

- Bone, A. (10 Feb. 2013). *Electroscope Demo ScienceLibrary.info* [Video]. YouTube. https://www.youtube.com/watch?v=Ngv2OlqFWXU
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