Electrostatic Orbits and Water
Astronaut Pettit's Experiment Redesigned

This lesson is a continuation of the lesson on **Electrostatic Properties in Space**
To build background prior to this lesson, see Electrostatics in Space

Introduction

In microgravity environments, where there is very little or no gravity, the behavior of electrostatic forces can be different than on Earth. On Earth, gravity can affect how charged particles or objects move and interact with each other. But in microgravity, the electrostatic forces can be the primary factor that determines the behavior of charged particles and objects. This means that electrostatic experiments done in microgravity can provide important information about its effects on objects and spacecraft.

Electrostatic properties can influence the motion of objects in space three ways. First, the presence of other charged objects can exert force on an object, causing it to deviate from its original trajectory. For example, a spaceship near a planet may experience a force that attracts or repels it, leading to a change in its orbit.

Second, plasmas, (gasses that contain charged particles), are commonly found in space and can interact with spacecraft, modifying their orbits. This interaction is determined by the electrostatic properties of the plasma and the spacecraft surfaces.

Third, the charging of a spacecraft's surfaces can affect its motion through the air and how it interacts with the Earth's magnetic field. A charged surface can lead to a buildup of charge on the surface and changing the spacecraft's behavior.

In this lesson, students will design and build an experiment that will demonstrate the electrostatic properties of charged particles in a microgravity environment. This experiment uses Astronaut Don Pettit's electrostatic experiment he performed on board the International Space Station.
Target grade level: 6-12tth grades

Suggested time frame: 3 hours

Standards: NGSS

MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
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.
HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
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-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Objective

To build an apparatus that will demonstrate the electrostatic properties of charged particles in a microgravity environment.

This experiment uses Astronaut Don Pettit's electrostatic experiment he performed on board the International Space Station.

Note: Safety precautions should be taken while conducting this experiment. Students should wear safety goggles and lab coats (optional) to protect their eyes and clothes.

Materials:

- Student's should test and define materials for the experiment
- Suggested materials:
- Medication syringe
- Medical tubing
- Clear containers (must be sealed and waterproofed)
- Ziplock bags (secondary containment)
- Water
- Food coloring
- Teflon knitting needle
- Nylon for charging
- Additional materials upon request

Engage

- Build background by teaching the lesson: Electrostatics in Space.
- Play video of Astronaut Don Pettit's electrostatic experiment on board ISS (5 min 23 seconds)
  Pettit: Electrostatic force in microgravity
- Have students think, pair and share their connections with the video and how it relates to their previous learning about electrostatic properties in space. Have them discuss the different materials and characteristics of these materials that Dr. Pettit used to enable the charges to interact.

Purpose

To build an apparatus that will demonstrate the electrostatic properties of charged particles in a microgravity environment.

Procedure

1. In groups, discuss the experiment and brainstorm ways to build an experiment to replicate Dr. Pettit's experiment in a microgravity.
2. Sketch prototype designs and discuss the materials needed to build it.
3. Submit a list of materials needed to teacher
4. Begin building prototype according to your designs, with the following considerations:
    - Maximum 10 mL water
    - Water must be contained at all times
    - Experiment must have a double containment system (ex. Ziploc)
    - Camera attachment system for hands-free video during flight

    Link for example of my students testing electrostatic forces with nylon charging: https://photos.google.com/photo/AF1QipOdMfyV4HbACzCmMWaIEKy1fQKg7Sy7rQY8U9gJ

5. Test your prototype as you build, testing it for functionality along the way. Record and justify any modification. This process will take several class periods.
6. Ground test final prototype (with video) and record video observations. Link for example of student ground testing: https://photos.google.com/photo/AF1QipP3CXpDS9W8jCfBVtTPAI-IOHekoowSwoLVCUOW
7. Continue ground testing of prototypes and make changes to improve the functionality and efficiency of their experiment.
8. Present final design to the class explaining each component and its importance while on board G-Force One.
9. Develop step by step instructions on how their experiment will be conducted.
    - Include anything requiring assembly prior to flight
    - Detailed procedures during flight
    - Tasks to be completed post flight.

Assessment

Use interactive notebook to record the engineering process involved in the build, beginning with brainstorming and sketches. Make and explain predictions experimental success on board G-Force One in microgravity.

Extend!

Showcase Zero-G student projects and other experiments in a grade-level or school fair or at a family night.

Include lessons on microgravity, parabolic flight, and topics such as electrostatic forces, as well as presentations, demonstrations, slide shows, and creative video presentations.

Resources

This lesson is a continuation of the lesson on Electrostatic Properties in Space. To build background prior to this lesson, see Electrostatics in Space

Astronaut Don Pettit's experiment on board the International Space Station (5 min. 23 sec) https://www.youtube.com/watch?v=9NbCzbDdd-g

Additional Resources: Examples of materials and student designs