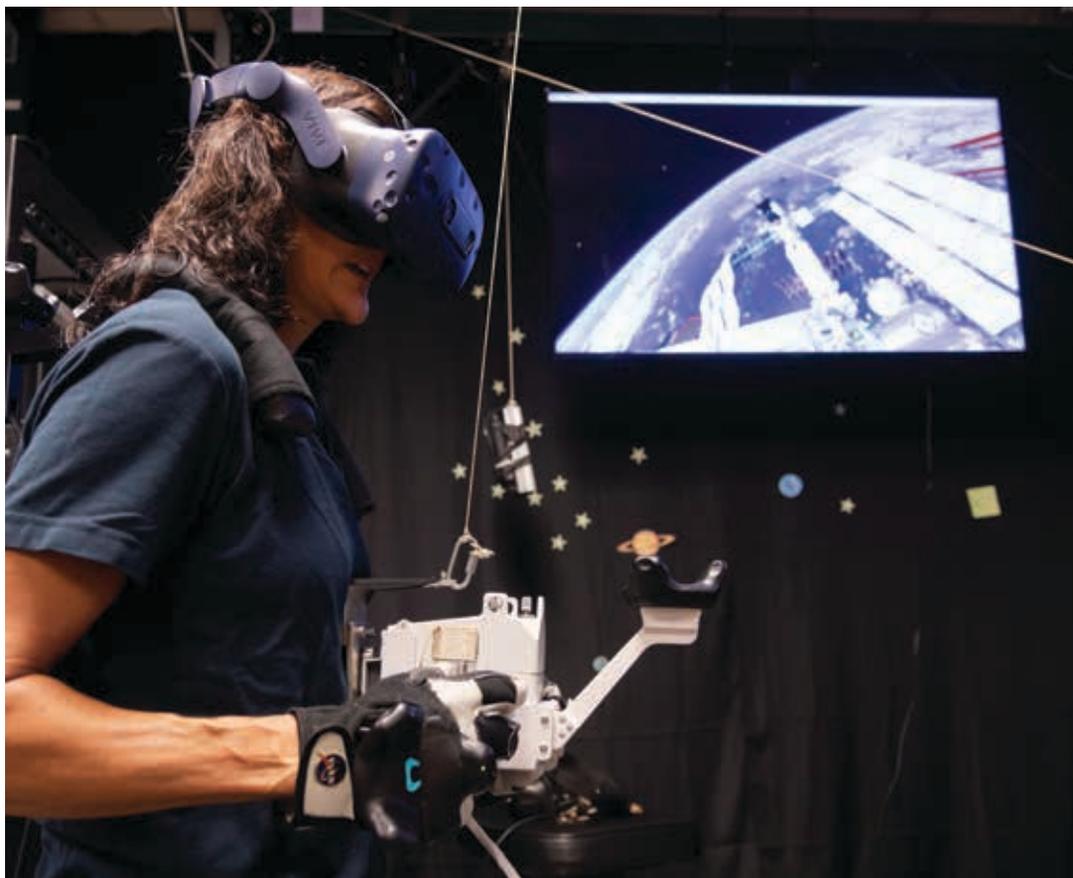


## Electric Field Transporter

### MODELING

**T**HE MAGNETIC TRANSPORTER designed by the space engineers met all of its criteria. However, the design was not able to satisfy an important constraint. Transporting large magnets by rocket is difficult because they have a lot of mass. But static charge can be generated on the Moon with simpler and smaller equipment. The space engineers decide to explore how they could use an electric field for their transporter.

In this activity, you will apply what you know about electric fields to a computer simulation. The gravitational field on the Moon will be simulated so you can design a transporter. This will help determine if electric fields can be useful for the Moon transporter.



Astronaut Suni Williams uses a virtual reality simulation to practice walking in a low-gravity environment for her next mission.

## GUIDING QUESTION

**How can the Moon transporter use an electric field?**

## MATERIALS

For each student

- 1 computer with Internet access

## PROCEDURE

### Part A: Exploring the Simulation

1. Go to the *SEPUP Third Edition Fields* page of the SEPUP website at [www.sepuplhs.org/middle/third-edition](http://www.sepuplhs.org/middle/third-edition). Follow your teacher's instructions to open the simulation.
2. Review the variables in the simulation.
3. Think about how each of the variables will affect the hover height of the transporter above the track in your system. Record your ideas.
4. Select **EARTH'S GRAVITY** and **100-kg**.
5. Change the amount of electric charge on the track and on the cart until the cart hovers between 0.3 and 0.4 m above the track. Record the total amount of charge you used.
6. Find at least three different ways to make the cart hover between 0.5 and 0.8 m above the track. For each way, record the charge on the cart and on the track.

## Part B: Design Challenge

7. Select MOON'S GRAVITY and 500-kg.
8. Review the following criteria and constraints for designing and testing your hover cart simulation.

### Design Criteria

The cart must

- hover above the track between 0.5 and 0.6 m in the Moon's gravity.
- hold a mass of 500 kg.

### Design Constraints

The solution is limited by

- using only electric charge to make the cart hover.
  - five simulation tests.
9. Make a table to record the input and output values from the simulation for the five runs.
  10. Decide how much charge you want to place on the track and on the cart for your first simulation test. Adjust the slider values.
  11. Press TEST. Record the data from the first simulation.
  12. Plan how you will continue to test, evaluate, and redesign your hover cart for the remaining four simulation tests. Make sure your plan addresses what data you will record and what you will do if
    - the tested cart hovers too high.
    - the tested cart hovers too low.

Record your plan.

13. Continue until you have used all five simulation tests. If needed, adjust and update your plan from Step 12 as you work.

## Part C: Optimizing your Design

14. Review the optimization criteria and constraints shown below. You have five more simulation tests for this optimization.

### Optimization Criteria

The cart must

- meet all of the previous criteria.
- use as little charge as possible.

### Design Constraints

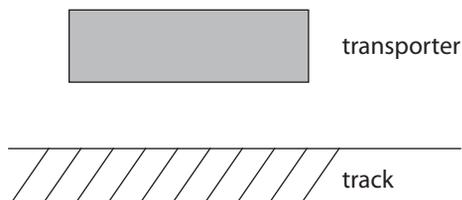
The optimized solution is limited by

- using only electric charge to make the cart hover.
- five additional simulation tests.

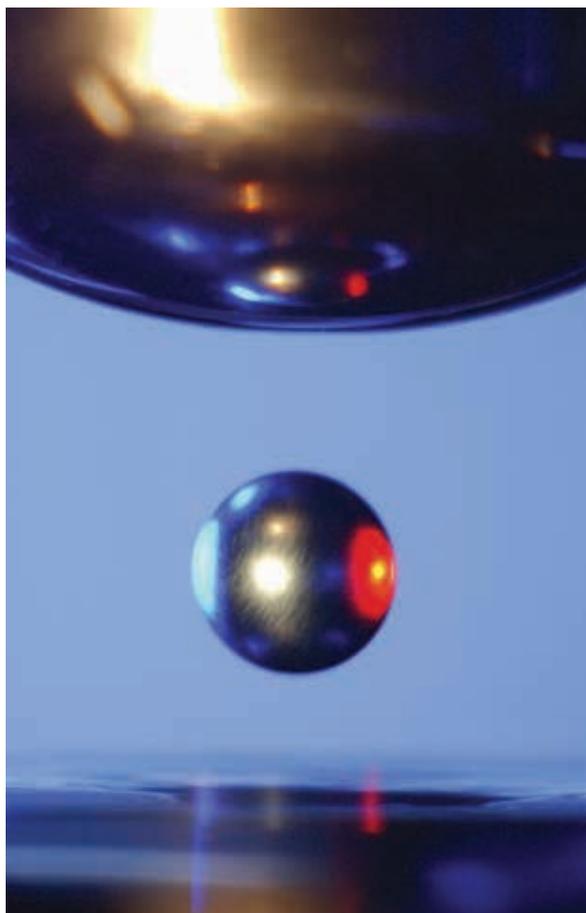
15. Brainstorm an optimization plan that will lead to meeting the criteria.
16. Follow your plan. When making changes to the design, record why you thought change would optimize the design.

## ANALYSIS

1. Compare the amount of charge in your optimal design to that of the amount of charge of static electricity when rubbing two objects together, or about 1,000 nC. Does the amount of charge on the track pose a safety problem? Explain.
2. Why did the electrostatic transporter hover at a different height on the Moon than on Earth?
3. If your transporter is hovering at a height above the track and you remove some charge from the track, will your transport continue to hover at that same height? Explain.
4. Draw a diagram, like the one below, of the electrostatic transporter hovering over the track.



- a. On the transporter, draw one arrow to show the electrostatic force. Draw another arrow to show the gravitational force. Label your diagram.
- b. Draw a second diagram of the electrostatic transporter hovering over the track. In this diagram, show what happens when mass is added to the transporter. Describe what would happen to the cart's hover height, and explain why it changed.
- c. Imagine that the electrostatic forces on the cart and track were suddenly removed. When the cart hits the track, what evidence would there be that energy was transferred?



*Electrostatic levitation is used to hover a metal ball between two surfaces. It is suspended inside a special chamber so it can be studied without contacting other materials.*