National Aeronautics and
Space Administration

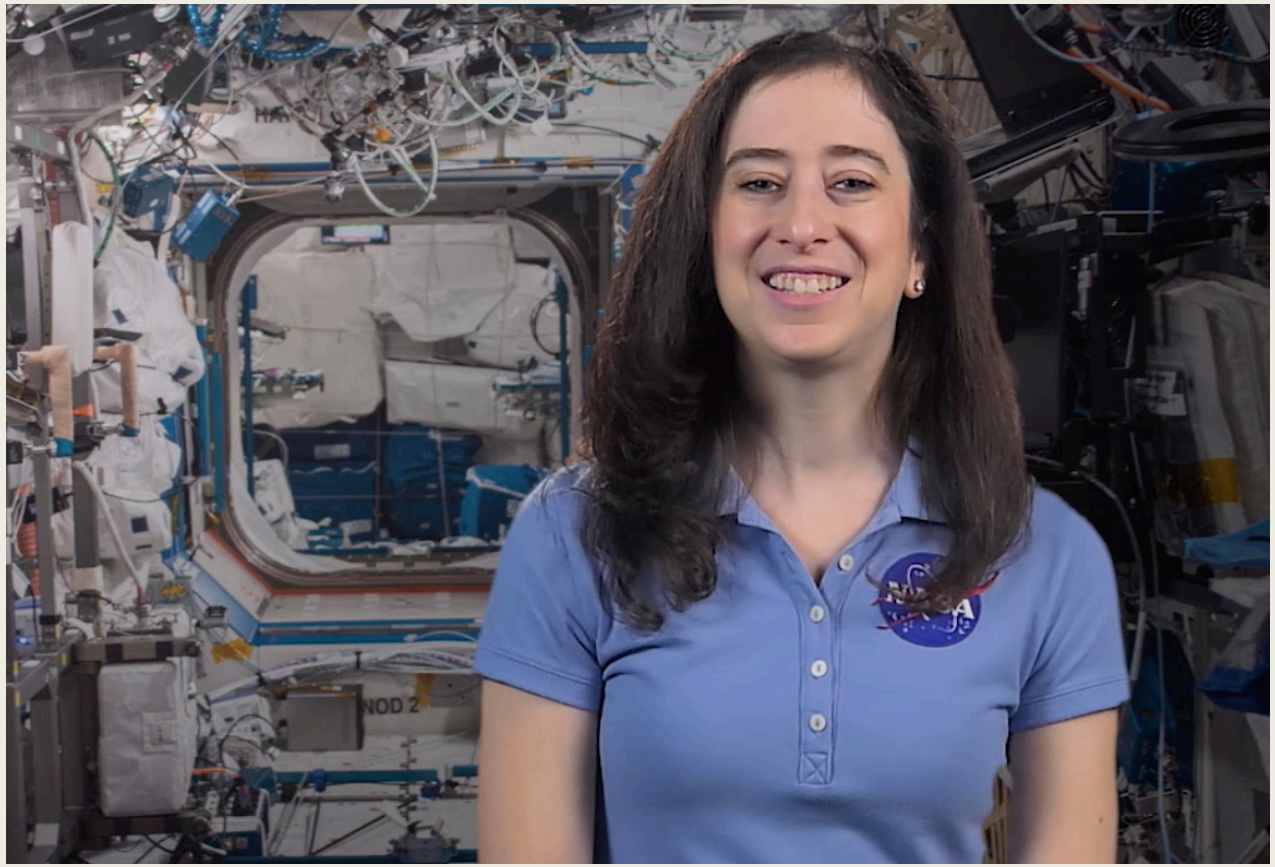
INSPIRE - ENGAGE - EDUCATE - EMPLOY

The Next Generation of Explorers

Astro Socks

Introductory Video

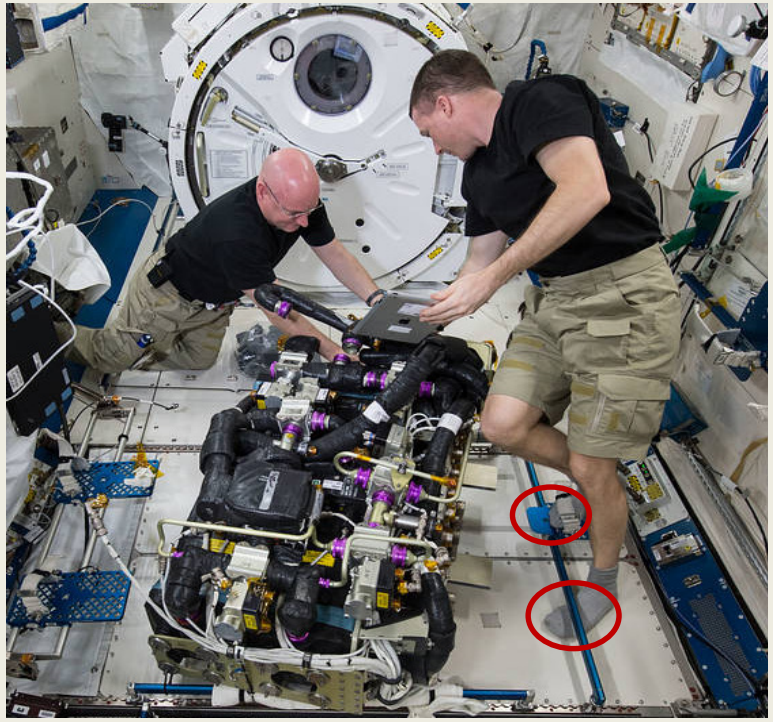
- Introductory Video



View the video at http://y4y.ed.gov/stemchallenge/nasa

Engineering Design Challenge: Astro Socks

How can our team develop footwear for the International Space Station (ISS) astronauts that will both protect and provide comfort for their feet while they live and work in space?



NASA astronauts Scott Kelly (left) and Terry Virts (right) on the International Space Station. Note Virts' foot under the foot rail (bottom right). (NASA)

Identify a Need or Problem

Astro Socks Challenge Guidelines

Student teams will

- Construct a sensor sock with four foot sensors that will gather and record test data at four different locations. The four sensors will measure the pressure that ISS foot restraints exert on the top of an astronaut's foot.
- Collect and record the test data using an Arduino Uno®, which collects and channels data directly into a Microsoft® Excel® spreadsheet through the Data Streamer.
- Build a test sled that will lift a mass and simulate pressure placed on the foot by the ISS foot restraints.
- Modify and address each of the four pressure points on the astronaut's foot to design a comfortable and protective Astro Sock for both male and female astronauts.
- Measure and record the mass of the Astro Sock, including all of the modifications and enhancements needed to address each of the pressure points on the foot.
- Develop a description of how the engineered Astro Sock will provide comfort and protection to the feet of the astronauts.

Research

Watch the introductory video for Astro Socks.

- What questions do you have?
  - Challenge scenario
  - Criteria and constraints
- Where can you find the answers?
  - Internet
  - Conduct an interview with a NASA scientist or engineer

Stephanie Wilson, STS-131 astronaut, uses a foot rail for stability in the Cupola Observation module of the International Space Station. (NASA)

Astro Socks Challenge Criteria

- The student team will develop an Astro Sock that will protect the top of an astronaut's feet while he or she is working and living on the ISS.
- The Astro Sock must be able to be worn comfortably while an astronaut is working and engaging in his or her daily routine.
- The Astro Sock must fit both men and women astronauts.
- The Astro Sock must be constructed from materials that can be washed, reassembled, and reused.
- The team must develop a description of the Astro Sock that is supported by their data.
- The team must develop and build pressure sensors that will gather data through an Arduino Uno to measure the amount of pressure being exerted on the top of the foot.
- The team must engineer a test sled that will simulate the ISS foot restraints by lifting a weight.

Astro Socks Challenge Constraints

- The mass of the Astro Sock prototype must not exceed 150 g.
- The Astro Sock prototype must reduce the measured pressure on the foot of the astronaut by at least 50 percent. A reading as close to zero as possible would be desirable.
- The test sled must securely lift a minimum mass of 250 g so that the pressure can be detected by each of the four sensors.
- Student teams must calculate the final cost by recording on their Budget Worksheets the cost of each of the modified and enhanced materials used in the Astro Sock's construction.

Design

Develop and draw a labeled diagram of the prototype.

- Work independently to create a drawing.
- As a team, create a drawing that represents the best of all the individual ideas.

Prototype

As a team, build a prototype based on the team drawing.

- Use materials provided.
- Follow safety protocols.

Remember: The Astro Sock must fit over the sensor sock and the test rig must be close to the foot to record the pressure exerted on the foot by the test sled.

Test and Evaluate

- Teams should test their Astro Sock prototype three times, using a variety of pressure tests that will simulate the pressure exerted on an astronaut's foot by the foot restraints on the International Space Station (ISS).
- Record each trial in the Microsoft® Excel® spreadsheet and Student Journal.
- Using the test data, make improvements and modify prototype designs.

Communicate, Explain, and Share

Create a student team presentation that documents and describes progress through all the steps of the engineering design process.

- Use scripts, photographs, and video clips.
- Include all the team members.

Video: NASA STEM Challenges: Telling Your Story

https://y4y.ed.gov/stemchallenge/nasa/stem-challenge-videos-webinars

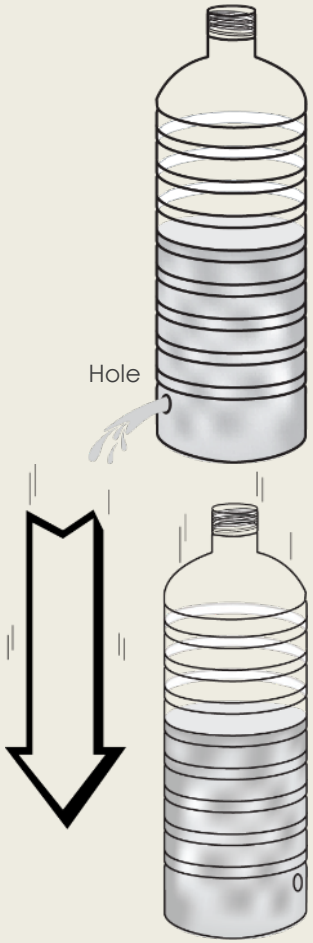
Astro Socks
STEM Investigation: Science

How Does Water Behave in Microgravity?

STEM Investigation: Science

How Does Water Behave in Microgravity?

Explore what happens to water when it is in free fall, or a simulated microgravity environment.



Water Bottle Drop

1. Make a hole in an empty, clear plastic water bottle at approximately one fourth of the height of the bottle.
2. Fill the water bottle half full with clean water and hold the bottle so that the hole is covered with one finger.
3. Lift the water bottle to a height of 2 m over a large, empty bucket.
4. Begin the slow-motion recording.
5. Move the finger from the hole in the bottle and record the water flowing out of the bottle for a few seconds.
6. After a countdown, release the water bottle so that it lands in the bucket.
7. Stop the slow-motion recording.

Data Analysis

Watch the slow-motion video of the water bottle drop and describe what happened in the simulated microgravity environment.

1. How did the water behave before the drop?
2. What happened to the water during the drop?

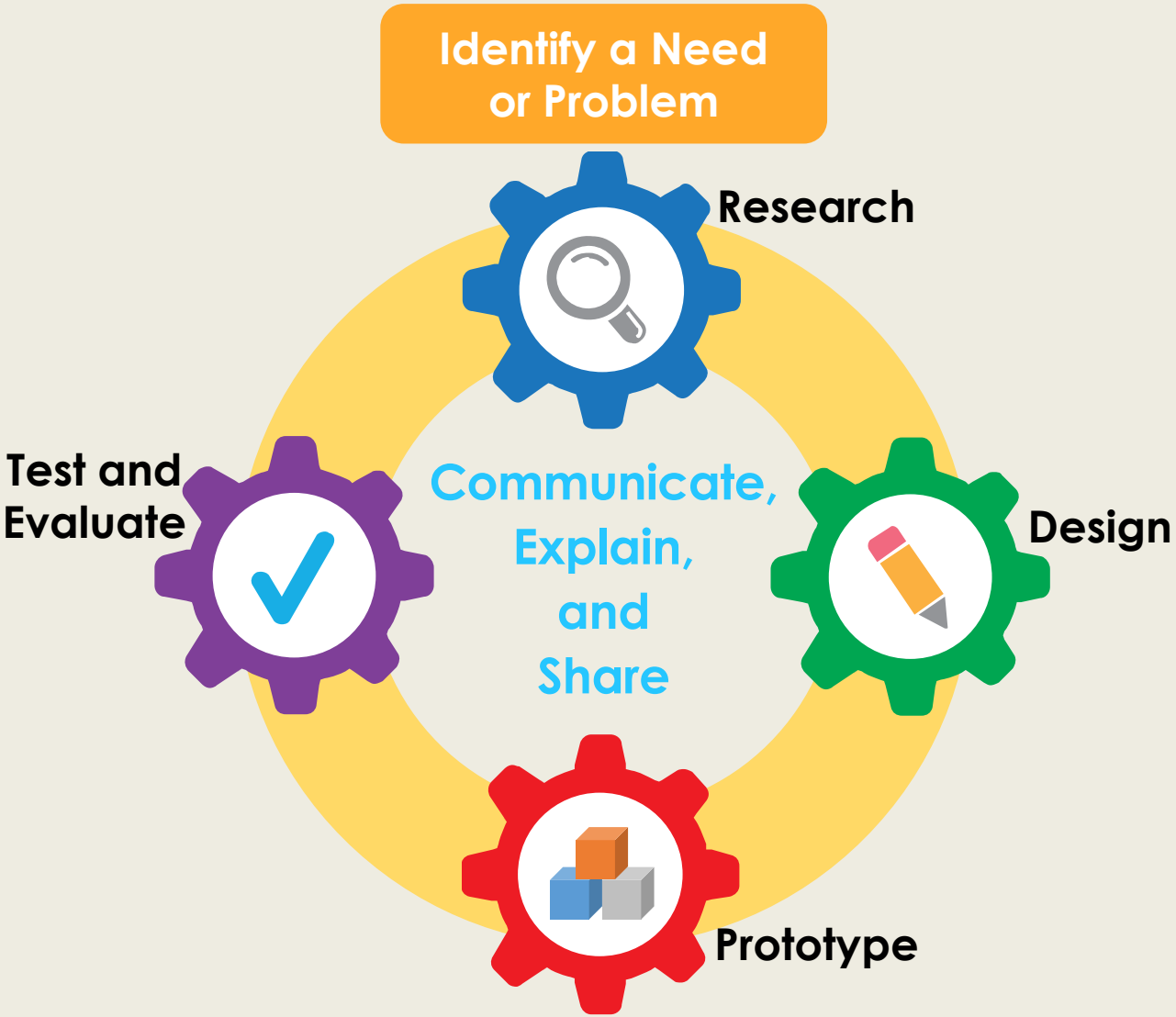
Discussion

Video: Drinking Water on the ISS

https://www.youtube.com/watch?v=Fg1RMElP6i4

How does water behave on the International Space Station?

Engineering Design Process



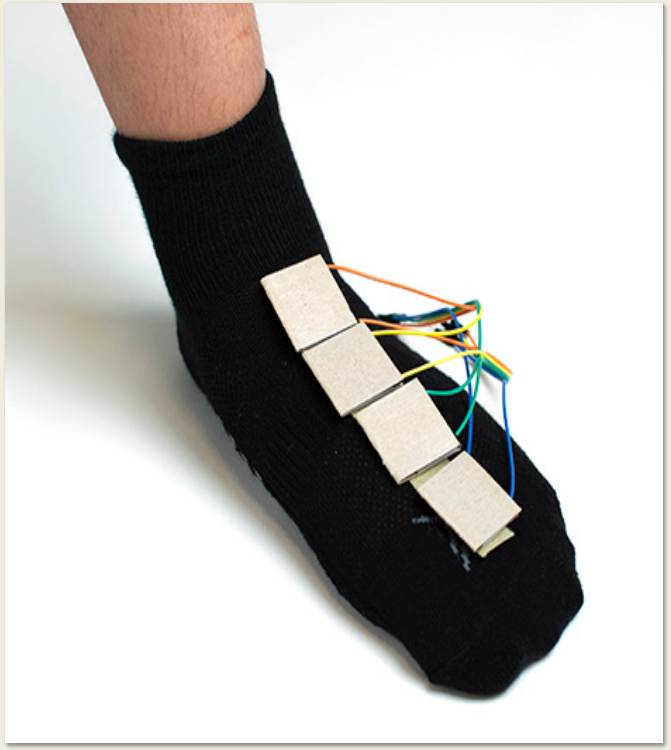
Astro Socks
STEM Investigation: Technology

How Do I Construct a Test Rig?

STEM Investigation: Technology

How Do I Construct a Test Rig?

Construct a test rig that will be used to construct, collect, record, and analyze pressure data for the Astro Sock prototype.



Building the Sensor Sock and Arduino Uno and Breadboard

Follow the steps on the Microsoft® Educator Center website:

Designing Astro Socks – Teacher Resources – Build Instructions

https://education.microsoft.com/en-us/hackingStem/nasa

Data Streamer and Sensor Test

Astro Socks Excel® workbook: http://aka.ms/astrosocks-workbook

- Follow the instructions on each tab. Test each of the sensors by collecting baseline data from the foot of the student astronaut.

Discussion

Why is a spreadsheet a necessary component for collecting data with the test rig for the Astro Sock prototype?

Engineering Design Process

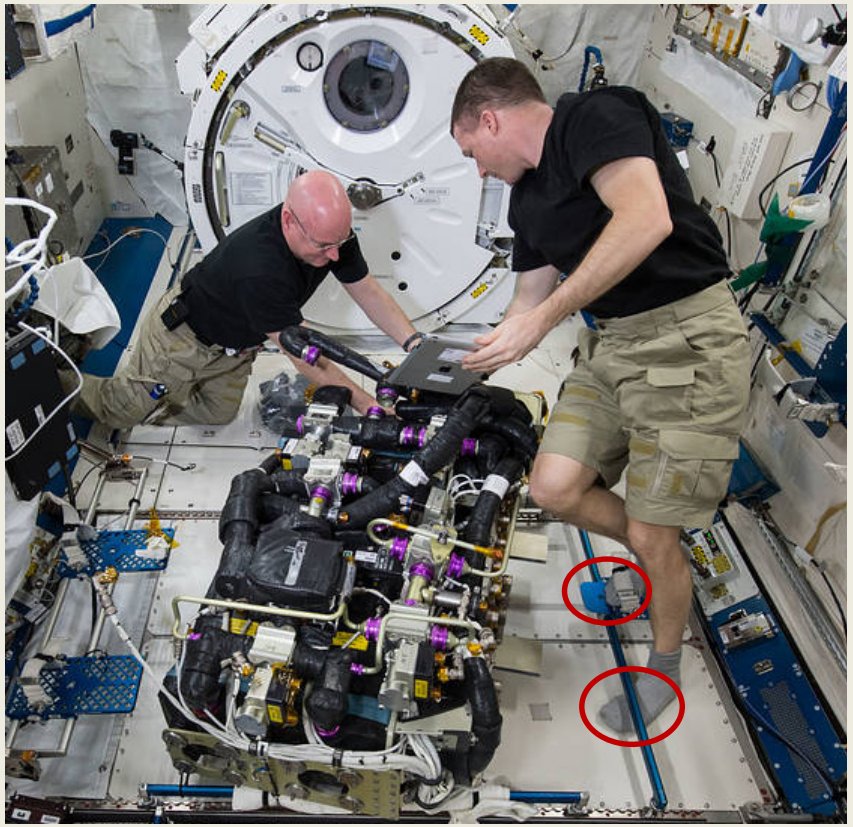
Astro Socks
STEM Investigation: Engineering

How Do We Engineer a Test Sled?

STEM Investigation: Engineering

How Do We Engineer a Test Sled?

Engineer a test sled that can securely hold a minimum of 250 g of mass while it is being lifted by the foot of a student astronaut to a height of 20 cm.



NASA astronauts Scott Kelly (left) and Terry Virts (right) on the International Space Station. Note Virts' foot under the foot rail in the bottom right. (NASA)

Test Sled

- Research – www.nasa.gov
  - What kinds of foot restraints are found on the ISS and where are they located? Characteristics?
- Design a test sled.
  - Must meet the building specifications.
  - Make a drawing of the test sled and label each of the parts.
- Build a prototype of the test sled.
  - Must be secure and stable to support the mass.
  - The test sled must have a foot rail that will allow the student astronaut to hook the sled onto his or her foot.
- Test and evaluate the test sled.
  - Must rest on the sensor sock.
  - The test sled must be structurally secure so that the same mass can be used for several tests of the Astro Sock prototype.

Discussion

How did we use the engineering design process to create our test sled?

Engineering Design Process