National Aeronautics and Space Administration

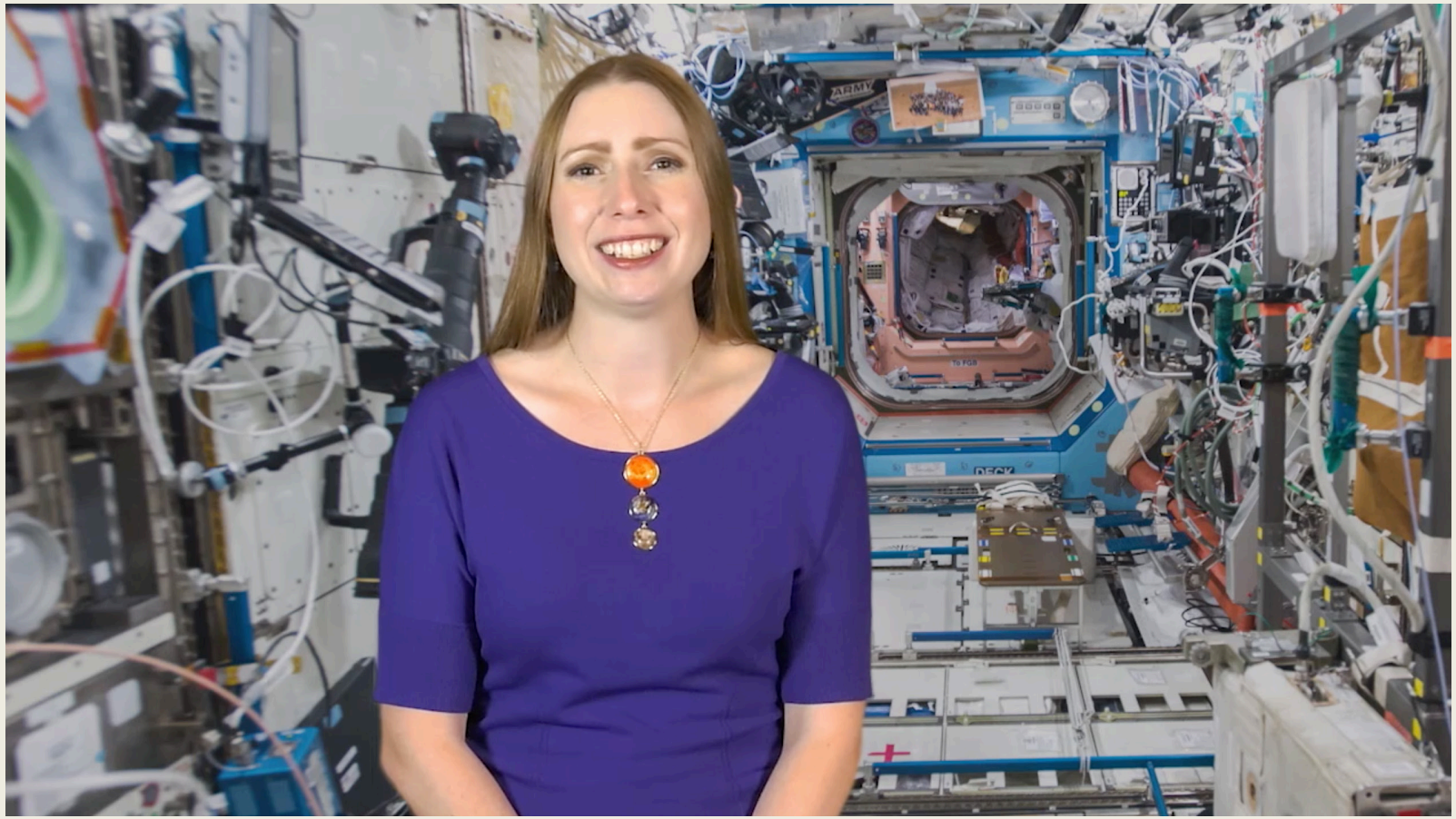
INSPIRE - ENGAGE - EDUCATE - EMPLOY

The Next Generation of Explorers

Lunar Water

Introductory Video

- Introductory Video



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

Lunar Water Scenario

While living on the Moon, it is essential that water consumed in the lunar habitat is recycled, purified, and reused. Because of the limited-weight requirements to ship cargo on the Space Launch System (SLS) and Orion spacecraft, the amount of water that can be transported and supplied for long-term missions must be precisely calculated.

Artist's impression of a multidome lunar base. (ESA/P. Carril)

Lunar Water Scenario

All the water used by the astronauts on the International Space Station (ISS) is recycled, purified, and returned back into the ISS water systems. In a space habitat, this wastewater—also known as gray water—includes moisture exhaled by the astronauts, sweat from their workouts, and water from food preparation, shaving, and the bathroom shower.

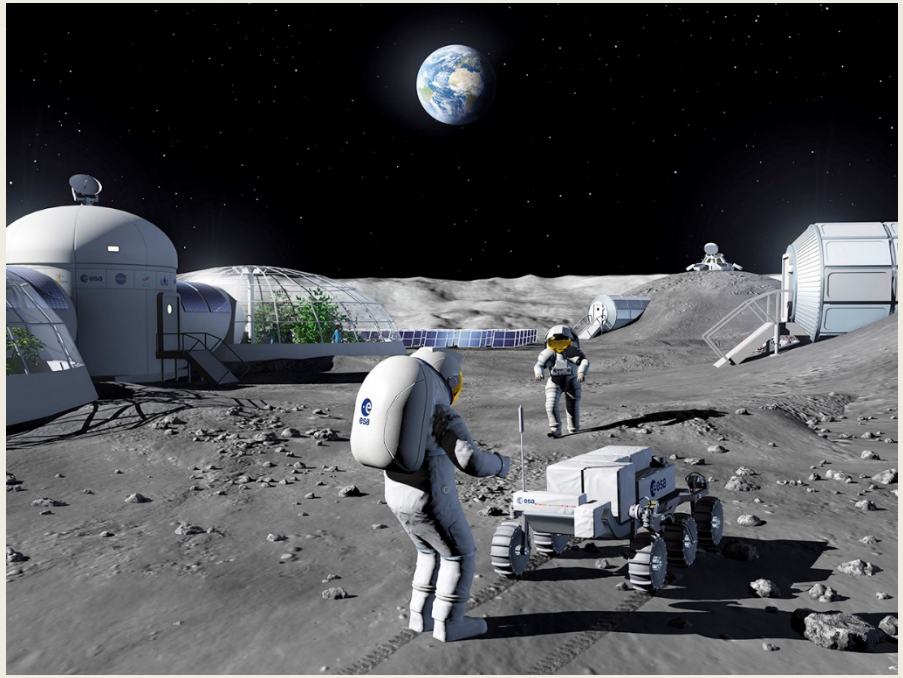
Lunar Water Scenario

During the Artemis program, the gray water will be recycled, purified, and reused both on the Gateway and in the lunar habitat. For the lunar crew living and working on the Moon, the purified water must have a pH range of 6.0 to 8.5 and be clear of all debris. It should also be odorless.

Lunar Water Challenge

Challenge Question

How can gray water be recycled, purified, and reused so that it can sustain our astronauts in the lunar habitat?

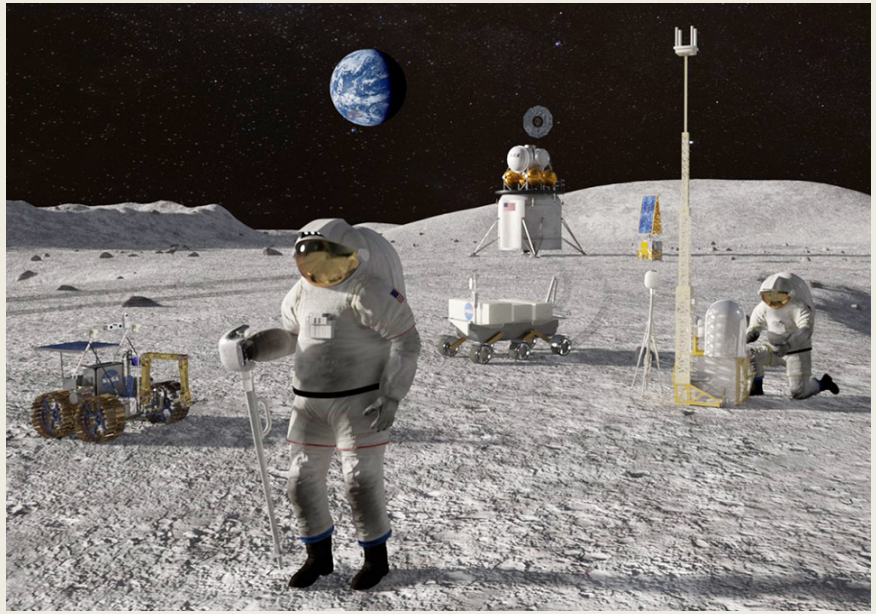


Artist's impression of a multidome lunar base, based on a three-dimensional (3D) printing concept. Robots will cover the inflated domes with a layer of 3D-printed lunar regolith to help protect occupants against space radiation and micrometeoroids. (ESA, P. Carril)

Lunar Water Challenge

The Challenge

Each team will design, develop, and test a water filter that will recycle, repurpose, and transform gray wastewater into purified drinking water for the lunar habitat.



Artist's concept of astronauts walking on the Moon's surface during an Artemis mission. (NASA)

Lunar Water Challenge

Where To Begin

Each team will need to develop a water filter that consists of both a container and filtering material that will clean the pollutants and contaminants out of the water. The water filter will have an opening where the gray water is poured into the filter. Once the gray water has drained through the filter, the purified water will be collected in a graduated cylinder.

Lunar Water Challenge

Filter Material Disposal

Unlike on Earth, the used filter materials cannot be distributed or buried. Each team will provide recommendations or suggestions describing the safest way to process the used filter material, which now contains contaminants that have been separated from the water.

Lunar Water Challenge Guidelines

Student teams will

1. Gather and record test data that describes both the clean water (bottled drinking water) and the gray water (four parts water and one part Italian salad dressing). Record pH levels and observations on odor, debris, and contaminants.
2. Measure and record the mass of the filtration materials used in the water filter in grams (g).
3. Using a graduated cylinder, measure and record the following:
    a. Amount of gray water to be poured into the filter
    b. Amount of water that drains out of the filter
4. With a timer, measure and record the amount of time it takes the gray water to seep through the filter.
5. Once the water filtration process is complete, develop a disposal plan that includes suggestions on how to safely dispose of the filtration material without dispersing it on the lunar surface.

Lunar Water Challenge Criteria

Develop a water filter that will clean 250 ml of gray water as determined by the following four tests:

1. **pH Scale Test**: The pH of the filtered water must measure as neutral (between 6.5 and 7).
2. **Debris Test**: The filtered water must be observed as clear, with no floating debris.
3. **Odor Test**: The filtered water must not smell like Italian salad dressing.
4. **Contaminants Test**: All pollutants and contaminants that were in the gray water must be removed by the filter.

Lunar Water Challenge Constraints

1. The filter must process 250 ml of water.
2. The mass of the filtration materials (up to three different types) together with the container must not exceed 1,000 g of mass.
3. The graduated cylinder used to collect the discharged water draining through the filter must be large enough to accommodate the filtered water.

Lunar Water
STEM Investigation: Science

What Is pH?

STEM Investigation: Science

What Is pH?

With your team, investigate the pH scale. Use litmus paper to determine the pH level of drinking water and other liquids.

NASA engineer Matt Mansell is shown with containers illustrating the Environmental Control and Life Support System (ECLSS) for recycling water and air aboard the International Space Station. A mockup of the ECLSS is in the background. (NASA)

Test for pH

1. Locate a pH scale by doing an image search on the internet.
2. What is the difference between a base, a neutral, and an acid?
3. Using litmus paper, test a variety of liquids and record the results in the table.

Complete the Chart

Liquid	pH measurement	Base, neutral, or acid
Drinking water		
Orange juice		
Laundry soap		

Discussion

How is the pH level of safe drinking water measured and determined?

Why would drinking water that tests as an acid or a base be harmful to drink?

Engineering Design Process

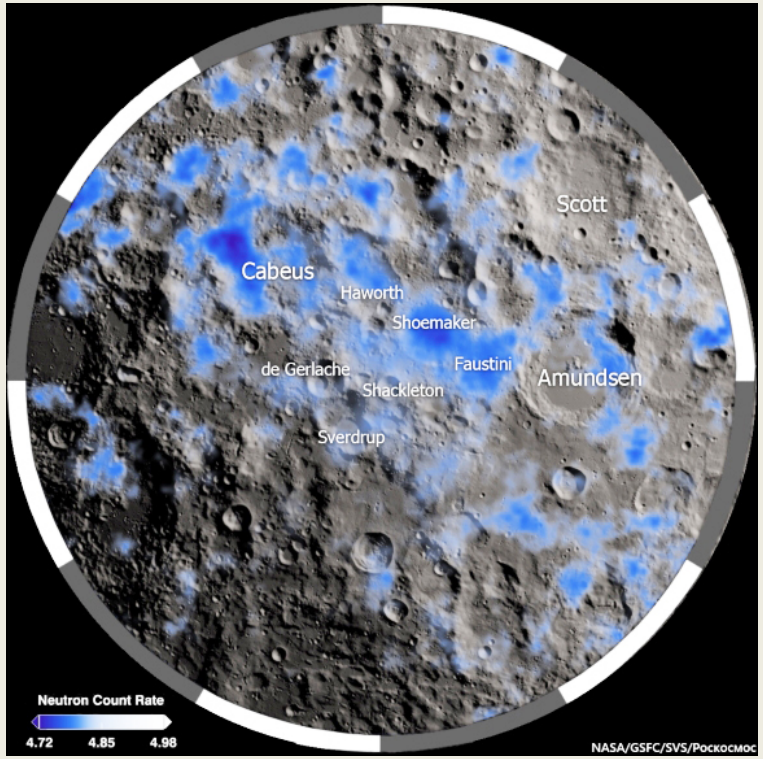
Lunar Water
STEM Investigation: Math

How Long Does It Take Water To Drain Out of Sand?

STEM Investigation: Math

How Long Does It Take Water To Drain Out of Sand?

Water on the Moon is frozen in the regolith, or lunar soil. As a team, set up an investigation to collect and analyze data that will determine the amount of time needed to drain the liquid water out of the soil.



Lunar Reconnaissance Orbiter observations indicate that the Cabeus, Shoemaker, and Faustini craters show great potential for containing subsurface ice. (NASA)

Investigate

1. In a plastic container filled with sand, freeze 250 mL of water.
2. Engineer a stand that will hold the container filled with sand in an inverted position.
3. Under the container, place a layer of coffee filters that will catch any sand from the container as it thaws.
4. Place a graduated cylinder under the stand to catch and measure any liquid water.

Complete the Data Chart

Record the time and water measurement data in the table below. In the Student Journal, make a line graph to display your data.

Time	Water, mL	Time	Water, mL

Discussion

What did you discover from your data?

Record your responses in the Student Journal.

The near side of the Moon always faces the Earth. (NASA)

Engineering Design Process

Lunar Water
STEM Investigation: Technology

How Do I Use a Spreadsheet?

How Do I Use a Spreadsheet?

It is extremely important that scientists and engineers have electronic tools to help them collect and analyze data throughout the engineering design process.

A spreadsheet can be an extremely important piece of technology that organizes and displays data from investigations. In this STEM Investigation, you will have the opportunity to enter data and explore a spreadsheet.

Investigate a Spreadsheet

1. Open a spreadsheet on your computer using an application such as Microsoft® Excel®.
2. Locate the data from the "How Long Does It Take Water To Drain Out of Sand?" activity.
3. In the first row of your spreadsheet, place the two headings for the data: **Time, sec** (seconds) and **Water, mL** (milliliters). You may want to bold the headings.
4. Using the data, enter each of the time measurements and corresponding water measurements into the cells of the spreadsheet.

Print Out Your Spreadsheet

5. Many spreadsheet features are valuable to a scientist or an engineer when analyzing data. Spend some time exploring the spreadsheet.
6. Explore some of the many instructional videos on YouTube® that demonstrate how to use spreadsheets.
7. Print out your spreadsheet and tape it into your Student Journal.

Discussion

Why is a spreadsheet an important tool to use when collecting and analyzing data?

Record your responses in the Student Journal.

Artist's concept: An astronaut uses advanced techniques to extract and process water from lunar soil, or regolith. (NASA)

Engineering Design Process