

NASA.GOV/POWER-TO-EXPLORE

- **Section 1:** The Power to Explore Challenge
- **Section 2:** The Moon
- **Section 3:** Nuclear Power Systems
- **Section 4:** Digital Scavenger Hunt
- **Section 5:** Brainstorm Your Entry



Section 1: The Power to Explore Challenge

The Challenge Overview

Dream about exploring the Moon with NASA using nuclear power! **Create one illustration and a written submission** that accomplishes the following:

- **YOUR ILLUSTRATION:** Learn how nuclear energy can be used in lunar exploration and illustrate your vision of a nuclear-powered lunar base that supports human and robotic exploration of the Moon's surface.

- **YOUR WRITTEN SUBMISSION:** Using 200 words or less, describe at least one personal superpower that could help NASA explore the Moon with nuclear power.

Your entry must be original and entirely your own—no generative AI is allowed – and don't include your name or anyone else's name in your entry. Let's watch the challenge video and then dive into challenge details!


WHAT WOULD
YOU POWER?

Prizes

Entries will be judged in three grade-level categories: K-4, 5-8, and 9-12, and the prizes are:

- 45 Semifinalists will be selected to win a NASA prize pack (15 in each category)
- 9 Finalists will receive an exclusive virtual session with a NASA expert (3 in each age category) and a finalist prize pack
- 3 Grand Prize Winners will receive a trip for two (student and parent chaperone) to NASA's Glenn Research Center in Cleveland, Ohio, to learn about the people and technologies that power NASA missions (1 in each age category)



Photo Credit: NASA
NASA's Glenn Research Center in Cleveland, Ohio

Challenge Timeline



Section 2: The Moon

Before we learn about power, let's learn about the Moon so you can decide where your lunar base goes and what it needs to power.

The Moon

We bet you were inspired by the Artemis II mission–we were too! Now, imagine what it would be like to live and work on the Moon. NASA is building a Moon Base to unlock scientific discovery and prepare humanity for missions to Mars.



Photo Credit: NASA The crew of NASA's Artemis II mission captured extraordinary images of our home planet during their journey around the far side of the Moon.

The Moon

Our Moon is the planetary body that orbits Earth. It has about 1/6th the amount of gravity as Earth and no breathable atmosphere.

The Moon is full of impact craters, which are the depressions left behind after an asteroid, meteoroid, or comet collided with the Moon. These craters can be huge! For example, the Moon's South Pole-Aitken basin is the largest known impact crater in the solar system, spanning more than 1,550 miles across!

The Moon does not have erupting volcanoes today, but it was once flooded with flowing lava. The Moon has signs of past volcanic activity like caves, plains, and domes made of cooled lava.

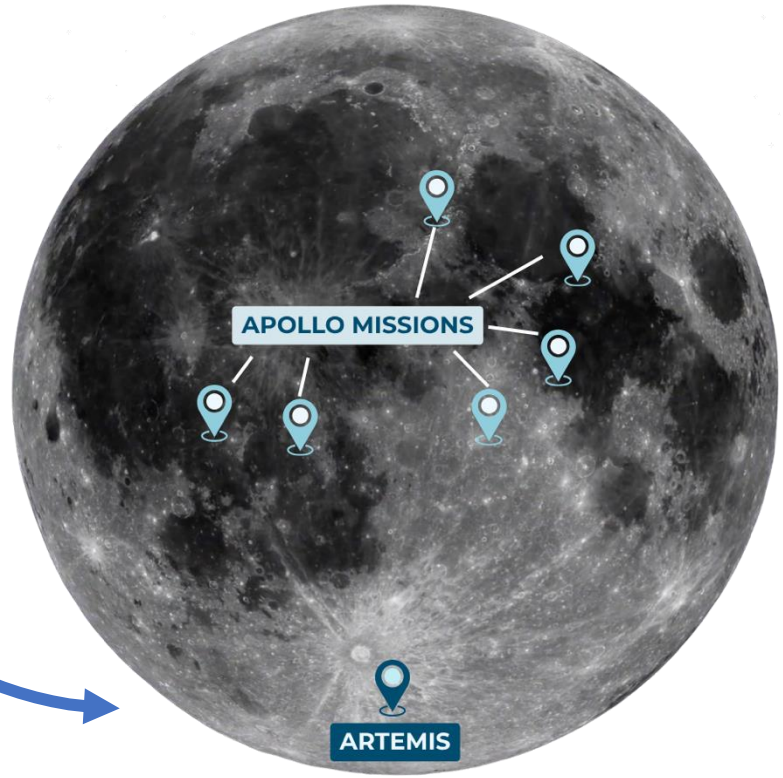


Photo Credit: NASA
The Moon's Giordano Bruno crater from the Lunar Reconnaissance Orbiter

POWER TO EXPLORE

Where is NASA going?

NASA has been to the Moon before. Apollo astronauts first set foot on the Moon on July 20, 1969. Now with the Artemis program, NASA is returning to the Moon, and this time to stay. Specifically, NASA is going to the **Lunar South Pole.**



Why is NASA going to the Lunar South Pole?

The Lunar South Pole region offers unique **opportunities** for exploration, scientific discovery, and establishing a long-term human presence. Studying this part of the Moon could help scientists answer important questions about the history of the Moon, Earth, and our solar system.

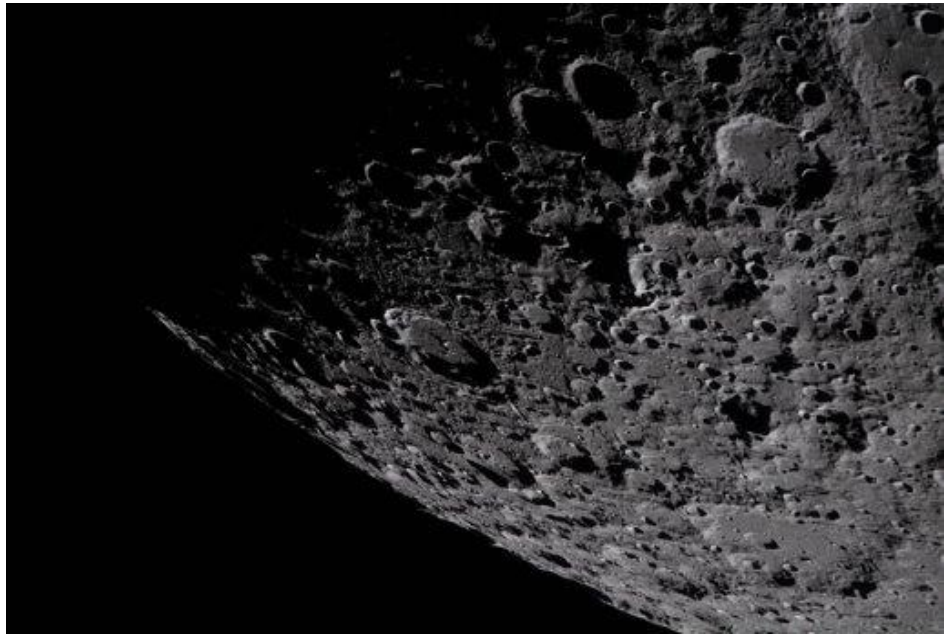


Photo Credit: NASA
Eastern edge of the South Pole-Aitken basin

Opportunities: Scientific Discovery

The final Apollo Moon mission was in 1972. Scientists have been investigating lunar samples and data from the Apollo missions ever since, but it also led to many new questions. Lunar scientists look forward to using new research equipment to support new investigations at the Lunar South Pole. Lunar scientists hope to:

- obtain new samples to examine the Moon's composition and uncover more evidence of how the Moon formed
- continue to investigate the origins of water and its behavior
- use portable seismometers to study moonquakes
- and so much more!

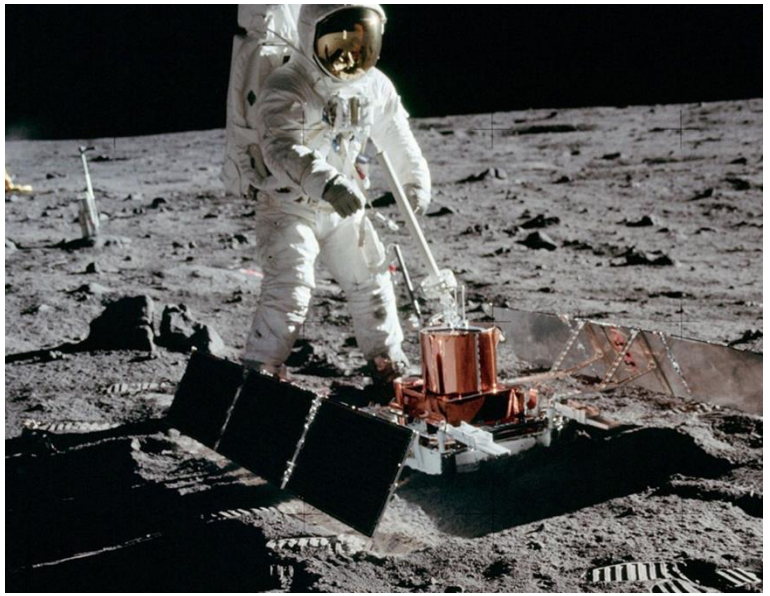


Photo Credit: NASA
Apollo 11's Passive Seismic Experiment

Opportunities: Learning to Live off the Land

Bringing everything from Earth is hard. Instead, NASA wants to prioritize **using what they find where they are**, which is called In-Situ Resource Utilization (ISRU).

Some natural materials on the Moon could one day help support future exploration. But first, we need to find out what is there and how to use it.



Opportunities: Harvesting Water Ice

NASA has found evidence of water ice at the Lunar South Pole. The Lunar South Pole region features craters that are unique in that sunlight does not reach their interior. These permanently shadowed regions on the Moon preserve water ice and other frozen materials dating from the early solar system.

Scientists are still learning where that ice is, how much exists, and how difficult it will be to collect. If we can collect it and clean it, the water could be used to make oxygen, produce materials for rocket fuel, or provide drinkable water for astronauts.

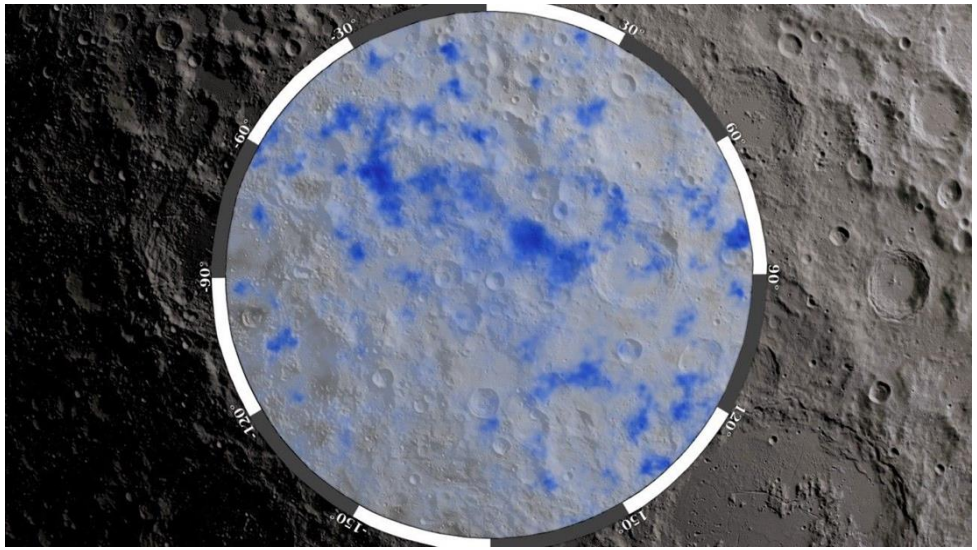


Photo Credit: NASA
Areas of the Moon's south pole with possible deposits of water ice, shown in blue. The map is based on data taken by NASA's Lunar Reconnaissance Orbiter.

Opportunities: Lunar Regolith

The Moon is covered in lunar regolith (lunar soil). While it may look like regular dirt, it's not at all like earth-based garden soil. Regolith is sharp, rough, and made of a combination of broken rock and fine dust.

And since it is *everywhere, e*ngineers are testing ways to dig, move, and use lunar regolith to make protective mounds/hills and even produce oxygen. NASA and industry are also testing ways to build with lunar regolith by 3D-printing large-scale habitats or landing pads.

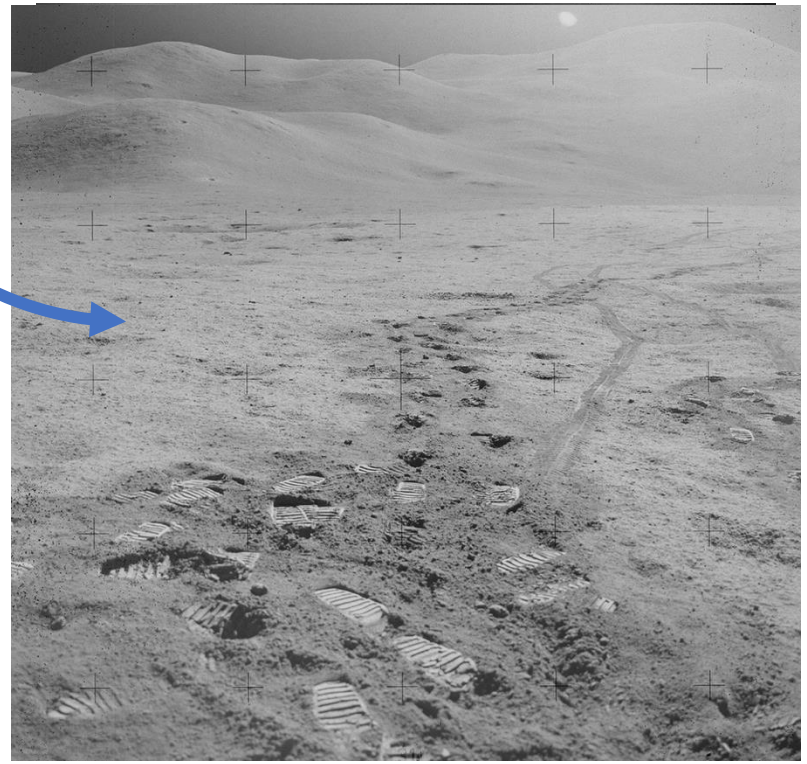


Photo Credit: NASA
Apollo 15 Astronaut Bootprints in Lunar Regolith

What are the challenges at the Lunar South Pole?

Building an enduring human presence on the Moon means designing for extremes. There is **no air** to breathe**, rugged terrain,** long periods of **darkness, cold temperatures, radiation,** and **lunar dust.**

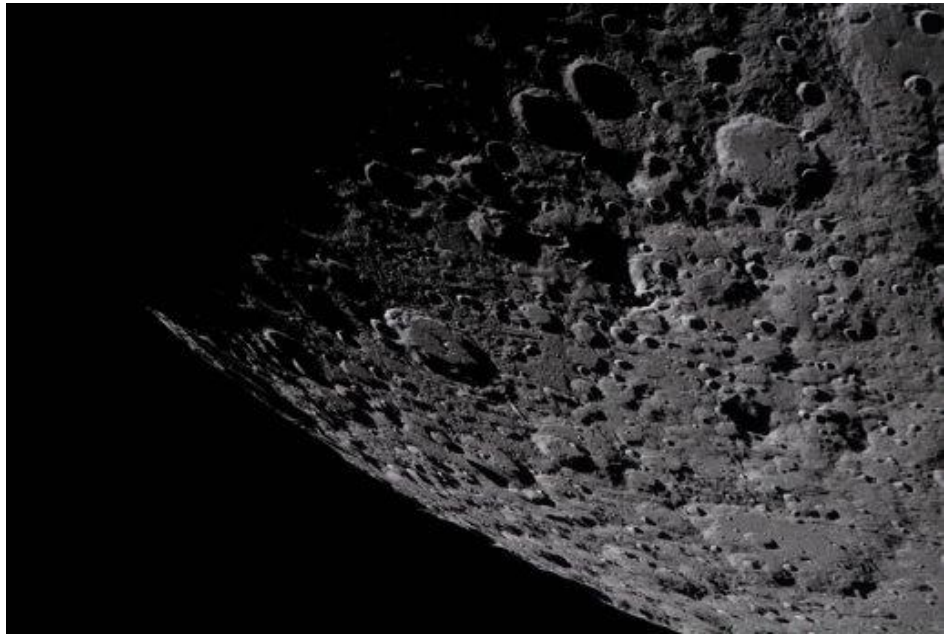


Photo Credit: NASA
Eastern edge of the South Pole-Aitken basin

Challenges: Rugged Terrain

The Lunar South Pole region is rugged. Steep slopes, ridges, deep craters, and rocks shape nearly every part of the landscape.

Some of the region's most interesting scientific destinations are among the most difficult to reach. Detailed mapping and robotic exploration will help NASA identify safe landing areas, determine where habitats and other structures can be placed, and plan how astronauts and robots will move across the Moon's surface.



Photo Credit: NASA
A close-up view of an astronaut's bootprint in the lunar soil

Challenges: Darkness

Near the Moon's South Pole, the Sun never climbs high. It skims along the horizon and casts long shadows. Some high ridges get sunlight much of the time, while the floors of deep craters never see the Sun at all. Even the sunniest spots have periods of darkness. Reliable power becomes especially important in dark, shadowed places.



Credit: NASA/GSFC/Arizona State University

Challenges: Environmental Conditions

The Moon has almost no atmosphere. There is no air to breathe, and nothing overhead to block radiation in the same way that our atmosphere and magnetic field protect us here on Earth. On the Moon, astronauts must bring their own air, and they must live inside protected habitats shielded from radiation.

Also, the lunar surface experiences extreme temperatures. With almost no air to spread heat around, temperature depends only on sunlight. Sunlit areas can be much warmer, while some permanently shadowed craters drop to about -334°F (-203°C), among the coldest places in the solar system.



Challenges: Lunar Dust

Apollo astronauts experienced firsthand how easily lunar dust can cling, scratch, jam, and cover equipment. Managing lunar dust will be an important part of sustaining reliable operations on the Moon for longer periods of time.

Moon dust is sharp, clingy and everywhere. With no wind or water to wear it smooth, lunar dust stays jagged, sticks to spacesuits and gets into machines. It can also coat solar panels, making them less effective.



Photo Credit: NASA
An artist rendering of an astronaut working on the lunar surface during a future Artemis mission.



Section 3: Nuclear Power Systems

Now that we know about the challenge and the Moon, let’s learn about nuclear power systems.

Why is nuclear energy a good power choice for lunar missions?

A lunar base will need continual power in dark, dusty, and cold conditions.

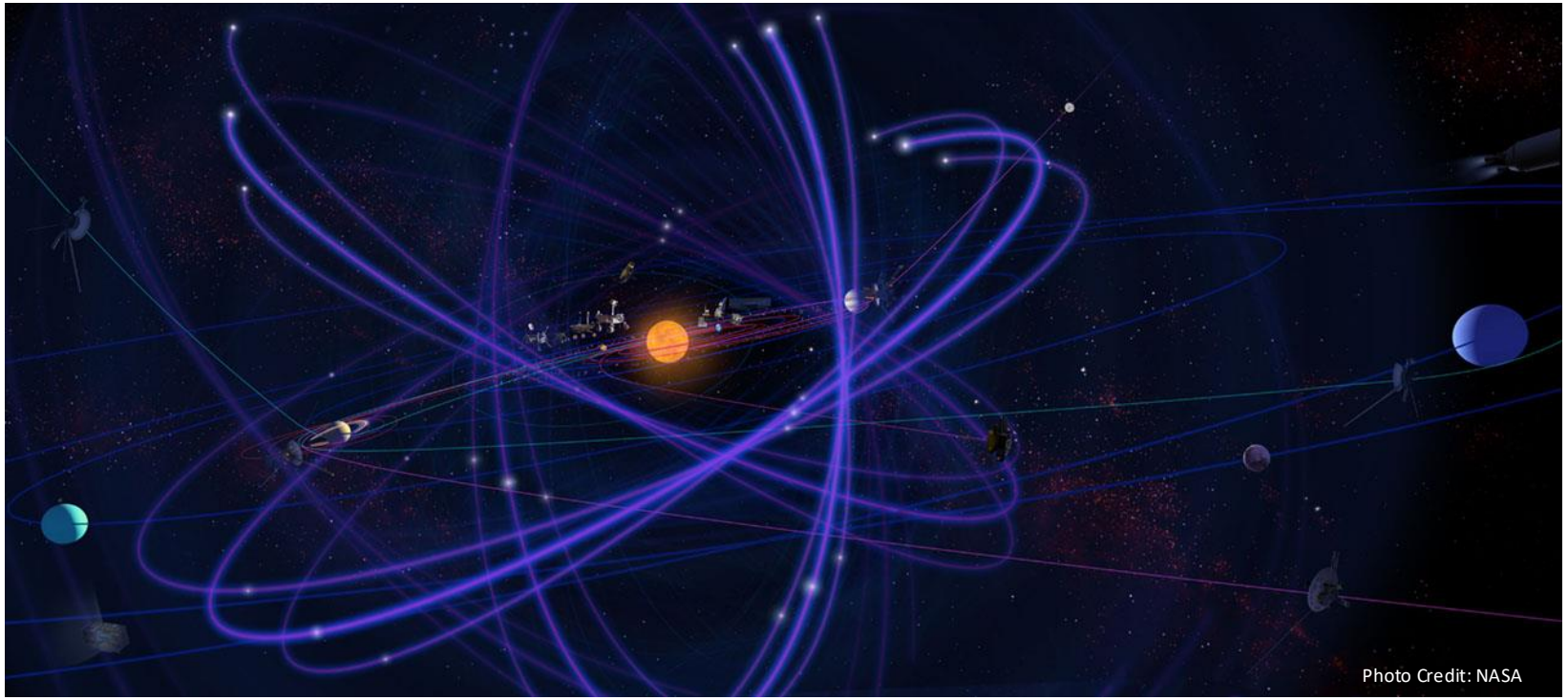


Photo Credit: NASA

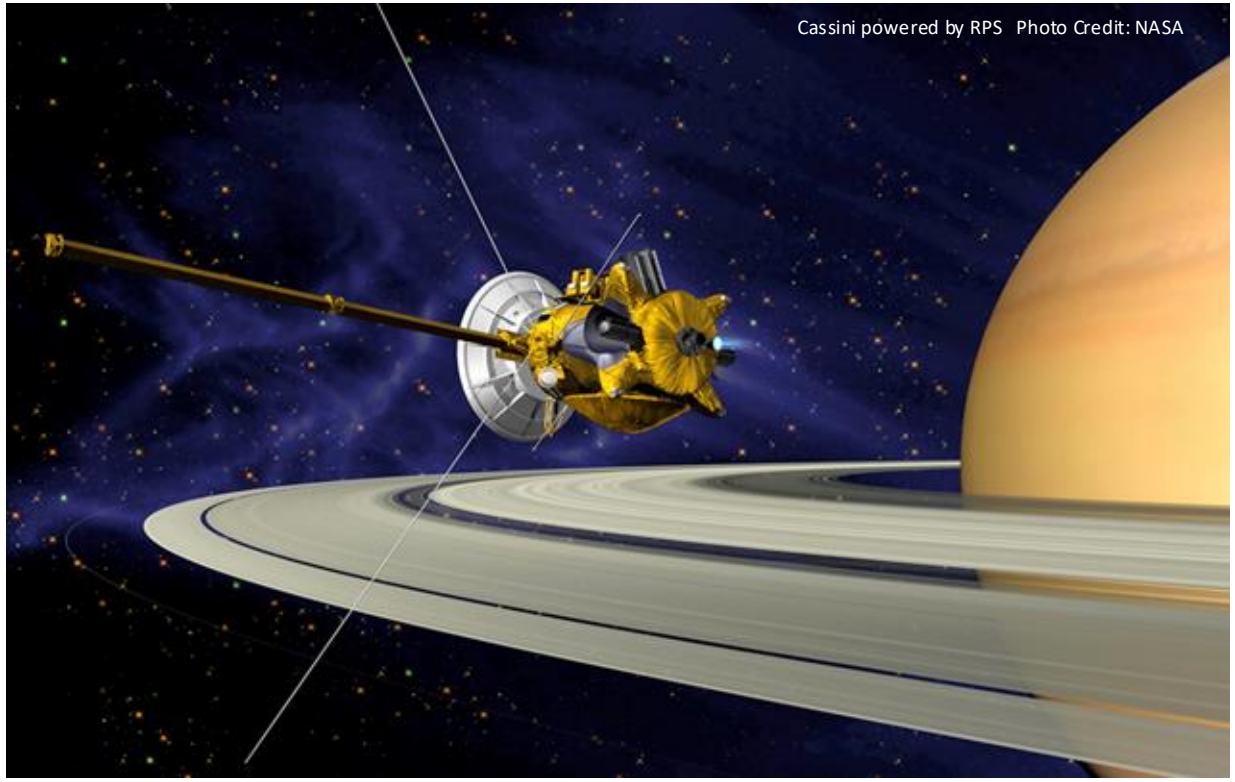
Solar Energy vs. Nuclear Energy

Solar energy (energy from the sun) can be used if there is enough sunlight to power solar panels.

In dark, dusty conditions, **nuclear energy** (energy released from the nucleus of an atom) is the best option for providing continual power.

On **the Moon**, nuclear power systems will work during long lunar nights, in permanently dark craters with water ice, and in dusty conditions.

Yes, solar energy can be used on the Moon in areas of constant sunlight, but for this challenge, we are focused solely on nuclear energy.

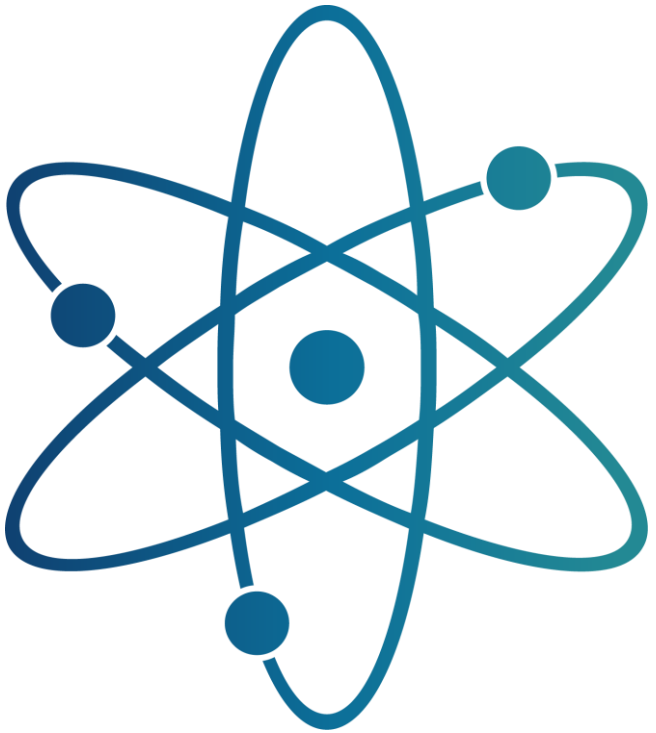

Cassini powered by RPS Photo Credit: NASA

What are Nuclear Power Systems?

NASA uses nuclear energy in areas where solar energy is absent, limited, or impractical. Nuclear energy can be used to generate electrical **power**, provide useful **heat**, or both. Nuclear power systems are always “ON” and don’t need to be recharged.

A **Radioisotope Power System (RPS)** is a small but mighty type of nuclear technology that relies on the natural heat of plutonium-238. RPS technologies include Multi-Mission Radioisotope Thermoelectric Generators (MMRTGs) and Radioisotope Heater Units (RHUs).

Fission power systems generate plentiful energy on demand through the collision of neutrons and uranium atoms that produce a controlled chain reaction to create heat that is converted into electricity.



POWER TO EXPLORE

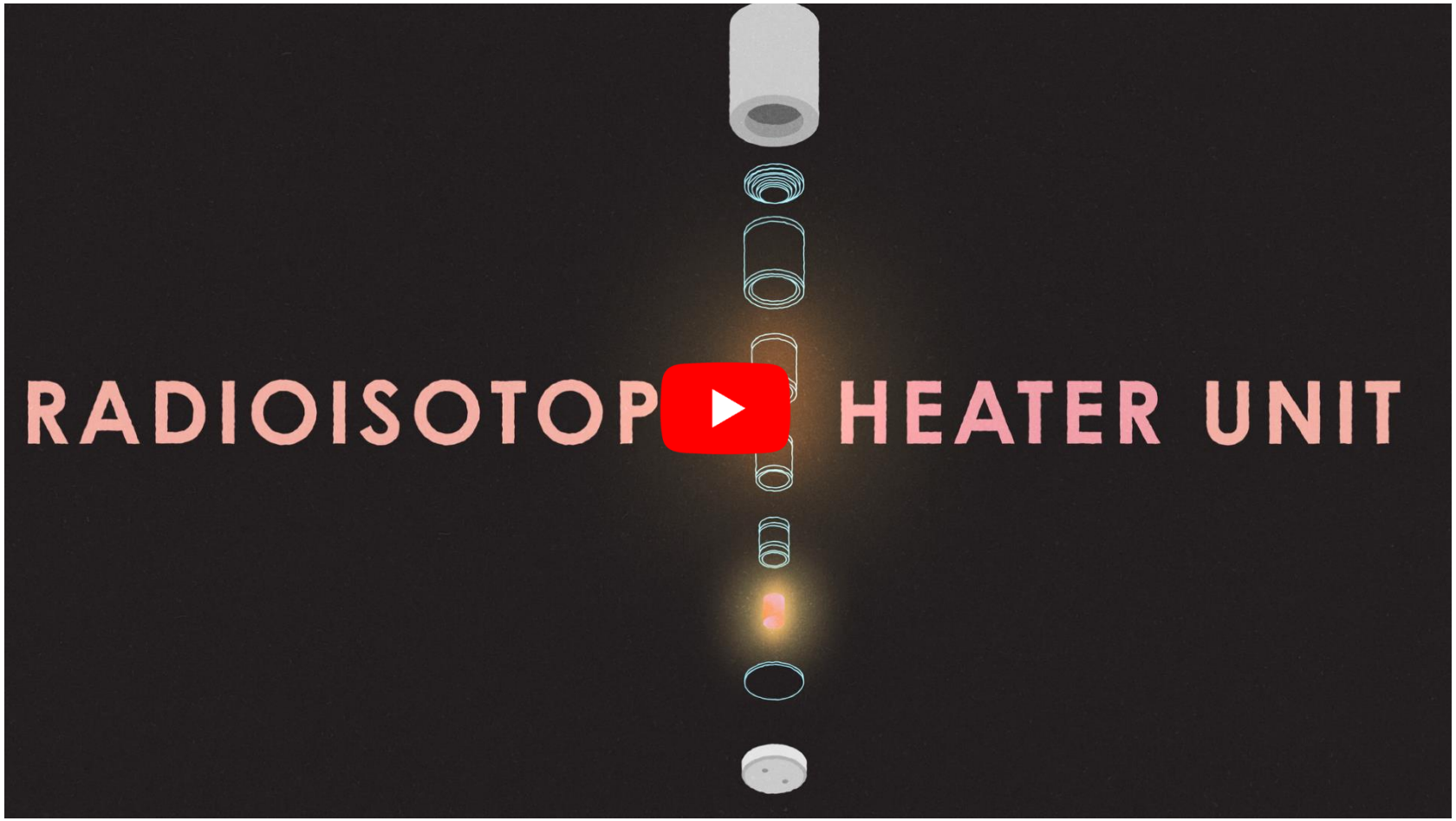
MMRTGs

A Multi-Mission Radioisotope Thermoelectric Generator, or MMRTG, generates small amounts of electricity. It is the perfect, ultra-reliable power system for remote observation equipment or robotic explorers and is currently used to power the Mars Curiosity and Perseverance rovers.



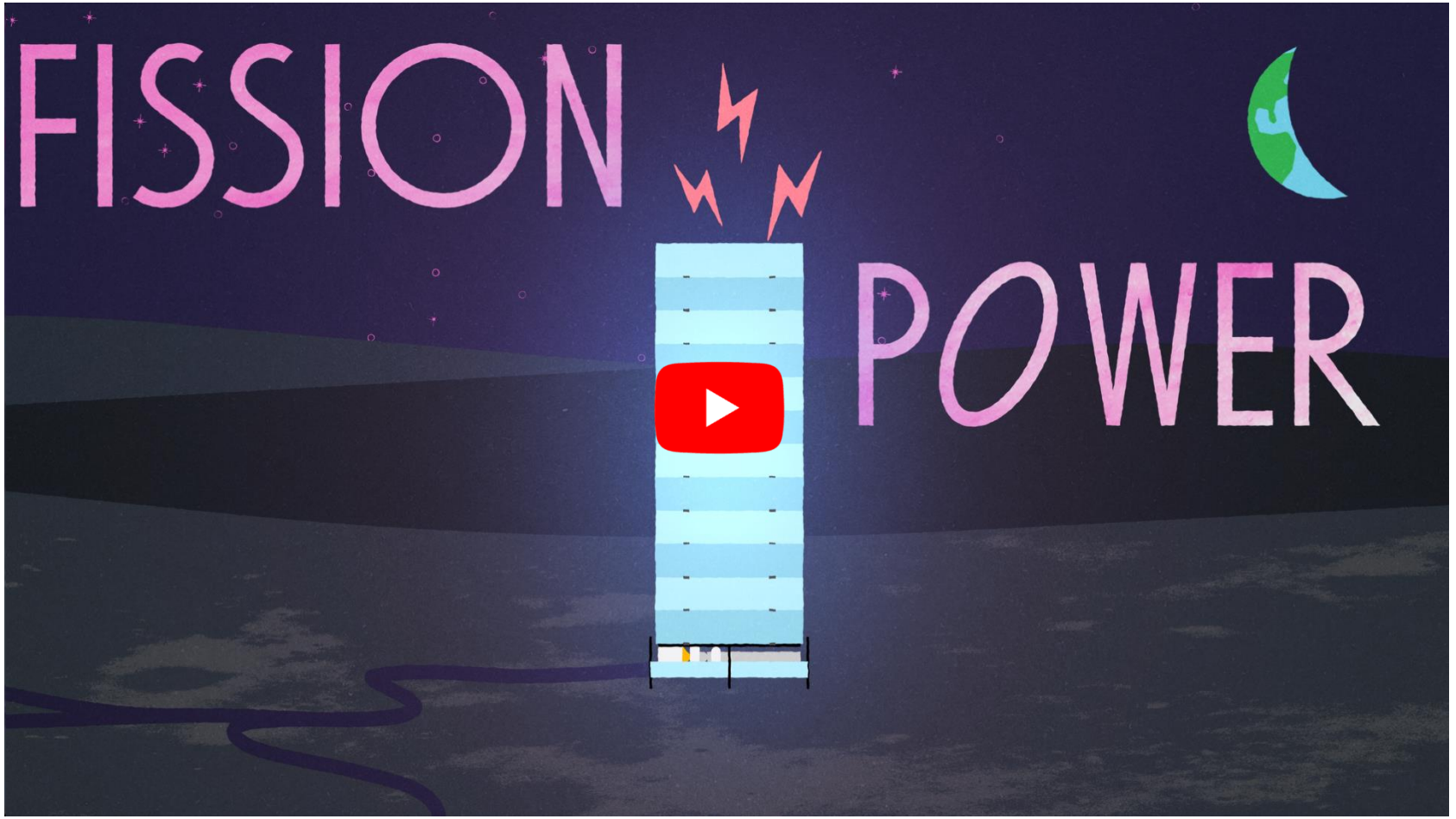
RHUs

A Radioisotope Heater Unit (RHU) generates heat. It won't provide electricity, but it will help space technologies that need to stay warm or survive cold lunar nights.



Fission Power

Fission power systems will generate great amounts of energy by converting heat to electricity. Large fission systems on Earth can power entire cities, but what could these smaller reactors power on the Moon? This technology would make an ideal, robust energy source for living, working, and building things on the Moon.



Section 4: Digital Scavenger Hunt

Welcome to the Digital Scavenger Hunt. It is time to use your internet sleuthing skills to track down answers to questions about the Moon and nuclear power systems.

You will need the “Digital Scavenger Hunt” worksheet and access to the internet!

Digital Scavenger Hunt Procedure

At the beginning of each section, you'll find a QR code. These QR codes can be clicked or scanned and lead to NASA website pages, where you'll find the answers to the questions in that section. The only section that does not contain a link is the **bonus question**.



POWER TO EXPLORE CHALLENGE

SCIENCE LESSON

DIGITAL SCAVENGER HUNT

It takes a special kind of power to explore the extremes of our solar system, and NASA wants to hear how it would energize your lunar exploration dreams! But before you plan your nuclear-powered lunar base, you need to know about where you're going (the Moon), and what RPS and fission power systems can do. Follow the trail and pick up all the know-how you need on this scavenger hunt to help you design a mission that will explore far beyond our own planet Earth. The hunt is on!

FOR THE CLASSROOM
POSSIBLE APPROACH FOR THE CLASSROOM

LESSON LENGTH
60-90 MINUTES

OBJECTIVE
LEARN ABOUT NUCLEAR POWER

MATERIALS
SEE BELOW

VOCABULARY:

- Lunar
- Lunar South Pole
- Lunar Regolith
- Apollo
- Artemis
- Nuclear energy
- Plutonium 238
- RPS
- RHU
- MMRTG
- Fission power systems
- Uranium

MATERIALS

- Power to Explore Challenge Slide Deck
- Digital Scavenger Hunt Work-sheet
- Device with Internet Access

PROCEDURE

In this lesson your students will participate in a digital scavenger hunt to help them learn about the Moon and nuclear power systems to complete the Power to Explore Challenge.

Download **Power to Explore Slide Deck**. This slide deck is intended to give students an overview of the challenge, the Moon, radioisotope power systems (RPS) and fission power systems. It will review the challenge details and why these systems are useful to dream up a Moon base. Feel free to customize it to suit your teaching needs.

The slide deck is divided into four sections.

1. Power to Explore Challenge
2. The Moon
3. Nuclear Power Systems (RPS and Fission)
4. Learn About Nuclear Power Scavenger Hunt

email: support@futureengineers.org/ web: https://nasa.gov/power-to-explore

Digital Scavenger Hunt Checklist

- ✓ Do you have your worksheet?
- ✓ Do you have a device with internet access?
- ✓ Got something to fill in the answers?

Then you are ready; the hunt is on! Good luck, and remember, everything you discover can help you come up with your challenge entry.

Congratulations! You've completed the scavenger hunt; now you're ready to brainstorm your entry ideas. Remember that you will need to include:

YOUR ILLUSTRATION: Learn how nuclear energy can be used in lunar exploration and illustrate your vision of a nuclear-powered lunar base that supports human and robotic exploration of the Moon's surface. Showcase the following nuclear power sources within your illustration:

- Radioisotope power systems (RPS)
  - **Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)**
  - **Radioisotope Heater Unit (RHU)**
- Space Reactor Systems
  - **Fission power systems**

YOUR WRITTEN SUBMISSION: We want to hear what powers you! Using 200 words or less, describe at least one personal superpower that could help NASA explore the Moon with nuclear power.

Go to the BRAINSTORMING section next to develop your entry idea.



Section 5: Brainstorm Your Entry

Now that we know about the challenge, the Moon, and nuclear power systems, let’s dive into challenge details and brainstorm your entry!

Brainstorming: Your Illustration

Let's think about some different possibilities for your nuclear-powered lunar base!

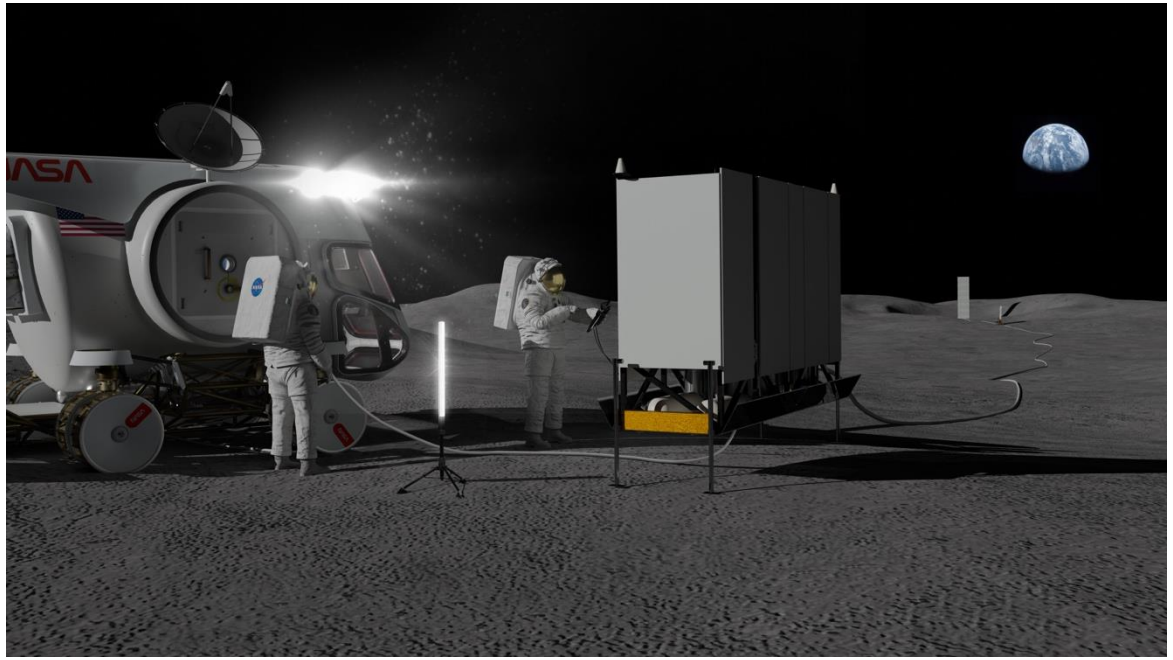


Photo Credit: NASA

Moon Base Habitat Systems

Astronauts will need a habitat on their Moon base that provides basic life support systems – including air to breathe, food to eat, water to drink, and a toilet to use. But there is also important work to do! What structures do astronauts need to live, work, and conduct important research on the Moon's surface? Just like a home or office here on Earth, these habitats will need a lot of continuous power! Think big power. Think fission power!

Lunar Science: Robotic Rovers & Scientific Explorers

Uncrewed lunar terrain vehicles, rovers, and propulsive drones can travel to distant locations and dark craters. There is so much to learn and discover on the Moon - from mapping lunar terrain to searching for lunar ice. Where will these rovers and explorers go? What will they explore? What kinds of scientific investigations will they conduct? With MMRTG power, you can dream up robotic explorers that can go out and explore for days, months, or even years on end.

Crew Lunar Mobility: Space Walks and Crewed Rovers

Astronauts will need to conduct spacewalks and drive vehicles around their Moon base. And they'll need reliable energy to do it! How will they recharge their vehicles or their spacesuits? Fission reactors can support charging stations for larger power needs, while MMRTGs can provide portable power that can go long and far.



Lunar Science: Stationary Science

Sometimes science needs to travel, and sometimes science can stay put. What standalone scientific instruments can be deployed to further understand the Moon? From monitoring moonquakes to placing sensors or cameras at specific locations to collect data - big knowledge can be collected in small packages, so long as it stays powered, toasty and warm!



Lunar Resource Utilization

Lunar regolith (lunar soil) might look dull and gray, but it's full of uses! It can be mixed with cement to make buildings. And don't forget the water ice! Ice can be harvested to make drinkable water or even separated out into hydrogen and oxygen to make rocket fuel. What heavy-duty machinery will you have on your Moon base that digs, mines, or harvests resources to build what astronauts need to live and work on the Moon? Big equipment takes big fission power, but there is plenty of small equipment that needs portable RPS power and heat, too.



Communications: Antennas and Receivers

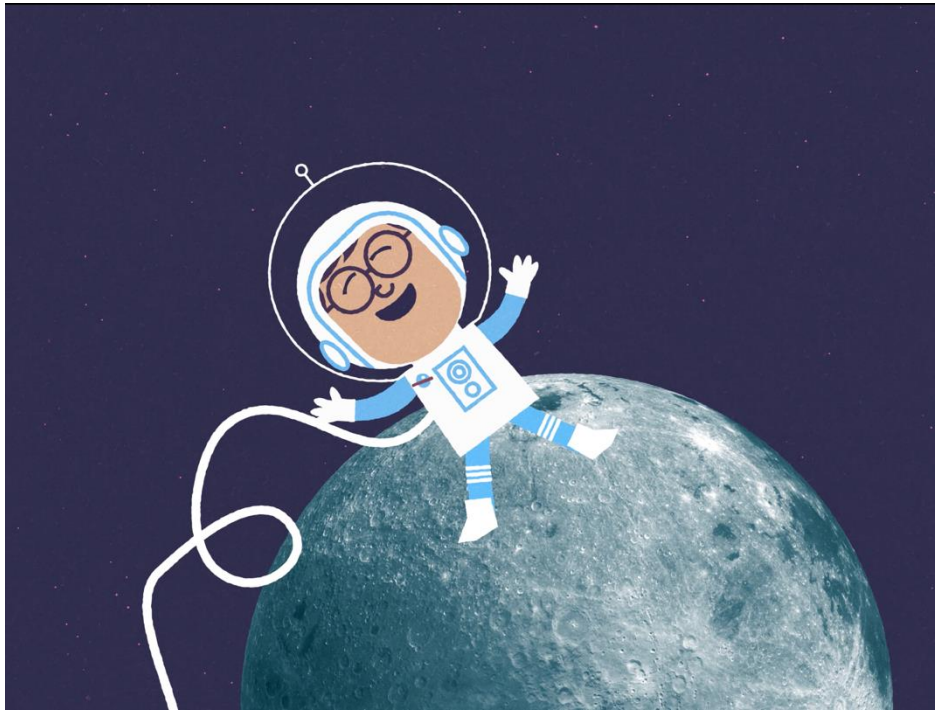
Sending and receiving information is a must-have in space! Astronauts need to talk with each other on the Moon's surface, talk with mission control back on Earth, and talk with their family back home. And don't forget that robots need to communicate, too! How does all that information get sent back and forth – from Moon to Earth? What communications equipment will be on your Moon base? What nuclear power will your communications equipment need?

Innovate Your Own

Have a nuclear-powered Moon base idea that doesn't fit into the categories above? No problem! Feel free to dream up anything you want; the possibilities are endless. How will radioisotope power systems and fission power systems help enable human exploration at your Moon base?

Brainstorming: Your Personal Power

We want to hear what powers you! Whether you are an astronaut on the Moon one day, or whether you use your powers here on Earth, it takes a team of many different skills and personality traits to explore! Let's brainstorm at least one of your personal superpowers that could help NASA explore the Moon.



Your Personal Power: Skills

Think about your Moon base, and what skills will be needed to support it. Not all missions work exactly as planned. What skills can you bring to the table when faced with new challenges? Whether it is the ability to solve a problem, code a program for a microcontroller, communicate effectively, or some other skill, think about how you would contribute to exploring the Moon.

Your Personal Power: Traits

Just like nuclear power has qualities that make it well-suited for space exploration, YOU also have unique personality traits that make you well-suited for exploration. Are you determined, brave, positive, or ambitious? Are you adaptable, resilient, or stable under pressure? Think about the personality traits you have that would make your lunar dreams come true.

Your Personal Power: You Pick!

If your power doesn't fit into the categories above, no problem! Choose any personal strength unique to you that will help you achieve success.

Ready to Submit Your Entry?

- Register and submit by March 1, 2027 | 11:59 PM ET/ 8:59 PM PT
  https://www.futureengineers.org/powertoexplore

- Have questions? Contact Future Engineers at: support@futureengineers.org