



# Launchpad STEM Group

Science, Technology, Engineering, Math

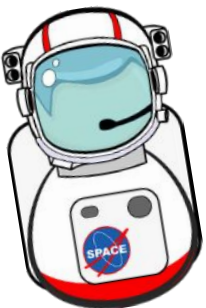
Mission to  
Moon

Middle School

Name:

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## Launchpad Oath & Rules



I promise to

1. Try my best
2. Believe in myself
3. Stay safe
4. Respect others and myself

Our class rules:





# Meet the Crew

1



*Congratulations!* You have been selected by NASA as the newest member of the United States **astronaut** class to embark on a mission to the Moon! Your team was selected from over 18,000 applicants.

My name is astronaut Alex, and I am your commander for this exciting journey! Some background on our mission: NASA plans to build a habitat on the Moon for humans to live and work. But first, they need to learn as much as possible about living there. Our mission is to explore the Moon, build a small base, and collect samples to be tested at NASA. Throughout our missions, **STEM** professionals will help our crew as we travel and explore the Moon.

Being an astronaut is a dangerous job, and **teamwork** is the only way to survive. Before we depart for the Moon, let's get to know each other and learn to work together! ~Astronaut Alex



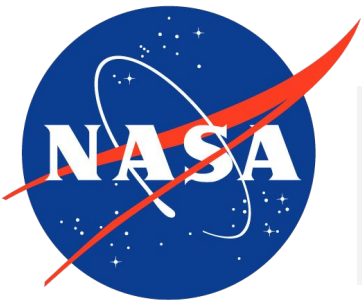
## Career Connection

**Astronauts** explore deep space, perform spacewalks, and conduct experiments in zero gravity. All astronauts have at least a bachelor's degree in a STEM field which includes science, engineering, or math. Many also speak different languages!

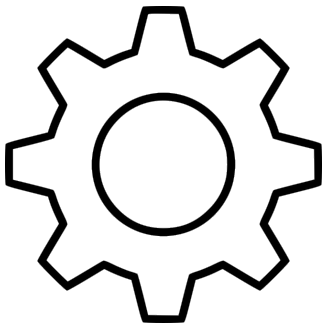


NASA Astronaut Class of 2017

**NASA News:** What exactly is NASA? NASA or the National Aeronautics and Space Administration is part of the United States federal government and is responsible for the civilian space program. For more than 50 years, NASA has led the way in space exploration from humans walking on the Moon to robots exploring Mars. These adventures in space are possible because of the over 18,000 people who work at NASA facilities across the country!



**Mission Warm-up:** What do you think having a STEM career would be like?



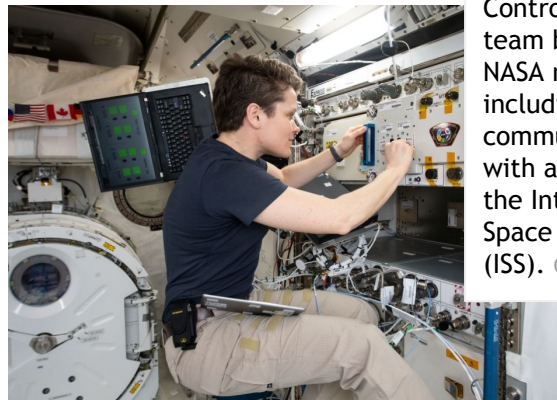


**Mission:** Learn to work as a team.

### Teamwork Rules

1. Always be kind
2. Communicate clearly
3. Respect others' opinions

**Mission Log:** What other rules are important in teamwork?



NASA's Mission Control is the team behind every NASA mission including communicating with astronauts on the International Space Station (ISS). Credit: NASA

## Teamwork



Mission Control during Apollo 11 with Director Gene Kranz. Credit: NASA

### Apollo 13: How teamwork prevented tragedy

Launched in 1970, Apollo 13 was to be the third lunar landing. 56 hours into flight, when the astronauts were 200,000 miles away from Earth, the mission was aborted after an oxygen tank exploded. The three astronauts along with support from Mission Control had to work quickly as a team to survive the mission and come back home!


The explosion caused a loss of electricity and water on board the spacecraft. Another huge problem was the buildup of carbon dioxide that would kill astronauts unless a filter could be replaced. Unfortunately, the filters on the spacecraft were the wrong shape and size. To solve the problem, Mission Control designed a new filter using available materials on the spacecraft including plastic bags, cardboard, and tape. Working as a team saved the astronauts' lives!

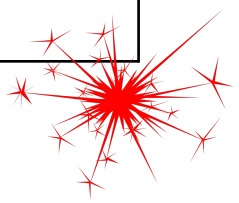


**Mission: Find your spark.**

1. Complete the Spark Quiz below.
2. Look over your answers. What stands out to you?
3. Select *one* to be your spark!

A **spark** is something you are passionate about, makes you excited, and is unique to you! Sparks can be something you like to do or an interest you have.

Find Your Spark Quiz	
What are 3 of your greatest strengths? 	1. _____ 2. _____ 3. _____
My favorite things to do in my free time are:	1. _____ 2. _____ 3. _____
What is your dream job?	
<b>My spark is:</b>	



Space can be lonely, and astronauts need ways to stay entertained! These are photos of astronauts using their sparks on the International Space Station. Credit: NASA



## Mission Patch

**Mission:** Create your personal mission patch.

**Mission patch includes:**

1. Your name
2. Name of spark
3. Visual representation of your spark



1

**NASA Mission Patches:** Have you ever noticed the mission patches on an astronaut's space suit? Every time NASA sends a crew of astronauts into space, they work with a graphic designer to create a mission patch to represent their team. The patch includes important parts of the mission and of the crew's lives.

**Expedition 43:** The mission patch above and worn by Astronaut Scott Kelly represents the start of a one-year mission on the International Space Station. The hexagonal shape represents the six crew members involved. The moon and planets represent future space exploration. The five stars honor the crews who have lost their lives in pursuit of human spaceflight.

**Artemis Program - Return to the Moon:** The program is named Artemis after the Greek Goddess of the Moon and the twin sister of Apollo. This represents NASA efforts to return humans to the Moon and then to Mars. Through the Artemis program, we will see the first woman and the next man walk on the surface of the Moon. The image to the right is the logo for the mission that is symbolic like a mission patch. What do you think each of the symbols represent?



## Reflection

**Mission Reflection:** List the sparks of the other members of your crew.



Great work today learning how to communicate as a team! I have enjoyed getting to know each of you, and I am excited for us to start our journey to the Moon! Next time, you will need to complete additional astronaut training including learning more about our destination. What do you already know about the Moon? What do you think we should pack for our journey? ~Astronaut Alex

# Astronaut Training

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Welcome back to Launchpad! Today, we continue our astronaut training to prepare for launch. As astronauts, we must learn everything about our destination. Going to the Moon is kind of like a camping trip, but your house is 238,000 miles away. And your campsite has no oxygen, food, or water...

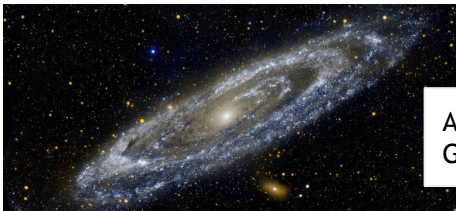
To learn about the Moon, we will get some help from astronomers. An **astronomer** is a type of scientist. **Scientists** study the world around us and make observations. Science is all about trying to answer questions. *Why is the sky blue? How do hurricanes form?* **Astronomers** ask questions about the universe. *What are the stars in the night sky? Why does the Moon appear red sometimes?*

Are you ready to complete your astronaut training? Besides learning about the Moon, we will also focus on **communication**. We have to be able to share ideas and work as a team to survive this mission! ~Astronaut Alex



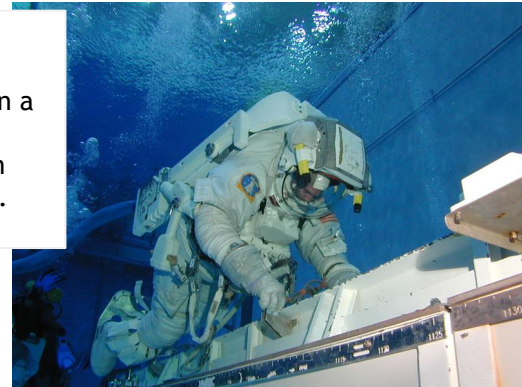
## Career Connection

**Astronomers** think big! They want to understand the makings of the universe from the sun to the galaxies and everything in between.



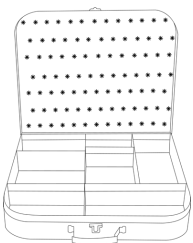
Andromeda Galaxy.

An astronaut training for space walks in a large pool at NASA Johnson Space Center.  
Credit: NASA



**NASA News:** Most of astronaut training takes place at NASA Johnson Space Center in Houston, TX. Astronaut candidates are trained on how to operate spacecraft systems and what to do in an emergency. They also learn about different cultures and languages since many of their crew members are likely to be from countries all over the world. NASA also has the largest pool in the world called the Neutral Buoyancy Lab (NBL) to help astronauts practice working in space. Floating underwater is similar to floating in space!

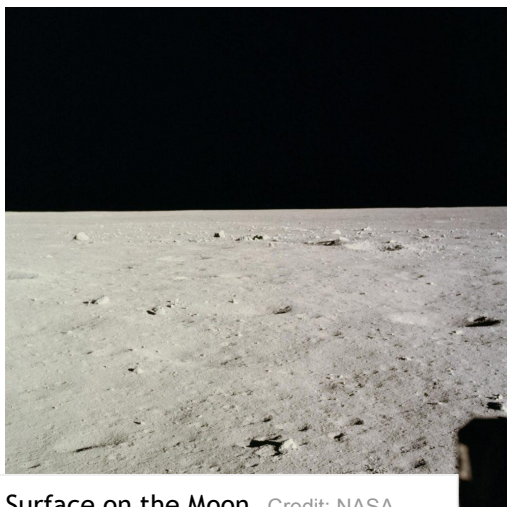
**Mission Warm-up:** Scientists study how the world works. They ask questions like what is the surface of the Moon made of. What other questions should scientists study to help us pack for our trip to the Moon?





Mission: Learn about the Moon

1. Complete the Moon - Earth matching game.
2. Complete the Moon Facts chart.
3. Think about: what are the challenges of living on the Moon? How will you survive?
4. Complete the bottom table. First describe how we get each item (oxygen, water, etc.) on Earth. Then describe what challenges we will face to get these on the Moon.



Surface on the Moon. Credit: NASA

Moon Facts	
Temperature Range	
Length of Day	
Atmosphere	
Gravity compared to Earth	

	How do we get this on Earth?	What challenges will we have on the Moon?
Oxygen		
Water		
Food		
Power		
Communication		





Mission: Answer the following mental challenges to complete your astronaut training.

Astronaut Tim Peake has shared some of the challenges he had to answer during the European Space Agency's selection process. The following are similar challenges designed to test your critical thinking skills.

1. The Moon's diameter is 3,476 km at the equator. About how long would it take to drive that distance at 80 km per hour?

(a) 43 hrs (b) 278,080 hrs (c) 434 hrs

2. What number should be on the last satellite assuming they are in order?

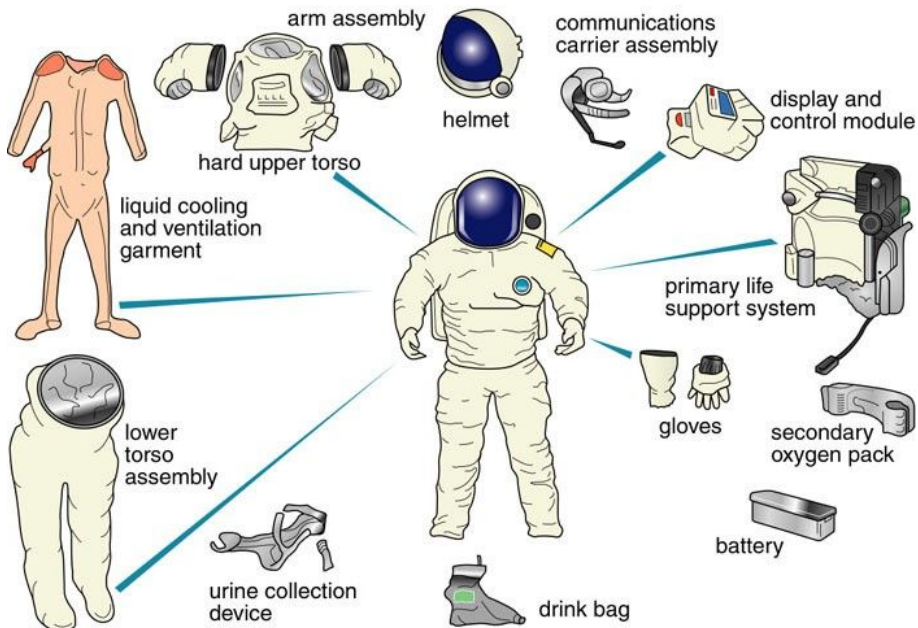
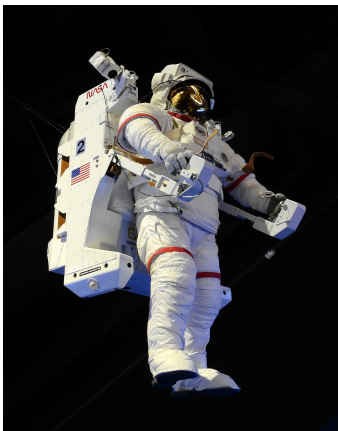
3. What combination of shapes should fill the missing square in the grid below?


a)

b)

c)

What do we bring to survive on the Moon? Spacesuits keep astronauts warm, protect them from radiation, and provide oxygen for breathing. Circle any items on the right that you want to learn more about. Credit: [Medium](#)





We packed our bags, but now we need to move them to the launchpad! Work as a team to create a track to quickly move supplies. Remember that sharing ideas and listening to your team is important to complete the challenge. Astronauts must communicate well to be successful!



### Team Challenge

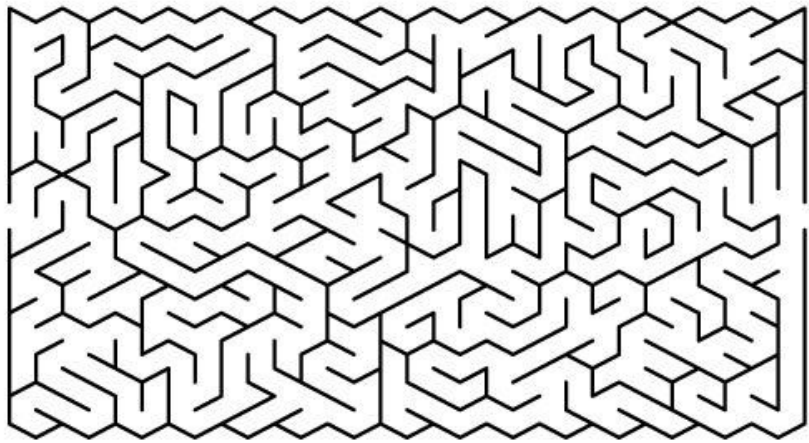
**Mission:** Move supplies to the launchpad.

#### Design Rules

1. 1 paper per person
2. Ball must stay in motion at all times
3. Ball lands in cup

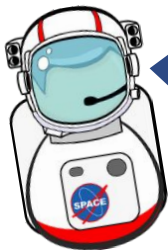


Keeping your brain sharp and focused is important when becoming an astronaut. Can you solve this maze and take the supplies to the rocket?



### Reflection

**Mission Reflection:** Think about what you learned about the Moon. What would you pack?



Congratulations - you have successfully completed astronaut training at NASA Johnson Space Center! You learned important information about the Moon, moved our supplies to the launchpad, and practiced working as a team and communicating. Next time, we build a rocket and embark on a journey of a lifetime! See you soon. *-Astronaut Alex*

# Getting to the Moon

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Astronauts, report for duty! NASA has decided our team is ready to launch to the Moon. But how will we get there? The Moon is an average of 238,900 miles away.

Last time, we learned about scientists. Today, you will learn about a different kind of STEM career: **engineering**. Engineers are problem solvers. They use math and science to design a solution to a problem. Today, our problem is that we need a rocket to get us to the Moon. We need the help of **aerospace engineers** to design our rocket. How will you power the rocket? What is the best shape for a rocket? This mission requires **critical thinking** to succeed. Remember before you start building, take the time to think carefully and plan your design. Best of luck! -Astronaut Alex



## Career Connection

**Aerospace engineers** design things that fly in the air and outer space. This of course includes rockets that fly to other planets! Here on Earth, aerospace engineers design helicopters, quadcopters, and airplanes. Did you hear about the drone that can deliver pizza?!



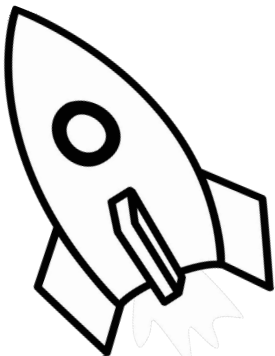
Quadcopter used for surveillance.



NASA SLS Rocket

**NASA News:** NASA is working on the world's most powerful rocket. This rocket is called the Space Launch System (SLS). The SLS will help humans get to Mars and even asteroids. The rocket's engines produces 9.2 million pounds of thrust. That is the same as 208,000 car engines!

**Mission Warm-up:** Engineers solve problems by designing things that make our lives easier, healthier, and happier. What do you want to design to make your life better?





## Science Background

Forces of Flight: Fill in the blanks with the name of each force acting on the rocket. Draw an arrow in the box showing the direction of the force.

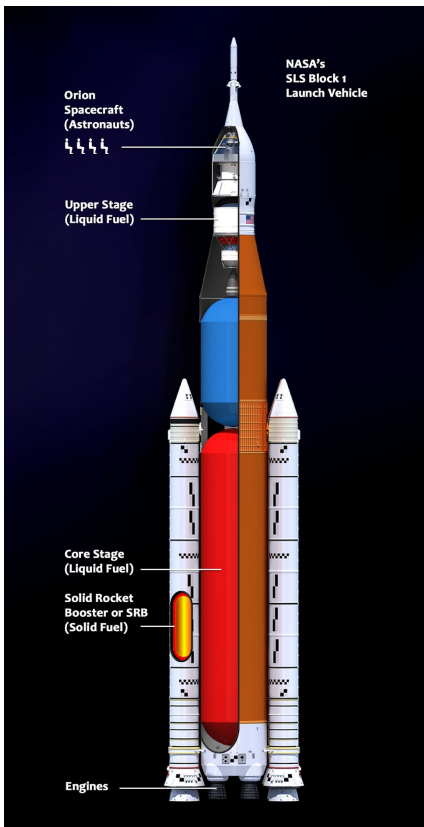
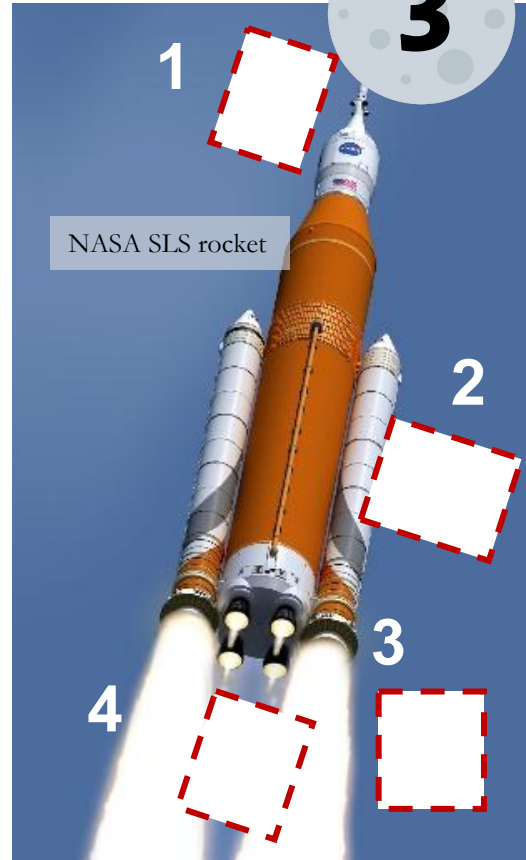
Force 1: \_\_\_\_\_ force is slowing the rocket down because of the friction from the air.

Force 2: \_\_\_\_\_ force is determined by the shape of the body and fins to stabilize and control direction of flight.

Force 3: \_\_\_\_\_ is a constant force pulling objects towards Earth.

Force 4: \_\_\_\_\_ force is created through a chemical reaction that expels gases and pushes rocket upward.

Word Bank: thrust, drag, lift, gravity



# Space Launch System

The Space Launch System (SLS) is the most powerful rocket ever built by NASA. This rocket will carry astronauts and supplies to the Moon and beyond!

The SLS can be used to send robotic explorers to the Moon, Mars, Saturn, and Jupiter. The SLS rocket will also be able to send a full astronaut team and equipment for the crew to stay and live on the Moon in the Orion spacecraft. NASA's Orion will carry astronauts on top of the SLS to connect to the Lunar Gateway orbiting the Moon. Orion will be the living quarters for astronauts during the long journey to the Moon and bring them safely back to Earth.

The largest configuration of the SLS rocket will have 11.9 million pounds of thrust and contain a payload volume of 34,910 ft<sup>3</sup>. The Saturn V rocket that took the Apollo astronauts to the Moon had 7.6 million pounds of thrust.



## Straw Rocket Challenge

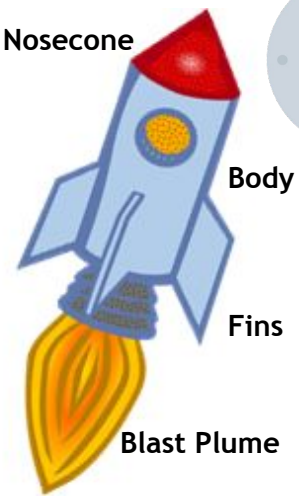
**Mission:** Launch a rocket the farthest distance.

### Design Rules

1. Rocket must have *at least 2* fins
2. Rocket must use a **small** piece of clay for the nose cone.
3. **Do not** block the blast plume end of the rocket straw.

**Mission Background:** Variables are things you change in an experiment such as the number of fins on the rocket. List all the variables you can change on the rocket.

Nosecone



3



SpaceX is a company that builds and launches rockets!



## Brainstorming

How will you use provided materials to build a rocket to travel the farthest?  
Brainstorm ideas for different designs.

*Draw and label a rocket design before testing.*

Rocket Part	Design
Number of fins	
Shape of fins	
Size of nose cone	
Length of Straw	

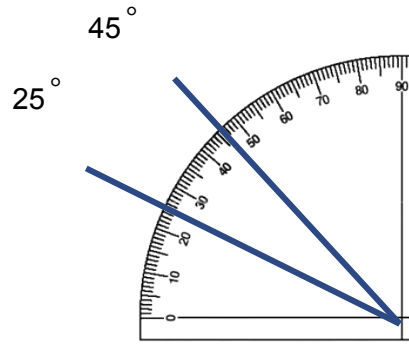


## Build & Test



### Variable Testing: Launch Angle

1. Get your rocket ready for launch!
2. Test your rocket at 25 and 45 degrees. Record the distance. Not using the Pitsco launcher? Approximate the angle using a protractor and rotating your head.
3. Select your own angle. Draw on the protractor. Record the distance.
4. Circle the angle with the longest distance.
5. Now time to **optimize** your rocket! Start changing other variables on the rocket to make it travel farther!



Angle	Distance Traveled
25°	
45°	

Farthest Distance Traveled: \_\_\_\_\_

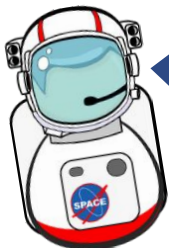


## Reflection

**Mission Reflection:** Look at the rocket design that went the farthest (including other student designs). Why did this rocket go the farthest? Describe the different variables involved.

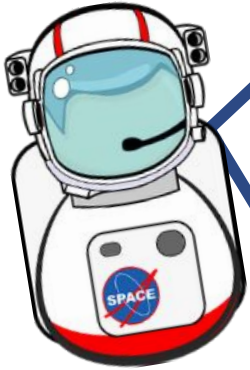
Great job aerospace engineers; NASA approved our rocket for lift off!

All astronauts are aboard the rocket, and in 3 days we arrive at the Moon! Pack lightly because we need plenty of space for fuel, food, air, and water. Are you excited to go to the Moon? What do you think it will be like going to outer space?  
-Astronaut Alex



# Powering Life on the Moon

4



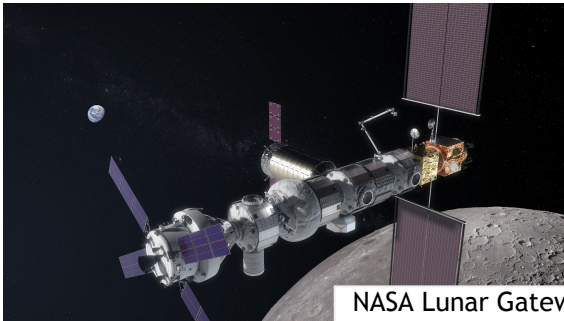
Welcome to the Moon! Don't waste too much time jumping around (you can jump 6 times higher than on Earth due to lower gravity!) because NASA just radioed our next mission.

Today, you will become **mechanical engineers** on a mission to design a welcome tower. Our tower will help us get back to base when we go out exploring. On the Moon, a day is 29.5 Earth days long. This means we will have 2 weeks of sunlight followed by 2 weeks of continuous darkness. So our tower needs to have a light!

How will we power our tower light? We need to find a source of energy that is renewable so we don't rely on bringing fuel from Earth. This mission requires **initiative** and confidence in your abilities. You can always ask for help when you get stuck, but never be afraid to try it yourself first! ~Astronaut Alex



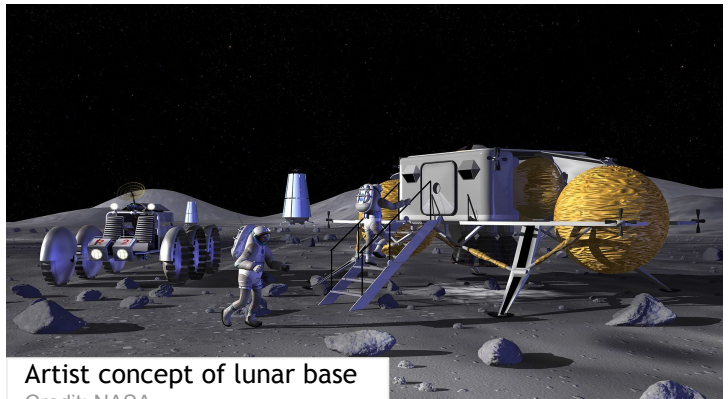
## Career Connection



NASA Lunar Gateway  
Credit: NASA

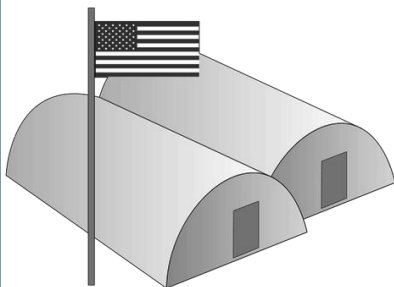
**NASA News:** NASA's first step to the Moon is the Lunar Gateway. The Gateway is a small spaceship that will orbit the Moon. It will have living quarters, research labs, and a lander to get astronauts to and from the lunar surface. The Gateway is a smaller version of the International Space Station and will use solar energy for power.

**Mechanical Engineers** are the most general kind of engineering and almost every object in your life has passed through a mechanical engineer! From your chair to your phone, a zipper on your jacket to the school bus, mechanical engineers help design and test objects we use. Mechanical engineers will be critical in designing rovers, habitats, and equipment needed on a lunar base.



Artist concept of lunar base  
Credit: NASA

**Mission Warm-up:** What should we call our lunar base?



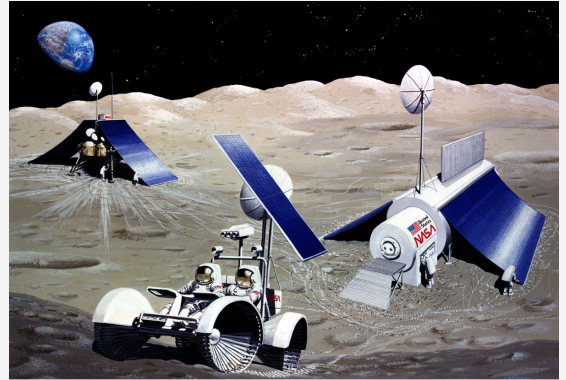


Under each type of power source, check the box if the statement is positive.

# Solar Panel

**How does it work?** Converts sunlight into electricity

- A night on the Moon is about 14 days long - a real challenge to using solar energy
- Moon's polar sites have longer periods of sunlight
- Environmentally friendly
- You can build multiple solar panels so one is always in daylight
- Moon has "peaks of eternal light" or places that almost always see sunlight.
- You can place solar panels in orbit and beam the power down as microwave rays

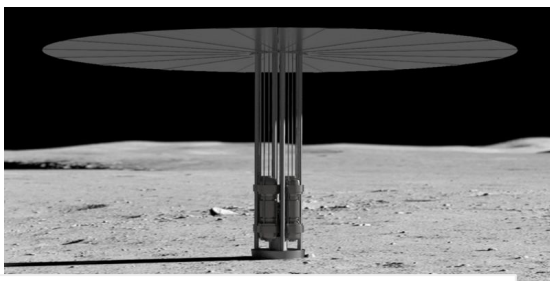


Artist depiction of a lunar base with solar panels. Credit: NASA

# Nuclear Power

**How does it work?** Harness the energy from splitting atoms to generate electricity.

- Fission system is compact, reliable, safe system
- Does not rely on sunlight
- Technology is still under development
- Need specialized skills to fix
- Nuclear accident is possible



Kilopower mini-nuclear power system being developed by NASA. Credit: NASA

# Fuel Cell

**How does it work?** Combines hydrogen from a tank and oxygen from the air to produce electricity, leaving water and heat as its only byproducts.

- Hydrogen needed could be sourced locally using the Moon's polar water and surplus solar power.
- Lightweight
- Technology is still under development
- Lower power output so ideal as a backup power



Fuel Cell. Credit: Hydrogenics

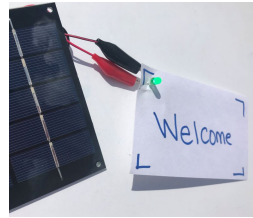
How will you power your lunar base? What are the challenges of this power source?





## Welcome Tower Challenge

Create your welcome sign on an index card. Include the name of your base. Add an LED light that will be powered by the sun.

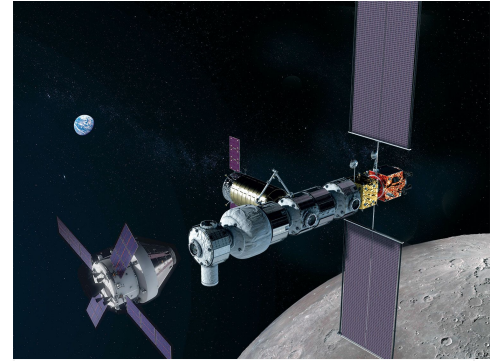


**Mission:** Build a tower to hold your welcome signs.

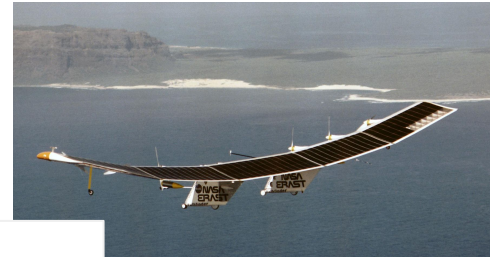
### Design Rules

1. Base is a paper plate.
2. Solar panel and welcome sign must be at least 1 foot (30 cm) in the air.
3. Solar panel must have full exposure to the sun (no blocking by the sign).
4. *Bonus: Make your solar panel rotate to follow the sun.*

**Mission Background:** A solar panel only works if receiving direct sunlight. How will your tower make sure the solar panel is always facing the sun?



NASA solar panels shown on the lunar Gateway. Credit: NASA



Pathfinder, NASA's solar powered airplane. Credit: NASA



## Brainstorm & Design

How will you use provided materials to build a welcome tower powered by the sun? Brainstorm ideas for different designs. Keep in mind that a sturdy base is critical for a strong tower.

*Draw and label a design before building.*



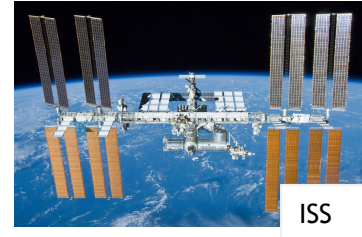
## Build & Test

Test your welcome tower! Place your tower in direct sunlight.

	Tower Stays Upright	Light turns on	Height of solar panel	Solar panel rotates	What improvements can you make?
1	Yes / No	Yes / No		Yes / No	
2	Yes / No	Yes / No		Yes / No	
3	Yes / No	Yes / No		Yes / No	

### Solar Tower Math:

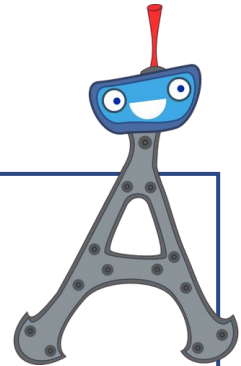
1. What is the height of your tower?
2. What is the surface area of the solar panel?
3. The International Space Station (ISS) is powered by 27,000 square feet (2,500 square meters) of solar arrays. How many of your solar panels would it take to cover the same area?



## Reflection

### Mission Reflection:

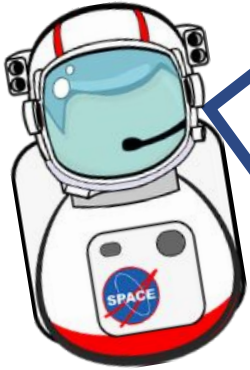
What were the most difficult parts of the welcome tower challenge? Why?



Awesome work being **mechanical engineers**! Your **initiative** paid off, and now we have welcome tower for our base powered by solar energy! Do you feel ready for another engineering challenge? Next time, we setup our base on the Moon. What do you think a home on the Moon would look like? ~Astronaut Alex

# Build a Base on the Moon

5



The crew is getting cramped living inside our Lunar lander. Time to design and build a more comfortable place where we can sleep, eat, and conduct our experiments. This will be our base of operations.

The Moon is a harsh environment with many dangers threatening our survival. Because the Moon has a very thin atmosphere, it leaves us unprotected from ultraviolet radiation and asteroid impacts. Today, you will become **materials scientists** on a mission to design a shelter that will protect our astronaut team. What materials will block the ultraviolet rays? How can your shelter withstand asteroid strikes? This mission puts your **problem solving** skills to the test. Our survival depends on a successful design! ~Astronaut Alex



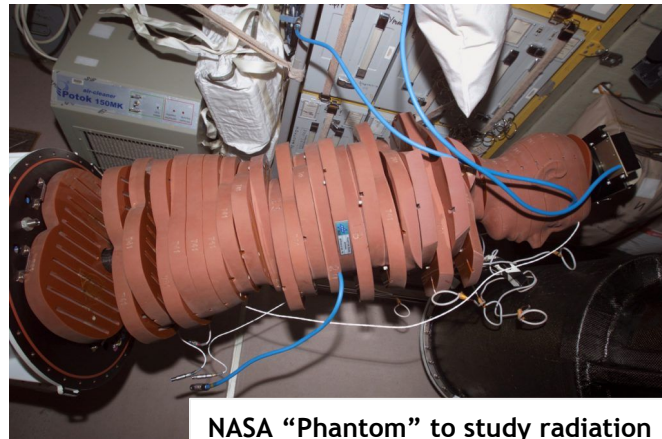
## Career Connection



Wearable Sweat Sensor  
Photo by Wei Gao, UC Berkeley

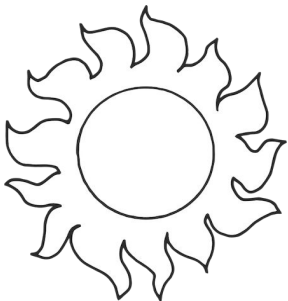
**Material Scientists** study materials such as plastics, metals, and ceramics! Materials scientists determine which materials are the best conductors of energy or the strongest for a building. Did you know that materials scientists have developed wearable skin sensors that use your sweat to monitor your health?

**NASA News:** NASA will be sending two “phantom” dummies equipped with 5600 sensors to study the radiation in space. The phantoms, named Helga and Zohar, will be flown during the Orion spacecraft’s first mission around the Moon. The impact of radiation on the human body can be up to 700 times higher in space than on Earth causing nausea, cataracts, increased risk of cancer, DNA mutations and other health concerns.



NASA “Phantom” to study radiation

**Mission Warm-up:** How do we protect ourselves from ultraviolet (UV) radiation (getting a sunburn) here on Earth?

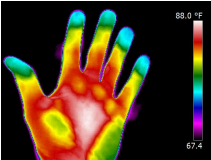






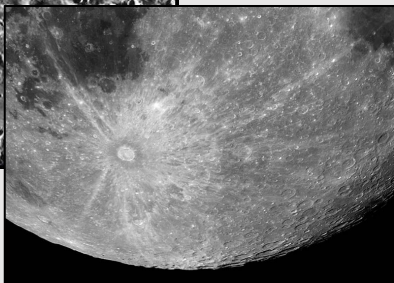
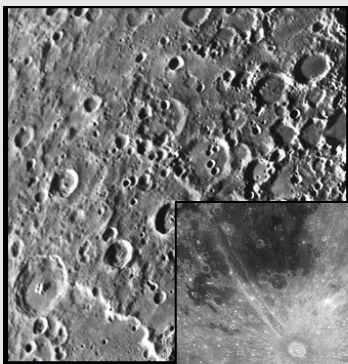
## Science Background

The Sun emits many different types of radiation, but not all of it is harmful! In fact, we need the Sun to stay alive. Complete the table below on three types of radiation from the sun.

**Word Bank:** infrared, ultraviolet, visible light

Type of Radiation	Description	Examples	Is it harmful?
	Causes molecules it touches to vibrate and create heat. We can't see it, but we can feel it as heat!		
	Human eyes are most sensitive to this radiation. We can see it as different colors in a rainbow.		
	Causes sunburns and can damage your skin. The high level of energy can damage human cells and even mutate its genetic code.		

## Asteroid Impact



Have you looked up at the Moon lately? Craters cover the lunar surface and can be seen from Earth with the naked eye. One of the most visible craters is Tycho (shown in the bottom photo). Most craters are impact craters formed when a meteor or asteroid slams into the planetary body.

The Moon has more craters than Earth because of the very thin atmosphere. This leaves the Moon more exposed to asteroids. The impact causes craters and because there is no weather on the Moon, the craters take a long time to erode. On Earth, the atmosphere burns up most space rocks that come our way.



## Safety Shelter Challenge

**Mission:** Build a safety shelter to protect astronauts from UV rays and asteroid impacts.



Astrorad vest.  
Credit: StemRad



### Design Rules

1. Must have four walls and 1 entrance
2. Astronauts stay protected from ultraviolet radiation after 1 minute.
3. Asteroids (rocks) must not make a hole or collapse the structure when dropped from 1 foot (30 cm) above the roof.

Vests like this can block harmful UVs rays to protect astronauts.

**Mission Background:** Which materials block UV radiation? Conduct a science experiment with different materials using a black light and the UV beads. Use table below.

Material	Prediction: Will it block UV rays?	Result: Did beads remain clear?
	Yes / No	Yes / No
	Yes / No	Yes / No
	Yes / No	Yes / No
	Yes / No	Yes / No



## Brainstorm & Design

How will you use provided materials to build a Safety Shelter? Brainstorm ideas for different designs. How will you block UV rays? What materials and what shape will protect against asteroids.

*Draw and label a design before building.*



## Build & Test Test your safety shelter!

5

**Before asteroid testing,** make sure your shelter can pass each test below.

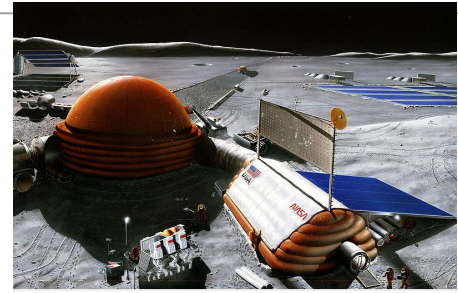
- Shelter has 4 walls and 1 entrance.
- Astronauts stay protected from ultraviolet radiation after 1 minute (stay colorless).

For asteroid testing, start with a lightweight rock (or small object) and keep increasing weight to see how much your shelter can withstand!

	Type or size of rock	Did your shelter stay intact and upright?	What improvements can you make?
1		Yes / No	
2		Yes / No	
3		Yes / No	

### Shelter Math:

1. What is the approximate volume of the interior of your shelter?
2. If 21% of the air inside the shelter needs to be oxygen (like our breathable air on Earth), how much oxygen must be supplied to your shelter?



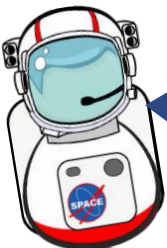
Artistic depiction of a NASA lunar base



## Reflection

### Mission Reflection:

How did the shape of the shelter affect how well it stayed protected during asteroid impact?



We are safe! Great job building a protective base for our mission. Just like this challenge, it is important to focus on each issue needing to be solved before moving to the next one. Now that we are safe from the elements on the Moon, we need to figure out how to get some food. What do you like to eat? ~Astronaut Alex

# Staying Alive

6



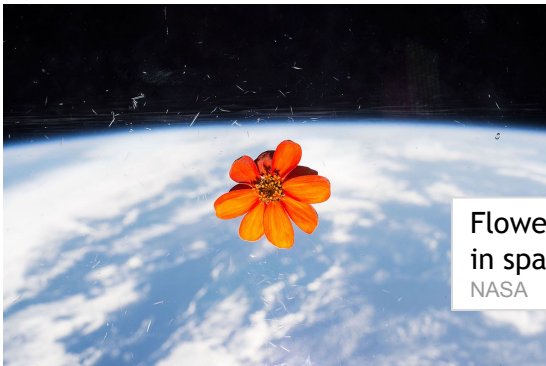
Life is good on the Moon! Well, until you run out of food. Earth has over 50,000 edible plants. Rice, maize, and wheat provide 60% of the world's food energy intake. In order to sustain human life on the Moon, we must figure out how to grow plants here!

Today, you will become **botanists** on a mission to design a plant growth system. Growing plants can be complicated. How will the plants get water and sunlight? What temperature and air composition is needed? This mission requires **resilience** to succeed. Be patient as you plan, build, and study your results! You've got this! ~Astronaut Alex



## Career Connection

**Botanists** are a type of biologist who study plants! A botanist may discover new plant species, uses, or study the effects of pollution on plant growth. Botanists recently discovered that they can train pea plants! In an experiment, they were able to get the plants to turn towards a fan if the plants "learned" that the fan's wind predicted the direction of sunlight.



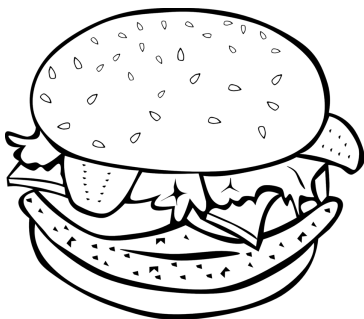
Flower grown in space. Credit: NASA

**NASA News:** NASA is studying how plants grow in space using the Vegetable Production System (Veggie) module currently aboard the ISS. Veggie was designed to produce salad-type crops to provide the crew with a delicious, nutritious, and safe source of fresh food. Growing plants is also relaxing and enjoyable for the astronauts!



NASA Veggie  
Credit: NASA

**Mission Warm-up:** What kind of food should our crew eat? How will we get food to our Moon base?





# Science Background

**Word Bank:** roots, leaf, radicle, seed coat

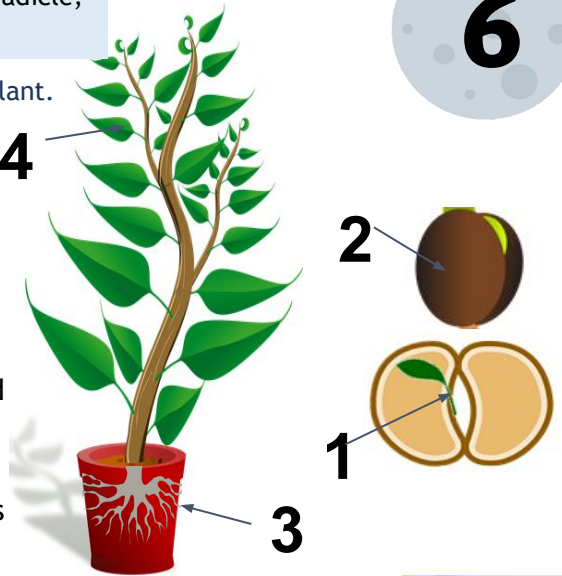
Plant Anatomy: Fill in the blanks with the name of each part of the plant.

1: The \_\_\_\_\_ is a small stem of an embryo plant.

2: The \_\_\_\_\_ provides protection as the outer layer of a seed.

3: The \_\_\_\_\_ are how plants collect water and nourishment.

4: A \_\_\_\_\_ is the main organ of photosynthesis and transpiration for the plant.



## PHOTOSYNTHESIS,

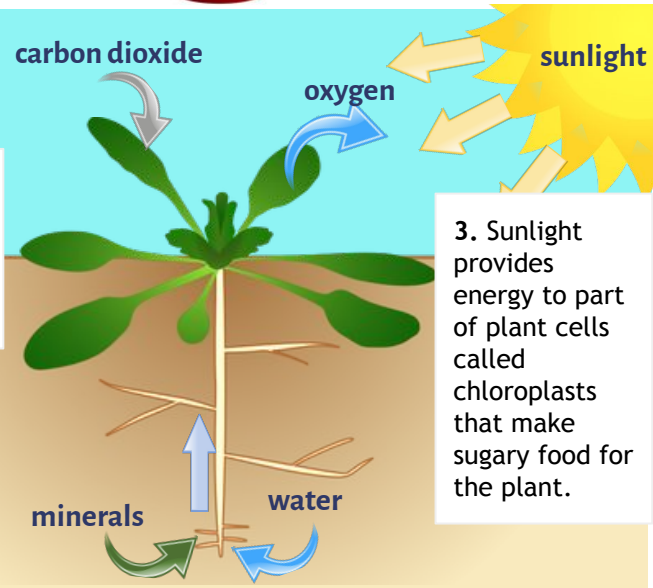
how green plants make their food.

What 4 things do plants need?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

2. Plant leaves take in carbon dioxide from the air and release oxygen during photosynthesis.

1. The plant draws up water and minerals from the ground through roots.



3. Sunlight provides energy to part of plant cells called chloroplasts that make sugary food for the plant.

## HYDROPONICS



Hydroponics is a method of farming that allows plants to grow without soil. NASA is testing out this method to grow plants in space. Here are some basics on hydroponics:

- Why not use soil? Soil is too heavy to transport and does not exist on the moon.
- Plants will grow with their roots exposed to the mineral water solution. All the nutrients that are in soil will instead be injected directly into water.
- The nutrients in hydroponics can be from fish waste, manure, or chemical fertilizers.
- The growth rate on a hydroponic plant is 30-50 percent faster than a soil plant grown under the same conditions. The plant also tends to produce more fruit.





## Hydroponic Plant Device Challenge

**Mission:** Build a device to grow plants on the Moon.


### Design Rules

1. Plant container remains upright with opening facing upward.
2. Plant container is held at least 6 inches above the ground.
3. Plant container is only supported from the top and sides.
4. Plant must be visible from both sides to get full sun exposure.

**Mission Background:** In addition to sunlight, plants need water and CO2 to survive. How will your plant device meet your seeds' needs to allow it to grow?



Plants at NASA being grown using hydroponic techniques. Credit: NASA



A **greenhouse** protects plants from the weather and temperatures outside. The transparent walls trap the Sun's energy to keep plants warm.



## Brainstorm & Design

How will you use provided materials to build a support device for your plants? How will your device raise your plants 6 inches off the ground? Brainstorm ideas for different designs.

*Draw and label a device before building.*



## Build & Test

Check to make sure your plant device meets all the design rules:

- Plant opening facing upward.
- Plant container is at least 6 inches from the ground.
- Plant container is only supported from the top and sides.
- Plant visible from both sides to get full sun exposure.



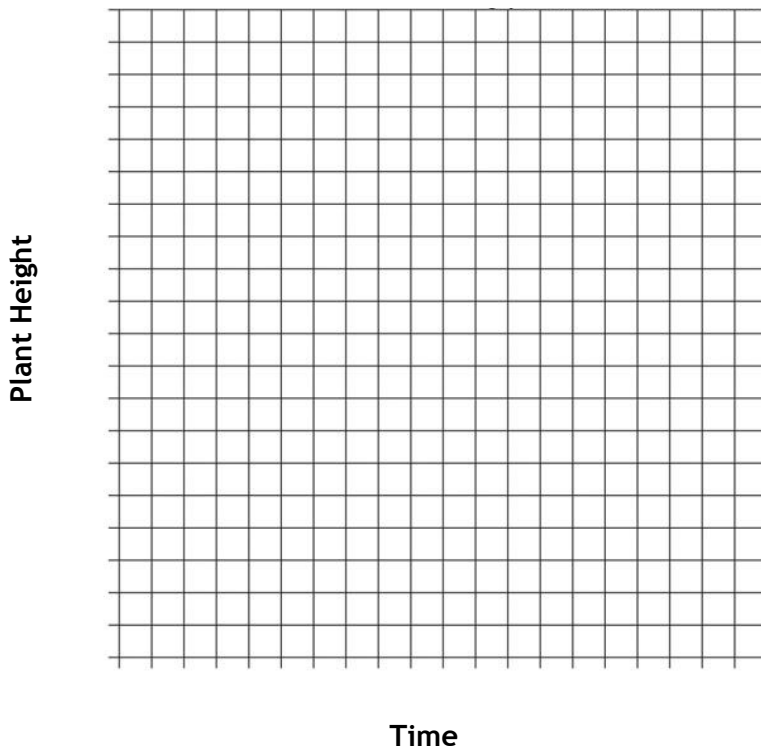
### Plot your plant's growth!

1. Place your seed in your device and set in a window that gets 6+ hours of sunlight each day.
2. Each day, use the grid to plot the growth of your plant. Label your axis with appropriate units.

### Math extension: Your plants need space!

1. What is the approximate volume of your device?
2. If you were to use 100 of your devices to grow a garden on the Moon, how big would the room that holds them need to be?

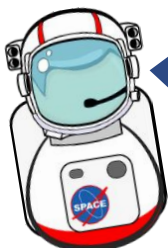
## PLANT GROWTH



## Reflection

### Mission Reflection:

Think about the challenges of living on the Moon. What additional protection will your greenhouse need for the plants to survive?



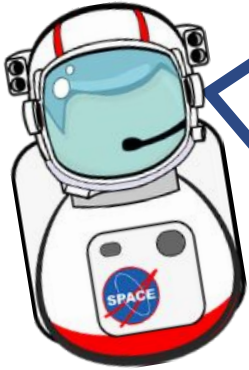
Mission success - your base is now growing pinto beans to survive! What other food should we grow? Why do you think resilience is important in engineering?

With our basic needs now met, we are ready to explore the Moon! Get some rest because next time, we head out into the Lunar surface to collect some samples.

-Astronaut Alex

# Collect Samples on the Moon

7



Now that we have set-up our base and started growing food, it is time to go explore the Moon! You will notice that the lunar surface is full of craters. Scientists believe that some of these craters may have ice, which would be very helpful to humans living on the Moon.

Today, your mission is to collect rock samples from deep inside a crater. We will get help from **biomedical engineers** to design a device to grab and move the rocks. In this mission, **leadership** skills are needed to direct our team to work together and accomplish the goal. Have fun exploring! ~Astronaut Alex



## Career Connection

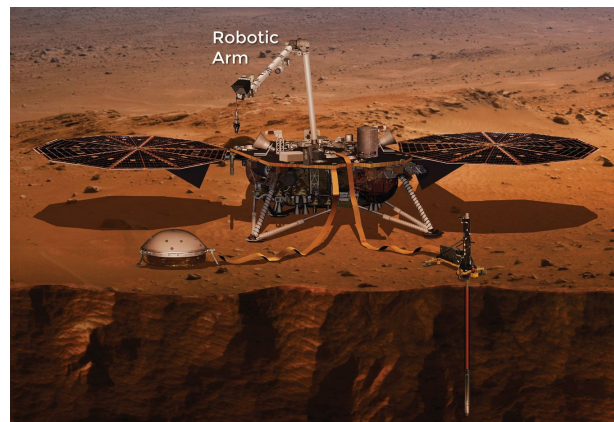


Myoelectric prosthetic archery arm

Photo credit: The Guardian

**NASA News:** Do you see the robotic arm on the lander pictured to the right? This is NASA's InSight Lander using an Instrument Deployment Arm (IDA) to place instruments on the surface of Mars. The 5 foot 9 inch long arm is just like a human arm with shoulder, elbow, and wrist joints. The end of the arm has five mechanical fingers that can grab a handle. Similar scientific rovers are being developed for lunar missions.

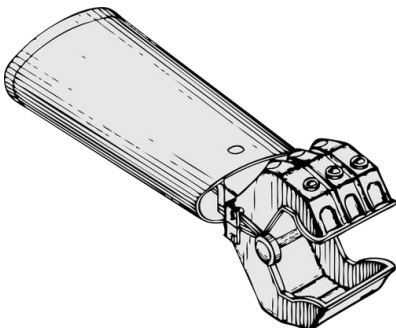
**Biomedical Engineers** solve problems in medicine. They may design a prosthetic leg for a disabled person or new medicine for a sick person. They can even design artificial arms to mimic human motion in the hand. One example shown to the left is a prosthetics arm for archery!



NASA's InSight Lander on Mars

Credit: NASA

**Mission Warm-up:** Describe a time you needed to be a leader.





Can you figure out the type of crater in each picture? Read the descriptions and classify each photo as a simple or complex crater.

### SIMPLE CRATERS

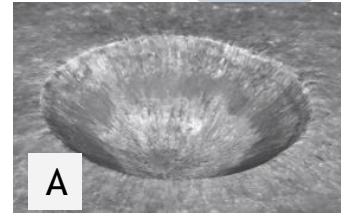
- Relatively small
- Smooth bowl shape

Simple Craters: \_\_\_\_\_

### COMPLEX CRATERS

- Relatively large
- Shallower depth compared to diameter
- Contains a central peak or peak ring

Complex Craters: \_\_\_\_\_



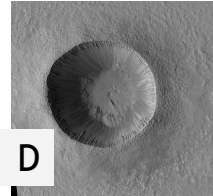
A



B

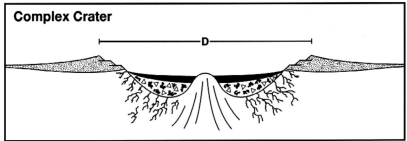
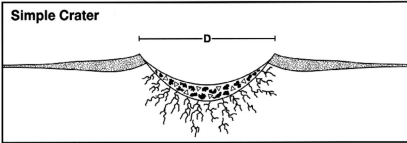


C



D

The lunar surface is full of craters because the thin atmosphere provides no protection from asteroids. Moon craters are typically much wider than those on Earth because of the lower gravity (1/6 of Earth).

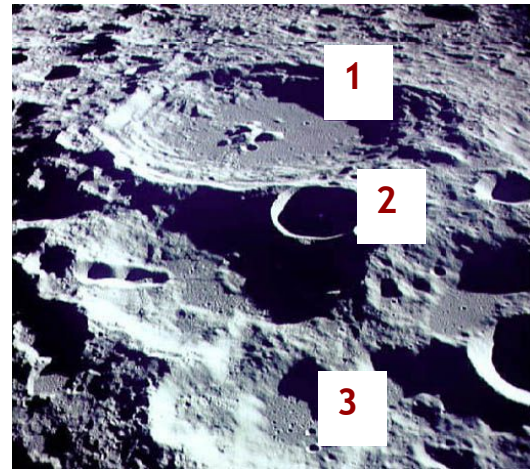


Credit: NASA

## THE AGE OF CRATERS

How do scientists determine the age of a crater? Their features give us hints on when they may have formed. Read each description and assign it to a number from the photo.

- \_\_\_\_\_ crater is relatively new due to the preservation of the walls and depth.
- \_\_\_\_\_ crater is very worn and contains younger craters within it, indicating that it is older.
- \_\_\_\_\_ crater shows some collapsing of the walls after impact with a few younger craters within it. It is neither the youngest nor the oldest crater in the picture.



## Living in a Crater

When selecting a site for a lunar base, NASA is looking for optimal conditions such as: ice, ample sunlight, and relatively moderate temperatures. One possible option is Shackleton crater. Here are some facts about this crater located on the South Pole of the Moon.

1. 13 miles (21 km) across and 2.5 miles (4.2 km) deep
2. Peaks of the crater are exposed to almost continuous sunlight. How can you use this for solar energy?
3. Walls of the crater are in near constant darkness.
4. Evidence exists of ice deposits inside crater that could be mined for water.

Shackleton Crater

Credit: ESA





## Grabber Challenge

7

**Mission:** Build a device to collect rock samples and place into collection area.

### Design Rules

1. No body part can touch the rocks
2. No body part can cross into the crater
3. All team members must be involved
4. Start over if rocks fall out of device



Valkyrie. Credit: NASA

**Mission Background:** How will your device “grab” the rock sample? Does the device need to change if the rocks are different sizes?

Meet Valkyrie, a NASA humanoid space robot! She’s 6 feet and 2 inches tall, weighs about 300 pounds, and cost \$2 million. One day, this type of robot might help humans colonize the Moon and Mars. Valkyrie’s hands work similar to human hands so she can use the same tools as an astronaut.



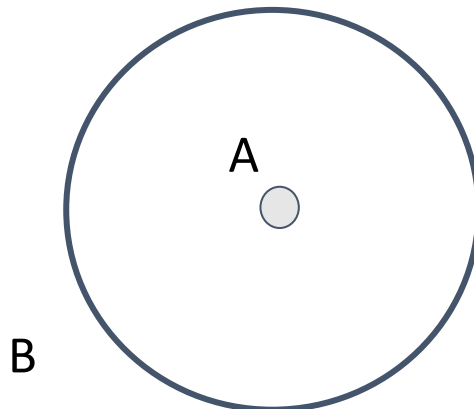
Valkyrie’s hand. Credit: NASA



## Brainstorm & Design

How will you use provided materials to build a rock collection device? Remember that you can not enter the crater.

*Draw and label a design to move rocks from A to B. The circle represents the crater.*





## Build & Test

Test your device! Remember that all members of the team must be involved.



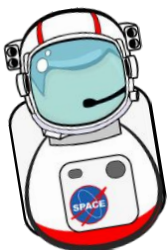
Trial	Did you keep all body parts out of the crater?	Did you move the sample to the collection area without dropping?	Design Notes <i>What worked? What do you need to change?</i>
1	Yes / No	Yes / No	
2	Yes / No	Yes / No	
3	Yes / No	Yes / No	

**Grabber Math:** Ask your teacher for the length of string used to make the crater (the circumference of the crater). Calculate the distance required to move the rock samples from the center to the edge of the crater (the radius of the crater).



## Reflection

**Mission Reflection:** What was your final design? Draw it below. How does it compare to the brainstorming on the previous page?



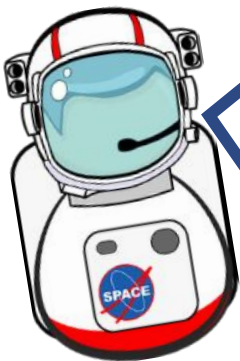
Great job today using your biomedical engineering skills to grab and move your rock samples! How did you use leadership skills to accomplish the task? Now that we have the rock sample, next week we build a rover to move it back to base! ~Astronaut Alex



e-NABLE 3D prints prosthetic hands for kids and adults.

# Build a Rover

8



Great job collecting the rock samples from the crater! Now we need to transport them back to base for testing.

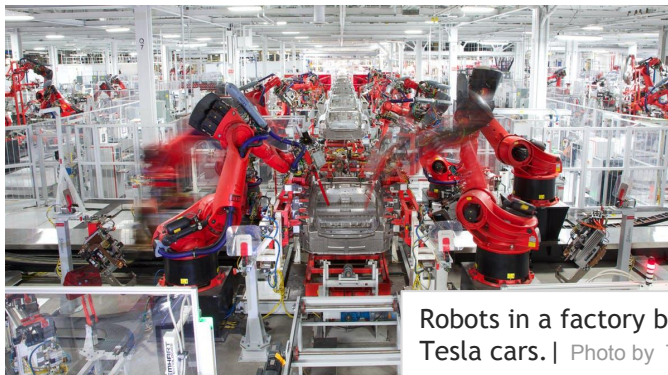
However, these rocks are too heavy to carry. Today, you will become **electrical engineers** on a mission to design a rover to transport our samples. A rover is a type of robot that travels on the surface of another planet like the Moon.

How will you power your rover? How will it transport the samples? Be warned...this rover might not behave the way you want! You will need to be **adaptable** by being resourceful and overcoming unexpected challenges.

Best of luck getting those precious rock samples back to base! ~Astronaut Alex

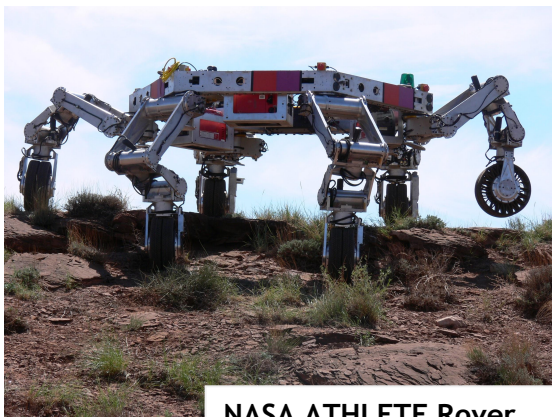


## Career Connection



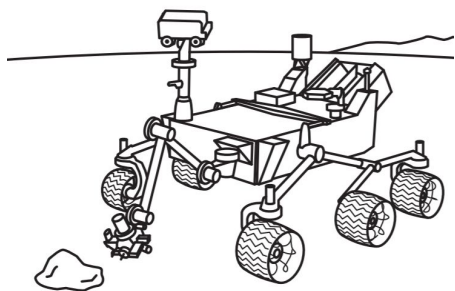
Robots in a factory building Tesla cars. | Photo by Tesla

**NASA News:** Future moon missions call for new rover designs. The All-Terrain Hex-Legged Extra-Terrestrial Explorer (ATHLETE) is a six-legged robotic lunar rover being testing by NASA. This rover has the unique ability to both roll and walk over a wide range of terrains.



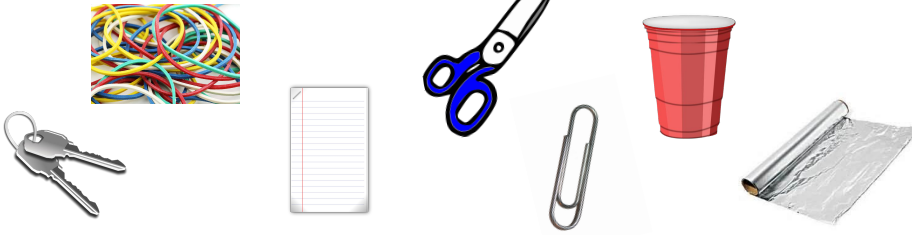
NASA ATHLETE Rover

**Mission Warm-up:** If you could design a robot, what would it do?



## Science Background

Time for a science experiment! Our rover will require **conductive** materials. These are materials that will allow electricity to pass through them. Circle the things below that you think will conduct electricity. Test out your hypothesis (guesses) using an energy stick.



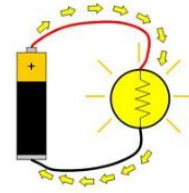
What other conductive materials can you find? List them below!

## Electricity

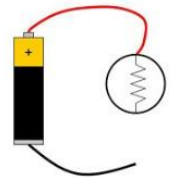
Use the word bank to complete the sentences below.

1. Electricity is the \_\_\_\_\_ of electrons.
2. A circuit is a \_\_\_\_\_ through which electricity can flow.
3. A **closed** circuit is a \_\_\_\_\_ circuit that allows for the electricity to flow from one end to the other without interruption.
4. An **open** circuit is an \_\_\_\_\_ circuit that does NOT allow the electricity to flow from one end to the other.

**Closed circuit**



**Open circuit**



**Word Bank:**  
Complete, incomplete, flow, power, path

# Lunar Rover

NASA is looking to upgrade previous lunar rovers to support the new Artemis mission to send humans back to the Moon. One example is the Space Exploration Vehicle (SEV) shown to the right.

The SEV is the size of a small pickup truck and can house two astronauts for up to two weeks.

**Docking Hatch:**  
Allows pressurized crew transfer from Pressurized Rovers-to-Habitat, Pressurized Rovers-to-Ascent Module and/or Pressurized Rovers-to-Pressurized Rovers

**Suitports:**  
Allow suit donning and vehicle egress in less than 10 minutes with minimal gas loss

**Pressurized Rover:**  
Low mass, low volume design enables two pressurized vehicles, greatly extending contingency return (thus exploration) range

**Suit Portable Life Support System-based Environmental Control Life Support System:**  
Reduces mass, cost, volume and complexity of Pressurized Rovers Environmental Control Life Support System

**Chariot Style Aft Driving Station:**  
Enables crew to drive rover while conducting extravehicular activities, also part of suit port alignment

**Modular Design:**  
Pressurized Rover module is transported using Mobility Chassis. Pressurized Rover and chassis may be delivered on separate landers or pre-integrated on same lander

**Ice-shielded Lock / Fusible Heat Sink:**  
Lock surrounded by 2.5 cm of frozen water provides SPE protection. Same ice is used as a fusible heat sink, rejecting heat energy by melting ice vs. evaporating water to vacuum.

**Pivoting Wheels:**  
Enables crab-style driving for docking

**Work Package Interface:**  
Allows attachment of modular work packages (e.g. winch, cable, backhoe or crane)



Credit: NASA





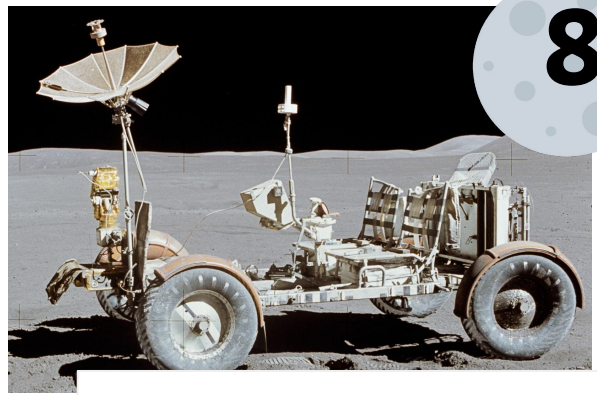
## Rover Challenge

Mission: Build a rover to transport your rock samples.

### Design Rules

1. Only use provided materials.
2. Must carry at least 1 ping pong ball 1 foot (30 cm).
3. Use the vibrating motor to propel the robot.

**Mission Background:** Read the building tips to the right. What do you think will be hardest part of this challenge?



NASA Lunar Roving Vehicle from 1970s.

### Building Tips

- **Keep Falling Over?** Keep your center of gravity in the middle, otherwise you will tip over.
- **Motor falling off?** Make sure to firmly press into tape.
- **Motor not working?** Make sure that each wire on the motor is attached to a different side of the battery, but the two motor wires can't touch. Check that nothing is blocking the rotating weight on the motor.
- **Not going straight?** Think about adding legs to balance or push your rover in a certain direction.
- **Not moving at all?** The heavier the rover, the slower it will move.



## Brainstorm & Design

How will you use provided materials to design a rover to move a ping pong ball? Brainstorm ideas for different designs.



Motor



Battery

*Draw and label a design before building.*



## Build & Test



Test your rover! Complete the table below to continue to improve your design.

Trial	Does your rover move forward?	Can your rover carry a ping pong ball?	How far can your rover travel?	What improvements can you make?
1	Yes / No	Yes / No		
2	Yes / No	Yes / No		
3	Yes / No	Yes / No		

**Rock Collecting Math:** The NASA Apollo program returned 2,200 samples from the Moon weighing a total of 382 kilograms (842 lbs.)! Use the time it took your rover to travel 1 foot to calculate how long it would take for your rover to transport 2,200 samples that same distance.



## Reflection

### Mission Reflection:

How could you improve your rover to move the ping pong ball?

How did you show adaptability during this challenge?

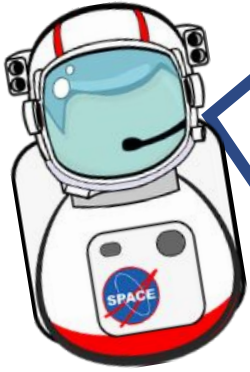


Wow, getting that rover to move straight was definitely a challenge! Great job being adaptable, not giving up, and helping move our rock samples back to base. After all that hard work, I am really excited to have some fun on our next mission!

~Astronaut Alex

# Entertainment on the Moon

9



Your crew has now been on the Moon for 3 months! While you enjoy jumping around and exploring the surface, everyone is starting to get grumpy and homesick. The small lunar base is feeling very cramped, and you really miss your family and friends back on Earth. The NASA space **psychologist** has noticed that the crew is starting to lose motivation, and she has asked your team to find some entertainment.

After thinking about the activities you miss on Earth, the crew has decided to design a roller coaster for some fun! For this mission you will become **civil engineers** and use your **creativity** to design and build a thrilling ride that will increase crew morale. I can't wait to try out the first roller coaster in space!

~Astronaut Alex



## Career Connection

**Psychologists** research how the brain works to drive human nature and how humans relate to each other and the environment. A special kind is a **space psychologist** who works with astronauts to understand how space travel affects their behavior and moods. They work to keep astronauts happy and prevent any mental health issues.



NASA astronaut on the International Space Station looking out of a window at Earth below.

Photo NASA

**NASA News:** NASA's Human Research Program looks for ways to optimize the health and well-being of astronauts. During a mission, scientists remotely monitor the behavior and mental health of astronauts through periodic video conferences or phone calls. They also send astronauts a care package to help with homesickness. The care package may be a favorite snack or a family photo. Keeping astronauts happy and healthy is critical to the success of the mission.



NASA astronaut celebrating the holidays from the International Space Station.

Photo NASA

**Mission Warm-up:** How can you use your spark to bring happiness to your crew on the Moon?





So far, our focus has been keeping humans alive on our Mission to the Moon. We designed a shelter to keep astronauts protected from radiation and asteroids. We designed a greenhouse to provide us food. But what about keeping astronaut happy in a desolate place 238,900 miles away from Earth with nothing but grey rocks to look at?

Think about your life on Earth. List 5 activities, places, or experiences that bring you happiness.

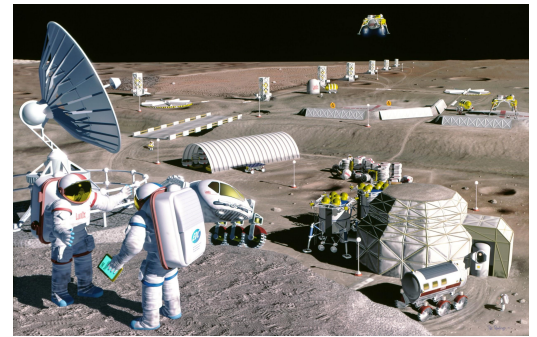
1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_



A life in a Moon colony is very different than on Earth. List 5 challenges to human happiness on the Moon.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_

Astronauts on long space missions face a lot of challenges that we don't experience on Earth. For example, they live and work in isolated, small, and dangerous environments.



## Keep Crew Happy

During space missions, space psychologists evaluate astronauts' mental health at regular intervals. Some of the issues they are looking for include:

- Difficulty sleeping
- Irritability
- Lack of motivation
- Homesickness
- Fighting between crew members

To prevent these issues, NASA tries to provide astronauts with lots of entertainment and hobbies. Activities include reading books, listening to music, playing an instrument, talking with family members, or playing a sport. These same activities help humans on Earth stay happy too!





## Roller Coaster Challenge

**Mission:** Build a roller coaster to enjoy while on the Moon.

### Design Rules

1. Ball released at least 18 inches (45 cm) above cup.
2. Ball makes at least 1 turn.
3. Ball lands and stays inside cup.

**Mission Background:** How will you keep the ball moving throughout the roller coaster?

How will you keep the ball from flying off the roller coaster?



Kings Dominion Theme Park



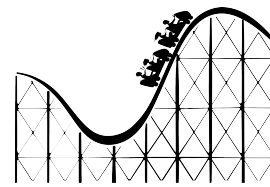
## Brainstorm & Design

How will you use provided materials to build a roller coaster?  
Brainstorm ideas for different designs.

*Draw and label a design before building.*



## Build & Test



Test your roller coaster! Complete the table below to record results as you continue to improve your design.

Trial	Height of roller coaster	Number of turns	Design Notes
1			
2			
3			

### Roller Coaster Math:

- How long it takes for the ball to travel to the bottom of the roller coaster? **Total time:** \_\_\_\_\_
- Can you figure out the distance that the ball travels? This requires you to measure the length of each track. You may need to estimate for the curved tracks. **Total distance traveled:** \_\_\_\_\_
- Can you calculate the average speed of the ball? *Average speed = distance / time*

Average speed: \_\_\_\_\_



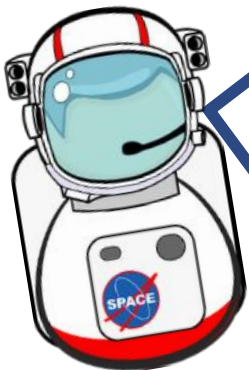
## Reflection

**Mission Reflection:** Why is it important to think about the happiness of the crew when designing a lunar colony?

Do you think a roller coaster is a good way to increase happiness? Why or why not?



Weeeeeeee! That roller coaster ride was so exhilarating! Great job using your civil engineering skills to design such a fun ride. And good news - NASA psychologists have informed me that our crew morale has improved! This came just in time because we have finished collecting our samples, and we need to head back to Earth! Are you excited to be going back? ~Astronaut Alex



**Mission success!** After months on the Moon exploring, building a base, creating a food source, and facing daily challenges to survive, our crew has successfully returned to Earth with rock samples for NASA to analyze. These samples are important to help **scientists** learn more about the resources on the Moon, such as the location of ice in craters. This knowledge will help **engineers** design a permanent lunar colony in the best location on the Moon.

But before you can go home and see your family, NASA requires all astronauts to undergo physical and mental health testing. They want to see how our journey to the Moon affected our bodies and minds. ~Astronaut Alex



## Career Connection

Do you notice something missing? Meet Waymo, a self-driving car!

Photo Waymo



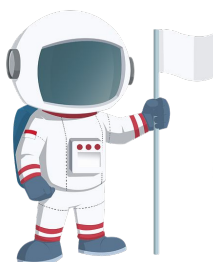
**NASA News:** NASA is more than astronauts. Behind every mission is a team of scientists, engineers, IT specialists, accountants, technicians and many different types of STEM careers supporting the mission to space. Beyond exploring space, NASA is also developing cutting-edge technologies to study the Earth including weather patterns and storm prediction. Learn more at [www.nasa.gov](http://www.nasa.gov).



Photo NASA

**STEM careers** have a focus in science, technology, engineering, and math. Throughout our missions, you learned about various STEM careers such as aerospace engineering and biology. In a STEM job, you will have the power to shape the future and solve the biggest problems facing our world. Whether you want to send humans to Mars, design a self-driving car, or create the next big video game, a career in STEM is an exciting and rewarding path. To learn more, check out [www.stemstudy.com](http://www.stemstudy.com) or [www.sciencebuddies.org](http://www.sciencebuddies.org).

**Mission Warm-up:** Would you go to the Moon or Mars? Why or why not?





Just like any muscle, the more you work your heart, the stronger it gets. Knowing your heart rate is an important factor in understanding the health of your heart. Living in lower gravity like the Moon lessens the effort your heart has to make in order to pump blood through your body. And, like any less-exercised muscle, it can lose strength after a long visit in space.

NASA wants to check your heart rate during various exercises. Complete the following:

1. Sit down and relax. Measure your resting heart rate using the Cardio app or by finding your pulse. Record below. If using your pulse, count rate for 10 seconds and multiply by 6 to get beats per minute.
2. Walk in place for 30 steps. Measure your heart rate and record.
3. Calculate your percentage increase compared to resting.
4. Continue filling out the chart for each exercise. Compare to resting rate.
5. How did your heart rate change with exercise?



Activity	Heart Rate (HR) <i>Beats per minute</i>	Percentage Increase Compared to Resting
Resting Heart Rate		0%
Walk in place for 30 steps		
15 Jumping Jacks		
25 Fast High Knees		

# Artemis Program



Through the Artemis program, NASA is working to land American astronauts, including the first woman and the next man, on the Moon by 2024. The destination is specifically the lunar south pole. This program is the next step to having a permanent presence on the Moon and a stepping stone to humans on Mars.

How will it work? NASA’s powerful new rocket, the Space Launch System (SLS), will send humans aboard the Orion spacecraft to the Gateway, an orbiting spaceship. The Gateway is where astronauts will live and work around the Moon. The crew will also have missions to the lunar surface to conduct research and explore.





# SCIENTIST

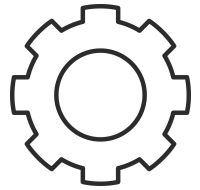
Scientists study how the world works. Describe a scientific experiment we completed during our Mission to the Moon.



What are you curious about? Write a question related to how the world works that is interesting to you.

# ENGINEER

Engineers design things to solve problems. Describe an activity where we had to solve a problem during our Mission to the Moon.

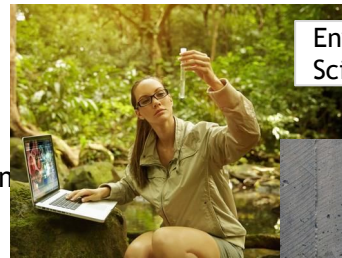


What problem do you want to solve? Write a specific problem in the world or your personal life that you want to solve.



## STEM Careers BINGO Game

Remember your spark? As you play the STEM Careers BINGO game, list any STEM careers that sound interesting to you.



Environmental Scientist



Zoologist  
Photo Smithsonian

*Whatever your spark, a STEM career can be for you!*



Marine Biologist

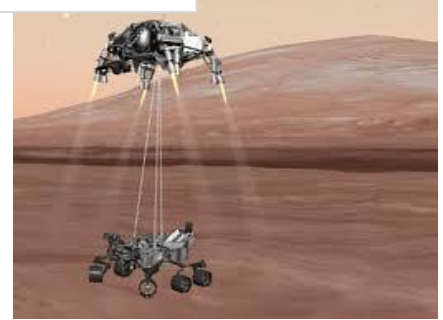
## Celebration

**Mission:** Celebrate the success of our mission!

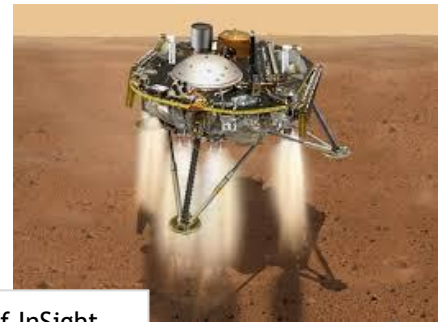
Behind every NASA mission, a team of people work for years (sometimes decades!) to design, build, and test technology to make sure they have success. The final part is the launch of the mission that is coordinated by Mission Control. Here are some photos of the celebration after a successful mission!



After landing of Curiosity rover on Mars. Photo NASA



After landing of InSight probe on Mars. Photo NASA



## Reflection

**Mission Reflection:** What was your favorite mission? Why?

If you could pick any STEM career, which one would you want to do? Why?

I am so proud of our crew! We overcame many challenges, but we stuck together and worked through each one as a team. Space travel is difficult, but it was definitely an unforgettable experience. I can't wait to see you again for our next adventure! Where should we go next? *-Astronaut Alex*

