

Space Club

Instructor Guide

This guide belongs to:

**Mission
to Moon**

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ABOUT VIVIFY

Vivify is a K-12 STEM education resource company founded by two aerospace engineers, Natasha and Claire, with a passion for providing access to quality STEM education.



Our philosophy is that STEM transforms classrooms into an exciting world of curiosity, problem-solving, and creativity. STEM education can be an empowering interdisciplinary approach that brings math, science, and engineering concepts to life through challenging opportunities that mimic the complexities and excitement of the real world.

Every teacher or parent can incorporate STEM into their classroom or home given the right resources, and that is where Vivify comes in! We love creating STEM materials and are excited to bring STEM to more classrooms and homes! [Click here to learn more about Vivify.](#)



Connect with us for free STEM resources!

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Want more STEM?

For a complete list of all of Vivify STEM resources by topic and grade, go to:

<https://www.vivifystem.com/curriculum-map>



Help! I need to plan a year-long STEM class! What should I cover? What is appropriate for each grade level?

We can help! [Click here](#) for guidance on a scope and sequence of a STEM class plus resources and examples for planning a STEM curriculum map.



3 Stages of STEM

STEM generally revolves around the Engineering Design Process that embraces failure, relies on teamwork, and requires critical thinking and creativity. While exciting, educators often become intimidated as a search for curriculum leads to an overwhelming range of activities from index towers to robotics competitions. At Vivify, we believe that not all STEM is created equal. Educators should adopt a [3 Stages of STEM](#) approach by progressively building towards more complex projects.

Click images for lessons for each stage!

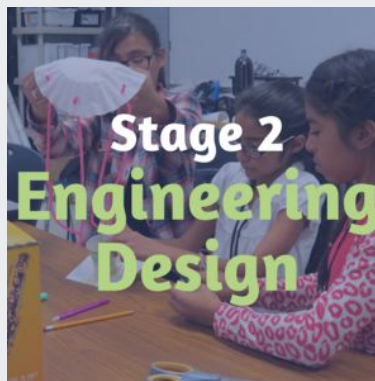


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Mission 8 is a more complex challenge that involves designing a habitat on Mars. This can be added for a long-term capstone project!

Space Club Basics

Space Club Overview

Space Club engages youth with space exploration and builds a foundation of STEM skills through real-world engineering design challenges.

Launched in 2014 by an aerospace engineer, Space Club began in San Antonio, Texas as an afterschool STEM program that inspires at-risk youth with hands-on engineering design and space exploration activities. Space Club now inspires students around the world! [Click here to read the history of Space Club.](#)

Why should we teach kids about space?

The inspirational value of the space program is probably of far greater importance to education than any input of dollars...A whole generation is growing up which has been attracted to the hard disciplines of science and engineering by the romance of space."

Arthur C. Clarke, First on the Moon, 1970

Every child has looked up at the twinkling stars on a clear night and wondered about the vastness above. The night sky captures a child's imagination and leads to profound thoughts and questions about our place in the world. The need to explore and discover is a common thread among humans, and the greatest unknowns lay in the night sky above us. Giving students a window into the beauty of space and teaching the journey of humankind's exploration of other worlds is a powerful tool to inspire and engage an interest in science and engineering.

In our years running Space Club, we have witnessed the awesome impact that launching a rocket or imagining a colony on Mars can have on a student's confidence and dreams.

What is the purpose of Space Club?

The main goal of Space Club is to connect academic subjects to a real-world engineering problem through engaging, hands-on learning. The curriculum is not meant to replace math and science courses. Instead, Space Club reinforces concepts taught in the classroom and provides an opportunity to apply knowledge. Below are additional outcomes for a STEM academic and enrichment program.

1. Increase academic confidence
2. Increase awareness of STEM careers
3. Increase interest in STEM careers
4. Increase persistence in STEM pathways

Looking for professional development?
Join our [Space Club Educator's Portal](#)
for virtual self-paced training on this
curriculum!

Curriculum Design

WHAT IS THE ENGINEERING DESIGN PROCESS?

In STEM learning, students apply math and science concepts to solve an engineering problem using technology. Students tackle these problems with the Engineering Design Process which helps them brainstorm, develop a design, test, and redesign for an optimal solution. However, the Engineering Design Process should not be confused with the commonly used Scientific Method. The table below describes the differences between science and engineering. We recommend that instructors fully understand these differences and emphasize during the program.

	Science	Engineering
Goal	Seek to understand the world around us	Solve problems to make our lives easier, healthier, and more fun
Method to Reach Goal	<i>Scientific Method:</i> Conduct experiments to collect data	<i>Engineering Design Process:</i> Apply knowledge to solve a problem
Example Activity	Students discover what happens when Mentos are placed into Diet Coke. Students hypothesize that adding more Mentos will increase the height of the Diet Coke geyser.	Students are challenged to build a device to launch a ball to knock over a tower. Students must use the stored elastic potential energy of rubber bands to build a catapult to launch the ball. Through continual testing and re-design they optimize their product until successful.
Related STEM Careers	Biology, Physics, Astronomy, Chemistry	Biomedical Engineering Mechanical Engineering Aerospace Engineering

For Stage 2 STEM, students apply math and science concepts to problems using the Engineering Design Process. This process can be visualized with the diagram on the next page. Instead of immediately building, students are systematically guided through a process of brainstorming, designing, building, testing, re-designing, and sharing their solutions. For example, in the catapult challenge, students apply knowledge of elastic potential energy to design a catapult device to either hit a target or maximize distance. During the testing phase, students analyze catapult designs to re-design and improve their results. This process enhances student critical thinking skills while integrating math and science skills into an engaging hands-on engineering project. Real-world connections further enhance the activity.

[Click here](#) to read more about the Scientific Method vs Engineering Design Process. [Click here](#) to learn more about planning a year long STEM program.

Session Planning

Space Club curriculum was created for an informal, out of school time setting, but it can easily be incorporated into a classroom or homeschool program. Missions have been aligned to meet classroom standards to reinforce content. Note that many of the missions are intended for groups or partners, so a minimum of 6 students is recommended.

Session Length

Space Club is typically run as a daily or weekly program through sessions of 45 minutes to 90 minutes. However, missions that utilize the engineering design process may require longer to fully complete the design, test, and reflection phases. For these activities, plan for a 1.5 hour session or spending 2 sessions to complete the challenge. The engineering design process is discussed further in the next section along with guidelines on extending these missions even further.

Session Recommendations

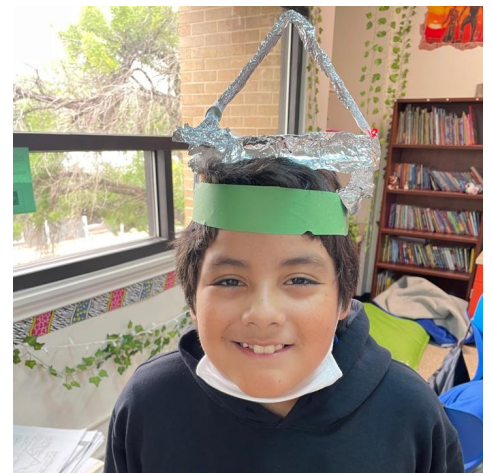
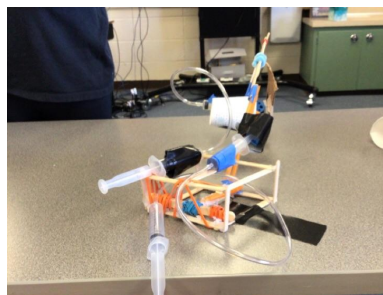
- Have a clear transition to start the group. For afterschool, allow 15 minutes for snacks and socializing.
- Start the sessions with a hook to capture student interest. Video links are provided that are exciting ways to introduce the content and provide a real-world connection.
- Do not release students until work area is clean.
- Try to spend a minimum of 5 minutes on reflection time.

Space Requirements

- Group tables to allow for students to work and build in teams. While not optimal, grouping together traditional desks will work.
- Laptop and projector to show videos.
- Open space for testing, or access to hallways or common areas.

Mission Prep

- Review Mission Overview, activity guide, and student handouts.
- Gather activity materials.
- Gather student handouts and pencils.
- Prepare laptop, speakers, and projector for videos.



Engineering Design Process

1
 **Identify the Problem**

2
Brainstorm 

3
 **Design**

4
Build → **Test & Evaluate** → **Redesign** → **Build**

5
Share Solution 

Mission to Moon Overview



Space Club

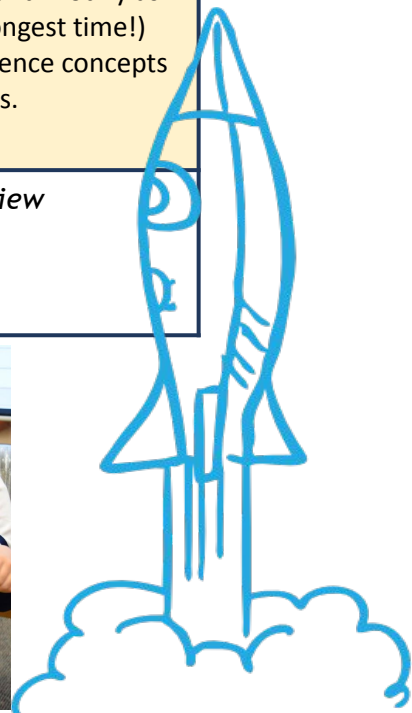
Overview of Units for Grades 4 – 8

In Space Club, students transform into a team of astronauts on an unforgettable space adventure! From robotic arms to rovers, students will complete engineering design challenges that connect to real-world space exploration and careers. Educators have the option to run the Mission to Moon or Mission to Mars units. Each activity is independent and does not require a specific sequence. The final Build a Base mission is a more intensive research capstone project.

Mission to Moon	Mission to Mars	Recommended Sessions
Meet the Crew		<p>Each of these missions generally takes about 90 minutes, which can be broken into 2, 45 minute session:</p> <p>Session 1: Background, Planning, Building</p> <ul style="list-style-type: none"> Engage: Play mission video and review design challenge Brainstorm: Gather materials and sketch design ideas Build: Build initial prototype <p>Session 2: Review, Test, Modify, Reflect</p> <ul style="list-style-type: none"> Review: Play another background video and review challenge Build: Complete building Test & Modify: Test prototype and modify as needed (this should take the longest time!) Reflection: Connect back to science concepts and discuss success and failures.
Astronaut Training	Get to Mars	
Space Suit	Land on Mars	
Plants in Space	Explore the Surface	
Welcome Tower	Live from Mars	
Robot Arm	Collect Samples	
Rover Exploration	Transport Samples	
Build A Base		<p><i>Session 1: Reflect on Earth & Overview</i></p> <p><i>Session 2 - 3: Planning</i></p> <p><i>Session 4 - 6+: Build habitat</i></p> <p><i>Present habitat</i></p>

Mission to the Moon

Mission to Mars



Standards Alignment

Mission to the Moon

The following is the standards-alignment for Mission to Moon. Note that while all these concepts are part of each activity, the activities are generally focused on promoting engineering design principles. Additional instruction is needed for science concept development.

Mission	Next Generation Science	Science TEKS (Texas)
2: Roller Coaster Engineering Design	Engineering Process Skills: 3-5-ETS1-1, 2, 3 MS-ETS1-1, 2,3 MS-PS3-3 Energy	Process Skills: 8.1B, 8.4A
3: Astronaut Helmet Engineering Design	Engineering Process Skills: 3-5-ETS1-1, 2, 3 MS-ETS1-1, 2,3	Process Skills: 8.1B, 8.4A 5.8D: Moon properties
4: Plant Device Engineering Challenge	Engineering Process Skills: 3-5-ETS1-1, 2, 3 MS-ETS1-1, 2,3 MS-LS2-3 Ecosystems	Process Skills: 8.1B, 8.4A
5: Welcome Tower Engineering Design	Engineering Process Skills: 3-5-ETS1-1, 2, 3 MS-ETS1-1, 2,3 4-PS3-4 Energy, MS-PS3-3 Energy	Process Skills: 8.1B, 8.4A 5.6A/B: Electrical energy, Circuit 6.6A, 6.9(C)
6: Robotic Arm Engineering Design	Engineering Process Skills: 3-5-ETS1-1, 2, 3 MS-ETS1-1, 2,3	Process Skills: 8.1B, 8.4A
7: Rover Exploration Engineering Design	Engineering Process Skills: 3-5-ETS1-1, 2, 3 MS-ETS1-1, 2,3 MS-PS3-3 Energy MS-PS2-3 Motion and Stability	Process Skills: 8.1B, 8.4A 5.6A/B: Electrical energy, Circuit 6.6A, 6.9(C)
8: Lunar Base Design (<i>separate lesson</i>)	MS-PS3-3 Energy Engineering Process Skills: 3-5-ETS1-1, 2, 3 MS-ETS1-1, 2,3	5.8D: Moon properties Process Skills: 8.1B, 8.4A

Mission to Moon Supplies

Below is a list of materials needed per team to complete the Mission to Moon challenges. Many supplies can be found at your local grocery store. Actual pricing will depend on quantity and vendor. To use digital tools, students will need a mobile device, tablet, Chromebook, or computer with camera.

[Click here to purchase these materials from Pitsco!](#)

Material List	Qty per Student	Notes	Approx cost for 24
Printing of Handouts	1		About \$175 depending on vendor and quantity.
Bag for supplies	1		
Masking Tape	1 roll	Clear tape also works	
Ruler	1		
Scissors	1		
Pencil	1		
Construction Paper	40 pages	To simplify supplies, use construction paper or copy paper for all the challenges needing paper. However, the robotic arm in Mission 5 works better with cardstock.	
Cardstock Paper	6 pages		
Ziplock Sandwich Bag	6	(Mission 3) Any resealable clear bag will work. Only 1 bag required. The other 5 are for packing materials for kits.	
Beans or Seeds	4	(Mission 3) Pinto beans plus another seed or popcorn kernel are recommended to compare results.	
Cotton Balls	4	Jumbo size works best	
5 oz Paper Cups	4		
Bendy Straws	30		
Paper Plates (7 - 9 in)	7	Exact size is not important	
Ping Pong Ball	1		
Foil	30 in x 12 in or 76 cm x 30 cm	Amount doesn't need to be exact. Use this as a minimum. Can also purchase foil sheets.	
String or twine	5 feet or 1.5 meters	This is a minimum amount for Mission 5. We like to provide students with the entire ball of string.	
Vibrating Motors	1	Make sure to test out the motors and batteries by placing a wire on each side of the coin cell battery to complete the circuit and power the motor.	\$36
Coin Cell Battery (3V)	4	1 battery needed for Mission 6 rover. Additional batteries can be used in place of the solar panel in Mission 4 & 8. Please ensure coin cell batteries are handled safely. Read this.	\$22
LED Lights (5 mm)	4	Voltage range should be between 2.0-2.2V	\$6
			\$239
Optional Materials			
Solar Panels (2V output)	1 (\$6.45)	A coin cell battery can be used instead.	\$143
Recycled materials		Missions can be enhanced with common recycled materials like cereal boxes, plastic containers, magazines, etc.	

Session Planning

Space Club activities on the following pages are intended for grades 4 - 8, but educators can adapt down to elementary levels with additional support. Differentiation for student level is provided during the instructional videos.

Running a Space Club Session

Each Space Club activity follows the engineering design process and will take around an hour for students to complete. Mission to Moon curriculum is adapted for distance learning with activities being designed for individual, hands-on learning. However, teachers may also run the program during a traditional classroom setting.

A typical virtual Space Club session includes:

- Teacher creates Flipgrid board for the mission
- Students receive Mission handout, Flipgrid code, and supplies
- Student accesses Flipgrid board and watches Mission Introduction & Instructional videos
- Student completes engineering design challenge
- Student uploads a video to Flipgrid board reflecting on mission
- Teacher provides feedback by commenting on Flipgrid videos
- Optional - teacher hosts a group video session to reflect on challenge.

The next page provides examples of how to run a Space Club session during virtual or in-person learning.

Building Student Relationships: Creating a learning community that is built on positive student relationships is an important part of Space Club. We recommend incorporating student sparks as a way to build stronger relationships. Read more here: [Building Relationships with Sparks](#)

Instructors can also incorporate additional team challenges or icebreakers during in-person or virtual Zoom sessions.

In-Person Icebreakers

- [Best 3 Back to School Icebreakers](#)
- [Pipe Cleaner Challenge](#)
- [Back to School Towers](#)

Distance Learning Icebreakers:

- [Icebreakers & Games for Distance Learning](#)
- [STEM Activities for Distance Learning](#)

Session Planning

A minimum of 90 minutes should be allocated for each mission. This can be distributed over multiple sessions.

Virtual: Student-Led Session

Prior to session: Provide materials

- Flipgrid code
- Handout
- Supplies

Independent Work: Students follow Flipgrid instructions to watch videos, complete activity, and post response.

Feedback: Teachers respond to Flipgrid videos with comments.

Reflection Zoom session: Discuss and share engineering challenge, make connections to science concepts, and discuss real-world connections.

Virtual: Teacher-Led Session

Prior to session: Provide materials

- Flipgrid code
- Handout
- Supplies

Zoom Session I

- Icebreaker Activity
- Mission Introduction Video & discuss career connection and space news
- Review EDP process and Flipgrid

Independent Work: Students follow Flipgrid instructions to watch videos, complete activity, and post response.

Feedback: Teachers respond to Flipgrid videos with comments.

Zoom Session II - Reflection: Discuss and share engineering challenge, make connections to science concepts, and continue discussion on real-world connections.

Classroom Session

Engage

- Icebreaker Activity (optional)
- Watch Mission Introduction Video
- Group discussion or journal prompt

Engineering Design Challenge

- Watch Instructional Video
- Introduce science concepts
- Complete EDP challenge individually or in teams
- Monitor student progress and ask guiding questions to support struggling students

Reflection

- Students post individual reflection on Flipgrid
- If time, share designs with class and make connections back to science concepts.
- Clean-up

Activity Guide

Mission 1

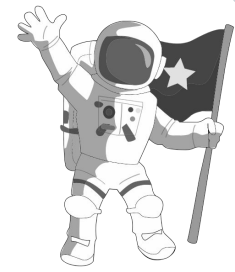
Meet the Crew



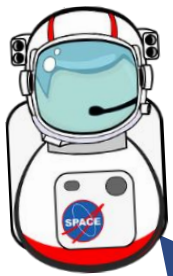
Mission to Moon



Mission Overview



1. Welcome to Space Club! Introduce the program and discuss logistics.
2. Watch the Mission Overview video or read script
3. Complete the “Mission Warm-up” box. In the future, this can be completed as students walk into the classroom.
4. Complete team challenges - many options are provided! Distance learning? [Find activities here.](#)
5. Astronaut Mental Training and Mission Patch Activity: Answer the mental challenges and mission patch activity on the student handouts. Use the teacher slides as a guide.
6. Complete the “Spark Quiz.” Sparks are something you are passionate about, makes you excited, and is unique to you! We recommend instructors sharing their personal sparks with students. [Learn more about sparks from the Search Institute.](#)
7. Complete *Sparks Mission Patch*. Students will create their personal mission patch. Watch: [Our World: Mission Patches](#) (5:22)
8. Optional: Create a class or club mission patch that can be turned into t-shirts, stickers, or badges for the entire group to have a shared identify.



STEM Career: Astronaut

Word of the Day: Teamwork

Activities center around how astronauts need to work together as a team to accomplish the mission. Everyone must participate to succeed!

Great videos to show:

[We Are NASA](#)
(2:23 min)

[Becoming a NASA Astronaut](#) (1.5 min)

[Becoming Astronauts: Are you next?](#)
(4 min)

Welcome to Space Club Mission Control! 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.

Hi! I am part of Space Club Mission Control 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. First, you will complete astronaut training. Next we will launch to the moon and learn how to survive by growing our own food. We will then build a solar-powered welcome tower to help us find our way back to base when exploring the lunar surface. We will then complete a scientific expedition by collecting and transporting rock samples for further study. Finally, we will design a new base on the Moon for humans to someday live!

To get started, let me introduce your crew's first mission. At NASA, before astronauts get sent into space, they design a mission patch. Creativity is important as each of the over 150 different patches is uniquely designed to represent the team and mission.

In today's mission, your challenge is to design a mission patch that represents- YOU! We look forward to seeing your mission patch designs!

-Space Club Mission Control



Resources

Video Resources

Real World Connection

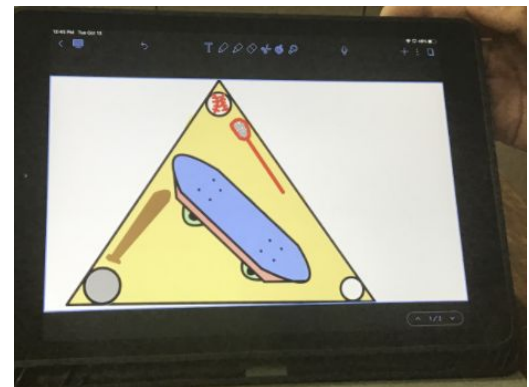
- [NASA 2021: Let's Go to the Moon](#) (3:23 min)
- [We Are NASA](#) (2:23 min)
- [We Go as the Artemis Generation](#) (1:11 min)
- [Meet the Artemis Team](#) (1:59 min)
- [#AskNASA | What is Artemis?](#) (2:57 min)
- [Our World: Mission Patches](#) (5:22 min)
- [The Artemis Program Patch with Dee](#) (3:44 min)

STEM Career Connection

- [What Do Astronauts Do?](#) (4:41 min)
- [Meet the Artemis Astronauts](#)
- [Becoming Astronauts: Are You Next?](#) (3:42 min)
- [Why did you want to be an astronaut?](#) (3 min)
- [A day in the life of an astronaut?](#) (9 min)

Extension Activities:

- Connect sparks to STEM careers! [Read more here.](#)
- Use sparks as icebreakers during a Zoom call including Show & Tell.
- [Click here for more icebreaker activities.](#)



Students create their own personal mission patch.



Build a Mission Patch

Materials

- Construction or Cardstock Paper
- Pencil
- Colored Pencils / Markers

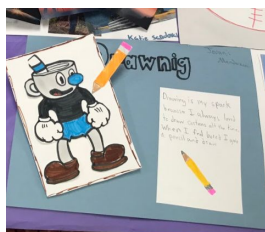
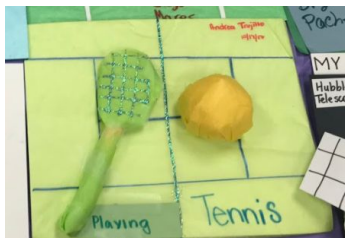
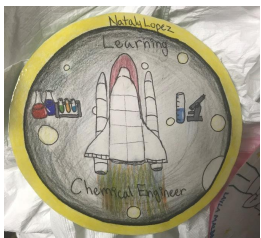
1. A spark is something you are passionate about, makes you excited, and is unique to you! Sparks can be something you like to do or an interest you have. Sparks are a great way to build relationships with students and help them feel connected to Space Club.
2. Ask students to think about their interests. Use the student handouts to brainstorm ideas and narrow down to one spark. You may need to help students get beyond the silly phase and select something they are actually passionate about.
3. Once every student has selected a spark, time to create a personal mission patch! The purpose is to have a way to display their spark and keep it as a reminder during Space Club. Teachers should also use this spark as a way to get to know students and connect lessons to personal interests.
4. The mission patch should include: student name, name of spark (i.e. “football”), and decoration to represent that spark. Students that don’t like to draw can use stickers, magazines, or other materials to add to their mission patch. You can also have students create digital artwork to print and add to their mission patch.
5. Optional: challenge your students to make the mission patch 3D by adding a pop-out component to a physical mission patch. Or a digital patch can be animated!



Teacher Tips: Students can save the mission patch to add to their astronaut helmet on the mission 3.

Sparks can be referenced throughout Mission to Moon. Ask students to create a digital Zoom background with their spark, share a story related to their spark, or have a show and tell day.

You may also consider making a team mission patch to represent the group as a whole.



Teamwork: Pipeline Challenge

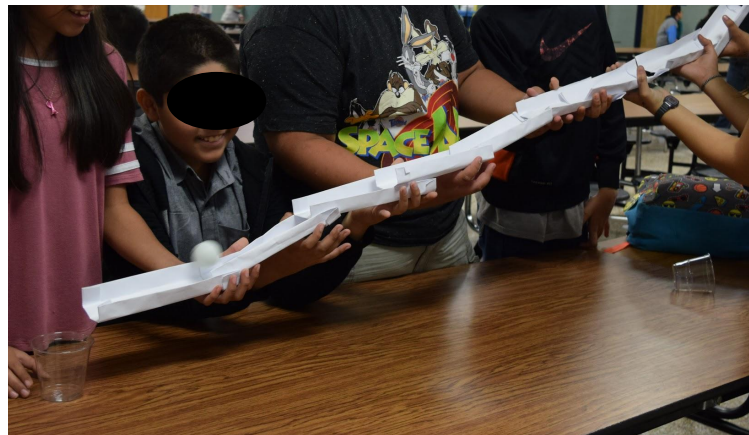
Student groups work to move a ball by creating a track as a team.

Group Size: 4 - 8 students



Prior to Activity

1. Collect materials.
2. Find a large open space for activity.



Materials

- 1 page of copy paper per person
- 1 cup per team (9 oz recommended)
- 1 ping pong ball per team



Activity Instructions

1. Put students in teams of 4 - 8 students. The larger the groups the more challenging the activity.
2. Provide each team with materials listed. Make sure each person has a piece of paper.
3. Have students form a line. The person at one end of the line has the cup. Place the cup on the ground. The person at the opposite end has the ball.
4. The goal is to have the ball land in the cup without touching the ball once in motion. The paper is to be used as the track. The ball must remain in motion at all times. If the ball stops or falls off the track, start over! The ball must land inside the cup at the end of the track.
5. Once the team accomplishes the task, move the cup farther way. You can even move it across the room! Now the team will realize that they have to do a relay race. Once the ball leaves the first person's track, that person must run to the end of the line ready to catch the ball and keep it moving!
6. Hint: Start with smaller groups for younger students, but we recommend no less than 4. Older students can even go up to 10+ students! Can you get the whole class to work together?

Teamwork: Head Tower Challenge

Student partner teams work together to stack blocks on top of a plate on their head.

Group Size: 2 students



Prior to Activity

1. Collect enough blocks for each team to have 5-8 depending on how difficult you believe they would be to stack.



Materials Per Group

- Blocks
- Paper plate



Activity Instructions

1. Students form pairs and designate one person to be the “block head” first. The block head must hold a plate on top of his/her head.
2. The partner is to hold a handful of blocks and when the teacher says “go” hands the first block to the partner. The partner’s job is to hand more blocks to the block head as they request more. They should also verbally assist the block head in positioning each block that is stacked or telling the blockhead how to balance the plate/stack of blocks.
3. Partners should be competing with other partner teams to see who can have the highest stack of blocks at the end of 1 minute. If a team builds a tower of blocks that is taller than all the other teams but falls before the timer ends, they do not win.
4. The objective of this icebreaker challenge is to facilitate good communication between partner teams. Emphasize that the partner is the eyes of the team and the blockhead is the hands so they must work together to be successful.



Teamwork: Straw Tower Engineering Challenge

Build a straw tower to hold 2 ping pong balls.

Group Size: 2 - 4 students



Prior to Activity

1. Review the engineering design process handout.
2. Review activity instructions and handouts.
3. Gather materials.



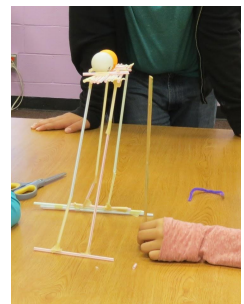
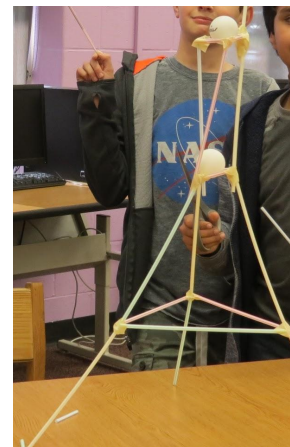
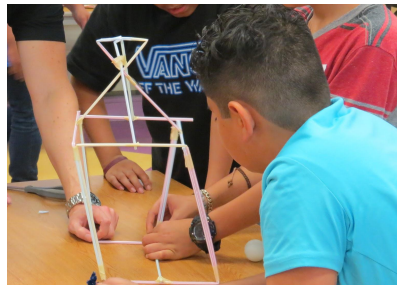
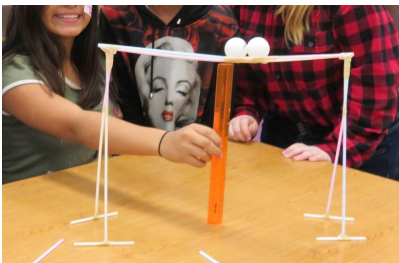
Materials per Team

- 20 straight straws
- 2 ft masking tape
- 2 ping pong balls
- Ruler



Activity Instructions

1. Introduce engineering design process using the handout provided. Explain to students that real-world engineers use this process to create engineering designs such as rockets, airplanes, skyscrapers, and computers. More great resources [here](#) and [here](#).
2. Split students into teams of 2 - 4. Grades K - 2 work best in partners, while older teams work well in groups of up to 4. We do not recommend doing this challenge individually.
3. Explain the challenge. **The mission: Build a straw tower to hold 2 ping pong balls at least 1 foot or 30 centimeters off the ground.** The rules or constraints:
 - a. Freestanding tower: no taping or securing to the ground or table.
 - b. Do not tape ping pong balls to tower or together.



Mission 2

Astronaut Training

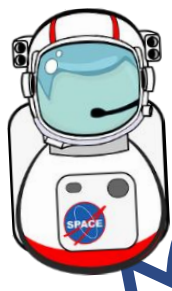


**Mission
to Moon**



Mission Overview

1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video or read script
3. **Science Background:** Read about the science of roller coasters and complete the potential and kinetic energy activities.
4. **Roller Coaster Challenge:** Introduce the engineering design process with the roller coaster challenge - always a student favorite! Connect to Mission to Moon with the vomit comet that uses changes in acceleration to prepare humans for space travel. How can the roller coaster cause changes in acceleration to a ping pong ball?



STEM Career:
Astronomer

Word of the Day: Communication

Ideas only come to life if you can clearly communicate them! As a team, you must be able to communicate effectively to work together and complete the mission.

Before we head to the Moon, we must first get ready for traveling in space. When NASA selects an astronaut for a space mission, he or she must undergo years of rigorous physical and mental training. One example of this training is riding an airplane that simulates weightlessness felt in space. The airplane flies in a wave pattern of steep climbs and sharp dives. As it climbs up, passengers get several seconds of weightlessness at the top. The airplane can even simulate lunar gravity. Each flight includes 40 - 60 repetitions of this change in G-forces, and 1 in 3 passengers get sick leading to the nickname of "Vomit Comet"!

While we can't send you on a Vomit Comet ride, you can experience similar sensations at an amusement park! Roller coasters cause a series of low- and high-gravity sensations that mimic the free falls and accelerations of airplanes and spacecraft. For example, as the coaster reaches the bottom of a hill or goes around a curve, you feel your body pressing into the seat. Similarly, acceleration during launch makes astronauts feel two to three times heavier than they are.

In today's mission, your challenge is to design and build a roller coaster that will cause changes in acceleration. Keep in mind that our Mission to the Moon will require you to take initiative and be bold! Don't worry about failure, that's part of the engineering design process! To succeed, you must first have the courage to try.

~Space Club Mission Control

Great videos to show:

[The Vomit Comet ft. Emily Calandrelli](#)
(5:16 min)

[What is Engineering?](#)
(6:20 min)

[The Physics of Roller Coasters](#)
(3:38 min)

Video Resources

Real World Connection

- [What zero gravity really feels like in the “vomit comet”](#) (7:42 min)

STEM Career Connection:

- [How do you become an Astronomer](#) (8 min)
- [NASA Explorers S4 E3: Training the Astronauts](#) (6:15 min)
- [#AskNASA | How Can I Be An Astronaut?](#) (3:53 min)
- [#BeAnAstronaut: Why Did You Want to Be an Astronaut?](#) (3:06 min)

STEM Career Connection: Engineering

- [I Am A Scientist](#) (2:31 min)
- [I Am An Engineer HD 1080p](#) (1:37 min)
- [Meet an Aerospace Engineering Student](#) (2:10 min)

Science Connection

- [How roller coasters affect your body - Brian D. Avery](#) (5:01 min)
- [Roller Coaster Forces: Explained](#) (7:21 min)



Science of Roller Coasters

Do you love riding on a roller coaster and feeling the heart-pounding sensation of flying out of your seat? Ever wonder how roller coasters work?

ALL ABOUT ENERGY

As you go up the first hill, a motorized chain pulls your cart to the top (that's the click click sound you hear at your feet). The first hill is usually the tallest and has the most **potential energy** or the amount of energy stored due to the object's height. The amount of energy stored from falling down the first hill will be enough to carry riders all the way to the end of the ride! The taller the first hill, the farther gravity can pull riders downward.

As riders scream while falling down the hill, **gravity** takes over. All the built up **potential** (stored) energy now changes to moving or **kinetic energy**. The further down the hill, the faster you go! As riders go up and down hills, the energy changes from potential to kinetic and back at each hill.

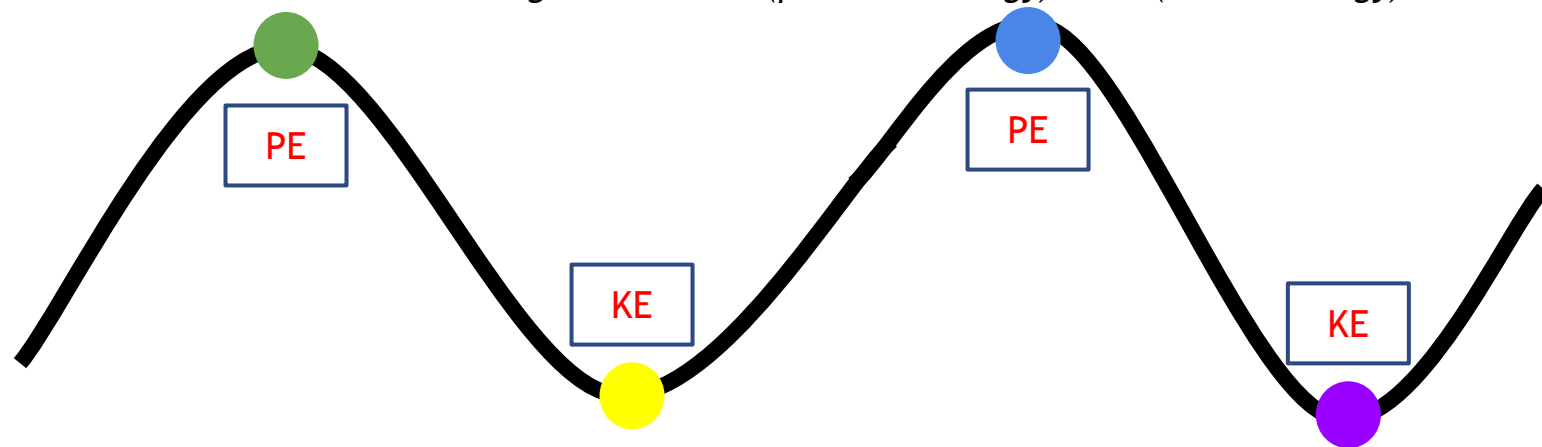
NEWTON'S FIRST LAW OF MOTION

According to Newton's First Law of Motion, an object in motion stays in motion. This should mean that the roller coaster will keep moving forward forever! However, **friction** forces slow down the cart as the wheels move over the track. **Air resistance** or **drag** forces caused by the cart moving through the air will also slow you down.



Potential and Kinetic Energy

Label the colored dot as having maximum PE (potential energy) or KE (kinetic energy)



Did you know a skateboarder uses gravitational potential and kinetic energy to do cool tricks?

1. Go to: <http://phet.colorado.edu/en/simulation/energy-skate-park-basics>
2. Click the link for a skateboarder simulation showing gravitational potential and kinetic energy.
 - Click play
 - Select Intro
 - Check bar graph
 - Place the skateboarder on the track to see how the energy changes

What is another real-world example of gravitational potential and kinetic energy?

Student answers will vary- another example besides the roller coaster and skateboarder could be bouncing a ball, rubber band, biker on a hill, object falling from above etc.

Students build a fun and safe roller coaster to get a ball into a cup.



Build a Roller Coaster

1. Mission: Design a safe and fun roller coaster!
2. Design constraints:
 - a. Ball must stay in motion at all times
 - b. Ball makes at least 1 turn.
 - c. Ball lands in cup.
 - d. Nothing inside cup.
3. Test: When students finish, they will test their roller coaster to make sure it meets all the design constraints. They can also measure the height, number of turns, and the time it takes the ball to reach the bottom.

Extension: Can you make the ball reach the bottom faster? Can you increase the height of the roller coaster? Can you add more turns? [Read more about this challenge here.](#)

A mental health activity to practice is “roller coaster breathing.” You can find more information [here](#) or through this [video](#).

Roller coaster math extension problems: How long does it take for the ball to travel to the bottom of the roller coaster? Can you figure out the distance the ball travels? Can you calculate the average speed of the ball?

Materials Per Student

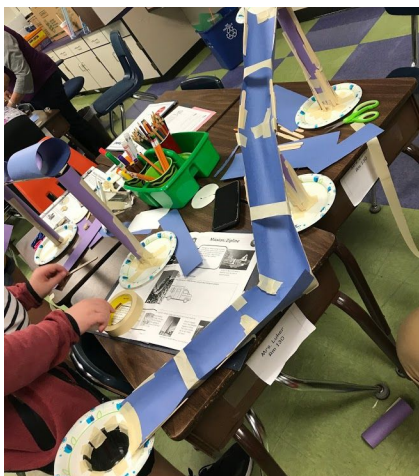
- Scissors
- Tape
- 8 Pieces of construction paper
- 4 Paper Plates
- 1 Paper cup
- 1 Ping Pong Ball
- Optional - other recycled materials

Note: no need to constrain materials on this challenge. Let the students use whatever is available (Amazon boxes, cereal boxes, etc.) to create a wild ride! But if providing a supply kit, make sure they only use those items above so they have materials for the rest of the activities!

Watch this activity in action!

[Student Flipgrid Examples](#)

[Student Project Highlights](#)



Mission 3

Astronaut Helmet



**Mission
to Moon**

Mission Overview

1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video or read script
3. **Science Background:** Learn the science behind space suit design and the parts of a helmet. Complete the activities on the page to learn more about space suits and helmets.
4. **Astronaut Helmet Challenge:** Design and build an astronaut helmet to stay protected on the Moon.



STEM Career:
Aerospace Engineer

Word of the Day: Critical Thinking
Students have the tendency to jump right into a project without thinking through the best approach.

As we prepare for launching to the Moon, we need to pack our bags. Going to the Moon is kind of like a camping trip, but your house is 239,000 miles away, and your campsite has no oxygen, food, or water...

First we need to have protective gear to survive the elements of space travel and living on the Moon. In this mission, you will learn about astronaut space suits and design your own astronaut helmet.

When astronauts go on a mission they wear a space suit to protect themselves. Astronaut suits have over 13 layers and weigh 280 pounds. Along with wearing a spacesuit, another way astronauts stay safe is through teamwork. During training, crew members learn to work together and build important team skills such as communication and collaboration. Can you think of a time you had to work as a team? What challenges did you face? Now imagine facing those same challenges during a dangerous space walk!

Good luck with your mission, and I look forward to seeing your designs! ~Space Club Mission Control

Great videos to show:

[#AskNASA | What are the Next Generation Spacesuits?](#) (3:31 min)

[It Takes Teamwork to Become an Astronaut - STEM in 30](#) (1:26 min)

[NASA astronaut Peggy Whitson #SuitUp Video](#) (1 min)

Video Resources

Real World Connection

- [#AskNASA | How Are We Going to the Moon?](#) (2:52 min)
- [#AskNASA | Who Is Going with Us?](#) (3:30 min)

STEM Career Connection

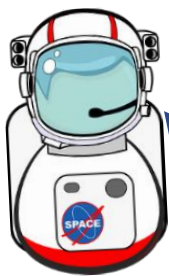
- [What is Aerospace Engineering](#) (5 min)
- [NASA Explorers S4 E2: The Scientists](#) (5:52 min)
- [Women of Artemis: Meet NASA Physicist Jennifer Inman](#) (2:59 min)
- [Who Works At NASA? What It Means To Be a NASA Employee](#) (2:55 min)
- [Our World: Careers at NASA - More Than Just Astronauts!](#) (6:05 min)

Science Connection

- [Spacesuit | HOW TO BUILD... EVERYTHING](#) (2:59 min)
- [SpaceX spacesuits - Take a deep dive](#) (2:19 min)

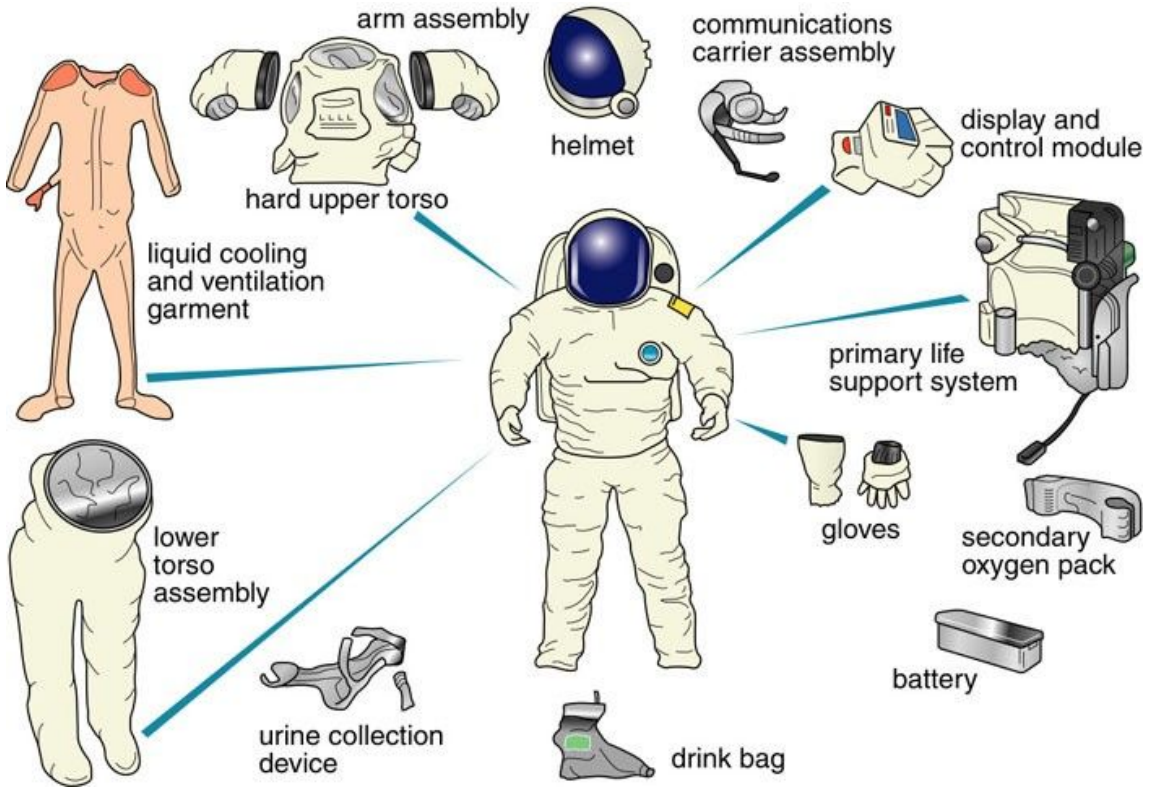
Extension Activities

- Do a spacesuit glove challenge with your students. Here are some resources from [NASA](#) and [Long Island's Air & Space Museum](#).
- [Have students do research about spacesuits and create a Flipgrid video.](#)
- [Suit Yourself Activity:](#) Students apply linear equation concepts to evaluate the oxygen component of an astronaut's spacesuit.





NASA designs spacesuits to keep astronauts warm, protect them from radiation, and provide oxygen for breathing. Learn more at www.nasa.gov/feature/spacewalk-spacesuit-basics

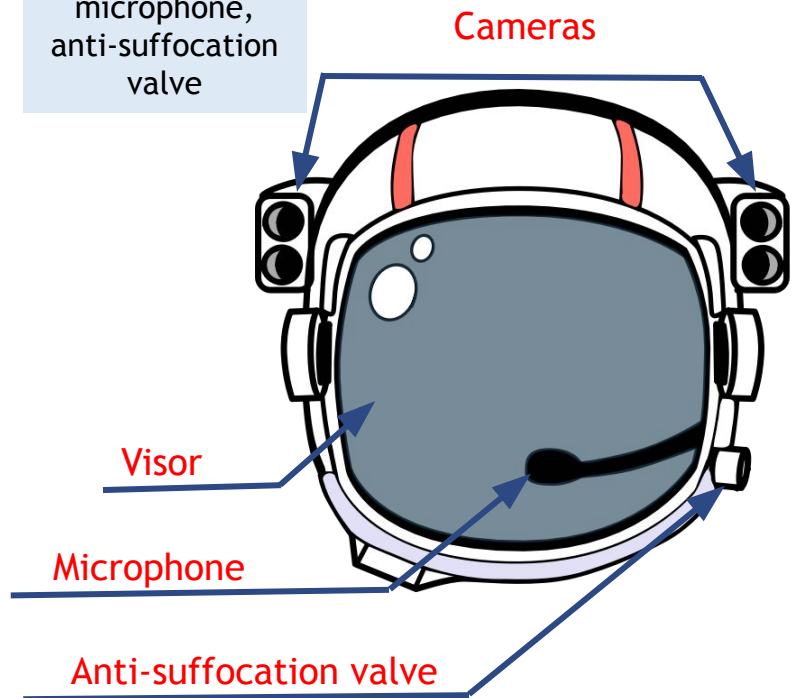


Space Suits for the Next Explorers

1. We need space suits to survive the harsh environment of living on the Moon! Watch the video to see the new NASA space suit called xEMU. <https://youtu.be/vPkamuLqwM8>
2. What is one thing that NASA improved in this spacesuit design?

Word Bank:
cameras, visor,
microphone,
anti-suffocation
valve

Label the parts of the helmet



Students create an astronaut helmet to stay protected on the Moon.



Build an Astronaut Helmet

1. Mission: Design and build an astronaut helmet to stay protected on the Moon.
2. Design constraints:
 - a. Cover entire head
 - b. Allow the astronaut to breathe and see
 - c. Rest comfortably on shoulders
 - d. Include a movable visor
 - e. Include a communication system
3. Test: For testing, make sure your helmet follows the design constraints. The goal is for students to also be able to explain why their astronaut helmet needs all these different constraints. For example, a communication system is to talk with NASA Mission Control or other astronauts.
4. Personalize and decorate your helmet! NASA puts stripes on the outside of the astronaut suits to tell one astronaut from another. If someone were to see just your astronaut helmet, how would they know it belongs to you? Also encourage students to include their spark.

Materials Per Student

- Scissors
- Tape
- 7 Sheets of construction paper
- 1 bendy straw
- Optional: Art supplies and recycled materials such as cereal boxes, cardboard, tissue boxes, etc.

Note: materials don't need to be restricted on this one, but make sure they don't use more than those listed from their supply kits.

Watch this activity in action!

[Student Flipgrid Examples](#)
[Student Project Highlights](#)

Note: the linked activities also included an astronaut boot. The boot was removed in this updated curriculum.



Note: the instructional video also has a boot challenge. We recommend focusing on part 2 for the helmet design.



Teacher Tips: Have students place all the helmets at the front of the classroom and have them guess who each helmet belongs to. This is a great icebreaker and way for students to get to know each other

For virtual learning, have students submit photos of their helmet design and over video chat have the students guess who the helmet belongs to.



Mission 4

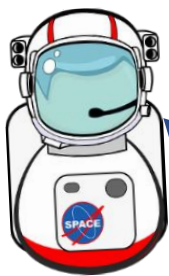
Plants in Space



Mission to Moon

Mission Overview

1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video or read script
3. **Science Background:** Learn the challenges of living in space and explore ways to grow food in order to stay alive.
4. **Plant Device Engineering Challenge:** Students will design a hydroponic greenhouse to grow plants including comparing two different seed types.



STEM Career:
Botanist

Word of the Day: Resilience
Activities emphasize the need to persevere through difficulties and be patient when waiting for success and results.

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!

~Space Club Mission Control

Great videos to show:

[NASA ScienceCasts: A Successful Mission Starts With Nutrition](#)
(3:52 min)

[How Astronauts Grow Plants In Space](#) (3:25 min)

[NASA | Eat Like an Astronaut](#)
(12:31 min)

Video Resources

Real World Connection

- [#BeAnAstronaut: How Did You Get Interested in STEM?](#) (3:00 min)
- [#AskNASA | How Do We Get New Science to the Moon?](#) (2:53 min)
- [How astronauts can get a taste of steak in space](#) (6:15 min)
- [ScienceCasts: Historic Vegetable Moment on the Space Station](#) (3:54 min)

STEM Career Connection

- [Keyanna Millinger '14: Botanist and Environmentalist](#) (3:17 min)
- [Jessica Meir, Ph.D. - From Marine Biologist to Astronaut](#) (29:59 min)
- [Space Plants - How they are adapting](#) (4:30 min)
- [Growing in Space](#) (2:40 min)

Science Connection

- [Space Plants - How Are They Adapting?](#) (4:27 min)

Science Connection

- [Vegetation Transformation: Crash Course Kids #5.2](#) (2:59 min)
- [How Does A Seed Become A Plant?](#) (3:45 min)
- [The Martian | "Do The Math" Clip](#) (0:56 min)

Extension Activities

- **Science Discussion:** How will your plant device meet your seed’s needs to allow it to grow?
Answer: The cotton ball contains the water that the seed needs to germinate. Air is sealed into the bag, providing the plant with CO₂. The bag is clear so it allows the sunlight to enter and provide the plant with the energy it needs for photosynthesis.
- Complete the [Food for Spaceflight](#) activity from NASA. This lesson will help your students answer the question: What foods are best suited for spaceflight, and what makes foods suitable for spaceflight?
- Complete NASA’s [Lunar Plant Growth Chamber](#) activity and [watch this video](#) from the ISS.



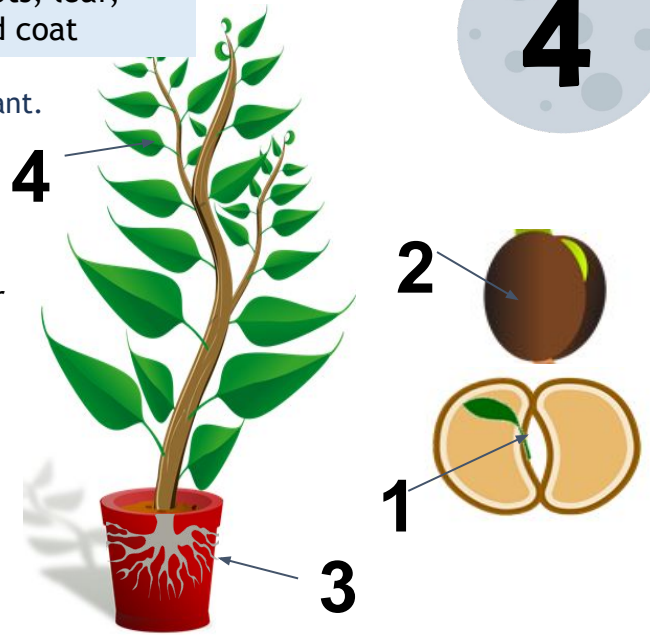
Plant Anatomy: Fill in the blanks with the name of each part of the plant.

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

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

3: The roots are how plants collect water and nourishment.

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



PHOTOSYNTHESIS

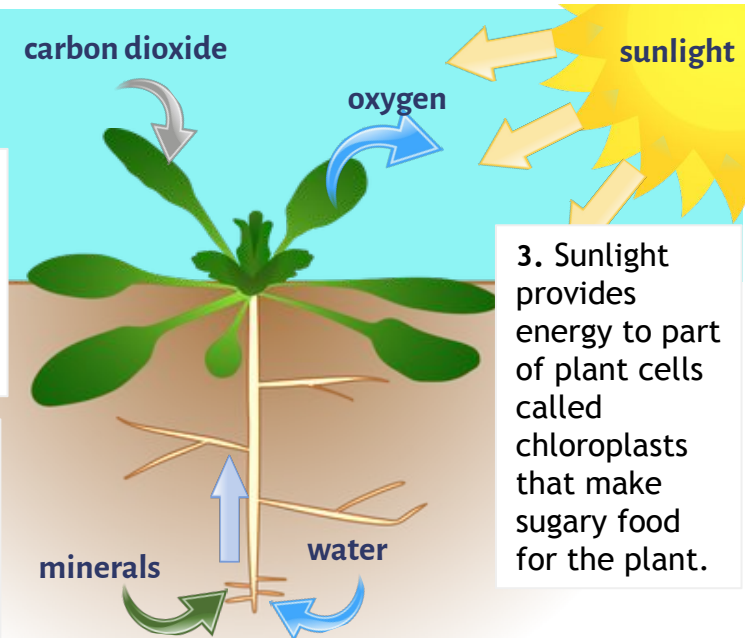
How green plants make their food.

What 4 things do plants need?

1. Carbon Dioxide
2. Water
3. Minerals
4. Sunlight

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.

Students will build a device to hold a Mini-Greenhouse and watch their plants grow!



Build a Plant Device

1. Students will first need to build a greenhouse. Then, students will be provided an assortment of materials for the plant device holder engineering challenge.
2. **Build a Greenhouse**
 - a. Students will need 2 seeds. We recommend one is a Pinto bean that is soaked for at least 1 hour. The second seed can be a vegetable or flower seed or popcorn kernels.
 - b. Soak 2 cotton balls in water and place in Ziplock bag.
 - c. Place a seed on top of each cotton ball.
 - d. Seal the bag. Do not squeeze any air out.
3. **Plant Device: After building your greenhouse, design a device to support your plant as it grows. The device must:**
 - a. Allow plant to get plenty of sunlight.
 - b. Hold plant bag upright.
 - c. Stand up on its own without you holding it.
 - d. Seeds in the bag are 6 inches (15 cm) above the ground

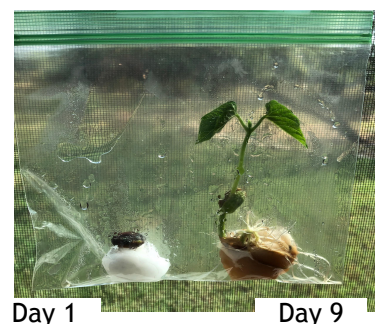
Materials Per Student:

- Scissors
- Tape
- 1 Ziplock Bag
- 2 Seeds or beans
- 2 Cotton Balls
- 2 Paper Cups
- 6 Bendy Straws
- 4 Pieces of Construction Paper
- Optional: add reflective materials

Note: constrain materials on building the device holder, otherwise it will be too easy.

Watch this activity in action!

[Student Flipgrid Examples](#)
[Student Project Highlights](#)



Bonus: How can you use reflective materials to direct more sunlight to the plants? This can be CDs, aluminum foil, etc.

4. **Test:** Students will build their plant holder device until design constraints are met. Students will then watch and observe their seeds growing and record the results. A minimum of 5 days is recommended for observation of plant growth. The student handout includes a chart to recording plant growth.



Teacher Tips: Students will be excited to watch their seeds grow! Make it into a competition to see who will grow the tallest plant. Students can share daily heights on a shared Google Doc or Slide. We also recommend having students compare seeds, and as a class, you can determine which seeds have the most successful plant growth.

Make sure to point out that no soil was needed. Plants don't need soil to grow! This is a major misconception for students.

Also, providing too many materials will make it too easy to build the plant holder. Part of the challenge is struggling to use the limited supplies to make it stable and hold up the bag.



Mission 5

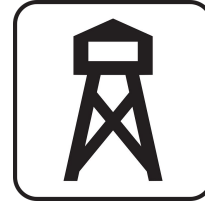
Welcome Tower



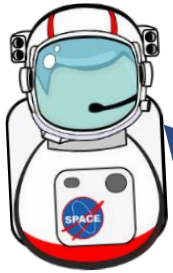
**Mission
to Moon**



Mission Overview



1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video or read script
3. **Science Background:** Explore how to power life on the Moon, different types of energy sources and how to complete a circuit.
4. **Welcome Tower Engineering Challenge:** Students will design a welcome tower that has a sign powered by an energy source and has an on/off switch.



STEM Career: Mechanical Engineer

Word of the Day: Initiative

Have confidence in your abilities! Challenge focuses on having confidence to apply effort to the activities immediately without waiting on others to start for them or provide hints.

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!

-Space Club Mission Control

Great videos to show:

[Will we ever live on the Moon?](#) (3 min)

[Exploring mechatronics and mechanical design through teamwork](#) (3:20 min)

[STEMonstrations: Solar Energy](#) (2:40 min)

Video Resources

Real World Connection

- [What if we covered the Moon in solar panels?](#) (3:30 min)
- [NASA's New Space Reactor Is Powered by Nuclear Fission](#) (7:06 min)
- [5 Inventions Showing Us the Future of Solar Energy](#) (10:05 min)

STEM Career Connection

- [Mechanical Engineer](#) (5:54 min)
- [Meet Mechanical Engineers at Google](#) (1:58 min)
- [What is Mechanical Engineering](#) (2 min)

Science Connection

- [What is engineering: How different disciplines work together to create a vending machine](#) (3:18 min)
- [The Power of Circuits! | Technology for Kids | SciShow Kids](#) (4:41)

Extension Activities

- Complete the [Solar Oven](#) activity. Through the construction and testing of a solar oven, students will understand the importance of solar energy to the establishment of a lunar base.
- Create a [paper circuit](#) and make a neuron star light up!

Science Background

In your own words, how does a circuit work?

Answers will vary - A circuit is complete path where electricity can flow. Circuits allow electricity to work like lights, and appliances. A circuit needs to have a power source such as battery, wire or some type of conductor material for the electricity to flow, and a device like a light bulb that uses the electric current

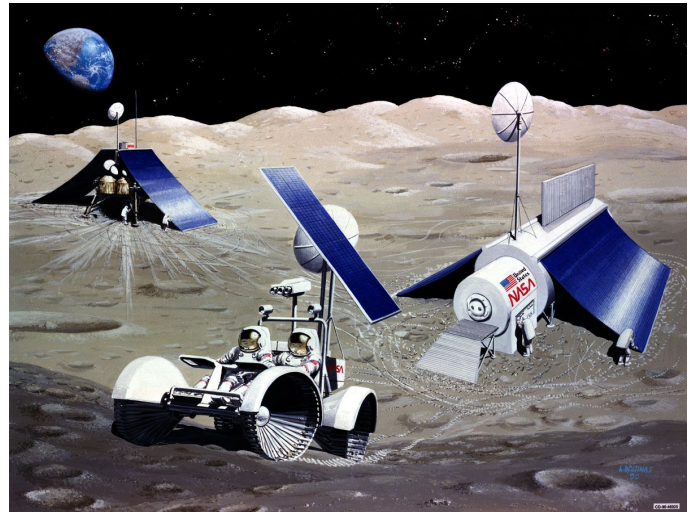
How will you power your colony?

Under each type of power source, check the box if the statement is a positive feature. All the statements are true however some are positive features and some are negative features of the power source.

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



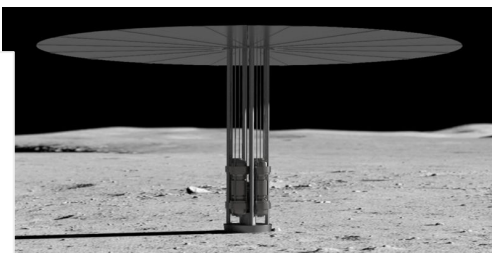
Artist depiction of a lunar base with solar panels. Credit: NASA

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.



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 source



Fuel Cell Credit: Hydrogenics

Students will build a welcome tower that holds a welcome sign powered by an energy source.



Build a Welcome Tower

1. **Mission:** First, create a welcome sign. Then build a tower that holds and powers the light up sign.
2. Create a welcome sign from a piece of construction paper at least 2 in x 2 in or 5 cm x 5 cm. Another option is to use an index card. The sign should include the name of your lunar base.
3. **Design Constraints:**
 - a. Use only provided materials (otherwise this becomes too easy)
 - b. Include welcome sign with LED light
 - c. Raise sign at least 1 ft or 30 cm from ground
 - d. Include a switch on the ground to turn light on and off

If using a solar panel:

 - e. Solar panel must have full exposure to the sun.
 - f. Allow for the solar panel to face different directions based on the location of the sun.

4. **Testing:**
 - a. Is the sign at least 1 foot off the ground?
 - b. Is the power source on the ground?
 - c. Does the switch turn the light turn on and off?

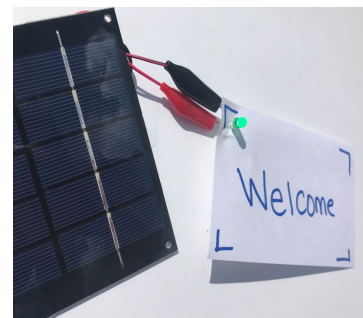
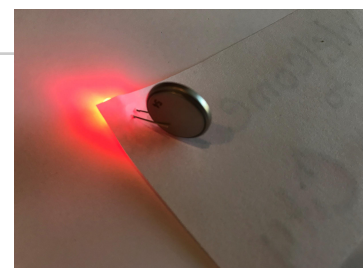
If using a solar panel, students will go outside on a sunny day to test:

- Is the sign at least 1 foot off the ground?
- Is the power source on the ground?
- Does the switch turn the light turn on and off?
- Can the solar panel rotate or face more than one angle?

Materials Per Student

Only use materials provided

- Scissors, Tape, Ruler
- 5 Sheets of construction paper
- 1 Sheet of cardstock
- 2 Paper plates
- 12 Bendy Straws
- 1 Solar Panel OR Coin Cell Battery (3V)
- 1 LED Light (2.0-2.2V)
- Aluminum foil: need enough to make a conductive path from LED to bottom of tower



[Student Flipgrid Examples](#) | [Student Project Showcase](#)

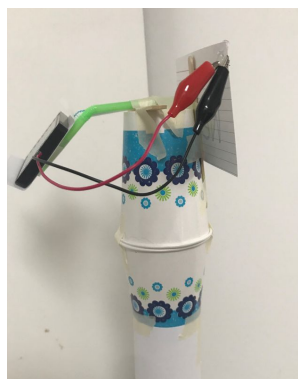
Note: the examples linked above did not have the constraint of a switch on the ground.



Teacher Tips: The aluminum foil is used for creating a path between the LED light and power source on the ground. In the pictures, the switch is pressing the two pieces of foil together.

Struggling to build a sturdy tower? Add plastic cups to make this an easier activity.

Using a solar panel? An incandescent light bulb can be used to charge if stuck indoors.



Mission 6

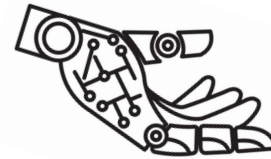
Collect Moon Samples



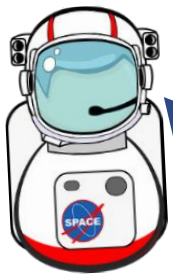
**Mission
to Moon**



Mission Overview



1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video or read script
3. **Science Background:** Learn how scientists collect samples on the Moon for testing and the types of craters found there. Learn more about the parts of a hand and the science of bionic hands.
4. **Robotic Arm Engineering Challenge:** Design a robotic arm to pick up and rock samples (ping pong balls).



STEM Career: Biomedical Engineer

Word of the Day: Leadership

Be someone who can inspire and motivate others to reach a goal! Becoming an independent thinker who understands how to work as a team.

You've probably noticed that the lunar surface is full of thousands of craters. So why are there so many craters on the moon, but we only know of 180 on Earth? Unlike Earth, the Moon has no atmosphere to protect itself from comets and asteroids. That means it has no wind, it has no weather, and certainly has no plants and nothing can remove marks on its surface once they are made. The dusty footsteps of astronauts who once walked on the Moon are still there today, and they aren't going anywhere anytime soon. Scientists also 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. How will we build a robotic arm that can not only move but be strong enough to pick up an object? This mission might be difficult, so be resilient as you encounter challenges and don't be afraid to redesign your device and try again! Have fun exploring!

-Space Club Mission Control

Great videos to show:

[Robotic Hand](#)
(3:38 min)

[Robonaut 2 on the Space Station](#) (1:05 min)

[60 Seconds With a NASA Bioengineer: Vanessa Wyche](#)
(1:30 min)

[BONES OF THE HAND](#)
(2:30 min)

Video Resources

Real World Connection

- [The New Tech Heading To The ISS Will Change Human Space Exploration](#) (7:26 min)
- [Valkyrie: NASA's Superhero Robot](#) (2:58 min)
- [8 NASA Robots That Will Study The Mysteries Of Space](#)
- [Valkyrie : NASA's Most Advanced Space Humanoid Robot](#) (2:22 min)
- [GM-NASA Space Robot Power Glove](#) (3:25 min)
- [Engineers Created A New Bionic Arm That Can Grow With You](#) (4:29 min)
- [Solving Rubik's Cube with a Robot Hand](#) (2:50 min)

STEM Career Connection

- [Biomedical Engineering student prints 3D hand](#) (0:59 min)
- [So You Want to Become a Biomedical Engineer](#) (2:30 min)
- [What does a Biomedical Engineer Do?](#) (1:30 min)

Extension Activities

- Create a robotic hand as an advanced grabber and have students calculate the ratio of each straw to the finger's length.
- Have students research the “Twin Study” and how space affects the human body. Then have them create a Flipgrid video of their findings.

YOUR HANDS

Whenever you throw a ball, write a letter, or eat a bowl of cereal, you are using the bones in your hand. Your wrist has 8 bones that make up the carpus region. The center of your hand is made of five separate bones, which are part of the metacarpus region. Each finger on your hand has three bones, except for your thumb, which has two. The bones of your four finger are attached with joints that can only curl inward. The thumb can rotate because of a joint called the carpometacarpal joint.



Bionic Hand

Alt-Bionics developed the Genesis Hand, an affordable prosthetic for patients with below elbow amputations. The Genesis Hand uses electromyography. Whenever you decide to move any part of your body, your brain sends electrical signals to the necessary muscle groups. These signals can be used to determine the intended motion a user is trying to make and translate it into the mechanical motion of the hand.



All About Craters

In this mission, you will use a robot hand to gather a rock from a crater. 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

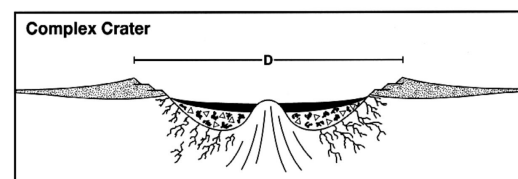
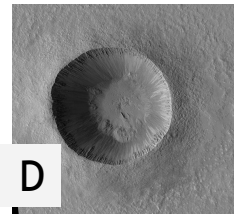
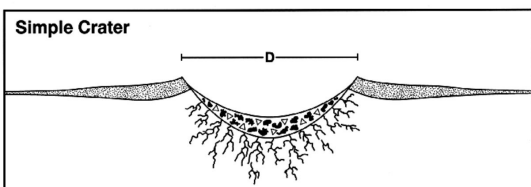
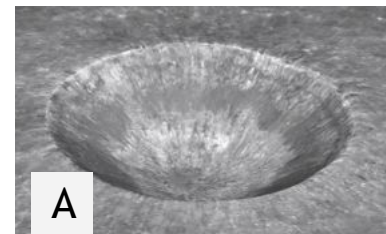
- Relatively small
- Smooth bowl shape

Simple Craters: **B, C**

COMPLEX CRATERS

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

Complex Craters: **A, 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).

Activity: Robot Arm

6

First, build a robot hand. Then, build a robot arm to pick up a rock sample.



Build a Robot Arm

- Students will need to build a robot hand. Then students will use the remaining materials for the robot arm.
- Build a Robot Hand:** Have students follow instructions in video on how to build the robotic hand.
 - Cut out an outline of your hand using the cardstock or cardboard.
 - Cut each straw into 3 pieces and tape along fingers. They will first cut the straw in half. Then take one of the halves and cut it in half again, giving them 3 pieces.
 - Thread string through the straws to move fingers.
- Robot Arm: After building their robot hand, design a robot arm that can pick up a ping pong ball.**
 - 5 Movable fingers
 - Robot arm must extend at least 6 inches or 15 cm beyond the length of your own hand
 - Picks up a ping pong ball
- Test:** Students will test the device by trying to pick a ping pong ball using only their robot arm. If they succeed, encourage them to pick up other heavier objects to see if their robot arm is strong enough.

Materials Per Student	
<input type="checkbox"/>	Scissors, Tape
<input type="checkbox"/>	Pencil or Marker
<input type="checkbox"/>	7 Straws
<input type="checkbox"/>	5, 12 inch (30.48 cm) pieces of string
<input type="checkbox"/>	3 Sheets of cardstock (<i>for robot hand</i>)
<input type="checkbox"/>	Ping pong ball or similar object
<input type="checkbox"/>	5 Sheets of construction paper
<input type="checkbox"/>	Recycled materials, such as cardboard

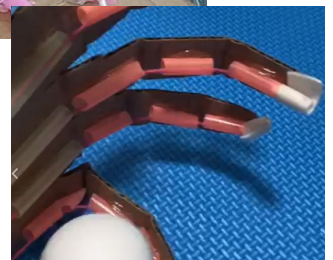
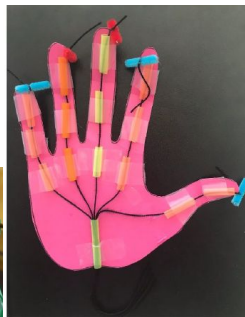
Note: the hand should be made of cardstock or cardboard to be sturdy enough to work!



Teacher Tips: Many teachers find this to be the most challenging activity. The robot hand is very much a step-by-step activity in the video, but the actual construction can be frustrating for younger students. Talk about persistence in keeping with the design and show some examples for motivation!

We highly recommend trying this one first before doing with students. Also, this activity will take longer than the others so plan accordingly. Building the robotic hand takes 45 min.

Older students can make their own variations of the hand using different lengths of straw and string.



One challenging part of the build is keeping the string on the finger. Notice in these pictures how one has tape at the end and other has the string tied to a small piece of straw.

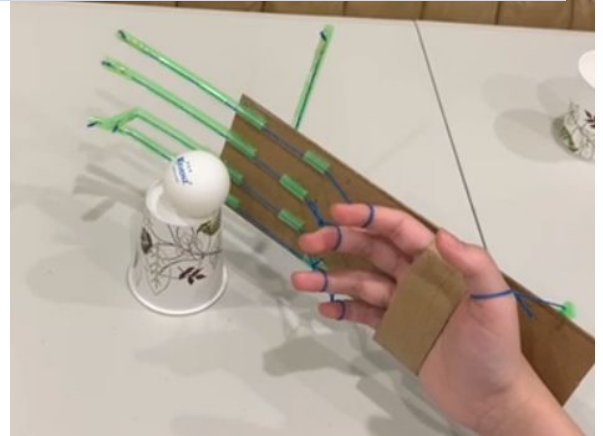
Activity: Robot Arm

6



Teacher Tips: After making the hand, students will need to figure out a way to attach to their arm and create a grabber. If students struggle with creating the robot arm, make sure to emphasize the they are building an arm to extend their cutout robot hand past their own hand. I also recommend having videos and photos ready to show students that are struggling to visualize this challenge.

Watch this activity in action!
[Student Flipgrid Examples](#)
[Student Showcase](#)



Mission 7

Rover Exploration

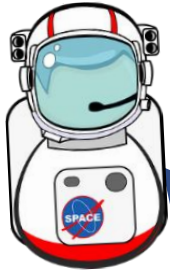
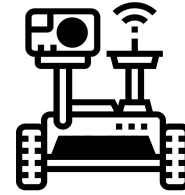


**Mission
to Moon**



Mission Overview

1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video or read script
3. **Science Background:** Learn about rovers on the Moon. Practice identifying conductive materials and difference between open and closed circuits.
4. **Rover Engineering Challenge:** Design a rover to transport the sample back to base for testing. Students will design a “rover” to carry a rock sample (ping pong ball).



STEM Career: Electrical Engineer

Word of the Day: Adaptability
Being able to adjust to different conditions. It is important to practice adaptability when you have failures and challenges along the way!

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

For today's mission you will be transporting the rock samples you collected in your last mission back to your base. However, these rocks are too heavy to carry. 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.

NASA has been sending rovers to space since 2003 to conduct preliminary research of planets and send information back to Earth for humans to study. This helps humans to be prepared for what they might encounter. For the Artemis mission, NASA will be sending the VIPER rover in 2022 and will go to the South Pole of the Moon to get a close-up view of the location and concentration of water ice that could eventually be harvested to sustain human exploration on 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! *-Space Club Mission Control*

Great videos to show:

[Design of Lunar Rover was mostly guesswork](#) (2 min)

[Introduction to Electricity- video for kids](#) (5 min)

[Mission: Solar System - Sandeep Yayathi, Robotics Engineer](#) (4 min)

Video Resources

Real World Connection

- [#AskNASA | Why Are We Going to the Moon?](#) (3:36 min)
- [NASA Moon Rover Books Ride to the Moon](#) (1:57 min)
- [Tri-ATHLETE](#) (2:30 min)
- [Awesome Robots Inspired by Nature](#) (5 min)
- [BB-8 visits the robots of NASA](#) (3:30 min)
- [Life at the Lab: Soft Robots](#) (1:55 min)
- [Boston Dynamics' amazing robots Atlas and Handle](#) (7:18 min)

STEM Career Connection

- [Career Spotlight: Robotics Engineer](#) (2 min)
- [James Fraction, Electrical Engineer](#) (3 min)
- [What is electronic and electrical engineering](#) (2 min)

Science Connection

- [What is electricity?](#) (2:33 min)
- [The Power of Circuits](#) (5 min)
- [The Power of Circuits! | Technology for Kids | SciShow Kids](#) (4:41)

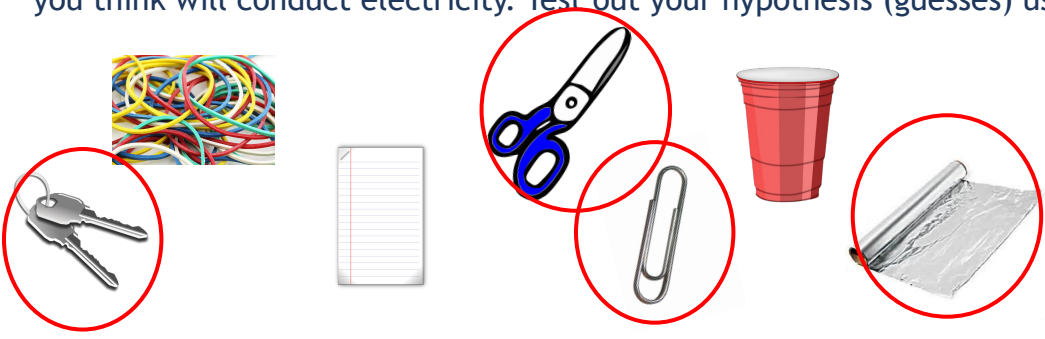
Extension Activities

- Have students explore open and closed circuits by creating [Light up Constellations](#)



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 objects below that you think will conduct electricity. Test out your hypothesis (guesses) using an energy stick.



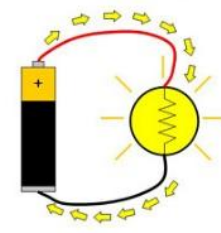
What other conductive materials can you find? List them below!

Answers will vary

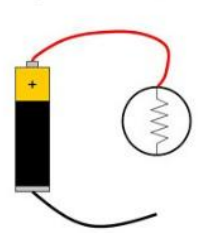
Use the word bank to complete the sentences below.

1. Electricity is the flow of electrons.
2. A circuit is a path through which electricity can flow.
3. A **closed** circuit is a complete circuit that allows for the electricity to flow from one end to the other without interruption.
4. An **open** circuit is an incomplete 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
- Pivoting Wheels:** Enables crab-style driving for docking
- 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.
- Work Package Interface:** Allows attachment of modular work packages (e.g. winch, cable, backhoe or crane)

Activity: Rover Challenge

7

Students build a rover to carry a ping pong ball.

Build a Rover

Watch this activity in action!

[Student Examples](#)
[Student Showcase](#)

1. Mission: Design a rover that can carry a rock sample (ping pong ball). Note that this is not a real robotic device as there is no way to program the robot to respond to commands. Students control the “rover” by modifying the design.
2. Design constraints:
 - a. Move at least 1 ping pong ball a distance of 1 foot or 30 cm
 - b. Use the vibrating motor to propel the rover forward
 - c. The rover may move freely or along a track
3. Test: This activity requires continual testing. We recommend using the ping pong ball from the start to allow students to continually refine their designs. Keeping the rover moving in a straight path is a real challenge. Providing a track such as a row of books or a ruler to guide the rover will make this an easier activity. Or challenge students to make their own track.



Materials Per Student

Note: not all materials need to be used.

- Scissors, Tape & Ruler
- 1 Coin cell battery
- 1 Vibrating motor
- 2 Bendy straws
- 1 Ping Pong Ball
- 1 Piece of construction paper
- 1 Piece of cardstock paper



Teacher Tips: If students use the cardstock and are struggling, advise them to only use 1/4th of the sheet because it can be heavy and slow the rover down. The rover needs to be very *light* to work!

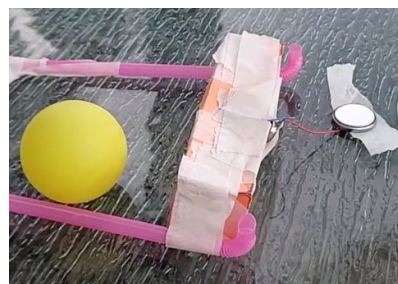
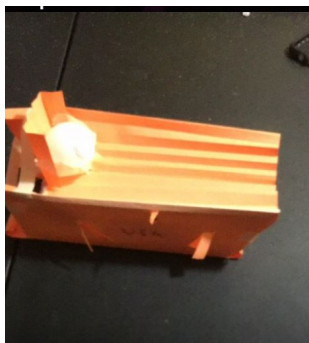
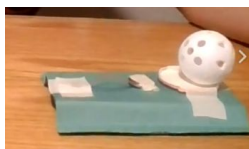
Note that some pictures show a paper cup. This was removed as it made the challenge to easy! But you may wish to add back in if students are struggling.



Motor



Battery



Bonus Missions

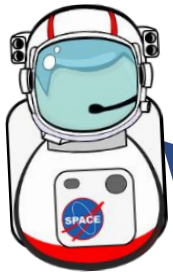


Mission to Moon



Mission Overview

1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video or read script
3. **Science Background:** Types of Radiation and Asteroid Impact
4. **Safety Shelter Engineering Challenge:** Students will apply the scientific method to test which materials block ultraviolet (UV) rays. Students will use the Engineering Design Process to design, build, and test a shelter from harmful radiation and asteroids.



STEM Career: Material Scientist

Word of the Day: Problem Solving

Activities center around how astronauts need to carefully work through the constraints and challenges to solve the overall problem.

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! ~Space Club Mission Control

Great videos to show:

[Why Can't We Live on the Moon](#)

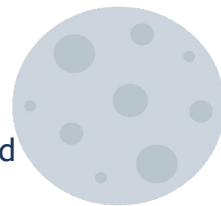
(3:50)

[3D Printed Moon Base](#) (1 min)

[3D-printing a lunar base](#) (5 min)

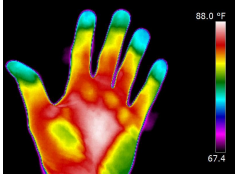


[Moon Village](#) (4:30 min)



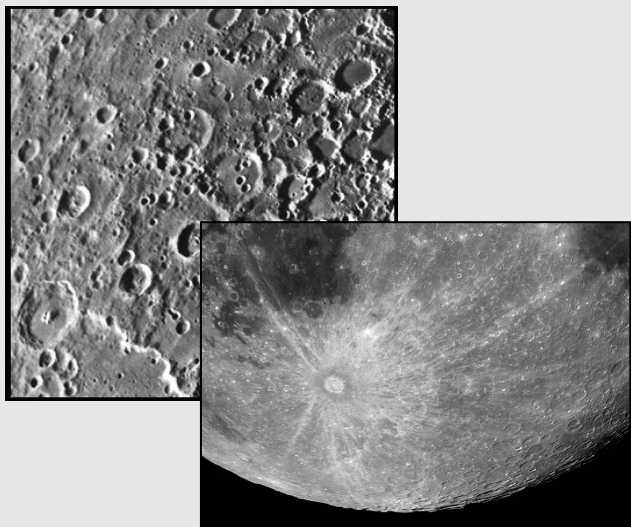


The Sun emits many different types of radiation, but not all of it is harmful! In fact, we need the Sun to stay alive. Complete the table below on three types of radiation from the sun.

Word Bank: infrared, ultraviolet, visible light

Type of Radiation	Description	Examples	Is it harmful?
<p>Infrared</p> 	Causes molecules it touches to vibrate and create heat. We can't see it, but we can feel it as heat!	<p>Electric heaters like toasters, toaster ovens etc. Short range communication like remote controls - Thermal imaging systems</p>	Typically not but can be if used improperly
<p>Visible Light</p> 	Human eyes are most sensitive to this radiation. We can see it as different colors in a rainbow.	<p>ROYGBIV Sunlight Light Bulb Glow Sticks</p>	No
<p>Ultraviolet</p> 	Causes sunburns and can damage your skin. The high level of energy can damage human cells and even mutate its genetic code.	<p>Sunlight UV lights</p>	Overexposure can be harmful

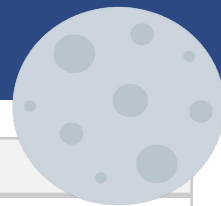
Asteroid Impact



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



Students build a shelter to protect an astronaut from harmful ultraviolet (UV) rays and asteroid impacts.

Group Size: Partners



Prior to Activity

1. Gather materials listed.
2. Build an example astronaut.
3. Using paper bag, create kits of testing materials per group.
4. Practice challenge.



Activity Instructions

1. In this activity, students will first build an astronaut individually. Then, they form teams to design a safety shelter to protect their astronauts from UV radiation.
2. **Mission:** Build a safety shelter to protect astronauts from UV rays and asteroid impacts. The constraints are as follows:
 - a. No larger than 1 sheet cardstock paper.
 - b. Four walls.
 - c. 1 entrance or doorway to enter shelter.
 - d. Astronauts stay protected (beads remain colorless) after 1 minute.
3. **UV Beads:** Before building, introduce students to the UV beads. Demonstrate the change to the beads when exposed to ultraviolet light (UV). 10% of the sun's rays contain UV light. You can go outside to demonstrate or use the black light.

UV radiation comes from either direct sunlight or a black light. Before exposure, beads are white (top blue photo). After exposure beads turn different colors (bottom). You can create little astronauts using the instructions that follow or a bracelet. Let students take them home!

Build Materials

Astronaut Materials (per student):

- 10 UV Beads
- 1 Pipe Cleaner

Shelter materials (per team):

- 10 Index Cards
- 10 Craft Sticks
- 6 Bendy Straws
- 1 Cardstock
- 1 Small Paper Plate (7")
- 1 Paper Bag
- Masking Tape
- Scissors

Testing Station Materials

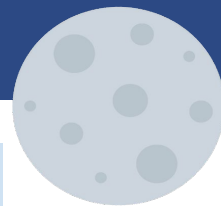
- Sunlight or Black Light

Warning: For black light do not shine in student's eyes. Only adults are allowed to handle.

- Rocks or simulated rocks such as modeling clay, bouncy balls, or the pinto beans in a ziplock bag (about 1/3 cup)



UV Light Shelter



Build Astronaut

Alternative: Create a bracelet with pipe cleaner and beads.



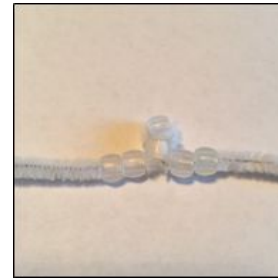
1. Gather pipe cleaner and 11 UV beads.



2. Slide 1 bead to middle and fold pipe cleaner in half.



3. Slide bead onto both sides of pipe cleaner.



4. Spread pipe cleaner apart again and slide 2 beads on each side for arms.



5. Bring pipe cleaner ends together and slide on bead onto both of them at once.



6. Split pipe cleaner ends again and add 2 beads on each end for legs.



7. Bend pipe cleaner ends up and over end leg bead. Then slide through the top leg bead and waist bead. Wrap remaining pipe cleaner end around the waist. Do this for both ends of the pipe cleaner.



Helpful Tips

- It is helpful to have students see what happens to their astronaut when exposed to the UV before getting into the challenge so they know what to look for in a failure.
- The color on the beads from the UV exposure fades very quickly. It is best to check the astronaut for color immediately after the shelter is exposed to the sun/blacklight. Have a student shade the shelter while you check the astronaut if needed.

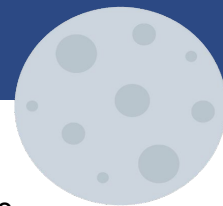
Before exposed to UV radiation



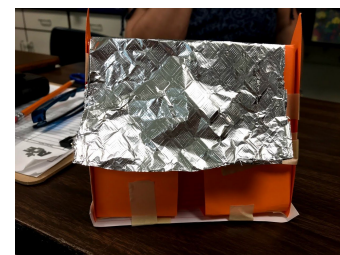
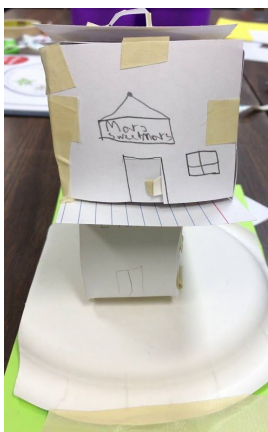
After exposed to UV radiation



Safety Shelter



4. **UV Experiment (Mission Background Section):** As a class, conduct a scientific experiment to determine which materials block UV rays. Use a UV bead astronaut or a bracelet of beads for this.
 - a. For our shelter, we need to select materials that will block UV rays. Not all materials will, so we need to think like a material scientist to test our options.
 - b. Start with a piece of cardstock. Ask students to predict if it will block UV rays. Put the UV beads on a table. Cover with the cardstock. Shine a black light on the cardstock for 10 seconds. Remove. Show that beads are colorless, which means they did not receive UV rays.
 - c. Test out additional materials. Try sunglasses, transparencies, plastic, and other clear or opaque materials.
5. **Design & Build:** Have students form teams and brainstorm ideas. Each student should draw their design idea before building. Provide the desired materials to each team and have them complete the challenge.
6. **UV Testing:** After building shelter, go outside to test for protection. Another option is to shine the black light on each wall of the shelter. It takes about 10 seconds of UV exposure to get a rich color from the beads.
 - a. Make sure shelter has 4 walls and an entrance. Place astronauts inside.
 - b. Exposure shelter to UV rays.
 - c. Move shelter away from UV exposure and immediately remove the astronaut to check for exposure (color change). You can also carefully open door to check for exposure. If beads remain colorless, test is a success!
 - d. If needed, discuss what needs improvement and redesign structure. Allow beads to return to color-less state.



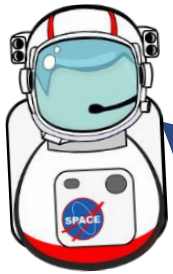
Note: Foil was one of the materials used for these safety shelters. Foil is not needed for this challenge and is replaced in your material list with copy paper.

Collect Samples on the Moon



Mission Overview

1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video or read script
3. **Science Background:** The Age of Craters
4. **Safety Shelter Engineering Challenge:** Students apply the Engineering Design Process to create a device to collect rock samples on the Moon.



STEM Career: Biomedical Engineer

Word of the Day: Leadership

Motivate others to achieve something new and better. Someone who other people will follow because they will inspire or motivate you to reach a goal.

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! ~Space Club Mission Control

Great videos to show:

[NASA Developing Mining Rover for Moon](#) (2:30 min)

[Moon 101](#) (3 min)

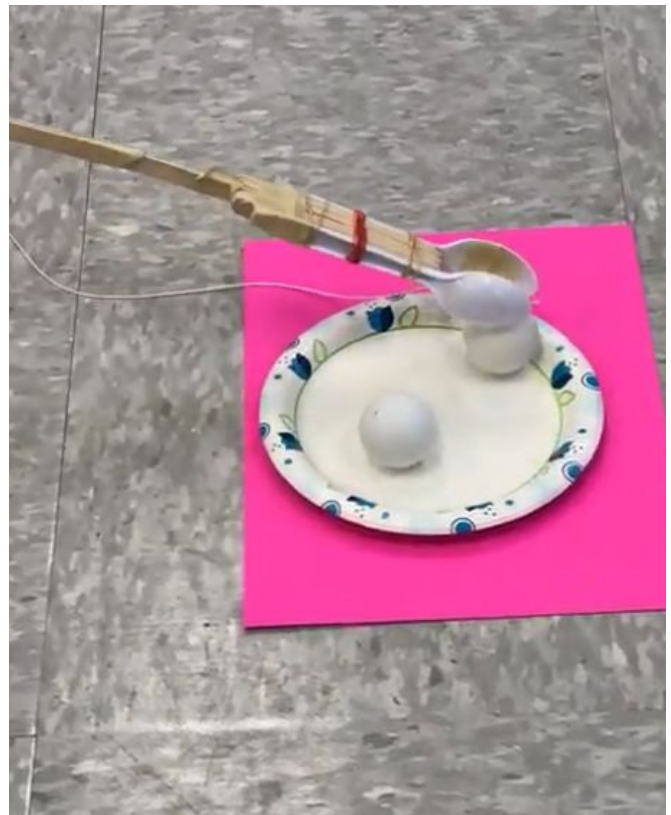
[Engineers Created a New Bionic Arm](#) (4 min)

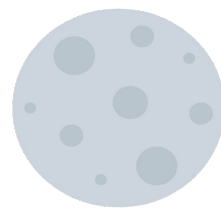
[Victoria - Biomedical Engineer](#) (5 min)

[Northeastern puts NASA's Valkyrie space robots through its paces](#) (5 min)

[How 3D printed prosthetic hands are changing kids' lives](#) (4 min)

[The Mind-Controlled Bionic Arm](#) (11 min)

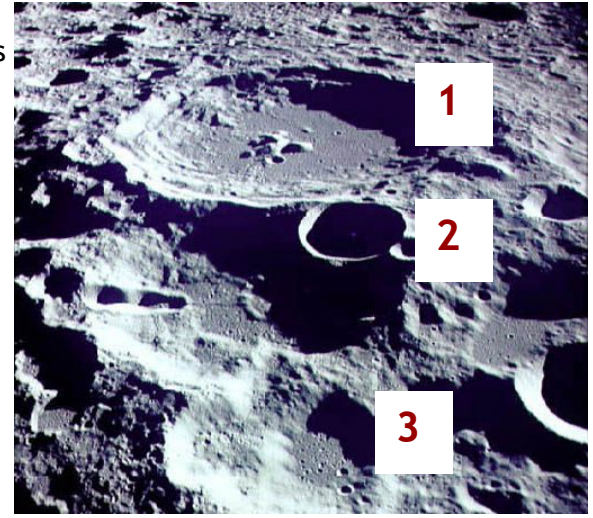




THE AGE OF CRATERS

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.

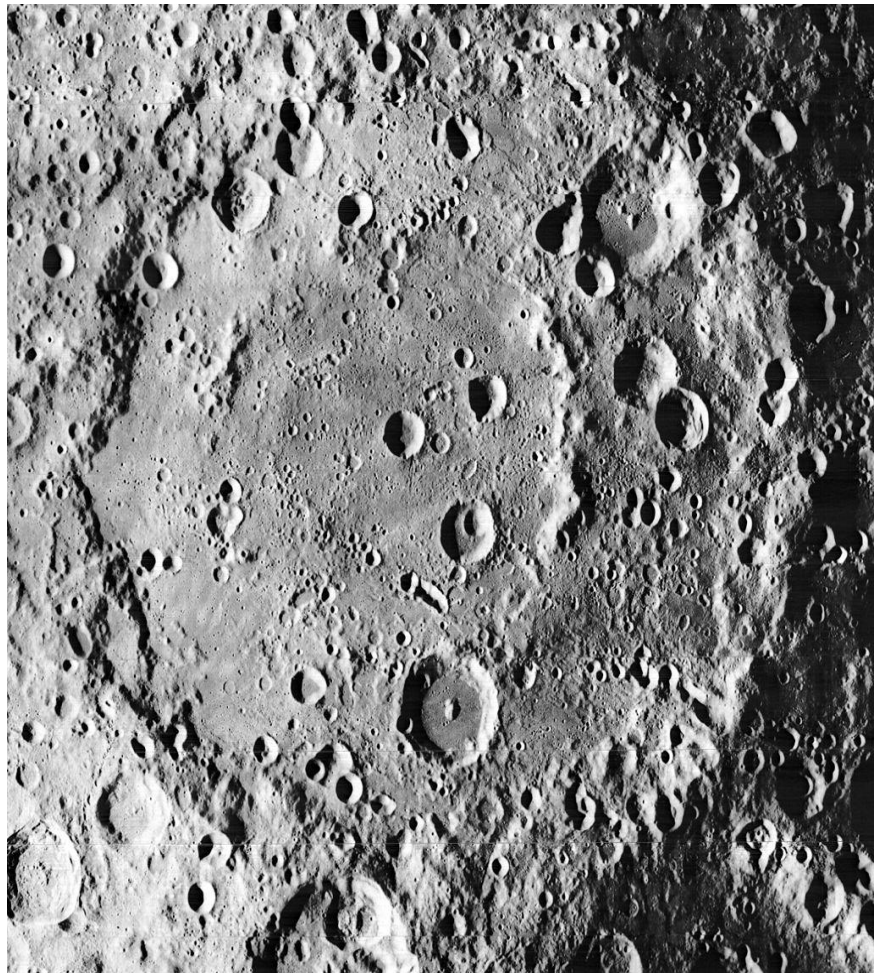
- 2 crater is relatively new due to the preservation of the walls and depth.
- 3 crater is very worn and contains younger craters within it, indicating that it is older.
- 1 crater shows some collapsing of the walls after impact with a few younger craters within it. It is neither the youngest nor the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



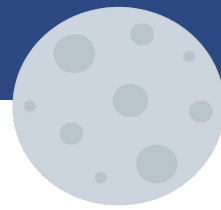
Anorthosite sample believed to be the oldest rock collected during the moon missions



3.5 billion years old basalt rock similar to rocks formed around Hawaii



Collect Samples on the Moon



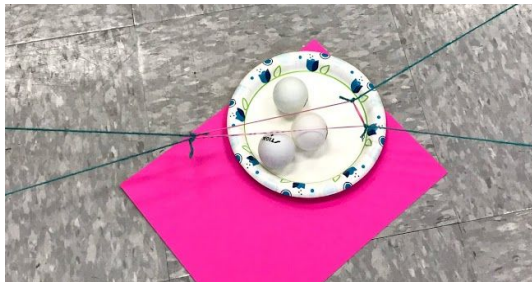
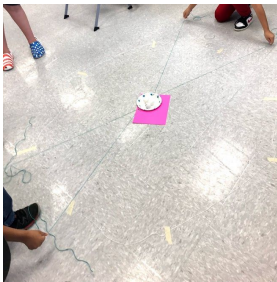
Students build a grabber to collect rock samples on the Moon.

Group Size: Partners



Prior to Activity

1. Gather materials listed.
2. Create kits of materials per group.
3. Create a large circle about 5 feet in diameter using string and tape. Place a plate with 3 ping pong balls in center. The plate should be 2.5 feet from the circle (radius of the circle).



Build a Grabber

1. Mission: Build a device to pick up rock samples and place into collection box. (Students usually work to collect one rock sample at a time.)
2. Design constraints:
 - a. Your hands may not cross into the collection area and cannot touch the rocks.
 - b. Your grabber must be able to place rocks into the collection box.
 - c. Must complete with a partner and both must be contributing to moving the ball.
3. Think about: How can my partner and I work together to accomplish this challenge?

Materials Per Group Grades: K-1

- Popsicle Sticks
- 2 Cups (5 oz)
- Masking Tape

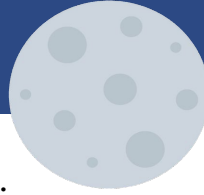
Materials Per Group Grades: 2-5

- 7 Popsicle Sticks
- 2 ft Masking Tape
- 4 Plastic Straws
- 1 Paper Bag
- 5 ft Yarn
- 2 Spoons
- 2 Rubber Bands

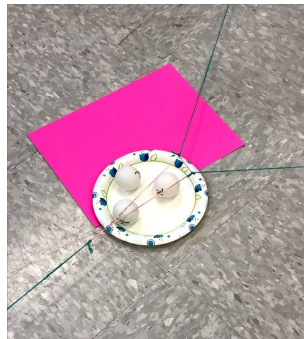
Testing Station Materials

- 3 Ping Pong Balls
- Small Paper Plate (7"-9")
- String and Masking Tape (to make collection area)
- Plate or cup (for collection area)

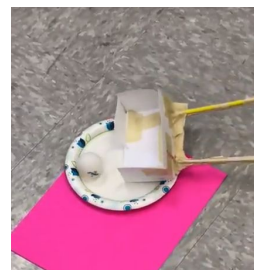
Collect Samples on the Moon



- 4. Brainstorming:** Show students the available materials. Ask them to think about different designs. Make sure teams sketch a design before building. Note that there are a lot of different ways to solve this challenge. Encourage creativity.
- 5. Building:** Teams may get stuck during building, so encourage them to just go for it and re-design as they test. When testing, they will realize that certain materials such as popsicle sticks are not enough to grab the ball. This challenge requires creative use of materials.
- 6. Testing:** Students are not allowed to get in line for testing if their team members are not present. When testing, teams have as many chances to try as there are ping pong balls on the plate. If they are trying to pick up a ping pong ball and it hits the floor - it is gone forever (for that testing trial)! They can no longer try to pick it up for the rest of their testing round. This gives the students a finite amount of testing so they can share the testing area with others students, and it forces them to go back and re-design.
- 7. Redesign:** How can we *reinforce* or strengthen the design so it can reach the middle of the crater? How can you make your collection device longer?
- 8. Extensions:** If teams finish early, remove a material such as the spoons and have them re-design with a material replacement. You can also challenge them to pick up different materials such as pencils to represent different type of rock samples. This also works great with candy as a rock sample!
- 9. For grades K-1st:** the limited supplies allows for an easier design solution. Once all the teams have successfully finished testing, have the teams do a competition to see how many ping pong balls they can pick up and place in the collection cup in 2 minutes!
- 10. Grades 2nd-5th:** Allowing for more supplies will give more creativity in design. For grades 2-3, you may wish to start with the K-1 version and then add supplies as they build confidence in their design and testing. Additionally, if any teams finish early, take away the spoons and have them redesign their device. You can also challenge them to pick up different materials such as pencils, bouncy balls, etc. to represent different types of rock samples.



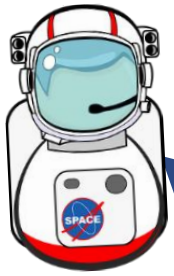
Allow the students to struggle with this challenge. DO NOT give them ideas or show pictures before they have at least attempted. Then, only ask guiding questions such as how can you make your device “grab” the ball or perhaps “scoop” the ball? They also will be tempted to look at the other teams, but make sure they realize there are multiple solutions.





Mission Overview

1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video or read script
3. Science Background: Heart Rate Activity and Artemis Program
4. Discuss “STEM Careers” as a recap to the career highlights.
5. Complete the *STEM Careers BINGO Game*.
6. Complete reflection activities.
7. Optional - Complete the *Coke Mentos Geyser* as a celebration of success or try out [Steve Spangler Atomic Slime](#) with the black light!



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. ~*Space Club Mission Control*

Great Videos to show!

[We Go as the Artemis Generation](#)
(1 min)

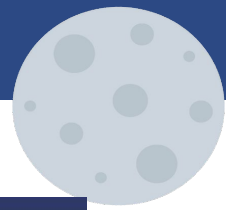
[What is Engineering?](#)
(6:30 min)

[We Are NASA](#)
(3 min)

[How We Could Build a Moon Base TODAY](#) (10 min)

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 or www.sciencebuddies.org.

Activity: STEM Careers BINGO



Students learn about STEM careers with a BINGO game.

Group Size: Class



Prior to Activity

1. Review career descriptions and BINGO game cards.
2. Print BINGO game cards and collect game markers.
3. Cut out STEM career descriptions and place into a container.



Materials

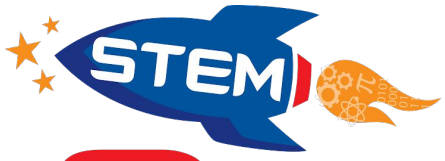
- STEM Career Descriptions
- Container (to place descriptions)
- BINGO boards
- BINGO game markers (paperclips work well)

[Click here to access BINGO Game cards.](#)



Activity

1. Pass out BINGO boards to each students along with 24 markers such as paper clips, beans, coins, etc.
2. If using the Google Slides PPT, open presentation to the first career slide. In “Present” mode, the name of the career will not appear until you click. This allows the students to first read the slide and attempt to guess the STEM career. The same can be accomplished by reading the career description from the paper version.
3. Announce the STEM career.
4. Note the different spark connections on the slide. Ask students to think about which career relates to their spark.
5. The first student to get 5 across, down, or diagonally wins! The FREE space can be used.



Space Club

Mission 8: Moon Habitat

**Mission
to Moon**

STEM Education



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Lunar Base Project Overview

Can you keep a team of colonists alive and happy on the Moon? Students work in teams to complete the ultimate project-based learning STEM experience: planning a long-term settlement on the Moon! As a student-driven assignment, the purpose of the teacher is to act as a facilitator.

How much time do teams need? We recommend around 10, 90 minute sessions that include:

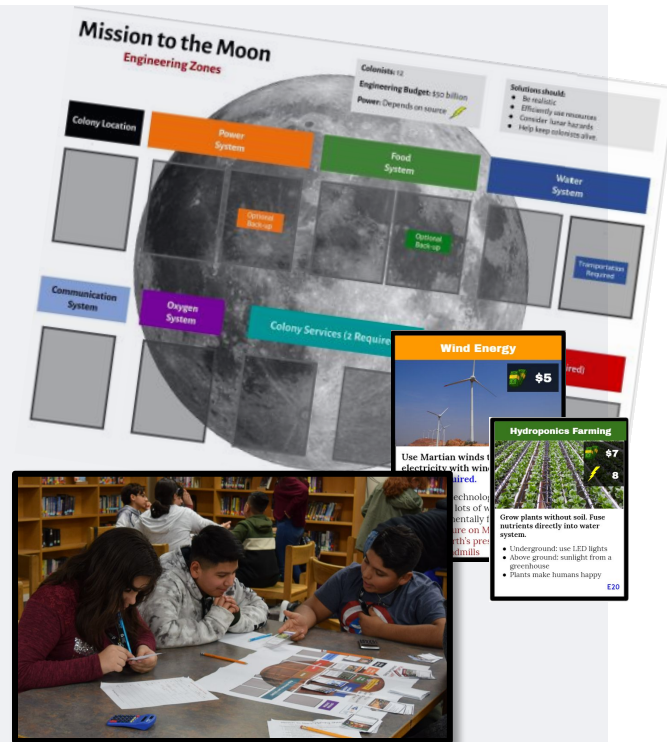
1. Identify the Problem (2 sessions): Learn about the Moon
2. Brainstorm Solutions (1 session): Lunar Base Planning Game
3. Design Base Layout (2 sessions): Lunar Base Layout
4. Build Base Model (3+ sessions)
5. Record Video + Complete Submission (2 session): Space Colony Competition Submission

Part 1: Design a Lunar Base

Planning Game: Students create base teams and complete the *Mission to Moon: Planning Game* to determine design components of a base on the Moon. Students consider various design solutions on engineering systems (food, water, power, oxygen, communication, and science labs) and mental health considerations (social, hygiene, exercise, sleeping, and entertainment). For each system, students read background cards to weigh the pros and cons while staying within budget and power constraints and maximizing human happiness. Each solution card provides details that are based on real technologies being developed by NASA. Once the solutions are determined, students create a scale-model of a lunar base to represent location and architectural components.

Base Layout:

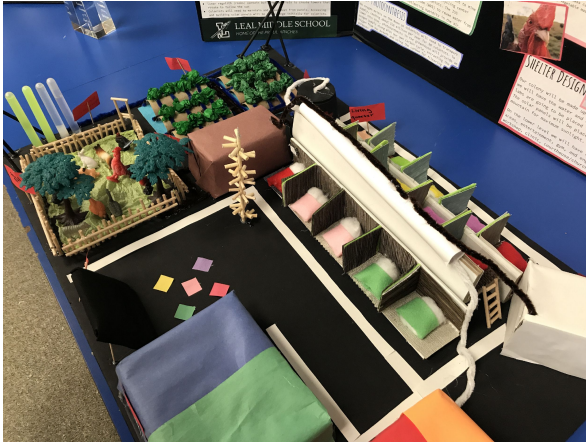
Once students have finalized all the engineering and mental health zones, teams create a layout of their design that incorporates the base location. Afterwards, teams can use this design as a blueprint for building a base prototype from recycled materials.



Part 2: Build a Lunar Base

After students have determined the solutions in their habitat, it is time to build the model! You may encourage additional research as they explore what needs to be included in each “zone”. Some tips:

- Students are each assigned a zone to be responsible for researching and building
- what is the scale for the items in the zone?
- Create a presentation with details on each zone.



Planning Game Materials

- Handouts
- Planning Game
- Pencils
- Colored paper
- 22 x 28 Poster board (per team)
- Tape

Building Materials

Students should collect recycled materials from home such as cardboard, toilet paper rolls, plastic containers, etc.

Recommended supplies:

- Scissors
- Foam board
- Paint
- Hot glue gun
- Cardboard
- Pipecleaners
- Recycled materials

Lunar Base Rubric

Student/Team:

Grade: _____ / 15

	Points	3 Exceptional	2 Acceptable	1 Marginal	0 Unacceptable
<p>Identify the Problem</p> <p><i>Reflection on Earth</i></p>		Complete understanding of design problem and constraints. Clear understanding of key scientific principles.	Overall sound understanding of design problem and constraints. Clear understanding of key scientific topics.	Limited understanding of design problem and constraints. Some understanding of key scientific topics.	Little or no grasp of problem and constraints. Lack of understanding of key scientific topics.
<p>Brainstorming</p> <p><i>Understanding the Moon</i></p>		Extensive research. Two or more solutions described. Pros and cons reflect high level of understanding of the Moon environment.	Some research. Two solutions described. Pros and cons reflect some understanding of the Moon environment.	Limited if little research. One solution for each area. Some pros and cons, but do not have clear connection to the Moon environment.	No research. Limited solutions with no connection to the Moon environment.
<p>Design</p> <p><i>Lunar Base design solutions</i></p>		Unique and realistic design solutions that reflect research and understanding of the Moon. Clear justification for selection.	Realistic design solutions with some justification. Limited understanding of the Moon environment.	Design solutions explained, but presented with little justification.	Superficial design solutions with little or no justification provided.
<p>Reflection</p> <p><i>Final Project Presentation</i></p>		Engaging presentation and clearly describes the base layout, design solutions, and justifications.	Understandable presentation that describes the base layout, design solutions, and justifications.	Somewhat unclear presentation with limited description of the base layout and solutions.	Unprepared presentation with unclear explanations.
<p>Teamwork</p>		Active collaboration, effective communication, and impressive effort.	Some collaboration, mostly effective communication, and average effort.	Limited collaboration, some negative communication, and limited effort.	Lack of collaboration, negative communication, and limited effort.

NEXT GENERATION SCIENCE STANDARDS

The Lunar Base Engineering Design Challenge follows the NGSS Engineering Design Standards for Elementary and Middle School.

3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2.	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3.	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2.	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3.	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4.	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
4-ESS3-1.	Obtain and combine information from books and other reliable media to describe that energy and fuels are derived from natural resources and their uses affect the environment.

OTHER TOPICS COVERED

- Research and summarization of scientific content
- Reflection on components of society: government, entertainment, etc.
- Types of government
- Space exploration
- Moon environment
- Effects of space on the human body

IMPORTANT LINKS

The following are links to student handouts and teacher materials to support implementation of this lesson.



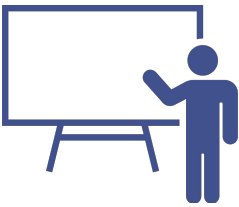
Google Slides

How to use Google Slide Links

These links makes a copy to your Google Drive to edit as needed. To print slides, click FILE and then PRINT. To convert to PDF, click FILE → DOWNLOAD → PDF.

If assigning Google Slides to students, here are some useful resources:

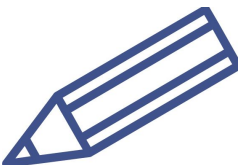
- To prevent students from editing the slides, [watch this](#).
- To send a copy of the file to your students, [watch this](#).



Teacher Instructional Slides & Video

To support your students, we have create editable teacher companion presentation slides and instructional video to guide your students through the lesson. For slides, you will need a Google Account to access the links. This link makes a copy to your Google Drive.

[Click for Editable Teacher Companion Slides.](#)



Printable Student Handouts

To allow for teachers to customize worksheets, we are providing a link to the Google Slides version for editing student handouts for this lesson.

[Click here to access this editable packet via Google Slides.](#)



Digital Student Handouts

Prefer a digital version of student worksheets or journals? The following can be assigned via Google Classroom. Students will need a Google account. [Click here for Google Slides Journal](#)



Assessment Rubrics

STEM challenges can be used for various learning outcomes such as engineering process skills, communication, science concepts, etc. Learning outcomes will greatly differ based on how the STEM activity is implemented, time constraints, and other factors. We have provided editable templates as a starting point. [Click here for editable rubrics.](#)

PROJECT RESOURCES

Moon Videos:

- [Building a Base on the Moon](#) (4 min)
- [Moon Village](#) (2 min)
- [Will We Ever Live on the Moon?](#) (3 min)
- [NASA Tour of the Moon](#) (4 min)
- [Apollo 11 Video Library](#)
- [Intro to Living on the Moon for Kids](#) (3 min)
- [How We Could Build a Moon Base TODAY](#) (10 min)
- [How Close Are We to Building a Moon Base?](#) (10 min)
- [How we will colonize the Moon](#) (8 min)
- [Building a lunar base out of Moon dust](#) (6 min)

NASA Mission to Moon Videos

- [We are Going](#) (3 min)
- [We Go as Artemis Generation](#) (2 min)
- [NASA's Moon to Mars Playlist](#)

General Moon Information:

- [NASA Moon Facts Part I](#)
- [NASA Moon Facts Part II](#)
- [NASA Mission to the Moon](#)
- [NASA Moon to Mars](#)

Moon Colony Resources

- [Regolith is Toxic](#)
- [Living on the Moon: The Challenges:](#)
- [How to Build a City on the Moon](#)
- [Moondust, Radiation, and Low Gravity: The Health Risks of Living on the Moon](#)
- [Establishing a Lunar Colony](#)
- [How it Works: Living on the Moon](#)
- [How to build a Moon base](#)
- [Dealing with trash on the Moon](#)
- [Moon Mining](#)
- [More Moon Mining](#)
- [NASA Sends Viper Rover to Find Water on Moon](#)

SPACE COLONY COMPETITION

Competition Overview

CAN YOU SURVIVE A MISSION TO SPACE?

Submit your design for a colony on the Moon or Mars that can keep a crew alive and happy! The Space Colony Competition is open to any team of up to 6 elementary or middle school students. Learn about the challenges of living in space, research and design a colony, and build a 3D model using recycled materials. Then, upload a video and presentation for a chance to win prizes, get feedback from real STEM professionals, and compete with students around the world!



COMPETITION DIVISIONS

Elementary: 3rd - 5th grade

Middle: 6th - 8th grade



Register at:

stemspaceclub.com/competition



Part 1:

Design a Lunar Base



Mission to Moon

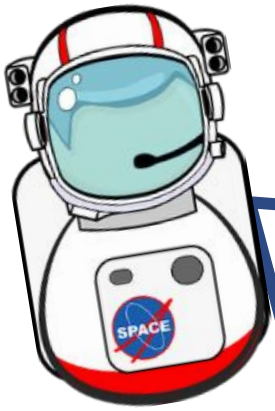


Mission Overview

1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video (linked in teacher slides) or read script below. [Click here to see a video of student examples.](#)
3. Complete the “Design a Lunar Base” to research solutions to keeping humans alive and happy. Teams will create a layout of zones with each solution. This teacher guide includes an overview of the Lunar Base Planning Game and how to create a layout.
4. The final project is to build a 3D model of the Lunar Base.

STEM Career:
Material Scientist

Word of the Day: Problem Solving
Activities center around how astronauts need to carefully work through the constraints and challenges to solve the overall problem.



Ever wondered what it was like to live on the Moon? Imagine being 238,900 miles away from your friends and families. No restaurants, grocery stores or movie theatres. You would get lonely pretty fast. When astronauts travel to the ISS they are allowed a PPK (Personal Preference Kit) this is used to carry personal belongings of each crew member. Here they are limited to only 20 items. So what would you take with you to keep you from getting homesick and keep you entertained? I would take some books and pictures of family.

In today's, mission you will research and design a colony on the Moon to keep humans alive and happy. Think about the essentials on Earth that keeps humans alive AND happy How will you grow food to feed your colonists? How will you produce electricity to power your kitchen, shower or TV? How will you make sure that there is enough water to drink and enough oxygen to breathe? These are all things NASA takes into consideration when planning a Mission to the Moon. It might sound like a lot of responsibility, but being a leader is key to having a successful mission. ~Space Club Mission Control

Great videos to show:
[How close are we to building a moon base?](#)
(10 min)

[NASA | BEST: Living on the Moon](#) (3 min)

[Day at Work: Architectural Designer](#)
(2:50 min)

TEACHER INSTRUCTIONS

- Engage:** Show a real-world example of the engineering design process related to the journey to the Moon (video links on Resources and Taking it Further page).

 - Introduce the engineering design process as described in the handout.
 - Read “Mission to Moon” sheet describing NASA’s Journey to the Moon.
- Mission Sheet:** Pass out Mission Sheet to student teams. Groups of 3 - 4 are recommended. No more than 6 students should be placed in a team. Discuss how students will learn about the hazards of living on the Moon and develop a solution for a possible lunar base. Emphasize that teams will be planning for both keeping humans alive as well as for their happiness. Showing a news clip of recent developments towards the Moon colonization is a great way to increase excitement.
- Identify Problem & Reflect on Society:** To help students plan a human settlement, they first need to reflect on our society here on Earth.
- Learn about the Moon:** Before planning a base on the Moon, students need to understand the environment of the Moon. A one-pager handout is provided as background information.
- Planning Game:** Students complete the Mission to Moon: Planning Game to determine design components of a lunar base. Students consider various design solutions on engineering systems (food, water, power, oxygen, communication, and science labs) and mental health considerations (social, hygiene, exercise, sleeping, and entertainment).



Lunar Colony Challenge

NASA has selected your engineering team to plan a human settlement on the Moon! Your mission is to design a colony that considers both human health and happiness.

COLONY

- Keep
- Prov
- Prov
- Sup
- Su

Mission to Moon

NASA is planning to send humans back to the Moon in 2025, with an end goal to establish a colony there as well as Mars. Would you join a mission to the Moon?

THE JOURNEY TO THE MOON

Artemis 1, NASA's first test flight that will launch its Orion spacecraft aboard the Space Launch System (SLS) rocket on an tentative date set for February 2022. Then in sometime around May of 2024, Artemis 2, a test flight that will send astronauts aboard Orion around the moon and back, will launch. Last but not least, Artemis 3, the first crewed lunar landing mission of this program, will launch "no earlier than 2025," says NASA Administrator Bill Nelson.

CHALLENGES OF GETTING TO THE MOON

Human exploration in space takes a lot of money. NASA officials said in November of 2021 that the cost of the SLS rocket development program through the Artemis 1 launch will run about \$11 billion while the projected cost of Orion through the second Artemis flight will reach \$9.3 billion. NASA can't cover these costs alone, so private companies such as SpaceX are working on new technologies to support the journey.

Another set of challenges are the physical difficulties of traveling and living in space. Astronauts will be exposed to high levels of radiation that can be toxic for the body and the Moon's low gravity, while fun for jumping and other fun activities, causes problems in bones, muscles, and vision.

CHALLENGES OF LIVING ON THE MOON

NASA is determined to build a human colony on the Moon. However, the Moon presents many challenges. First, humans must provide their own oxygen for breathing as there is no atmosphere. The Moon's surface, however, is approximately 45% oxygen. Unfortunately, that is trapped inside the regolith, which is trapped in the Moon's temperatures, ranging from a high of 260F (127°C) to a chilly -280F (-173°C). The Moon's gravity is also about 1/6 of Earth's.

In addition to physical challenges, humans will need to overcome psychological effects of isolation from Earth. They likely live in cramped conditions for long periods of time, and they will need to find ways to prevent homesickness, boredom, and depression.

Despite these challenges, many have lined up to join this next exciting chapter of human exploration!

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Design A Lunar Base

8

1

Your Mission: Research and design a base on the Moon to keep humans alive and happy.

2

Reflect on your life on Earth

Before we plan a new society on the Moon, we first need to think about our life here on Earth. Answer the following three questions. You can make a list for each question.

What do humans need to survive?	What do humans need to be happy?	Is there anything you would change about our society here on Earth?

Design A Lunar Base

8

All About the Moon

The Moon is desolate and hazardous place that does not support any known life. How can engineers design solutions to overcome the challenges of living on the Moon?

Location

- The Moon is 238,900 miles away from the Earth
- Communication between Earth and Moon has a delay of about 2.5 seconds
- A day on the Moon is about 29.5 Earth days. A day refers to the Sun returning to the same position in the sky. This means 2 weeks of daylight followed by 2 weeks of darkness!

Temperature

- The Moon is freezing cold. When in darkness, the Moon is about -280F (-173°C).
- The Moon is boiling hot. When in full sun, the Moon is about 260 F (127°C).

Atmosphere

- A very thin atmosphere provides no protection or oxygen for breathing.
- The thin atmosphere has little pressure, almost like the vacuum of outer space.
- No weather or wind. This means no clouds to block the sun.
- No protection from deadly solar radiation (energy emitted by the sun).
- No protection from meteorites.

Gravity

- The Moon has 1/6 the gravity on Earth.
- A person weighing 100 lbs on Earth would weigh about 16 lbs on the Moon.
- Lower gravity on the moon means you can jump 6 times higher than you can on Earth!

Lunar Dust

- The grey surface layer of the Moon is called regolith and made of lunar dust, soil, and broken rock. Regolith contains oxygen, silicon, aluminum, iron, and other minerals.
- Possible usage as building material for colonies.
- Lunar regolith has the consistency of powdered glass with jagged edges that cling to everything. It can cause health issues and clog buttons and hydraulic systems of spacecraft.
- Crops can't grow in lunar soil.

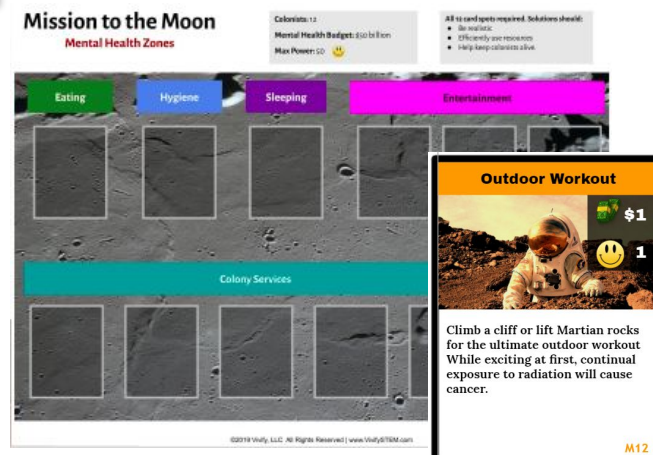
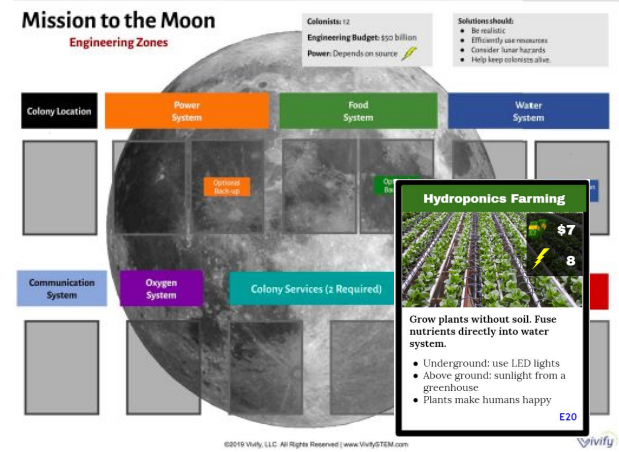
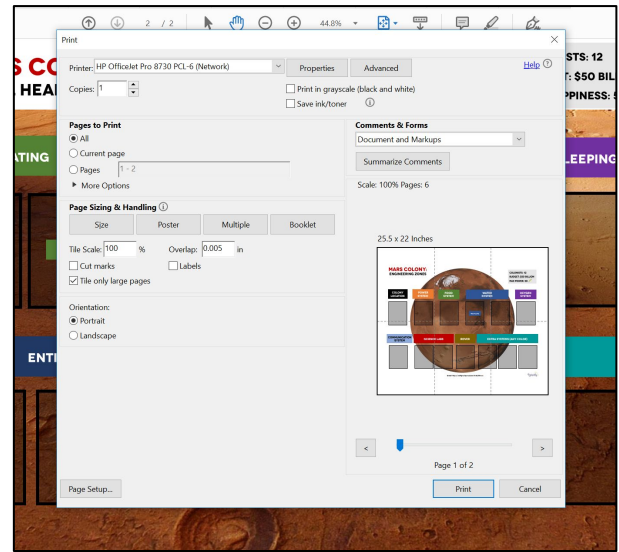
Other Features

- Water ice has been discovered deep inside craters at the poles.
- Lunar poles provide areas where sunlight is year-round.
- Moonquakes occur periodically on the Moon.

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Part 1: Prep Game

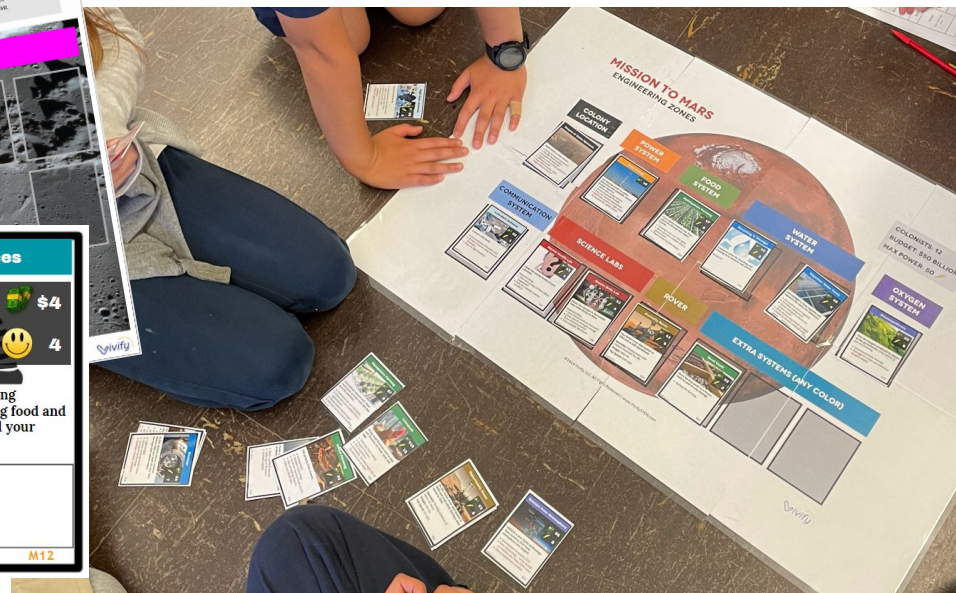
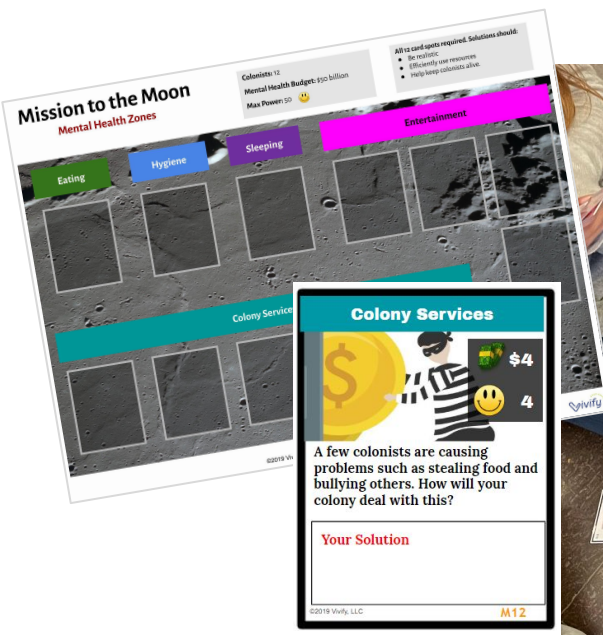
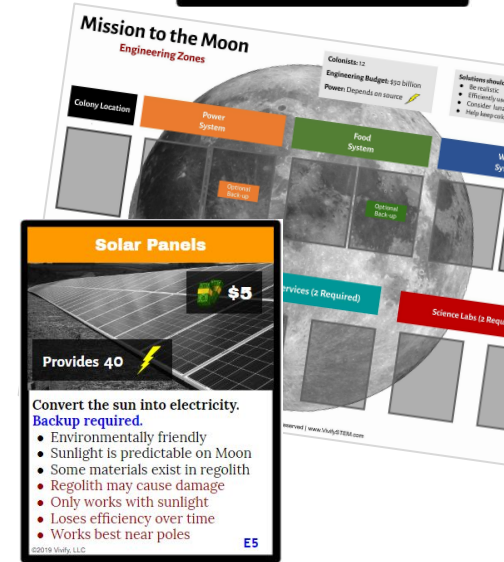
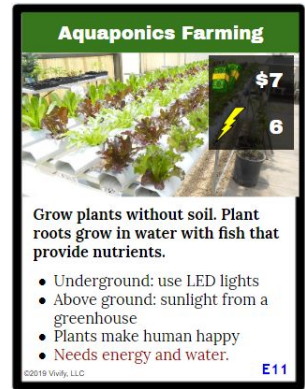
- [Click here for Game Cards.](#)
 - Download as a PDF and print
 - Cards will be updated to reflect current events and new technologies
 - Email info@vivifystem.com for any questions.
- [Click here for Game Board](#)
- Prep the game by printing the two game boards: Engineering and Mental Health Zones. The game can be printed as a large poster (24" x 18") or as tiles on regular copy paper. These tiles can be taped together to create the board. When printing as tiles, choose the "Poster" option on Adobe and see settings in image below. For any help on this, email info@vivifystem.com.
- Print the game cards (one-sided) preferably in color as the cards match each zone color. These may be laminated to last longer.



Activity Instructions

Part 2: Play Game

- Explain:** Introduce the game with the provided Lunar Colony Planning Game sheet and student handout. Show students the two game boards (engineering and mental health) and the corresponding game cards (each board has its own set of cards). At the bottom of the card, “E” is for engineering and “M” is for mental health. The colors correspond to the zones. For example, “Food System” cards are all green.
- The total budget for the game is \$100 billion. This amount must be equally divided between the two boards.
- Engineering Board:** The max budget is \$50 (billion). The max power is determined by the energy source provided. Note that some options required a back-up source. Backup sources are the fuel cell and battery cards. Total power is the combination of all power cards selected. For example: Solar Panels (40) and a Battery (5) gives you a max of 45 lightning bolts of power. You can't exceed this max even if you have more money left.
- Mental Health:** The max budget is also \$50 (billion). Cards must also provided a *minimum* of 50 smiley faces (happiness). Each spot on the board must have a card.
- Your Solution Cards:** A few cards have room for students to create their own solution. Students should brainstorm ideas first that realistic, use local resources if possible, and answer the scenario. Teachers should approval final solutions. If using laminated cards, consider having a Dry Erase marker for writing on the card.



Activity Instructions

- **Design Solutions:** Students will play the game by reading the cards for each zone. Teams will discuss the pros and cons while staying within budget and power constraints and maximizing human happiness. Each solution card provides details that are based on real technologies being developed by NASA. Assign a team member to use the included handouts to track budget, power, and happiness.
- **Test Solutions:** After solutions are finalized, students will test designs using the provided real-world scenarios. Teams can change designs if they determine too much risk is involved with their selected card.

6. **Layout Design:** Once students have finalized all the engineering and mental health zones, teams create a layout of their design that incorporates the base location.

- **Plan Overall Layout:** Students will think about their overall base design. Show examples of Lunar Base designs using links in the resource section. Have each student on the team sketch an idea for the overall base layout. Bring ideas together to finalize one overall base layout and draw on provided handout.
- **Plan Zone Placement:** Provide each team with a standard poster board to represent the area for their base. Using the sketch as a guide, have students plan out the location of each zone. Students will cut out colored paper to represent each zone solution. For example, students need to cut out an area for their water, food, and power system solutions. The paper will be placed on the poster board and arranged to create the colony blueprint. Use one color for engineering and a second color for mental health. A table is provided in the student handouts that gives a suggested size for each zone. These sizes are based on creating a layout on a standard poster board (size) with 8.5 x 11 copy paper. So $\frac{1}{4}$ refers to folding a sheet of paper in half twice.

Mental Health Zones: Budget Tracking 8

Habitat maximum budget is \$50 billion.

System	Name	Cost \$	Notes
Eating			
Hygiene			
Sleeping			

Your solution based on team sparks:

Engineering Zones: Power Tracking 8

Habitat maximum budget is \$50 lightning bolts.

System	Name	Budget Max: 500B	Notes
Colony Location		NA	
Power	Optional Back-up		
	Optional Back-up		
Food	Optional Back-up		
	Optional Back-up		
Water	Transportation		
	Antenna		
Communication	Antenna		
Oxygen			
Colony Services	Your solution:		
Science Labs	Your solution:		
Total Power Remaining			

Design A Lunar Base 8

Test -- Evaluate -- Improve

Time to put your lunar base to the test! Read each scenario below. Describe which zones will be affected by this scenario. Does your habitat have what it needs to survive these possible disasters? Provide any possible improvements to your design that could save the colonists.

Scenario	Colony Zone Affected	Possible solutions
Colonists are depressed being stuck in a small space.		
Colonists miss their friends and family back on Earth.		
The order in your colony is starting to fall apart. Some		

Design A Lunar Base 8

Plan your Lunar base

Using the final solutions for engineering and mental health, determine a layout for your zones. Where will they be located in the habitat? Consider also the overall habitat layout. Will you have multiple levels? Underground? Inside a dome? Use the space below or create a poster board with all your zones and habitat layout. The following pages are sizing suggestions if planning a habitat on a poster board.



Part 2:

Build a Lunar Base



Mission to Moon



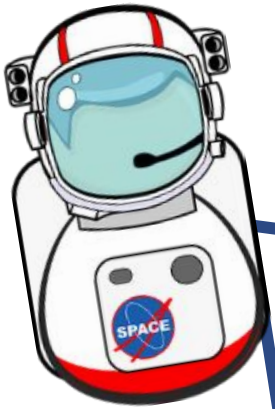
Mission Overview

STEM Career:
Civil Engineer

Word of the Day: Creativity

Coming up with different ideas or ways to tackle a problem that have not been thought of before.

1. Complete the “Mission Warm-up” box.
2. Watch the Mission Overview video or read script below.
3. The final project is to build a 3D model of the Lunar Base.



Congratulations Space Club! We have reached our final mission! I am proud of each team. You have accomplished so much and have persevered through some pretty difficult missions.

Last time, you created a design of a lunar base to keep humans alive and happy. Now we want to turn your drawing into a 3D model!

In today's mission, you will build a section of your lunar base powered by a solar panel. Select at least 2 areas of your colony to build: one that is essential to staying alive (such as a food area) and one that keeps your colonist happy (such as bedrooms or entertainment areas). Your task is to build a 3D model of both areas using recycled materials. You can combine these models into one structure or two separate structures. If you are working in a team, you might want to each build a different part of the base so altogether you have a complete colony!

For the outside of the structure, you should include walls but also a way for someone to see what is inside. You can make the roof removable or only have 3 walls to show what is inside.

As for inside the structure, make sure to include items that represents your space. For example, if you are building a hydroponics farm, you can include different plants and farming tools. You might need to research what parts need to be inside your structure. And don't forget to think about the scale of items. If a real-life plant is 1 foot tall you can represent it with a 0.1 foot model plant or 1.2 inches. This would be a scale that is 1/10th the original size. Use the same scale for other items in the structure so it best represents real-life. Feel free to modify the scale to best fit your model.

Remember that welcome tower powered by the sun? Hopefully you still have that solar panel or coin cell battery and a few LED lights because we want to light up our structure! After completing your 2 structures, find a place to attach an LED light in each room. Then make a conductive path to connect to the solar panel or coin cell battery. Conductive materials can be something like aluminum foil.

I am excited to see your final lunar bases! We hope you enjoyed this Mission to the Moon! You encourage you to follow the latest NASA missions by going to NASA.com, downloading NASA apps, or following NASA on instagram, Twitter, FB, or YouTube. Thanks for being an awesome Space Club crew, and we hope you will join us again in future mission! Mission Control signing off.

~Space Club Mission Control

Instructions on Building a Lunar Base

1. Students will review lunar base sketch. Select two areas of the base: one that is essential to staying alive (ex: food system) and one that promotes happiness (ex: living areas).
2. Build a model of both areas using recycled materials. They can be combined into one structure or two separate structures. Optional - teachers may want to put students into teams to create a single lunar base. Each student would be responsible for their own sections.
3. Both areas need to include an LED light that is powered by a solar panel or coin cell battery. The aluminum foil (or conductive tape) is needed to make a connection between the LED and energy source. Bonus: Can you make the LED light turn on only when a door to your structure is closed?
4. Design Constraints: Structure must include
 - a. Two areas of your lunar base (basic needs and happiness)
 - b. Detailed representation of the area (ex: if you select farming, includes plants and equipment)
 - c. At least one LED light powered by a solar panel or coin cell battery
5. Test: Test your structure to make sure it meets all the engineering design constraints. Does it include one area that supports keeping their colonists healthy and one area that supports keeping their colonists happy? Does it include an LED light that is powered by the sun?

Materials Per Student

- Scissors
- Tape
- Solar Panel or coin cell battery
- LED light
- Aluminum Foil or conductive tape
- Leftover building supplies
- Recycled materials that can be easily cut (tissue box, toilet paper roll, cereal box etc.)



Habitat Examples

Teacher Tips: While students only need to make 2 zones, many completed the entire base! Students in-person can work as teams to complete an entire base.

Using materials such as cardboard, plastic containers, and art supplies, teams build various components on a large foam board or other sturdy structure. Using the habitat layouts, teams can assign each member a specific zone to research and build. Final designs can be presented to local science and engineering professionals for feedback. Other ideas for this project:

- Include a trifold board or Google Slides describing zones
- Send home a letter asking for help to collect recycled materials
- Set height constraints, recommend 16 inches
- Provide budget for project supplies
- Create marketing materials for advertising habitat to potential colonists

[Join the Space Colony Competition!](#)

