

Space Club

Instructor Guide

This guide belongs to:

**Mission
to Mars**

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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.](#)



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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!

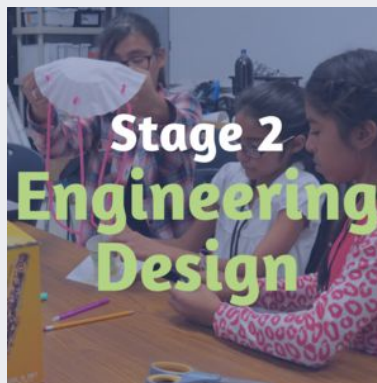


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Mission 8 is a more complex challenge that involves designing a habitat on Mars. This can be added for a long-term capstone project!

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.

Mission to Mars Overview

Through interactive sessions, Space Club students become a team of astronauts challenged to complete missions centered around a Journey to Mars. Each week, students will read a message or watch a video from Mission Control, who will introduce the activity and provide background context. Students will then engage in hands-on activities centered around the engineering design process.

Mission to Mars Components

The Mission to Mars curriculum is intended to be used as a series of lessons that follow a storyline and increase in complexity. However, besides the final mission, each activity can be conducted as a stand-alone session without prior knowledge of other missions. The final Mission 8 is a culmination of learning that involves designing and building a habitat on Mars.

Mission to Mars curriculum includes both teacher guides and student mission handouts. The handouts can be printed and combined to create a student notebook. A digital journal is also available.

Included in the curriculum:

- Mission Overview: Topics covered, activity outline, materials needed
- Activity Instructions: Detailed lesson plan for each activity
- Teacher Guide: A guide to the student mission sheet with helpful tips and reminders
- Student Mission Sheets: Student companion handouts that guide students through the mission.

Mission: Meet the Crew (1)

Mission Overview

- Welcome to Space Club! Introduce the program and discuss logistics.
- Watch the Mission Overview video or read script below.
- Read the optional Breaking News on finding water on Mars.
- Complete team challenges - many options are provided! Distance learning? Find activities [here](#).
- Students select individual sparks. Share sparks with teammates and work as a team to create a team "hype" video. Don't have access to technology? Complete the mission patch activity and create a poster with all the mission patches.
- Optional: Create a class or club mission patch that can be shared with friends, relatives, and badges for the entire group to have.

Background: Wearable Device (4)

All About Circuits

An electronic circuit is a closed path that allows for electricity to flow from one place to another through electronic components such as wires, lights, and switches. A flashlight is an example of a simple circuit that turns on a light.

A closed circuit allows for electricity to flow continuously through the circuit and can operate an electrical device or light up a lightbulb.

An open circuit stops the flow of electricity using a switch or by disconnecting a wire. You open a circuit every time you unplug a device or turn off a light switch.

Open **Closed**

Computer Keyboard: Each key on keyboard has a small electrical switch under it. When a key is pressed, the electrical circuit is completed causing the computer to react. A processor (a tiny computer) inside the keyboard records which circuits were completed and in what order. Can you find other examples of electrical circuits?

Circuits can be made of many different electronic components. You will be making a paper circuit that will follow the same basic design as a flashlight. Here are the components of your simple light circuit.

LED (Light Emitting Diode) has two prongs: the long prong is the positive side and the short one is the negative side. These prongs should be connected to the appropriate sides of the battery.

Aluminum foil works like conductive wire in allowing the electricity to pass from one point to the other. The foil should be bent at turns out 90 degrees or the circuit will be broken.

A coin cell battery provides the right amount of electrical current to light the small LED light. The aluminum foil must touch both sides (positive and negative) of the battery to complete the circuit. You can create a "switch" by wrapping the aluminum foil around a paper clip and pushing it down to "turn on" your light.

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Design A Mars Habitat (8)

Mars Planning Game (4)

When planning a habitat on Mars, we can't just bring everything with us! Traveling to Mars is expensive, and we are limited on resources such as power. To determine the best solutions for our habitat, we will complete the Mars Planning Game. Best of luck!

Rules of the game:

- Your habitat will have 12 colonists
- Choose cards for each Engineering and Mental
- All zones are required including the extra zone
- Read cards carefully to learn about any hidden
- Track your budget: \$50 billion per game box
- Track your power: 50 lightning bolts for energy
- Track your happiness: Must get at least 50 happiness

Build A Mars Habitat (8)

Your Mission: Build a section of your Mars habitat powered by the sun.

- Review your Mars habitat sketch. Select at least two areas of your colony: one that is essential to staying alive (ex: food system) and one that promotes happiness (ex: living areas).
- You will build a model of both areas using recycled materials. They can be combined into one structure or two separate structures.
- Both areas need to include an LED light that is powered by a solar panel or coin cell battery.

Engineering Design Rules (10)

Structure Includes:

- Two areas of your Mars habitat (basic needs and happiness)
- Detailed representation of the areas (ex: if you select farming, includes plants and equipment)
- At least one LED light

Gather Materials Needed

- Scissors & tape
- Construction paper
- Solar panel or coin cell battery
- Aluminum foil
- Recyclable materials (optional)
- Art supplies

Engineering Zone Constraints

Meet the Crew (1)

Questions	My Answers
What are 3 of your greatest strengths?	1. Type 2. Type 3. Type
My favorite things to do in my free time are:	Type
What is your dream job?	Type
I'm a rockstar at:	Type

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Recommendations for Supporting Students

Struggling Student Recommendations

Determine what the source of frustration is and then use the following suggestions.

- **Inability to work in teams:** Spend more sessions on team-building exercises such as the helium stick activity. More activities can be found at: <http://bit.ly/Vivifyicebreakers> Determine if the best way forward to implement the curriculum is in partners or individually.
- **Lack of focus:** Move quickly through the science background and instead insert commentary during the building phase. Skip the worksheets if needed and focus on the videos.
- **Frustration in failure:** Show video examples of failures in engineering. Discuss how failure is part of the engineering design process and that the best engineers learn and grow from their failures.

High Performing Student Recommendations

- Students will be able to go more in-depth with concepts. Consider having a laptop available for researching questions further.
- Place more focus on the career connections and encourage students to research interesting careers.
- Provide students with less directions and few or no examples for building challenges.

Working In Groups

- You can allow students to pick teams or randomly assign teams each week such as drawing a number out of a hat.
- Depending on size, teams typically are 3 - 4 students per group.
- Discuss the importance of collaboration and communication in teamwork.
- Do not allow one student to do all the work.
- Frustration is part of the engineering design process. Remind students that failure is important in engineering and allows them to learn from their mistakes. They will never be successful if they just give up.



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 weeks 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

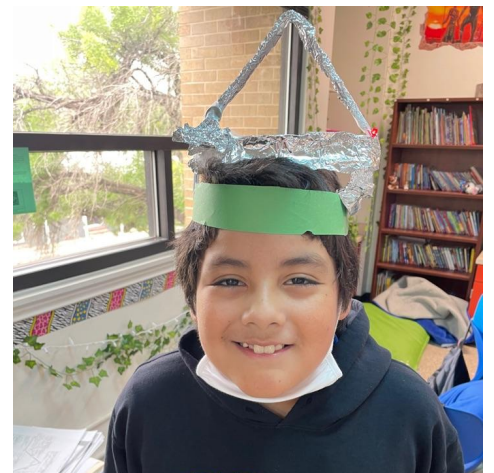
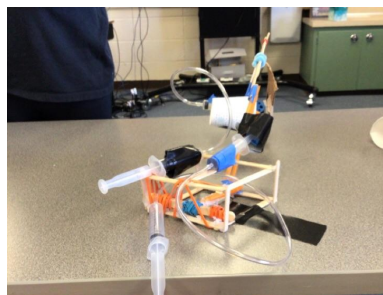
- Have a clear transition to start the group. For afterschool, allow 15 minutes for snacks and socializing.
- Start the sessions with a hook to capture student interest. Video links are provided that are exciting ways to introduce the content and provide a real-world connection.
- Do not release students 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.

Weekly 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

5
Share Solution 



Mission to Mars Overview



Space Club

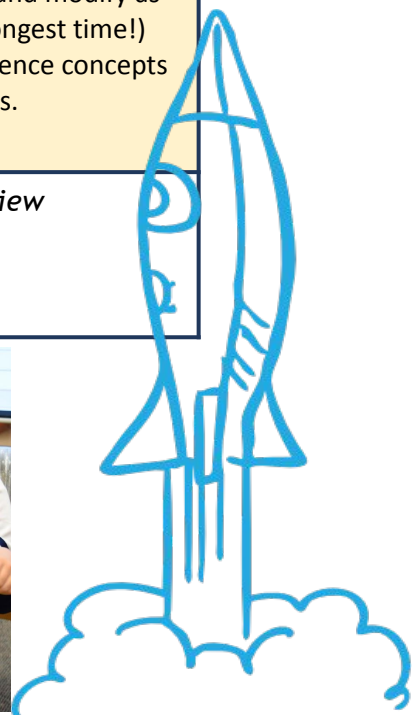
Overview of Units for Grades 4 – 8

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



The following is the standards-alignment for Mission to Mars. 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 Get to Mars	Engineering Process Skills: 3-5-ETS1-1, 2, 3, MS-ETS1-1, 2,3 MS-PS2-2 Forces	Process Skills: 8.1B, 8.4A 8.6A, C: Forces
3 Land on Mars	Engineering Process Skills: 3-5-ETS1-1, 2, 3, MS-ETS1-1, 2,3 MS-PS2-1 Forces	Process Skills: 8.1B, 8.4A 8.6A, C: Forces
4 Explore the Surface	Engineering Process Skills: 3-5-ETS1-1, 2, 3, MS-ETS1-1, 2,3 4-PS3-4 Energy	Process Skills: 8.1B, 8.4A 5.6A/B: Electrical energy 6.6A: Metals, 6.9(C): Energy
5 Live from Mars	MS-ESS1-2 Gravity MS-ESS1-3 Scale	6.11A Space 6.11B Gravity
6 Collect Samples (pneumatic)	Engineering Process Skills: 3-5-ETS1-1, 2, 3, MS-ETS1-1, 2,3 4-ESS1-1 Earth's Place in the Universe 5-PS1-1 Matter and Its Interactions MS-PS2-2 Motion	Process Skills: 8.1B, 8.4A 8.6A, C: Forces
7 Transport Samples (rover)	Engineering Process Skills: 3-5-ETS1-1, 2, 3, MS-ETS1-1, 2,3 MS-PS3-2,5 Potential Energy	Process Skills: 8.1B, 8.4A 6.8A,B,D: Motion 8.6A, C: Forces
8 Build A Habitat (Separate lesson)	Engineering Process Skills: 3-5-ETS1-1, 2, 3, MS-ETS1-1, 2,3 4-PS3-4 Energy MS-PS3-3 Energy MS-ESS1-2 Gravity MS-ESS1-3 Scale MS-LS1-6 Photosynthesis MS-LS2-1,4,5, Resources	Process Skills: 8.1B, 8.4A 6.9(C): Energy 6.11 B,C Space Exploration 8.8A Space

Mission to Mars Supplies

Below is a list of materials needed per team to complete the Mission to Mars 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.

Additional items needed include: writing utensils, scissors, art supplies, masking tape, clear tape, rulers, hot glue gun (optional), and recycled materials for the final Mission 8 habitat project.

[Click here to purchase these materials from Pitsco!](#) The [Straw Rocket Launcher](#) is sold separately.

Material List	Mission	Qty per Team	Qty for Class of 24 8 teams of 3 students	Cost for Class Set	Notes
Pipcleaners	1, 6	15	120	\$5.00	M1: only the pipecleaner team activity is included in supplies
Pitsco Straw Rockets Kit	2	1 kit	1	\$212.00	Pitsco kits have enough supplies for 30 students to make a rocket
Ping Pong balls	3, 6, 7	1	8	\$5.00	
Measuring tape	3		0	\$17.00	
9 oz plastic cup	3, 6	2	16	\$5.00	
Cardstock	3, 4	2	16	\$5.00	
Cotton balls	3	10	80	\$2.00	
Bendy plastic straws	3, 4, 6, 7	15	120	\$7.00	
Index cards	3	6	48	\$1.00	
Construction paper	4	4	32	\$4.00	
Aluminum foil	4	1	8	\$1.00	Pre measured sheets ideal
LED lights	4, 8	8	64	\$6.00	
3V Coin Cell battery	4, 8	2	16	\$11.00	
Syringe Kit	6	1/8	1	\$21.00	Each team needs: 2 syringes, 2 ft of plastic tubing and 1 syringe adaptor
Craft sticks	6, 7	32	256	\$7.00	
1/2 craft cubes	7	8	64	\$10.00	
7 inch rubber bands	7	2	16	\$7.00	
5 inch rubber bands	6, 7	5	40	\$8.00	
Wheel & Axle Set	7	1/5	2	\$40.00	
Zip ties	7	2	16	\$7.00	
			Total Cost	\$381	

Accessing Student Handouts & Toolkit

CLICK LINKS TO ACCESS MATERIALS
[Space Club Educator's Portal](#)

[Printed Student Handouts](#) - [Digital Student Handouts](#)

[Mission Intro Videos](#) - [Certificate of Completion](#)

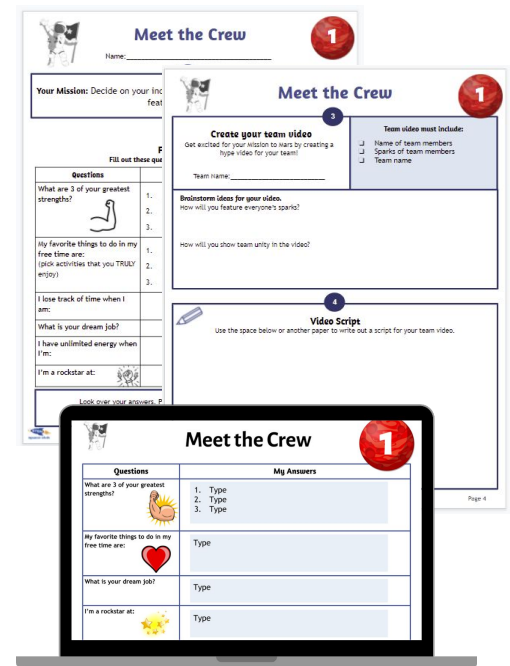
[Teacher Slides](#)

Student Handouts

The Mission to Mars student handouts will guide students through the engineering design challenge for each mission. **Two versions** are provided.

1: Printed Student Handouts: Handouts should be printed and used in a classroom setting.

2: Digital Student Handouts: A digital version of the handouts is provided for a classroom or distance learning. These Google Slides are sized to support use on a computer or tablet. Students will complete the journal by writing in the text boxes.



Bonus Materials

NASA Activities: Need more space-themed STEM activities? Check out these resources from NASA!

- [Code a Mars Sample Collection Video Game](#)
- [Land a Spacecraft on Target](#)
- [Make a Moon Crater](#)
- [Code a Mars Helicopter](#)
- [Design a Robotics Insect](#)
- [Make an Astronaut Lander](#)
- [Make a Solar Scale](#)
- [Space Origami: Make Your Own Starshade](#)
- [Explore Rocks Using Core Sampling](#)

NASA Apps:

- NASA
- NASA Selfies
- NASA Spinoff
- ISS Explorer
- Space Station Research Xplorer
- NASA Science: Humans in Space
- NASA Be a Martian
- ISS Spotter

Mission to Mars
Kahoot! Games

[Game 1](#)

[Game 2](#)

[Game 3](#)

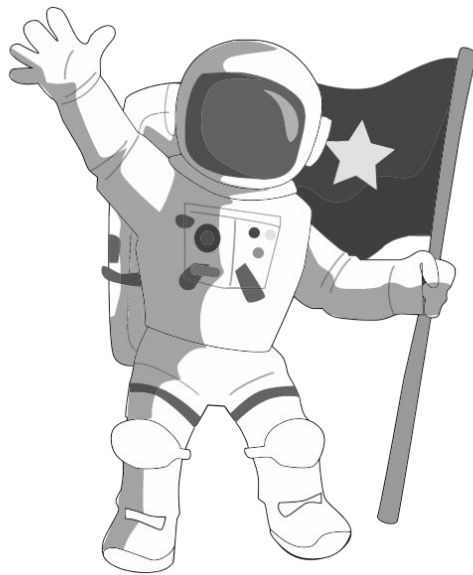
[Click for Mission to Mars
Supply Kit](#)



Activity Guide

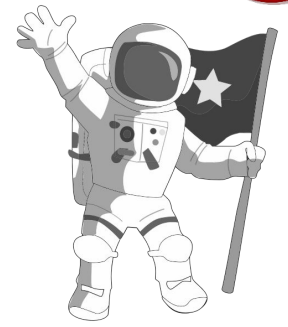
Mission 1

Meet the Crew

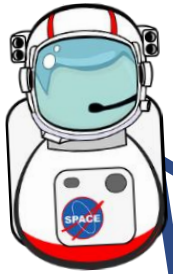




Mission Overview



1. Welcome to Space Club! Introduce the program and discuss logistics.
2. Watch the Mission Overview video or read script
3. Read the optional Breaking News on finding water on Mars.
4. Complete team challenges - many options are provided! Distance learning? [Find activities here.](#)
5. Students select individual sparks. Share sparks with teammates and work as a team to create a team “hype” video. Don’t have access to technology? Complete the mission patch activity and create a poster with all the mission patches.
6. 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.



Congratulations! You have been selected as the newest member of the United States astronaut class to embark on a mission to Mars! Your team was selected from over 23,000 applicants.

My name is <<insert your name or come up with a name!>>, and I am part of Space Club’s Mission Control. I will be here to support your crew on every step of this epic adventure.

Why are we going to Mars? We are the first humans to attempt to build a base and live on another planet! We will need to complete scientific and engineering missions to explore the red planet for critical resources to survive.

Let’s first learn a little more about NASA, or the National Aeronautics and Space Administration, which is part of the United States federal government and is responsible for the civilian space program. For more than 50 years, NASA has led the way in space exploration from humans walking on the Moon, robots exploring Mars, to living in lower Earth orbit on the International Space Station. These adventures in space are possible because of the over 18,000 people who work at NASA facilities across the country!

Throughout our Mission to Mars, STEM professionals will help our crew as we travel and explore the planet. Being an astronaut is an amazing job as you will get to travel to outer space and explore a new world. But the work is extremely dangerous, and you will need to train for two years to prepare for your first space adventure.

Another critical part of being an astronaut is working well with your teammates. Space is a dangerous place, and you will need to communicate to survive. So before we depart to Mars, let’s get to know each other and learn to work together! First, we will share our individual sparks or something you are passionate about like music, dance, video games, or sports.

Then, your mission is to create a short team video that highlights the sparks of your team. Think of it like a “hype” video that will feature how awesome you are and get you pumped to begin this epic adventure in space! Best of luck, and I can’t wait to see what you create! ~Space Club Mission Control

Great videos to show:

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

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

[NASA Johnson Style](#) (4 min)

BREAKING NEWS!

NASA Finds Evidence of Liquid Water on Mars



In 2011, NASA sent the Curiosity Rover to Mars. The goal of the rover's mission was to learn about the environment of the red planet and to find evidence of potential life on Mars. Historically, scientists have long thought Mars to be too cold to have liquid water.

However, recent discoveries by the Curiosity Rover have found signs of liquid water below the surface of Mars in the Gale Crater. Curiosity has found a type of salt in the soil that would lower the freezing temperature of ice on Mars, turning it into liquid water. A NASA satellite has also confirmed photographs of salt water flowing down crater walls and canyons.

Geological evidence suggests that billions of years ago, there was plenty of water flowing across Mars, collecting into pools, lakes, and deep oceans. New NASA-funded research shows a substantial quantity of its water - between 30 and 99% - is trapped within minerals in the planet's crust, challenging the current theory that due to the Red Planet's low gravity, its water escaped into space.

WHY IS WATER IMPORTANT?

Finding water on Mars is important to scientists because it may indicate a potential form of life. It could also be a source of water for when humans decide to live on Mars.



Credit: NASA

WANTED: FUTURE EXPLORERS

NASA is currently seeking young men and women to be the next generation of astronauts for the upcoming journey to Mars.

NASA is looking for people with a variety of interests and diverse backgrounds who are interested in exploring the possibilities of deep space. If you are an exceptionally talented man or woman please apply now!

PERSEVERANCE MISSION

In July of 2020, NASA launched the Perseverance Mars Rover, successfully landing on the red planet on February 18, 2021. Its mission? Perseverance is to go to be used for studying Mars' habitability, looking for signs of past microbial life, collecting and studying samples, and preparing for future human missions to Mars!

Team Activity: Pipecleaner Tower

1

Students will work in teams to build the tallest tower using pipecleaners.

Group Size: 2 - 4 students



Materials

Materials Per Team of 3 - 4 students

- ❑ 15 Pipecleaners per team

For testing: measuring tape or yard stick



Instructions

1. Place pipecleaners into bundles of 15.
2. Group students into teams of 2 - 4 and provide with a bundle of pipecleaners.
3. Instruct students that each engineering team is tasked to build the “tallest free-standing structure” with the materials provided. Free-standing means the structure can not be held, taped, wedged between desks, etc. Ask for any clarification.
4. **Timing:** You can project an online timer for 12 minutes (or longer if time allows). If you have flexible time, you can watch the progress of students and stop the time once the majority of teams have made good progress.
5. **After working for 2-4 minutes:** tell students to freeze. *Your team had an unexpected budget cut, and one of your resources has been depleted. EACH team member must now put one arm behind his/her back! Keep building!*
6. **2-4 more minutes:** freeze again. *Your engineering company realized that the loss in resources were detrimental to the product. The manager has decided to expand your operations globally to bring in more business. Your team now operates in (insert favorite country here) allowing you to use both arms again. But now you are unable to speak the same language. Continue the task without any speaking!*
7. **1-2 minutes left:** freeze again. *Good news! Business is booming, and your company has hired translators. Complete the task with all your resources! Two minutes left!*
8. Countdown from ten and stop the activity.
9. Walk around the room and note the different shapes and designs of the towers. Determine the tallest tower and allow the team to explain their successful design. Emphasize that a sturdy base was critical to a tall tower.

Team Activity: Cup Challenge



Overview

Students will work in teams to make a tower of cups.

Group Size: 3 - 4 students

Time: 10 - 15 minutes



Materials

Materials Per Team of 3 - 4 students

- 6, 16 oz Plastic cups
- 1 Rubber band
- 8 ft. String **OR** 4, 2 ft. pieces of string
- Scissors



Prep Work

1. Prep materials per group.
2. Read directions below and determine if you wish to provide the solution to the students or let them figure it out on their own. If you provide the solution, cut the string into 4, 2 foot sections.



Cup Challenge

1. Give each team a set of materials. The cups starting position is all stacked together.
2. Challenge the students to stack 6 cups into a pyramid. Students can not touch the cups and each member must help move each cup. Set up an example tower shown.
3. **Cup Tower Rules**
 - Can not touch or pick up the cup
 - All team members must participate
 - If students become frustrated, provide them with hints
4. **Solution:** Cut the string into as many pieces as there are team members and tie the string around the rubber band. Each student on the team should have their own string. When they each pull on their string at the same time it will expand the rubber band large enough to be placed over the cup.
5. Create a new tower design to keep the challenge going.



Learn how to communicate and work in a team.
This activity is great for younger students!

Group Size: 3 - 4 students



Prior to Activity

1. Gather materials listed.
2. Build a long stick with straws and tape using at least 1 straw per student in the group.

You can also use a hula hoop so students are facing each other. Make sure to model constructive communication.

Make it harder by adding more students in a team!



Materials Per Group

- Straight straws
 - Clear tape
- or [Straw Builders](#)



Activity Instructions

1. Students form 2 lines facing each other.
2. Everyone holds arms out and points index fingers.
3. Lay straw stick across everyone's fingers. Adjust finger heights until stick is horizontal and everyone's fingers are touching the stick.

The challenge: Lower the stick to the ground! Rules include:

- Everyone's fingers must be in contact with the stick AT ALL TIMES. Must restart from the beginning if someone loses contact.
 - No pinching or grabbing the stick
4. You will notice that instead of the stick going down, it will "magically" start to move upward! And of course the stick does not contain helium. The secret is that the collective upward pressure created by everyone's fingers tends to be greater than the weight of the stick. As a result, the more a group tries, the more the stick tends to 'float' upwards

Activity: Team Video



Students create a team “hype” video featuring individual sparks.



Individual Sparks

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.

Materials	
<input type="checkbox"/>	Paper & pencil
<input type="checkbox"/>	Tablets or phones for filming
<input type="checkbox"/>	Props if needed



Team Video

Another option is to create a class or Space Club video featuring all the students and teams together! Student leaders can be responsible for scripting, filming, and editing.

1. Determine what platform teams will use to create a video. [Flipgrid](#) is a great option. If you want to encourage editing, check out these tools: iMovie, Loom, WeVideo, and Zoom.
2. Form teams that will be used throughout the Mission to Mars.
3. Have teams share individual sparks and get to know each other. The provided team challenges are a great icebreaker.
4. Teams will work together to create a team video showcasing:
 - a. Team Name
 - b. Student Names
 - c. Individual sparks of team members
5. Brainstorm video scripts:
 - a. How will you feature individual sparks? Students can act out, draw, describe, animate, etc to present their spark. Get creative!
 - b. How will you show a team identity? Make sure to agree on a team name. How will it be featured in the video? Students can wear a team logo, create a team chant, or other ways to show unity.
6. Film videos! Videos can be as simple as putting a camera on a stand and doing a presentation in front of the video. Share the video with classmates, parents, and other Space Club sites!

Video Tips: No need for fancy editing! Have students create a script and practice. Then record in one take using a tablet or phone. A great option that allows students to share the video in a class group is Flipgrid.

Distance learning? Use Zoom to record a video.

Activity: Mission Patch



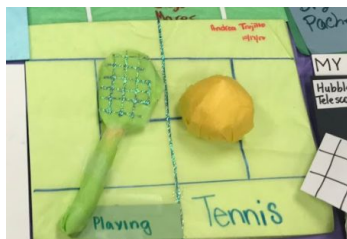
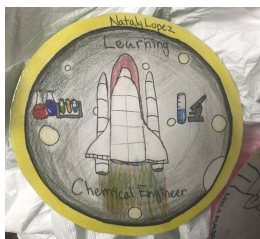
Students create their own personal mission patch. This activity can be used with the team video or as a replacement activity.



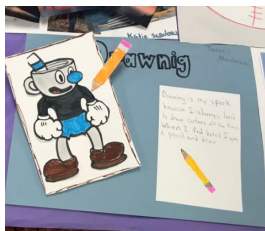
Build a Mission Patch

Materials	
<input type="checkbox"/>	Construction Paper or Cardstock
<input type="checkbox"/>	Pencil
<input type="checkbox"/>	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: You may also consider making a team mission patch to represent the group as a whole or a poster featuring all the mission patches.



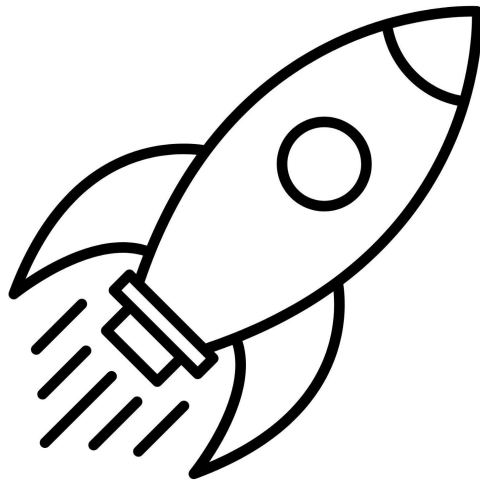


My Name: _____

My spark is: _____

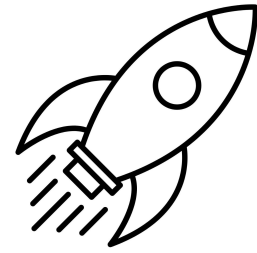
Mission 2

Get to Mars



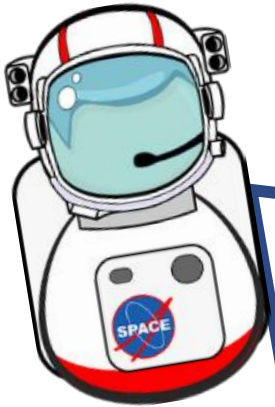


Mission Overview



1. Watch the Mission Overview video or read script below
2. Complete straw rockets activity or alternative paper rocket

Note: Students can work individually on this challenge to design and test an optimal rocket through trial and error. Students can also work in teams to figure out the optimal rocket design by testing out different variables (straw length, fin shape, amount of modeling clay). For example, one team member builds 3 rockets with different lengths to figure out the best length to use.



Astronauts, report for duty! NASA has decided our team is ready to launch to Mars! But how will we get there? Mars is 140 million miles away, and the journey takes over 7 months! We will need a powerful rocket to make the journey through deep space.

To design our rocket, we need the help of engineers. Engineering is a STEM career that uses math and science plus some creativity to solve problems to make our lives better. Engineers design safer football helmets, filters to clean water, or solar panels to make clean energy.

For our problem of getting to Mars, we need a specific engineer called an aerospace engineer. Aerospace engineers design things that fly in the air and outer space. This of course includes rockets that fly to other planets! Here on Earth, aerospace engineers design helicopters, quadcopters, and airplanes. Did you hear about the drone that can deliver pizza?!

To get to Mars, we will use NASA's new Space Launch System (SLS). The SLS is the world's most powerful rocket. The rocket's engines produces 9.2 million pounds of thrust. That is the same as 208,000 car engines! The SLS is designed to launch humans to Mars and even asteroids.

Today, you will help aerospace engineers design our rocket. First, we need to learn a little rocket science. How many forces are acting on the rocket? Well, we need a force to push our rocket into space. That force is call the thrust!

Second, everything on Earth feels the force of gravity pulling it downward. And as our rocket goes up, it will experience air resistance or the air pushing down on the rocket. The thrust will need to be powerful enough to overcome both the pull of gravity and air resistance. Then it can break free and reach our destination to Mars!

In your mission today, you will design, build, and test your very own rocket! Your thrust will be the force of air pushed into the rocket, and just like a real rocket, it will be slowed down by gravity and air resistance.

Best of luck getting to Mars! ~Space Club Mission Control

Great videos to show:

[NASA Journey to Mars](#) (2 min)

[The Most Powerful Rocket Ever Built](#) (2.5 min)

[What's an Engineer](#) (4.5 min)

[Lift off of Artemis 1](#) (3 min)



Answer Key



Science Background

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

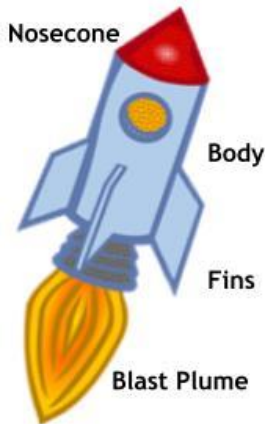
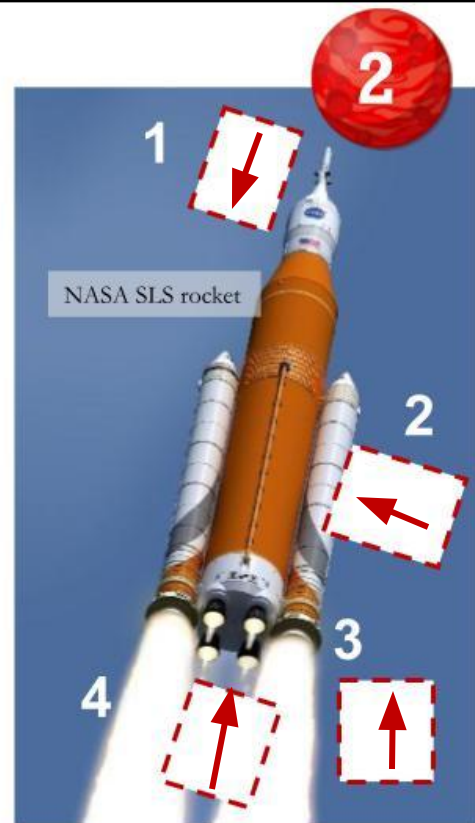
Force 1: drag (air resistance) force is slowing the rocket down because of the friction from the air.

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

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

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

Word Bank: thrust, drag, lift, gravity



Mission Log: To the left is a diagram of the components of our rocket. Instead of a blast plume, you will push air into the rocket using a launcher or your lungs. What variables will impact the design of our straw rockets?

- Mass/ Size of nose cone
- Length of Straw
- Number and shape of fins
- Placement of fins

LAW OF ACTION - REACTION (NEWTON'S 3RD LAW)

For every action there is an _____ and _____ reaction.

For straw rockets, the air being pushed down the tube is the _____ and the straw flying up is the _____

Word Bank
reaction
action
equal
opposite

Students will build and launch straw rockets to travel the farthest distance. *No Pitsco launcher? See alternative paper rocket (page 30).*

Group Size: Individually



Prior to Activity

1. Gather materials listed.
2. Build an example straw rocket using instructions on next page.
3. **Set-up testing station.** Place rocket launchers at the end of a long hallway. Create a starting line for testing. Use a measuring tape (100 ft) or markers at every 10 feet to determine distance. With markers, students can measure distance to the closest foot.
4. Test your rocket first to determine best launch angle and column height.



Materials Per Student

- 2 [Straws](#)
- 2 Index cards
- 1/2 inch modeling clay
- Masking Tape
- Scissors
- Pencils

Testing Station Materials

- [Pitsco Straw Rocket](#) Launcher
- Measuring tape for distance
- Markers for distance



Activity Instructions

1. Demonstrate how to build and launch a straw rocket.
2. Discuss variables: Variables are things you change in an experiment such as the number of fins on the rocket. Ask: what are the variables you can change on the rocket? Possible answers: number, shape, and position of fins, length of body tube (straw), size and shape of nose cone, angle of launcher, and thrust from launcher. The goal is to optimize these variables!
3. Bonus: show students how variables can impact distance. Launch two rockets with different nose cone size and compare distance.
4. Challenge the students to build a rocket to travel the farthest distance. Keep the launcher at a set column height (this controls the amount of power or thrust on the rocket).
5. How can students change the variables on their straw rocket (like number of fins) to change the distance traveled? *Students will become competitive!*

How to Build a Rocket

1. Draw the chosen fin shape on an index card. The most *aerodynamic* fins (have the least drag or air resistance) are triangles, but students are allowed to experiment. Students should also think about symmetry to keep their rocket straight. Folding a card in half allows for two identical fins.
2. Cut a piece of tape as long as the edge of the fin. Attach the fins so they are evenly spaced around the straw. Trim off any excess tape using the scissors. **Make sure the tape does not block the straw opening!**
3. Carefully shape the clay to match the desired nose cone shape. The surface of the nose cone needs to be smooth. Press the nose cone on top of the straw rocket body. The outside edge between the straw and nose cone should be sealed carefully with the clay.
4. Launch the straw rocket using the Pitsco Straw Rocket Launcher by lifting the rod (light green column with numbers) and releasing. **Do not slam down launcher!**

Building Tips

- Amount of modeling clay does not need to be exact. Students can request more if needed. However, less is better for farther distance.
- Make sure the tape does not cover the straw opening.
- To launch the rocket, pull up the bar and release. Do not force it down.





Extension Activities

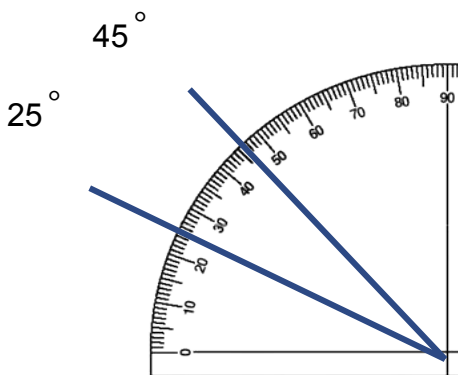
Activity 1: Optimize Launch Angle

1. Build a straw rocket.
2. Launch straw rocket at multiple angles and measure the distance traveled.
3. Graph the results. Which angle resulted in the farthest distance?
4. Repeat with a different straw rocket to determine if optimal angle is different for each rocket design.

Activity 2: Optimize Rocket Design

Optimize your rocket design by systematically testing one variable at a time.

5. **Select rocket variable.** Ex: straw length, number of fins, nose cone mass, angle of launcher
6. **Determine hypothesis.** For each variable, predict how it will affect distance. Ex: a heavier rocket will fly farther.
7. **Build 4 - 6 straw rockets to test this variable.** Or build one rocket, test, and then change the variable. Keep all other variables the same.
8. **Test each rocket under identical conditions including launch angle and height.** Think about how you will measure farthest distance. Will it be landing spot or stopping spot (after gliding)? Record results in the table.
9. **Graph testing results.**
10. **Repeat for another variable.**
11. **Complete reflection questions.**



Activity: Get to Mars - Paper Rockets



Materials

No Pitsco Launcher? Use this paper rocket activity instead.

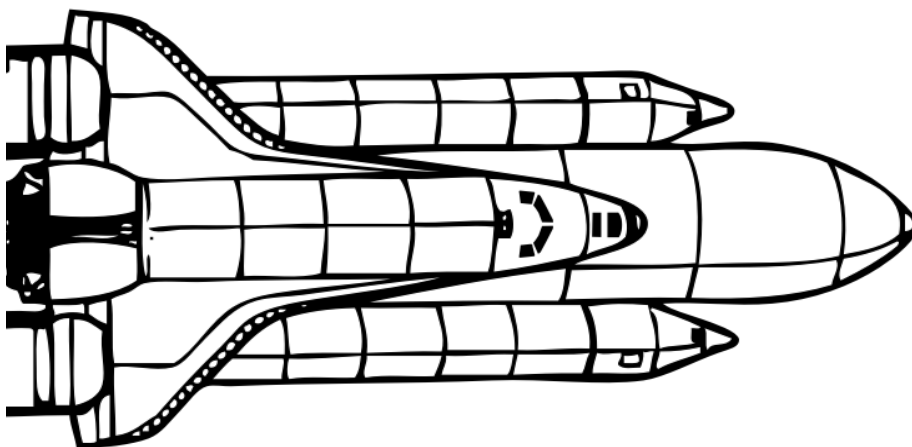
Materials Per Student	Testing Station Materials
<ul style="list-style-type: none"><input type="checkbox"/> Large diameter straight straw<input type="checkbox"/> Regular diameter straight straw<input type="checkbox"/> Tape<input type="checkbox"/> Scissors<input type="checkbox"/> Template below	<ul style="list-style-type: none"><input type="checkbox"/> Measuring tape for distance



How to Build a Rocket

1. Flatten and fold over one end of the big diameter straw and secure closed with tape.
2. Attach rocket to the back of big straw using tape.
3. Slide the rocket-straw onto the end of the regular straw. Determine where you wish to fly your rocket and blow into the regular straw to send it soaring!
4. Build a second rocket.
5. Conduct multiple trials for each rocket to determine farthest distance.
6. Try changing the angle by moving your head up or down to see if distance changes.

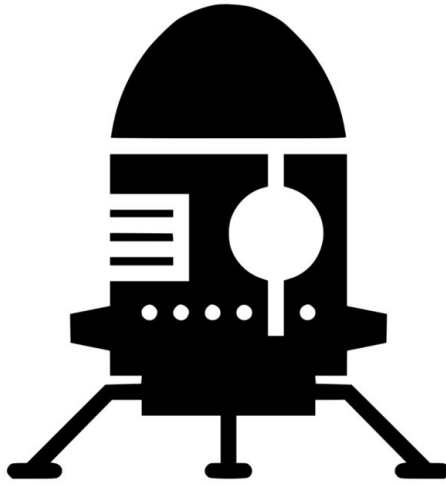
Saturn V



Space Shuttle

Mission 3

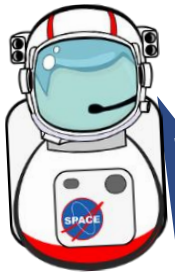
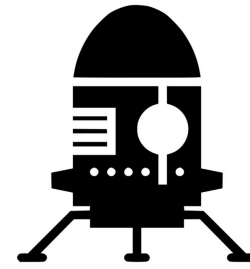
Land on Mars





Mission Overview

1. Watch the Mission Overview video or read script below
2. More background: [Mars 2020 Mission](#) and [7 minutes of terror](#)
3. Complete the space lander activity in teams.



After 7 long months, our team has reached Mars! Because of the very thin atmosphere, our spacecraft is falling at a speed of 7,800 miles per hour! We need to find a way to slow down our lander and keep our crew safely inside upon impact.

To design our lander, we need to use the **engineering design process**. Engineers use this to solve a problem. First, they learn everything they can about the problem. Then they brainstorm different solutions. From their ideas, they pick one to build and test. Engineers rarely get it right the first time, so they try and try again! After they fail, they learn from the test and create a better solution. *Failure is an important part of the process!*

Luckily for us, NASA has experience landing on Mars. Check out this video on the “7 minutes of terror” on how NASA landed the Curiosity rover.

Now it is our turn to land on Mars! The mission today is to design and build a space lander to land your astronauts safely on the surface of Mars. Astronauts will be represented by a ping pong ball and our lander will be this cup with a half sheet of paper taped on the bottom. What would happen if we just drop our lander now? They pop out!

To keep our astronaut inside, we need to think of a way to slow down the lander and absorb the force of impact. In this challenge, the constraints are to only build below the cup and not place anything inside.

One important science concept to keep in mind is air resistance or drag. Remember that from our last mission? To slow something down, you want to create more drag or friction from the surrounding air. (show a flat sheet of paper and a ball of paper) Which of these do you think will drop the fastest? The ball will drop faster because it has less friction from the air, while the sheet appears to float down.

Another idea to remember is shock absorption. Let’s do an experiment. I want you to stand up. Now jump in the air. Ok, now try it again, but keep your knees locked. How did that compare? Your knees bend to absorb the shock of impact. How can use this to help our lander?

Ok let’s get to work designing and building! See you on Mars!
~Space Club Mission Control

Great videos to show:

[NASA Intro to Engineering](#)
(2.5 min)

[The Engineering Process](#) (5 min)



Answer Key



Science Background

3

Air Resistance

- If you want to slow an object down, you want to create more air resistance / drag or friction from the surrounding air.
- The larger the surface area, the slower the object will fall.

Stability

- To keep your astronauts safe, the lander must remain upright. A stable lander evenly distributes the weight across the lander.

Shock Absorption

- Jump with your knees locked. How does that compare to a regular jump? Our lander needs to absorb the shock of impact (just like your legs) to keep our crew safe.



Word Bank
Air resistance
slower
air
faster
resistance
weight
force

Students build a lander to safely keep a ping pong ball in a cup when dropped.

Group Size: 2 - 4 students



Materials

Materials Per Team	Testing Supplies
<ul style="list-style-type: none"> <input type="checkbox"/> Clear or masking tape <input type="checkbox"/> 9 oz Plastic cup <input type="checkbox"/> Cardstock square (4 x 5 in) <input type="checkbox"/> 10 Cotton balls <input type="checkbox"/> 6 Flexible plastic straws <input type="checkbox"/> 6 Index cards 	<ul style="list-style-type: none"> <input type="checkbox"/> Ping Pong balls <input type="checkbox"/> Measuring tape <p>Alternative: Use 2 jumbo marshmallows, but use with a 3oz cup</p>




Prep Work

1. *Optional:* Tape the cup to the center of cardstock square. Or allow students to do this.
2. Divide supplies per team and place into a Ziploc bag.
3. Complete the challenge yourself so you can be familiar with the process.



Instructions

1. Form students into teams of 2-4 students.
2. Show landing platform with cup attached. Place ball inside and drop from about shoulder height. Ball will pop out. Explain to students that the mission is to keep the ball inside during impact.
3. Explain the design constraints (or rules) of the mission are:
 - Attach the cup to the landing platform (cardstock platform). Make sure to keep centered.
 - All building takes place underneath the landing platform. No covering the cup or platform.
 - Do not modify the cup or ball in any way including taping inside.
 - Ping pong ball must remain inside cup after landing.
 - Use as many or as little supplies as needed for your design. **You may decide to allow for more materials during building as students may change their design after testing.*



Activity: Land on Mars



4. **Discuss - shock absorption:** Something is needed in the design that will absorb the shock of landing. What is an example of a shock absorbing system or material? Ex: Air bag, mattress springs, shoes, trampoline. Compare the force of landing on concrete versus on a mattress. What happens? The force of the impact is absorbed by the springs of the mattress.
 - Did you know our bodies act like springs when we jump? Have the students jump in place and bend their legs as they land to see how their legs act as springs to soften their landing. Have them jump again with their knees locked. Do they feel a difference? Demonstrate how a notecard can be folded like an accordion to create a spring that can absorb the impact of their lander.
5. **Discuss - stabilization:** The design must have a way to keep the lander upright when falling and landing. This may include making the bottom of the lander heavier than the top and/or keeping everything symmetrical and centered on the lander.
6. **Ready to build!**
7. **Brainstorm and Design:** Ask teams to brainstorm ideas to keep the ping pong ball safely inside the cup after impact. Draw ideas on student handout.
8. **Build:** Students will collect supplies and build payload.
9. **Testing:** When design is complete, the team goes to testing station.
 - Place the ping pong ball in the cup
 - Raise your lander to one foot, as measured from the very bottom of lander
 - If mission fails, go back to redesign your lander.
 - If mission succeeds, raise to two feet and then three feet. How high can you go?
10. **Redesign:** Have teams think about how to improve the design. Modify or build a new device and repeat testing.
11. **Share:** Students should share results with others and discuss their success and challenges.
12. **Want a competition?** Have students form a large circle with their designs. This is a great time for students to share their design. Have a volunteer hold the measuring tape at the drop distance (starting at 1 foot) or the teacher's knee height (or table height). Each team will come forward with their design and the team will drop their lander. Allow for two trials per team drop. If the team is not successful after the test, return to their spot in the circle and sit down. After going through all teams, move up another foot. Repeat the testing to see who can go the highest!



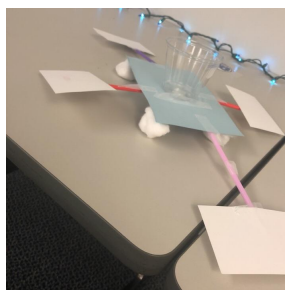
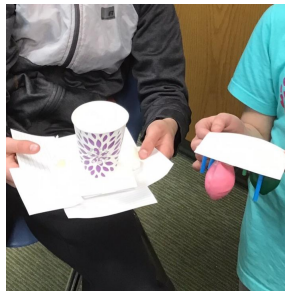
Helpful Tips

- The size of the cup is critical and can be changed to modify the challenge. A larger cup will allow the students to be able to drop the cup and keep the marshmallows/ping pong ball inside without any lander contraption. However, if the smaller cup is too hard, you can add a design constraint that the lander must be 2 inches above the ground upon impact. This way, a larger cup can be used for younger students.
- Stability is the hardest part. Making the contraptions too “springy” will cause it to topple over.
- Drag is not directly discussed, but some teams will discover that creating a large surface area with index cards will drastically slow down the lander.
- Do not allow students to place anything inside the cup.
- Students are easily swayed by examples, so don’t give them any hints!



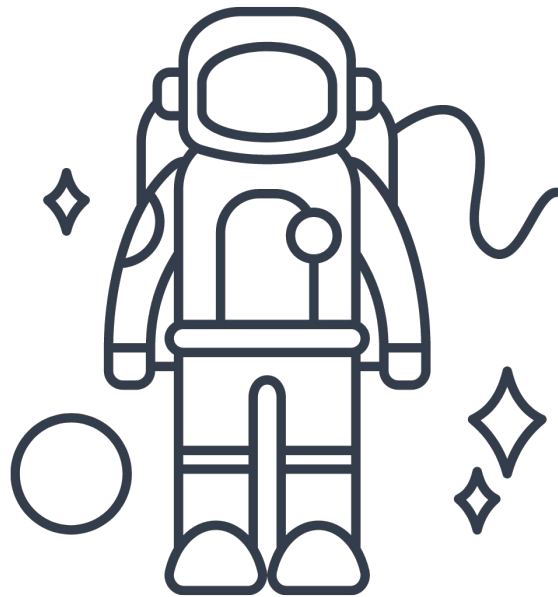
Building Tips

- *Tips over when it drops* - move the items on the lander to make it more symmetrical or balance the weight with additional materials.
- *Does not land softly* - Change the size, position or amount of shock absorbing materials. They can also add “feet” to the landing pad using cotton balls to help absorb the energy. Or ask them to think about using drag forces or a larger surface area to slow down the lander using friction from the air.



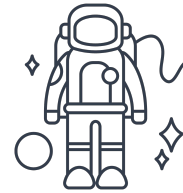
Mission 4

Explore the Surface

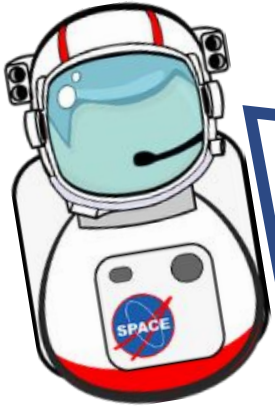




Mission Overview



1. Watch the Mission Overview video or read script below.
2. Start with a discussion of circuitry. If students have never completed a paper circuit, have each one make a practice circuit using foil, LED light, and battery on a piece of paper. [Click here](#) for background on paper circuits.
3. Complete the wearable device activity.



Congratulations! You are the first humans to set foot on Mars! I am proud of our team for making it this far, but now we need to work together to learn how to survive and accomplish our mission.

Before we go out exploring, NASA has requested that your team design a wearable device that will alert the base of an emergency. This device must be worn at all times so we can keep our crew safe. To help us with this device, we have the help of a biomedical engineer. Biomedical engineers use their knowledge of biology and medicine to create devices such as surgical robots or artificial limbs. Pretty cool!

The first part of the challenge is to figure out where this device will be worn. Perhaps you will make a bracelet or a headband. Or maybe you prefer a belt or a pin for a shirt. Whatever you decide, make sure your device will stay on during all types of movement and is easily accessible.

How will the device work? Your team will create a circuit with a switch to turn a light on and off. A circuit is a closed path that allows for electricity to flow from one place to another. A switch allows you to open or close the path, or turn a light on and off just like a light switch.

To create your wearable device, you will need to use conductive materials. These are materials like aluminum foil that allow electricity to flow. In your device, you will need to connect a light, a coin cell battery, and a switch to power the light on and off.

If you have never made a paper circuit, start by making a simple circuit on a piece of paper. Then, figure out how you can add a switch that will stop and start the flow of electricity by opening and closing the circuit. Finally, how will you wear this circuit to alert your teammates that you need help?

You might also consider adding multiple lights. What will each light be communicating? How else can we improve this device?

Best of luck designing your wearable communication device! See you in the next mission! ~Space Club Mission Control

Great videos to show:

[Power of Circuits](#)
(4.5 min)

[I am a biomedical engineer](#) (3.5 min)

[Biomonitor Space Shirt](#) (1.5 min)



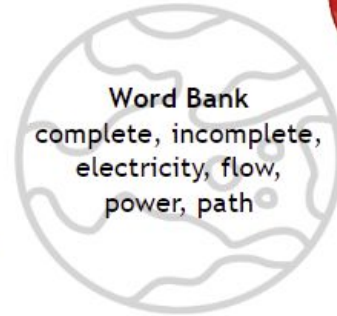
Answer Key



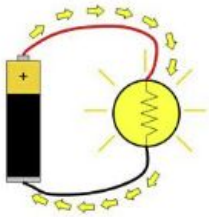
Science Background



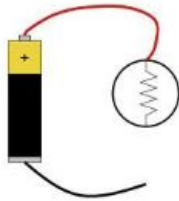
- Electricity is the flow of electrons to create electrical power.
- A circuit is a path through which electricity can flow.



Closed circuit



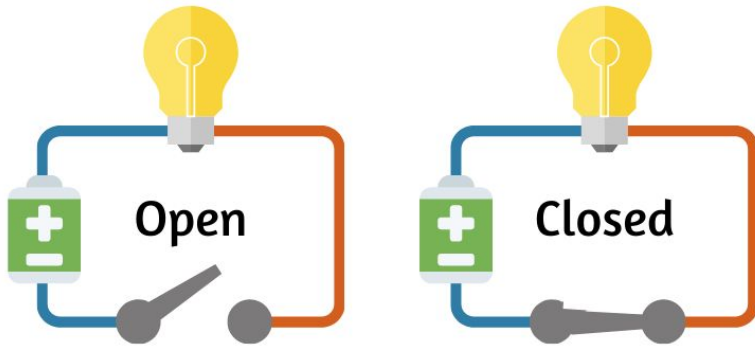
Open circuit



- A closed circuit is a complete circuit that allows for the electricity to flow from one end to the other without interruption.
- An open circuit is a incomplete circuit that does NOT allow the electricity to flow from one end to the other.

All About Circuits

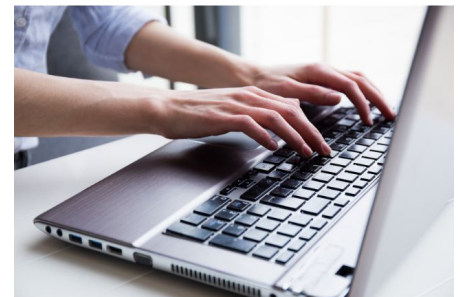
An electronic circuit is a closed path that allows for electricity to flow from one place to another through electronic components such as wires, lights, and switches. A flashlight is an example of a simple circuit that turns on a light.



A **closed circuit** allows for electricity to flow continuously through the circuit and can operate an electrical device or light up a lightbulb.

An **open circuit** stops the flow of electricity using a switch or by disconnecting a wire. You open a circuit every time you unplug a device or turn off a lightswitch.

Computer Keyboard: Each key on keyboard has a small electrical switch under it. When a key is pressed, the electrical circuit is completed causing the computer to react. A processor (a tiny computer) inside the keyboard records which circuits were completed and in what order. Can you find other examples of electrical circuits?

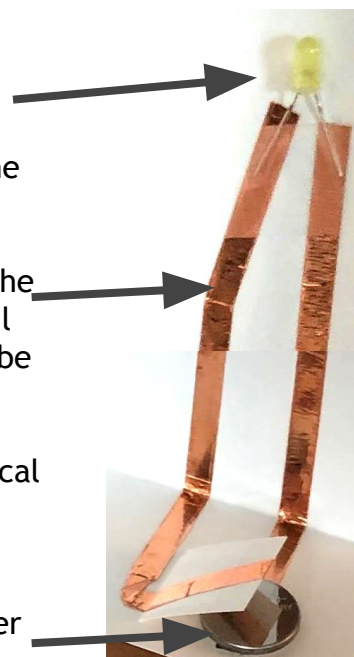


Circuits can be made of many different electronic components. You will be making a paper circuit that will follow the same basic design as a flashlight. Here are the components of your simple light circuit.

A **LED (Light Emitting Diode)** has two prongs; the long prong is the positive side and the short one is the negative side. These prongs should be connected to the appropriate sides of the battery.

Aluminum foil works like conductive wire in allowing the electricity to pass from one point to the other. The foil should be bent at turns but **not** cut or the circuit will be broken.

A **coin cell battery** provides the right amount of electrical current to light the small LED light. The aluminum foil must touch both sides (positive and negative) of the battery to complete the circuit. You can create a “switch” by wrapping the aluminum foil around a paper flap and pushing it down to “turn on” your light.



Tape over the prongs to press them against the aluminum foil and provide a good connection.

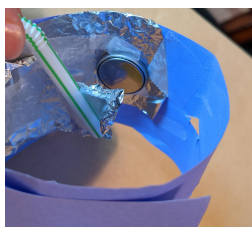
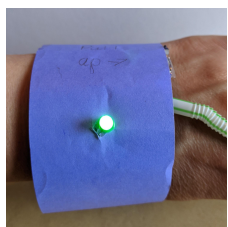
Activity: Wearable Device

4

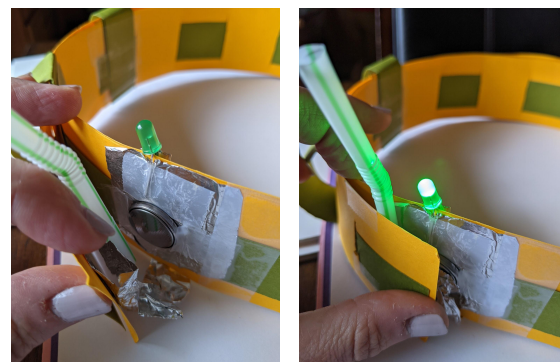
Students will design a wearable communication device for an astronaut.

Materials

- Scissors, Tape, Ruler
- 4 Sheets of Construction Paper
- 1 Sheet of Cardstock
- 5 Bendy Straws
- 1 Piece of Aluminum Foil
- 1 [LED light](#)
- [3V coin cell](#) battery



Safety Warning: Please carefully monitor children using batteries and LEDs to avoid accidental swallowing. Keep battery in protective case until ready to use. Storing batteries together will cause them to drain.



Instructions

1. If students have never completed a paper circuit, have each one make a practice circuit using foil, LED light, and battery on a piece of paper. Example: [Science Buddies: Make a Paper Circuit](#)
2. Use the engineering design process handouts to design and build a wearable communication device for astronauts.
 - Students are easily swayed by examples. We then recommend asking guiding questions such as “what can you do to improve your design?” or “why do you think this design is not working?”
 - Aluminum foil is used for creating a path between the LED light and the power source on the ground. The switch is pressing the two pieces of foil together.
 - Make sure students keep the light off (open the switch) when not using otherwise the battery will run out quickly.

Extension Activities:

- Using the website [Circuit Construction kit](#), have your students delve deeper into circuits and what materials are conductive and what materials are non conductive.
- Challenge your students to create Wearable Devices that have more than one light and one switch.

Mission 5

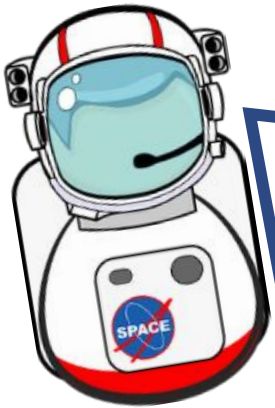
Live from Mars!





Mission Overview

1. Watch the Mission Overview video or read script below.
2. Play the Mars Matching Game to address any misconceptions about Mars.
3. For additional information, students can explore [this website](#).
4. Complete the “Live from Mars!” activity.



How are you feeling about your mission on Mars? To be honest, I am surprised your team is doing so well. Life on Mars is difficult due to very cold temperatures, lack of oxygen, and constant radiation. But it has been fun jumping around as we can bounce three times higher due to less gravity on Mars!

Since we are the first humans on Mars, this is a historical moment. The entire population on Earth is cheering our successful landing! While rovers have been exploring Mars since 1997, no human has ever set foot on the red planet.

In today’s mission, you are going to study the planet of Mars and then create a video describing life on Mars. People on Earth want to know:

- What are the greatest challenges to living on Mars?
- What impact does the change in gravity have on humans?
- What are the resources we can use on Mars?
- What is your favorite part of being on Mars?

As you create this video, which can be in any style you want, keep in mind these facts about Mars:

- Mars can be really cold and get down to -190°F (-120 °C)
- Mars has a really thin atmosphere, which can create dust storms, but it does not provide much protection from the Sun’s harmful radiation. We also don’t have enough oxygen to breathe.
- We have found water, but it appears to be in the form of ice at poles.

What else should we tell the Earthlings about our experience on Mars? I can’t wait to see what you come up with!

~ *Space Club Mission Control*

Great videos to show:

[What you need to know about Mars.](#)
(1 min)

[Could We Live on Mars.](#) (3 min)

[Mars in a Minute- Is Mars Red Hot?](#) (1 min)

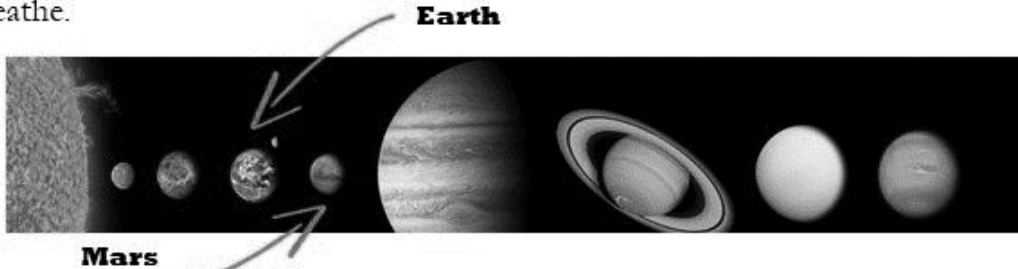


Answer Key

What makes the Earth livable?

Humans have yet to discover another planet with life. So why does Earth have life? Earth has just the right conditions to support life including: the perfect distance from the Sun, a protective atmosphere with oxygen, and plenty of drinkable water.

- Atmosphere is the layer of **Air / Gas** that surrounds the Earth. The *atmosphere* protects us from the Sun's radiation, regulates temperature, and contains oxygen for humans to breathe.

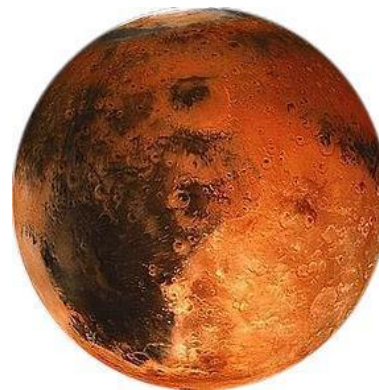


- Mars is the “red planet”. Does this mean it is hot? Compared to Earth, Mars is **further** from the Sun. This means less heat from the Sun will reach Mars compared to the Earth. But why is it red? The red color comes from **Iron** in the soil.



	Earth	Mars
My Weight		My weight divided by 3
Average Temperature (degrees F)	57 °F or 14 °C	-81 °F or -63 °C
Length of Day	24 hours	24 hours + 37 minutes
Atmosphere contains	78%: Nitrogen 21%: Oxygen Others	Mostly carbon dioxide

Play a game as a class to address any misconceptions about Mars.



Materials

- Mars Game cards
- 4 signs: Mars, Earth, Neither, Both

Distance Learning: This game can be played during a virtual meeting. Read out the card, and students can vote in the comments or by holding up a finger.

Prep Work

1. Print and cut out the Mars Game cards. Cards should have a fact on one side and the answer on the other.
2. Create 4 signs that read: Mars, Earth, Neither, Both. Tape one in each corner of the room.
3. Create an open space in the middle of the room to allow students to move around.

Instructions

1. Students gather in center of the room.
2. Shuffle the cards. Pull out the first flashcard. Each has two sides. The front side has a fact to show to students. The back side has the answer and an explanation.
3. Read or show the students the fact side. They will “vote” by moving to the corner that has the correct answer.
4. Flip the card over and discuss the answer. This is a great time to see what misconceptions students have about Mars!

Tallest mountain in the solar system

Mars

At 33,000 ft, the volcano Olympus Mons on Mars is the tallest mountain on any planet (3 times higher than Mt Everest). Lower gravity allows for higher mountains.

Front 1

Length of day: 24 hours	Length of day: 24 hours 37 minutes
A mix of landforms, water, vegetation, and life.	Covered in red dust that contains rust. You will choke to death if you breathe it in.
Tallest mountain in the solar system	Water exists on this planet
Average temperature: 57 °F or 14 °C	Average temperature: -81 °F or -63 °C
Hurricanes, typhoons, and tornadoes	Big dust storms that can cover entire planet.

Back 1

Mars

This is how long Mars takes to make a single rotation on its axis. A little longer than on Earth.

Earth

This is the amount of time it takes Earth to complete a single rotation on its axis.

Mars

The rocks and soil on Mars contains iron, so when it reacts with oxygen it rusts making the planet look red.

Earth

Earth has vegetation due to the large amount of water found.

Both

Water exists on the polar caps of Mars. Recent evidence of liquid water.

Mars

At 33,000 ft or 10 km, the volcano Olympus Mons on Mars is the tallest mountain on any planet (3 times higher than Mt Everest). Lower gravity allows for higher mountains.

Mars

Mars is cold! Being farther away from the Sun and having a thinner atmosphere to trap the heat causes cold temperatures.

Earth

The atmosphere is what keeps Earth from extreme temperatures.

Mars

These dust storms are a result of the thin atmosphere on Mars.

Earth

Not only does the atmosphere regulate temperature, it also produces weather as we know it!

Front 2

<p>A human on this planet would weigh on average 50 lbs or 23 kg</p>	<p>This planet has robots</p>
<p>Satellites orbit this planet</p>	<p>Scientists know everything about this planet.</p>
<p>Has seasons</p>	<p>Purple people live here</p>
<p>Found in the Milky Way galaxy</p>	<p>The farthest known planet from the Sun</p>
<p>You would float away if standing on this planet</p>	<p>The deepest canyon is 4 miles deep</p>

Back 2

<p style="text-align: center;">Both</p> <p>4 rovers have explored Mars. Two are still active. And lots of robots on Earth!</p>	<p style="text-align: center;">Mars</p> <p>Mars has about 1/3 the gravity of Earth so the average person is 50 lbs or 23 kg. A 100 lb person would weigh 38 lbs. A 62 kg person would weigh 21 kg.</p>
<p style="text-align: center;">Neither</p> <p>We have a lot to learn about Mars, but we are still discovering new things about our home every day!</p>	<p style="text-align: center;">Both</p> <p>4 active satellites are orbiting Mars studying the surface. 2,270 orbit Earth!</p>
<p style="text-align: center;">Neither</p> <p>No other life forms have been discovered in our galaxy.</p>	<p style="text-align: center;">Both</p> <p>Mars has spring, summer, fall and winter just like Earth does! Seasons are caused by the tilt of the planet as it rotates around the Sun.</p>
<p style="text-align: center;">Neither</p> <p>The farthest planet away from the Sun is Neptune!</p>	<p style="text-align: center;">Both</p> <p>Both planets are in the Milky Way Galaxy.</p>
<p style="text-align: center;">Mars</p> <p>The deepest canyon on Mars is 4 times deeper than the Grand Canyon</p>	<p style="text-align: center;">Neither</p> <p>Both planets have gravity so no floating away! Mars has 1/3 the gravity on Earth.</p>

Front 3

Atmosphere is: 77% Nitrogen 21% Oxygen	Atmosphere is mostly carbon dioxide that will cause you to suffocate
Has volcanoes	Low atmospheric pressure will cause your organs to push outside your body.
Atmosphere provides protection from radiation	Harmful radiation penetrates atmosphere and will cause eventual death
The third planet from the Sun	The fourth planet from the Sun
Planet is 7,926 miles or 12,756 km in diameter	Planet is 4,222 miles or 6795 km in diameter

Back 3

Mars

Humans need oxygen to breathe and pure carbon dioxide is deadly.

Earth

Having oxygen is what allows humans to breathe.

Mars

Having a thin atmosphere is the cause for extreme weather and temperatures on Mars.

Both

Mars has volcanoes too! They cover a vast majority of the planet.

Mars

Mars has an atmosphere 100 times thinner than Earth's. It does not protect the planet from the Sun's radiation.

Earth

Earth's atmosphere does not just protect humans from the sun's radiation, but it also regulates temperature and contains oxygen for humans to breathe.

Mars

Mars is 142 million miles or 210 million km from the sun and the second smallest in the entire solar system.

Earth

Earth is 93 million miles or 150 million km from the sun and the only planet in our solar system known to have life.

Mars

Mars is about half the size of Earth.

Earth

Earth is about twice the size of Mars.

Students present facts about Mars in a creative format such as a team video or presentation.



Instructions

Materials

- Paper & pencil
- Tablets or phones for filming
- Props if needed

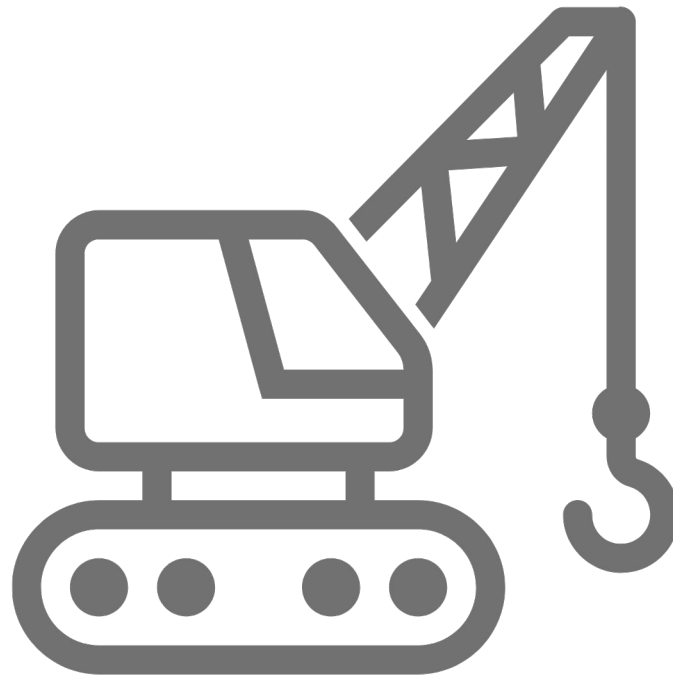
1. **Determine format:** This project can be completed as a video or through an in-classroom presentation. Like the first mission, [Flipgrid](#) is a great option. If you want to encourage editing, check out these tools: iMovie, Loom, WeVideo, and Zoom.
2. **Presentation style:** Teams should first determine the style of presentation/video. Examples: interviews, news anchor, public service announcement, recruitment for future astronauts, etc.
3. **Develop script:** Teams can start creating a script that will include the following information:
 - What are the greatest challenges to living on Mars?
 - What impact does the change in gravity have on humans?
 - What are the resources we can use on Mars?
 - What is your favorite part of being on Mars?
4. **Research Mars:** While developing the script, students can reference the provided handout. We encourage additional research if possible that considers the challenges of living on Mars. They can also investigate different locations on Mars.
 - <https://solarsystem.nasa.gov/planets/mars/overview/>
 - <https://www.google.com/mars/>
 - <https://mars.nasa.gov/all-about-mars/facts/>
5. **Career Connection:** Add in a career connection by having students research a real NASA engineer or scientist who works on the Mars mission! Ask students to incorporate this STEM professional into the video. For example, students can pretend to be the professional on Mars or conduct an interview. Go here for career profiles: <https://mars.nasa.gov/people>
6. **Approve script:** Teachers may want to approve the script prior to allowing filming or a presentation.
7. Share the presentation and video with the class!

Video Tips: No need for fancy editing! Have students create a script and practice. Then record in one take using a tablet or phone. A great option is Flipgrid that allows students to share the video in a class group.

Distance learning? Use Zoom to record a video.

Mission 6

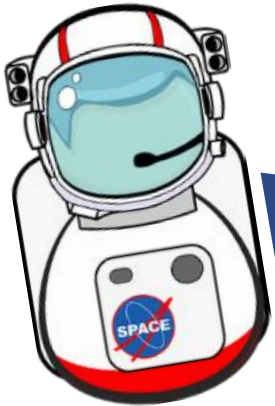
Collect Samples





Mission Overview

1. Watch the Mission Overview video or read script below
2. Locate Perseverance using [NASA's website](#) or [Google Mars Map](#).
3. Complete pneumatic device engineering challenge.



Listen up crew! I have some exciting news! NASA is sending our team on an expedition to collect soil samples and bring back to base for testing.

First, we need to locate the Perseverance rover. Back in February 2021, Perseverance landed on Mars with the mission of collecting core samples of Martian rock and soil and storing them in sealed tubes. Perseverance has been patiently waiting for our team to collect these samples so we can study them for signs of ancient microbial life!

After locating the samples, our team will need to find a way to lift and carry the samples back to base. This expedition will be in two parts. In today's mission, you will design a way to lift up the soil samples. Unfortunately, a crane was too heavy to bring with us from Earth. By the way, do you know much it costs to ship one pound to Mars? \$20,000! Can you figure out how much it would cost to send a 200 pound person to Mars? \$4 million!

Anyways, my point is that every pound of material has to be carefully selected. Instead of a crane, we decided that a pneumatic device would be a smarter choice. Pneumatic is just a fancy word that means a device that uses pressurized air like your bicycle pump. Every time you push down, air is forced into your bike's tires. Because they use air, these devices are really lightweight and perfect for traveling to a faraway planet like Mars!

In today's mission, our team needs to design and build a pneumatic device to lift up the soil sample. Next time, we will design a rover to bring it back to base for testing.

Good luck!
~Space Club Mission Control

Great videos to show:

Pneumatics:
[LEGO Pneumatic experiments](#)
[Pneumatic Tubes: Transportation of the Past... And Future?](#) (2 min)

Mars: [Seeking Signs of Life in Ancient Martian Rocks](#) (1 min)
[What kind of life on Mars will Perseverance look for?](#) (2 min)

[Lightweight, Soft Robotic Arm using Pneumatic Artificial Muscles](#) (1 min)

Pneumatics

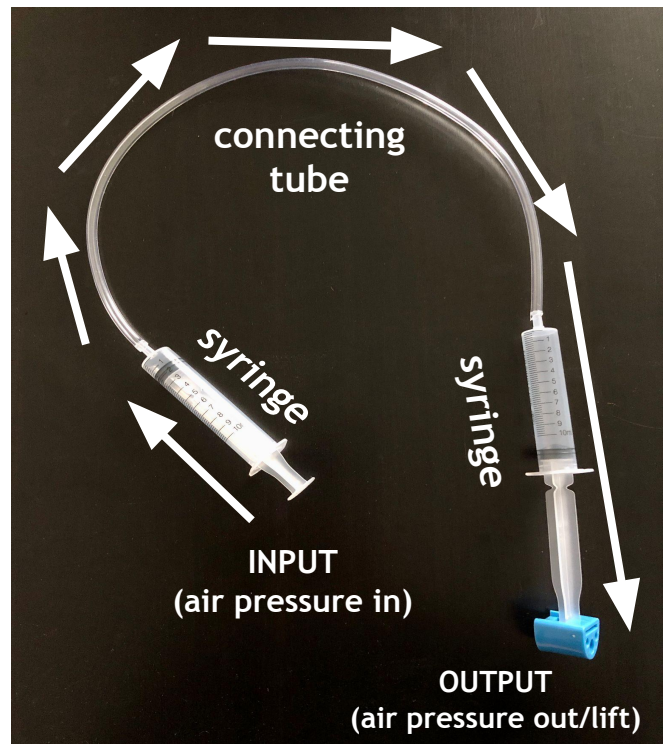
Pneumatics (pronounced noo·ma·tuhks) work by using air. When the air is placed under pressure it creates a mechanical response. There are many tools that use pneumatics like blood pressure cuffs at the doctor's office, nail guns, staplers, bike pumps, paint sprayers and even roller coasters! Japan has the world's fastest roller coaster, called Do-Dodonpa, and it is powered by air. A pneumatic device launches the coaster from 0 to 112 MPH in under 2 seconds!



This is the Soft Mate Lifting device created at NASA's Marshall Space Flight Center. This Soft Mate device uses a pneumatic system to power the hook and lift part of the device. The pneumatic system allows the device to gently lift and lower heavy and fragile equipment.

Inside the pneumatic system is a soft spring which allows the operators of the Soft Mate Lifting system to work with great precision and placement to lift or place any object the pneumatic device is carrying. This is very important when working with expensive NASA equipment and for the potential use of this device on Mars.

Pneumatic systems work by an input, compressed or pressurized air, and then an output. In this simple pneumatic system, the syringe on the left is the INPUT. The syringe is opened and filled with air. As the syringe stopper is pushed, the air pressure moves around the tube to the syringe on the right. This is the OUTPUT syringe. As the air pressure moves, it lifts the OUTPUT syringe stopper up.



(Left) Some banks use a pneumatic device to move money from inside the bank to a customer waiting in a car.



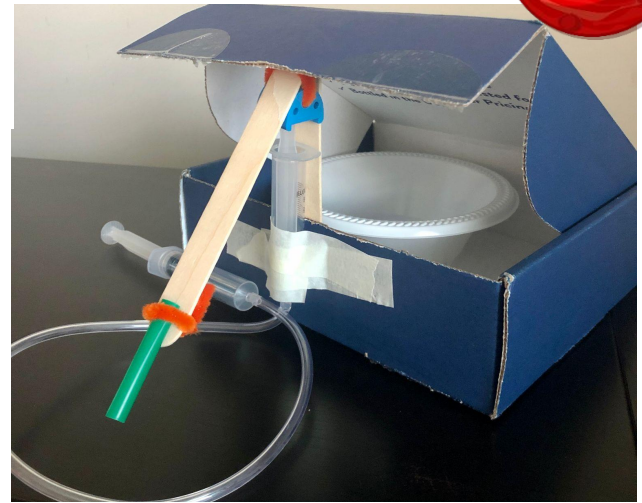
Activity: Pneumatic Device

6

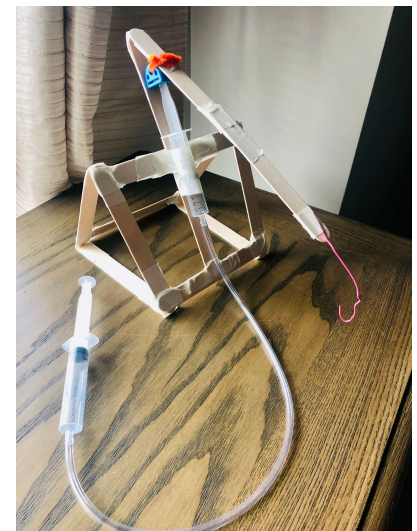
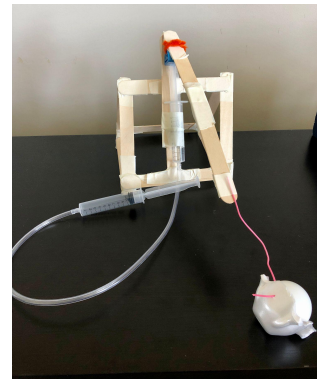
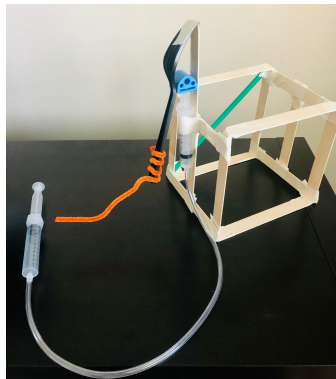
Design a pneumatic device that can pick up a soil sample on Mars.

Materials per team

- 1 Ping pong ball
- [Syringe kit](#) or each team needs:
 - 2 [Syringes](#)
 - 2 ft Plastic tubing
 - 1 Syringe adapter
- 20 Craft sticks
- 2 Rubber bands
- 2 Bendy straws
- 2 Pipecleaners



[Click here](#) for video examples of the pneumatic device in action. Do not show these videos to students!

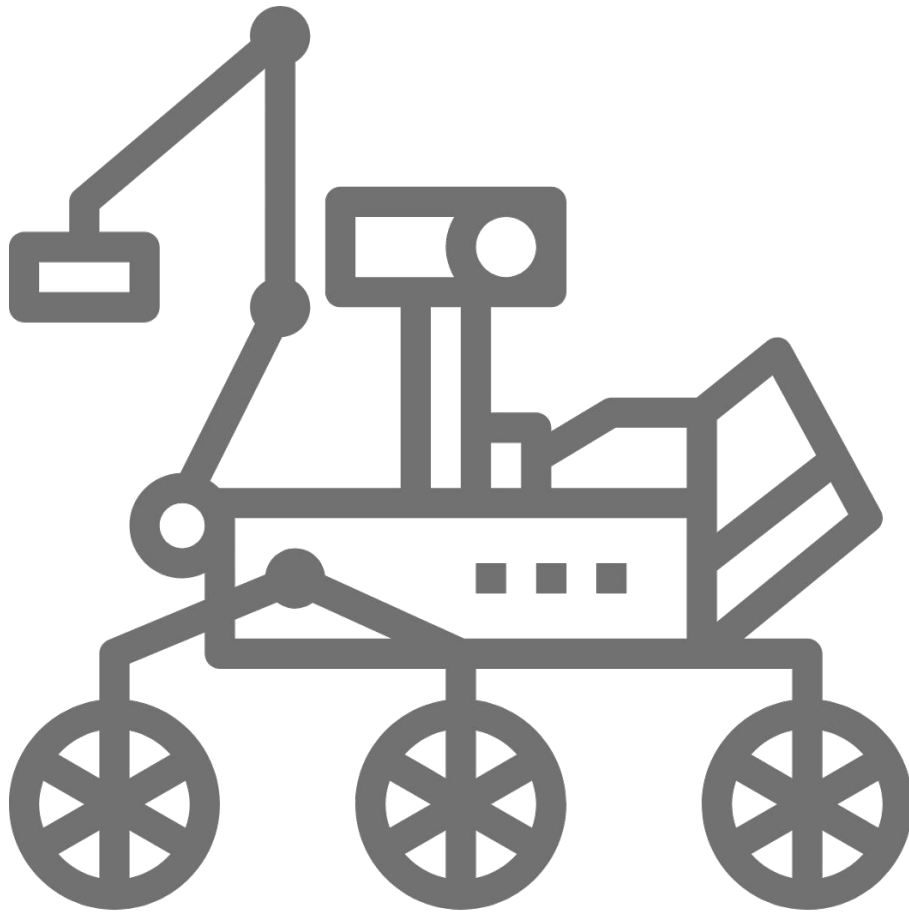


Instructions

1. Start with the following discussion questions:
 - Has anyone ever inflated a flat bike tire? How did you do it? Where did the air come from?
 - What are some other air-powered devices? (brakes on buses & trucks, paint sprayers, rock drills, blood pressure cuff at the doctor office, nail guns, exercise equipment, bank teller tubes at the drive-thru)
 - What would be the benefit of having an air-powered device on Mars? (lightweight, abundance of air “fuel”, easy to use)
2. Start with [this video](#). Use syringes and piping to create a simple pneumatic system.
3. Design and build a pneumatic device to lift a soil sample (ping pong ball) at least 2 inches off the ground. **Note:** This challenge will connect to the next mission! Here the device is lifting up the rock sample. In the next mission, students build a rover to transport the rock sample back to base. You may wish to connect these two activities for a more advanced option.
4. Students can make changes to their test pneumatic system to increase performance. Questions to ask: Could you make a simple pneumatic system? Did you use all of the parts? Are they all connected well? How could you set up the syringes so they could lift something? How do you define “best performance” with your pneumatic system?
5. Extension: Challenge your students to create a hydraulic device and answer the question: How does your hydraulic device perform compared to your pneumatic device?

Mission 7

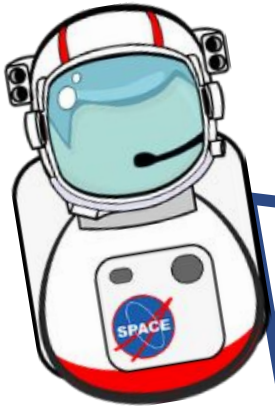
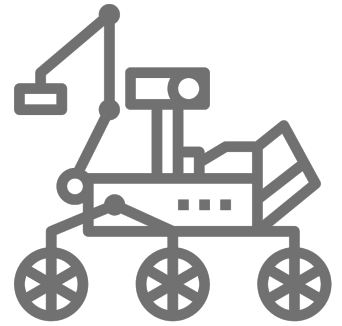
Transport Samples





Mission Overview

1. Watch the Mission Overview video or read script below
2. Complete rover design challenge to transport rock samples back to base.



Welcome back to another mission!

First, I would like to congratulate you on a job well done in building those pneumatic devices to lift our rock samples. Remember, we are looking signs of ancient microbial life! What do you think we will find? Unfortunately, we are a long way from our base, and the rock samples are heavy! How do we get them back to base for testing?

For today's mission, we need to design and build a rover to transport the rock samples back to base. We will need to use our mechanical engineering skills. **Mechanical engineering** is the broadest kind of engineer, and they know how to design and test tools, engines, machines and other mechanical devices. Mechanical engineers design roller coasters, robots that do surgery on humans, electric cars and more!

To power our rover, we are using energy stored in rubber bands. What happens if you stretch a rubber band and then let it go? It snaps back into its original shape! The more you stretch the rubber band, the more energy it stores. This stored energy is also called elastic potential energy. When you let it go, it turns into kinetic energy, or the energy of motion. We want to capture this kinetic energy and transfer it to make our rover move!

To capture this energy, connect your rubber band to the axle of your rover. This axle is then connected to a wheel. As the rubber band turns the axle, it moves the wheel and causes your rover to travel forward!

Now before you go design your rover, I want to give you a warning. This is a difficult challenge, and it will require critical thinking, creativity, and problem solving. These are skills you have been building during our previous missions, and I know you can do this! Don't give up! Remember that failure is part of the engineering process! If your rover doesn't work, think about what you can change to improve your design. You got this!

~Space Club Mission Control

Great videos to show:

[Day in the Life- Mechanical Engineer](#)
(3 min)

[Roving Mars](#) (6.5 min)

[Mars in a Minute- How Do Rovers Drive on Mars?](#) (1 min)



Answer Key

Potential Energy

- Potential energy is stored energy of an object relative to its position.
- A spring has more potential energy when it is compressed.

Kinetic Energy

- Kinetic energy is energy as a result of motion of an object.
- Kinetic energy is created when potential energy is released.

Friction

- Friction is created when an object rubs against the surface.
- A wheel and axle reduces friction.



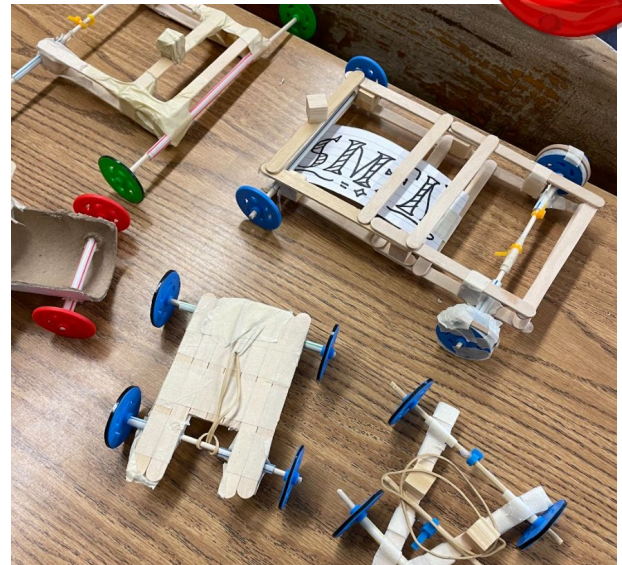
Design a rubber-band powered rover to transport rock samples.

Quantities per team

- 12 Craft sticks
- 8 [Craft cubes](#)
- 2 7 inch Rubber bands
- 3 5 inch Rubber bands
- 2 Zip ties
- 2 Straws
- 4 Wheels ([Wheel & Axle set](#))
- 4 Wooden dowels
- 1 Hot glue gun (recommended) or Elmer's glue
- Masking tape
- Scissors
- Cup

Recycled alternatives

- Rover body:** Cardboard, Paper plates, Plastic bottles, Styrofoam, Plastic Cups
- Wheels:** Cardboard, CDs, Empty toilet paper rolls
- Axles:** Plastic straws, Wooden pencils, Skewers/wooden rods



Here are some examples of rubber band cars. Note that any examples you provide will sway the student's designs!
[How to Make a Rubber Band Car](#)
[How to Make a mini-rubber band car](#)
[Young Engineers: The Best Rubber Band Car](#)

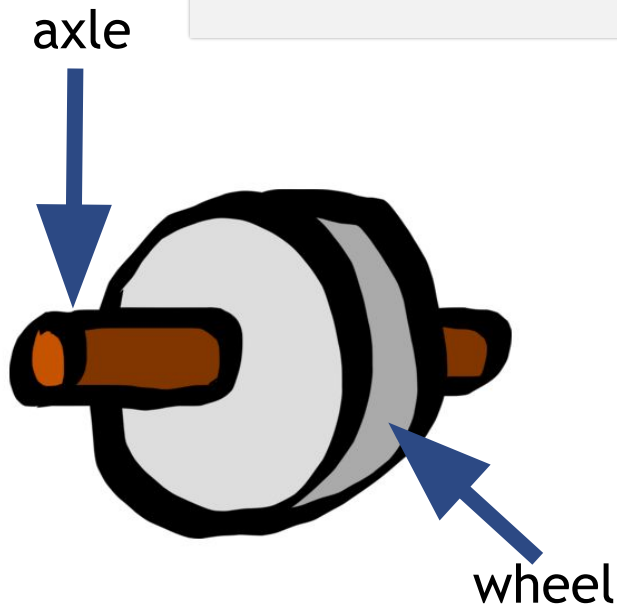
Instructions

1. The goal of this challenge is to transport a rock sample back to base! This connects with the previous mission. Options:
 - **Easy:** Build a rover that moves 12 inches.
 - **Medium:** Build a rover to transport a rock sample. The rover needs a way to hold the sample such as a cup.
 - **Hard:** Use the previous pneumatic device to place the ball on the rover. Rover transports rock sample.
2. Try out this challenge beforehand or watch the example videos above. [Click for example videos.](#)
3. The rover must be able to travel for a distance of at least 12 inches. Carpet works best for the testing as it allows for the rovers to grip the floor to move. Increase the difficulty by testing on a smoother terrain!
4. To set up the test area, place tape on the ground for a starting line and at a distance of 12 inches away (the rear of the rover must pass the finish line).
5. Discuss rubber-band power and wheel and axles. Useful videos to show: [Rubber Band-Powered Car Project](#) (first 1:20), [Science in a Snap: Make a Rubber Band Car](#), [What's the Difference between Potential and Kinetic Energy? | Science Max](#)
6. Design and build a rubber-band rover device!

How does the rover move?

Power:

Rubber band stores energy as it is stretched and releases energy in the form of motion as it contracts.



Wheel & Axle:

A simple machine that minimizes the amount of force needed to move an object. The greater the difference in the diameters between the axle and the wheel, the smaller the force required to accomplish the task.

Building Tip: The rougher your wheel is around the edge, the faster it will crawl. This improves **traction**, which is the ability of the wheel to grip the ground, and helps prevent the wheels from spinning out. How can you make your wheels more rough/rigid?

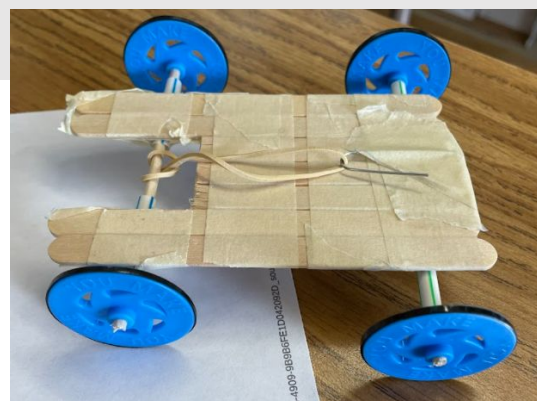
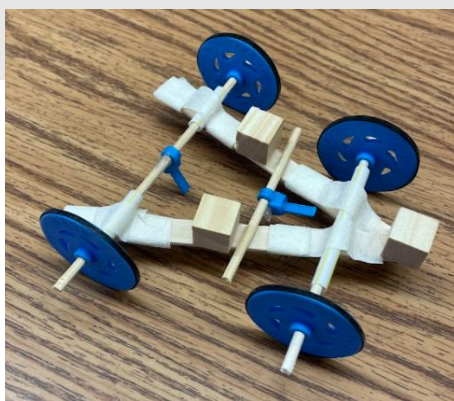
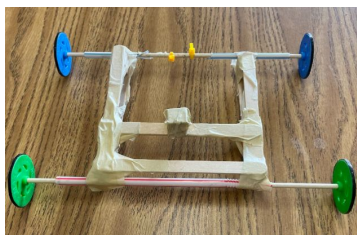
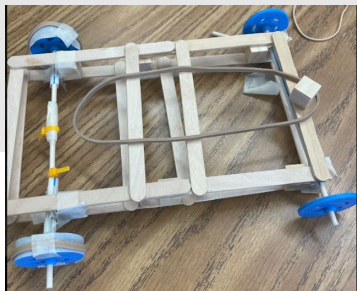
Deeper Understanding

Friction: Friction is a force that resists motion of solid surfaces sliding against each other. Using a wheel and axle system to move an object reduces the surface area of the object touching the ground and thus decreases the friction resisting the movement of that object. Think of how difficult it would be to slide a wagon across the ground without wheels!

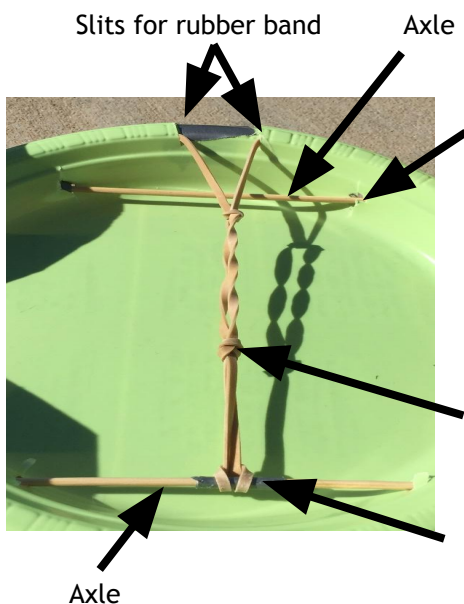
Potential and Kinetic Energy: Energy stored as a result of stretching the rubber band is called elastic potential energy. The greater the stretching, the more energy is stored. This stored energy become kinetic energy- the energy of motion- when the rubber band is released, causing the rover to move.

Helpful Tips:

- **Size and thickness of wheels:** The size and thickness of the wheels have a huge impact on the performance of the rover. Wheels may be any size or combination of sizes to meet the constraints.
- **Traction:** Students might need to add more traction on the wheels. Using the rovers on a carpeted surface will help provide enough traction. Tape or notches may be added around the wheel circumference to help them grip the surface
- **Glue:** Elmer's glue is possible, but hot glue will work much better and save time. If preferred, glue can be avoided and the design can be completed with masking tape.
- Make sure the rubber band does not slip on the axle. Putting tape underneath the rubber band by wrapping it around the axle may help as well as using sturdy and not smooth materials for axles.
- **To power the rover**, wind the wheels (that are attached to the rubber band) counter-clockwise. Note that the body of the rover must be able to withstand the force of the rubber band tightening.
- Students are easily swayed by examples, so don't give them any hints!



Below are tips if using recycled materials and common items for this challenge.



Make the front or rear axle be able to rotate freely in the rover body. To do this, make the holes in the body larger than the diameter of the axle.

Attach the rubber band tightly around the opposite axle as shown and attach to the other end of the body either by sliding into slits/notches or securing with tape, etc. If more length is needed with the rubber band, knot multiple rubber bands together as shown.

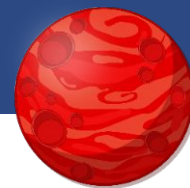
Loop the rubber band around the axle and through itself to form a knot. Duct tape may be needed to help the knot grip the axle. Wrap tape around the knot if the knot still slips on the axle.



Bonus Missions

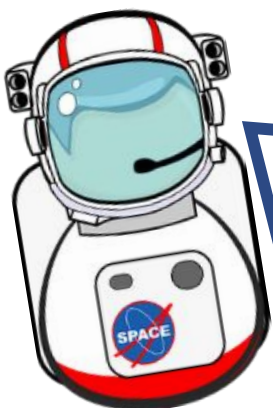
Bonus

Experiment in Mars



Mission Overview

1. Read the script below. There is not a mission video for the bonus missions.
2. Discussion: Guide students through science discussion about reactions and the scientific method.
3. Experiment: Complete Coke-Mentos Balloon Experiment. If time, go outside and use the Geyser tube with the 2L bottle for a big reaction!



For the first time in history, humans have landed on Mars! While your crew is celebrating, an alarm goes off in the control room. The alarm alerts your crew to a leak on the outside of your spacecraft. To go outside and fix the leak, crew members must first put on their space suits. Since Mars has little atmosphere, astronauts must wear a spacesuit to get oxygen and protection from radiation.

When arriving at the damaged area, astronauts find a dark mysterious liquid leaking from the ship. What could this mystery liquid be? A chemist on the team decides to conduct an experiment to find out. A chemist is a STEM professional who works in labs testing and learning about chemicals. One type of chemist works with police officers to test evidence at a crime scene. Another type conducts research to make better drugs for curing cancer. At NASA, chemists study the properties of planets. These chemists recently found a chemical on Saturn that could form parts of a cell, which means a possible sign of life.

Back to our sticky situation! The chemist suggests we perform an experiment to figure out if this mysterious liquid is dangerous. If found to be toxic, the spacecraft and entire mission is at stake. Hope to hear back from you soon!

~Space Club Mission Control

Great videos to show:

[Diet Coke & Mentos - MythBusters](#) (2 min)

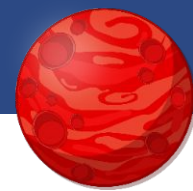
[Experiment on ISS](#) (1 min)

[Importance of Chemistry in Life, Everyday Uses](#) (3min)

[Just How Scientifically Accurate Is 'The Martian'](#) (5 min)



Experiment on Mars



Answer Key

Chemistry



Word Bank

able, not able,
reaction

Physical vs. Chemical change

- **1** A physical change is when the substance is **able** to go back to its original form.
- **2** A chemical change is when the object is **not able** to go back to its original form
- A change can also be called a **reaction**.

Write **P** for physical change or **C** for chemical reaction next to each scenario.

P Piece of paper is cut in half

P Butter melting

C Rust on a nail

C Milk goes sour

C Baking a cake

P Clay molded in new shape

P Ice melting

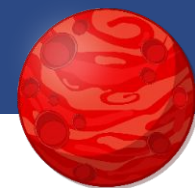
C Light a match

1: Crumple a piece of paper. This is an example of a physical change. The paper may be smaller than it was before, but it is still a piece of paper. It can return back to its original form.

Res:

2: An example of a chemical reaction is baking a cake. To bake a cake you combine eggs and flour and then put it in the oven. However, once the cake is baked, you can not separate out the eggs or flour.

Experiment on Mars



Answer Key

Mission: Observe the reaction of the “mystery liquid” combined with a Mentos.

1. **Make an Observation:** What happens to the balloon when the Mentos is added to the “mysterious liquid”?

It expands

2. This was a **physical** reaction because no new substance was created.

3. Do you think the amount of soda affects the size of the balloon when Mentos is dropped? Why? **varies**

4. My **hypothesis:** If I use less soda, my balloon will be **smaller / larger** (smaller / larger) when I add the Mentos.

5. What other **variables** can we change in our experiment?

Amount of Mentos, type of balloon, Type of soda

6. What do you think will happen if we remove the balloon after dropping the Mentos?

This is your cue for the big geyser experiment!

What is a hypothesis?

Educated guess that is proven true or false by an experiment

Provide supplies to students. Using a full bottle of Coke can create too much pressure and allow some liquid to escape. Recommend using $\frac{3}{4}$ of soda or less for experiment.

Have students predict and make a hypothesis of whether the soda affects the balloon size. Then ask students to complete the experiment. Compare balloons with various amounts of coke.

Recommended: Line up experiment with most soda to least. After balloon expands, carefully remove (without releasing liquid) and tie off. Compare size or measure circumference.



Good news, the chemist found that our mystery liquid is harmless! One of our technicians has fixed the leak, and we can continue our expedition to explore Mars. Our scientists will start conducting experiments and collecting samples to learn more about Mars. What elements will we find in the soil of Mars?

Interested in science? Download the BrainPOP Featured Movie app to watch short clips on lots of cool science topics. Have fun learning, and I will see you next time!

~Astronaut Alex

1: What is happening? The carbon dioxide gas inside the Diet Coke is being released. Initially, water molecules are trapping the carbon dioxide. When the Mentos is dropped in and falls to the bottom it disrupts this water mesh. All the gas is released and literally pushes all the liquid up and out of the bottle. What remains in the balloon is released carbon dioxide gas. These are all physical changes.

Experiment on Mars



Overview

Students will conduct two experiments: (1) Blow up a balloon using a 12 oz Coke bottle and Mentos (2) Create a big geyser from a 2L Coke bottle using Mentos and the Geyser tube.

Group Size: (1) Partners (2) Group

Materials

Experiment 1 (Per Student or Pairs)	Experiment 2
<ul style="list-style-type: none"><input type="checkbox"/> 2 balloons<input type="checkbox"/> 1 12oz Diet Coke<input type="checkbox"/> 2 Mentos<input type="checkbox"/> Sink or container to pour extra soda	<ul style="list-style-type: none"><input type="checkbox"/> 2L Diet Coke<input type="checkbox"/> Geyser Tube<input type="checkbox"/> Mentos



Prep Work

This is a potentially **messy activity** so make sure to have paper towels on hand. Experiment 1 can be conducted indoors as long as you ensure the balloon is fully sealed on the bottle. We recommend pouring out some soda first to prevent any accidental spills.

For experiment 2, complete the full explosion with the 2L Diet Coke outside! The soda can reach up to 40 feet! Remind students to stay away from the soda and not run towards it while the reaction is happening.

Mission Activities

Demonstrate reaction: 12 oz Diet Coke bottle

1. Open soda bottle and empty about $\frac{1}{4}$ of soda.
2. Stretch balloon, place 2 Mentos inside balloon, and attach to opened soda bottle. What do students predict will happen?
3. Prop balloon upright and push the Mentos inside the soda bottle.
4. Watch as the liquid is being pushed upward and the balloon expands! The Mentos forced the water molecules to release the carbon dioxide that is trapped in the soda (what gives it the carbonation). The released gas is now trapped in the balloon!

Perform Experiment #1: 12 oz Diet Coke

1. Group students into partners and provide with balloon and Mentos.
2. Ask students to pour out some of the soda.
3. Line up the students from most soda to least. You can assign each to an amount: $\frac{1}{2}$ soda, $\frac{3}{4}$ soda, etc. Great practice with fractions!
4. Students will stretch balloon and place Mentos inside. Place the balloon (with Mentos inside) securely on bottles.
5. One student holds bottle and the other pushes Mentos inside and keeps balloon upright.
6. Observe what happens to the balloon!

Perform Experiment #2: 2 L Diet Coke

1. Go outside to an open area like a field or parking lot.
2. Carefully open bottle.
3. Place bottle on ground so it does not tip over.
4. Load seven Mentos into the Geyser Tube. The goal is to get all Mentos into the bottle at the same time.
5. Pull trigger to drop Mentos and RUN! **Make sure students do not run towards the reaction!**



Vocabulary

Chemist: works in labs and searches for new knowledge of chemicals

Scientific Inquiry: A process scientists use when performing experiments and collecting data to make a conclusion.

Physical Reaction: A physical reaction is when the object is able to go back to its original form

Chemical Reaction: A chemical reaction is when the object is not able to go back to its original form

Helpful Hints

- Why Diet Coke? Diet Coke is used because there is no sugar, which makes it less sticky than regular soda.
- Students will want to drink the Diet Coke! Decide ahead of time if you will allow this or make them pour it out. It won't have carbonation.
- Students will want to eat the Mentos. You may reserve extras for eating after the demonstration.
- This can be messy! Make sure balloon is completely over the bottle opening.
- Have paper towels handy!
- Advanced: Ask students to record observations including difference in balloon diameters. *Optional: Use a string and ruler to measure balloon circumference and compare.*

Bonus

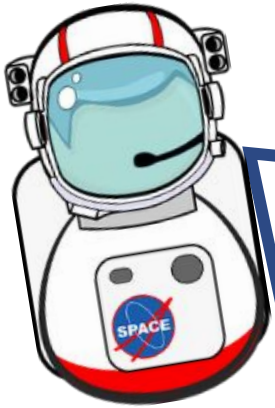
Exploring Mars





Mission Overview

1. Read the script below. There is not a mission video for the bonus missions.
2. Discussion: Discuss elastic potential energy
3. Engineering Challenge: Explain Catapult Challenge and discuss design constraints. Students complete challenge individually or in partners.



How are you feeling about your mission on Mars? To be honest, I am surprised your team is doing so well. Life on Mars is difficult due to very cold temperatures, lack of oxygen, and constant radiation. But we have set-up our base that includes water, food, and oxygen that will keep us alive. Time to go exploring!

After putting on space suits, we walk to the location provided by NASA. What is one cool thing about walking around Mars? There is 1/3 less gravity, so we can jump 3 times higher! Basketball would look pretty different on Mars!

We arrive to our location and find a large cave that is blocked by a sheet of ice. How will we enter the cave? Someone suggests that we wait for the ice to melt. But, considering the average temperature on Mars is -70°F , this ice will never melt! We decide to consult with our civil engineer. Civil engineers are STEM professionals that design and build structures that we live in and travel on: buildings, roads, and bridges. Civil engineers at NASA are learning how to use 3D printing to build a future colony on Mars.

Our civil engineer suggests we build a catapult. This device will use potential energy to launch a rock towards the ice wall and break it apart. This sounds like fun! Good luck engineers.

~Space Club Mission Control

Great videos to show:

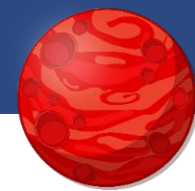
[Mars in a Minute- Is Mars Red Hot-](#) (1 min)

[The Physics of 'Punkin Chunkin'](#) (3.5 min)

[What Do Civil Engineers Do](#) (6 min)

[World's Largest Chunk- - Punkin Chunkin](#) (1.5 min)

[Build a Popsicle Stick Catapult](#) (1.5 min)



Answer Key



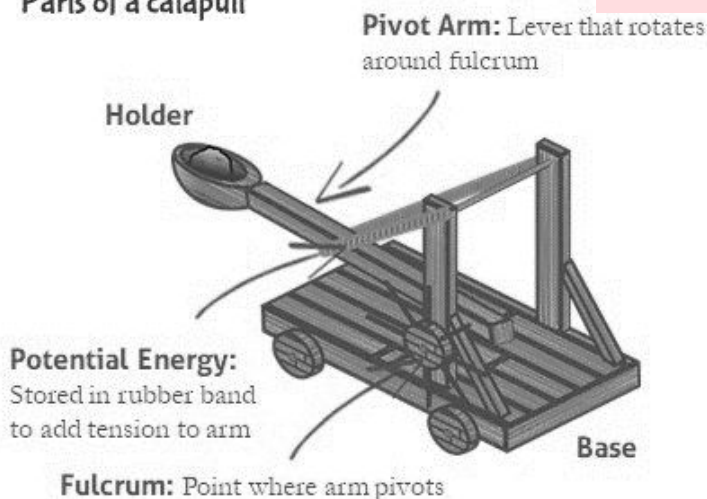
Physics Behind Catapults

- Energy is the ability for something to move.
- Potential energy is the energy that an object has because of its position, also thought of as stored energy.
- Elastic potential energy is a form of potential energy that happens when an object is deformed and then can return to its original shape.

Word Bank

deformed, move, position, stored, original

Parts of a catapult



Build a simple catapult ahead of time to show an example. See activity guide for examples. Don't give too many examples as you want students to be creative!

1: Stretch a rubber band and ask students what will happen if you let go. The rubber band will go back to its original shape. When stretched, the rubber band has a stored elastic potential energy. We want to capture this with our catapult designs. Winding and stretch the rubber band is a great way to store elastic energy.

Catapult Challenge



Overview

Students build a catapult to knock over a tower.

Group Size: Individually or in partners

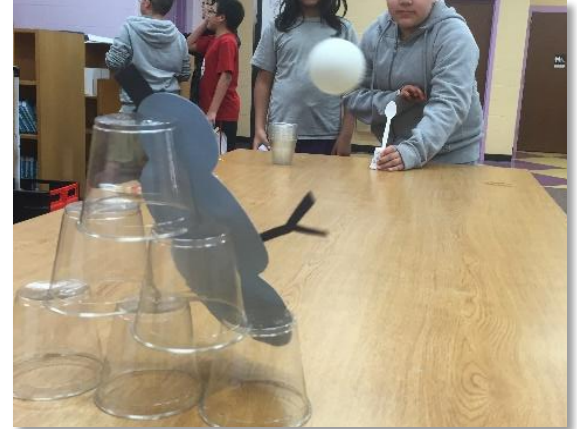


Materials

Materials Per Team	Testing Station Materials
Allow students to select materials as needed. <ul style="list-style-type: none"> <input type="checkbox"/> Plastic spoons <input type="checkbox"/> Craft sticks <input type="checkbox"/> Rubber bands 	<ul style="list-style-type: none"> <input type="checkbox"/> Ping pong balls <input type="checkbox"/> Plastic cups

Optional Additional Supplies

- Hot glue gun and glue sticks
- Newspapers
- Magazines
- Cans

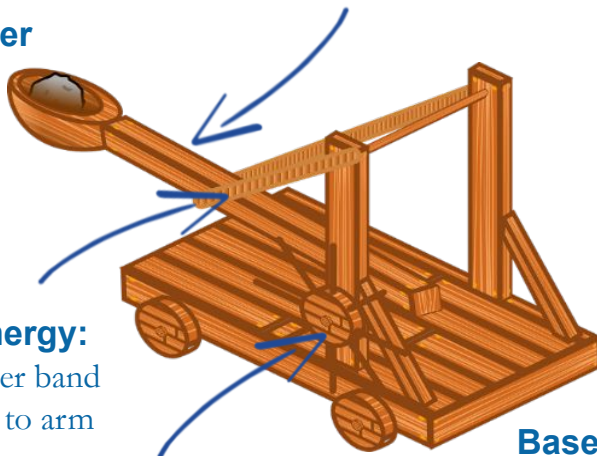


Prep Work

1. Set-up a launching zone. Create a tower of cups for students to aim at and knock over. Ideally, place the cups at the end of a long table against the wall. Placing against the wall will make it easier to collect the ping pong balls. You may wish to create multiple stations.
2. Collect materials. Build your own catapult and test to become familiar with challenge.
3. Complete the challenge yourself so you can be familiar with the process.
4. Read below to understand the components of a catapult.

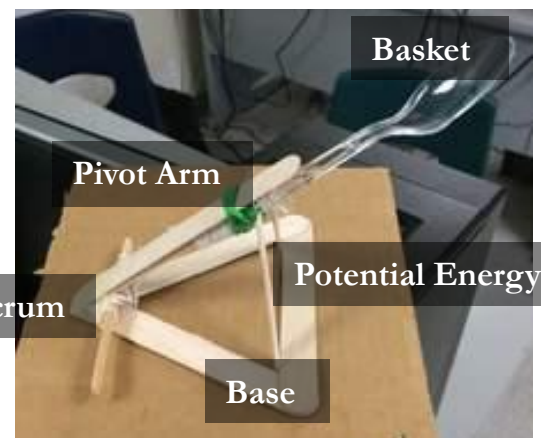
Pivot Arm: Lever that rotates around fulcrum

Holder



Potential Energy:
Stored in rubber band to add tension to arm

Fulcrum: Point where arm pivots



Catapult Challenge



Instructions

1. Explain mission is to build a device using *elastic potential energy* from the rubber bands. Show an example and describe **design constraints**:
 - No slingshots! Catapult must have a pivot arm and fulcrum.
 - Needs holder for ping pong ball.
 - Needs sturdy base that remains on ground during testing.
2. **Brainstorm and Design:** Ask teams to brainstorm and sketch ideas to launch their ping pong ball at the target.
3. **Build:** Students will collect supplies and build catapult. Note that you may wish to provide an example of a simple and complex catapult as a reference point. Students first try a more simple design such as using a rolled newspaper and attaching a spoon with a rubber band. A more complex design is using popsicle sticks to build the base and pivot arm.
4. **Testing:** When the designs are complete, the team s go to the testing station. Allow each catapult three tries before going back to re-design.
5. **Re-design:** . Think about: how can I make the ball go farther? How can I keep the ball going straight? Adjust the distance if the students knock over the tower.
6. **Share:** Students should share results with others and discuss their success and challenges.



Challenge students to use the stored elastic potential energy of a rubber band instead of just bending back the spoon.



Vocabulary

Civil Engineer: design and build the structures that we live in and travel on - buildings, roads, canals, and bridges.

Elastic potential energy: is a form of potential energy that occurs when some objects are deformed. Any object that can be deformed and then return to its original shape can have elastic potential energy.

Energy: ability for something to move

Potential energy: energy that an object has because of its position, also thought of as stored energy.

Kinetic energy: the energy an object has because of its motion

Bonus

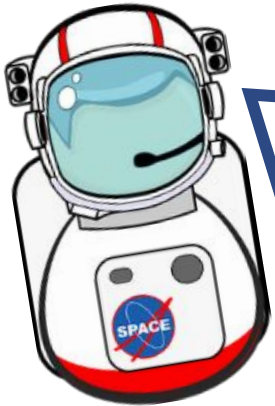
Emergency on Mars





Mission Overview

1. Read the script below. There is not a mission video for the bonus missions.
2. Complete Mission Warm-up
3. Complete zipline engineering design challenge



We have been on Mars for over a month now! How are you enjoying your stay? Some crew members are missing their families, and others are feeling lonely on the isolated red planet. Imagine living on a land of red rocks as far as you can see: no trees, no water, no animals, just rocks and dirt! How would you prevent homesickness?

To stay busy, the crew goes out exploring each day and collecting samples for research. During one such mission, one of the crew got hurt badly and is unable to get back to base! He is stuck high up on the edge of a crater, and you will need to use a zipline device to bring him down to safety.

Best of luck! *-Space Club Mission Control*

Activity: Zipline Challenge



Students build a zipline to carry an astronaut safely to the bottom.

Group Size: Partners



Prior to Activity

1. Gather materials listed.
2. Create kits of materials per group.
3. Set-up zipline using about 9 feet of fishing line. Top of zipline should be about 30 inches from the bottom end. Zipline can be attached to a chair, cabinet, desk, etc.

** Note: A 30" drop over 8 feet in the configuration shown takes 3 seconds.*



Activity

1. Introduce the mission: Design a zipline to carry an astronaut to the bottom safely.
2. Design constraints:
 - a. Astronaut must be able to freely move in and out of the vehicle- not taped or tied.
 - b. Do not cover vehicle.
 - c. Astronaut must stay in vehicle the entire ride to the bottom
 - d. Astronaut must reach the bottom in 5 seconds or less (adjust as needed).
3. Discuss center of gravity: the point within an object where all parts balance with one another. Have students balance a pencil on their finger. Once balanced, this is the center of gravity!
4. Discuss friction: force that resists motion. Friction occurs when two objects slide across each other like your hand on a table. Our carrier must glide smoothly down the zipline.

Materials Per Group

- 1 paper cup
- 2 straws
- 2 craft sticks
- 12 inches of yarn
- 1 foot masking tape
- 4 pipe cleaners
- 4 washers or pennies
- 4 paper clips
- 1 cardstock sheet

Testing Station Materials

- 1 ping pong ball
- 9 feet of fishing line, nylon thread, or smooth string.

1. Allow students to start building.
2. Hints while building:
 - a. Astronaut falls off: move the items on the vehicle to make it more symmetrical or balance the weight better with additional materials- effectively changing the center of gravity.
 - b. Astronaut doesn't slide smoothly or takes too long: Change the material used to slide along the line to something with less friction and/or add weight to make the vehicle move faster.
 - c. Washers are provided to add extra weight to the vehicle allowing it to move faster.
3. Allow students to test design when ready. Important note: the part of each vehicle that secures it to the zip line may need to be completed AFTER being placed on the line for testing since the ends of the zip line will already be secured. For example, if a straw is to be looped over the zip line and taped at each end to the sides of a cup, one end of the straw will need to wait to be taped to the cup until after it is looped over the zip line for testing.
4. Encourage redesign and re-testing! If more time, can you make the vehicle move faster while keeping the astronaut inside?
5. For a class competition, set-up two ziplines side by side for a race to the bottom!

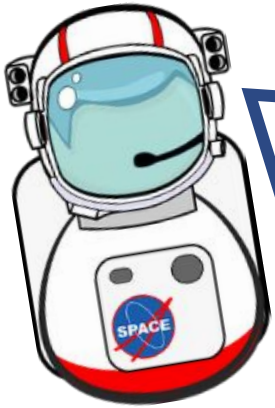


Bonus Mission Success



Mission Overview

1. Use this bonus mission as a way to celebrate success and explore STEM Careers!
2. Play the STEM Careers BINGO Game - available in the Space Club Educator's Teacher Toolkit or for purchase [here](#).



Congratulations on completing your mission to Mars! The time has come for us to head back to Earth. Don't forget to bring all your samples. NASA is waiting for us back in Houston to complete a mission debrief. They will also analyze our samples from Mars. I wonder what they will discover?

I am so proud of our team. We learned how to think like a scientist. We learned how to solve problems like an engineer. What an amazing adventure! Where should we travel next?

-Space Club Mission Control

Mission 8

Build a Habitat



Click for editable slides and handouts:

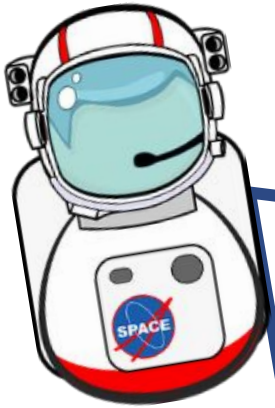
- [Teacher Slides](#)
- [Student Handouts](#)
- [Digital Student Journal](#)

**Mission
to Mars**



Mission Overview

1. Watch the Mission Overview video or read script below. [Click here to read an overview of this project.](#)
2. First, students will complete the “Design a Martian Habitat” 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 Mars Planning Game and how to create a layout.
3. The final project is to build a 3D model of the Martian Habitat.



I hope you have been enjoying your time on Mars! In our final mission, NASA has asked us to use our knowledge of living on Mars to design a Martian habitat that will keep humans alive and happy for a long term mission on Mars.

But first, let’s reflect on life on Earth. Think about these questions: What do humans need to survive? What do humans need to be happy?

Now let’s think about designing a new society on Mars. What would you keep the same? What would you change in your new home on Mars?

As you design your Martian habitat, remember what we learned in previous missions. Mars does not have air for us to breathe, we are constantly bombarded with harmful radiation, and we might freeze to death if we aren’t careful! How can we engineer solutions that will keep us alive and healthy on Mars? Your Martian habitat will need to include solutions for power, food, water, and oxygen. Consider researching what NASA is developing to solve these problems.

Next, your Martian habitat will need to be well planned out to keep your crew happy. Where will everyone sleep? Will you have a game room or other places for entertainment? I recommend asking your teammates what they like to do for fun and see how you can add it to your habitat.

The easiest way to design your habitat is to create zones for each area you want to include. Consider zones or areas for sleeping, eating, exercising, entertainment, and whatever else you want your habitat to include. Don’t forget the critical zones for power, food, water, and oxygen.

After planning out your habitat, time to build it! Use recycled materials and whatever might be leftover from previous missions to create a 3D model of your habitat. Add some LED lights to light up rooms in your base, and get creative on how you will represent each zone. I can’t wait to see your final Martian habitat!

~Space Club Mission Control

Great videos to show:

[NASA Journey to Mars](#)
(2 min)

[Could We Actually Live on Mars?](#) (4.5 min)

[Just How Scientifically Accurate Is The Martian?](#) (5 min)

[The Challenge of Living on Mars](#) (6 min)

[Hardest Thing about Living on Mars](#) (6:41)

[What If We All Lived on Mars?](#) (4:28)

SPACE COLONY COMPETITION

Competition Overview

CAN YOU SURVIVE A MISSION TO SPACE?

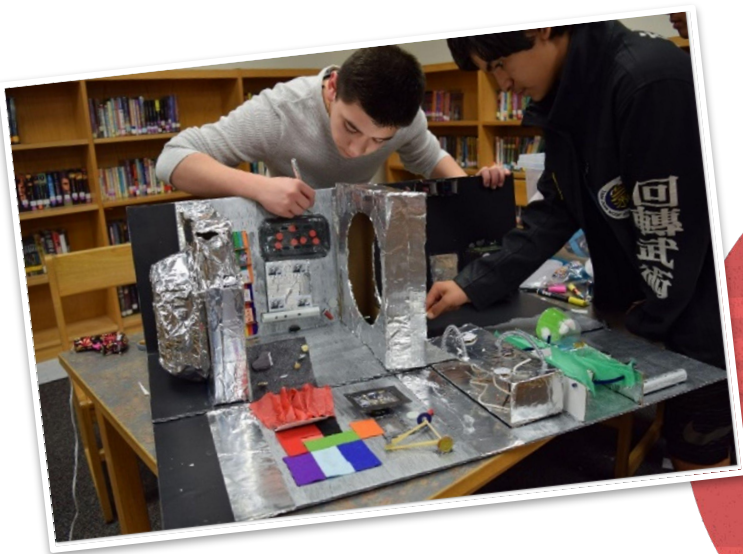
Submit your design for a colony on the Moon or Mars that can keep a crew alive and happy! The Space Colony Competition is open to any team of up to 6 elementary or middle school students. Learn about the challenges of living in space, research and design a colony, and build a 3D model using recycled 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



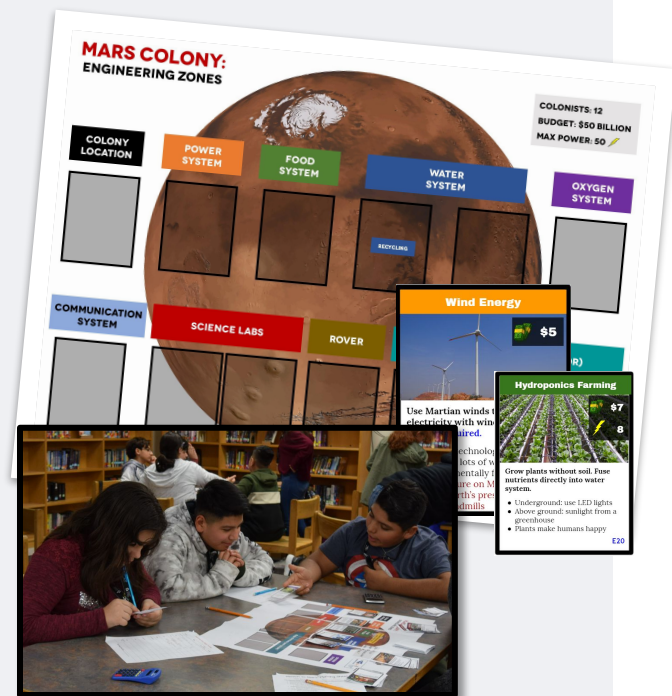
Mars Habitat Project

Can you keep a team of colonists alive and happy on Mars? Students work in teams to complete the ultimate project-based learning STEM experience: planning a long-term settlement on Mars! 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 Mars
2. Brainstorm Solutions (1 session): Mars Planning Game
3. Design Colony Layout (2 sessions): Mars Colony Layout
4. Build Colony Model (3+ sessions)
5. Record Video + Complete Submission (2 session): Space Colony Competition Submission

Planning Game: Students create colony teams and complete the *Mission to Mars: Planning Game* to determine design components of a colony on Mars. 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 Mars colony to represent location and architectural components.



Colony Layout:

Once students have finalized all the engineering and mental health zones, teams create a layout of their design that incorporates the colony location. Afterwards, teams can use this design as a blueprint for building a colony prototype from recycled materials. Full project guide found here: [Mars Colony Project](#)



PRIOR TO ACTIVITY

1. **READ** over the “Note to Teachers” overview on the following pages and the activity handouts to become familiar with the design challenge. Determine what will work best for your students, space, and time constraints.
2. **COLLECT MATERIALS** listed below. Two options are presented depending on whether students will build the final colony design.

Option 1: No Prototype

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

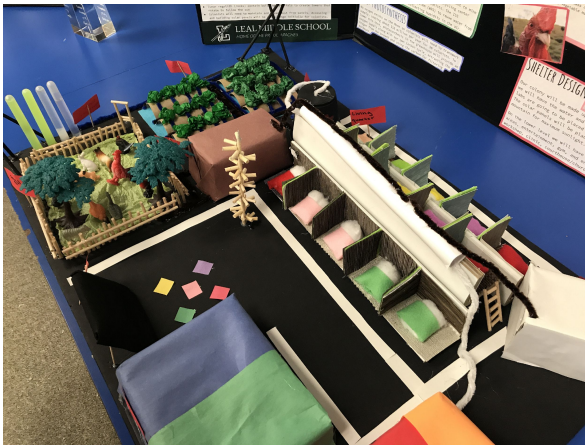
Option 2: Build Prototype

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

Final product: Build a Mars colony!



IMPORTANT LINKS

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



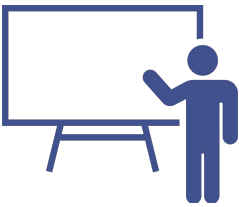
Google Slides

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:

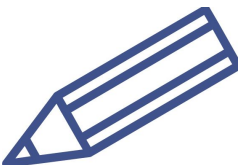
- To prevent students from editing the slides, [watch this](#).
- To send a copy of the file to your students, [watch this](#).



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.](#)

Mars Habitat 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 Mars</i></p>		Extensive research. Two or more solutions described. Pros and cons reflect high level of understanding of Mars environment.	Some research. Two solutions described. Pros and cons reflect some understanding of Mars environment.	Limited if little research. One solution for each area. Some pros and cons, but do not have clear connection to Mars environment.	No research. Limited solutions with no connection to Mars environment.
<p>Design</p> <p><i>Colony design solutions</i></p>		Unique and realistic design solutions that reflect research and understanding of Mars. Clear justification for selection.	Realistic design solutions with some justification. Limited understanding of Mars 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 colony layout, design solutions, and justifications.	Understandable presentation that describes the colony layout, design solutions, and justifications.	Somewhat unclear presentation with limited description of colony 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 Mars Colony Engineering Design Challenge follows the NGSS Engineering Design Standards for Elementary and Middle School.

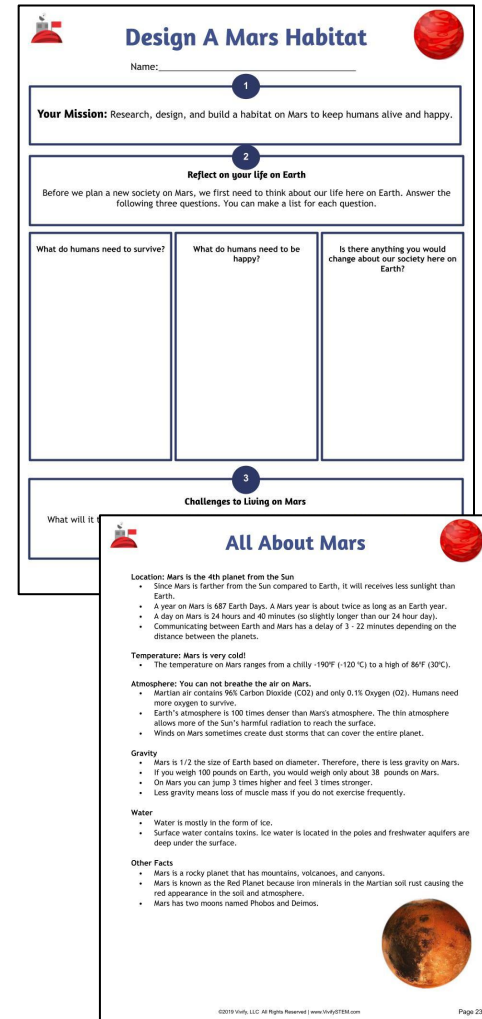
3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2.	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints 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
- Mars environment
- Effects of space on the human body

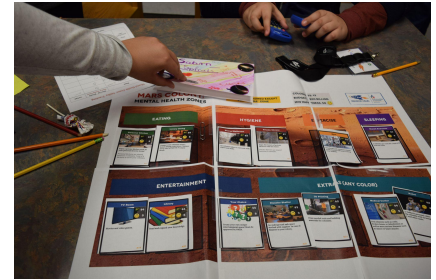
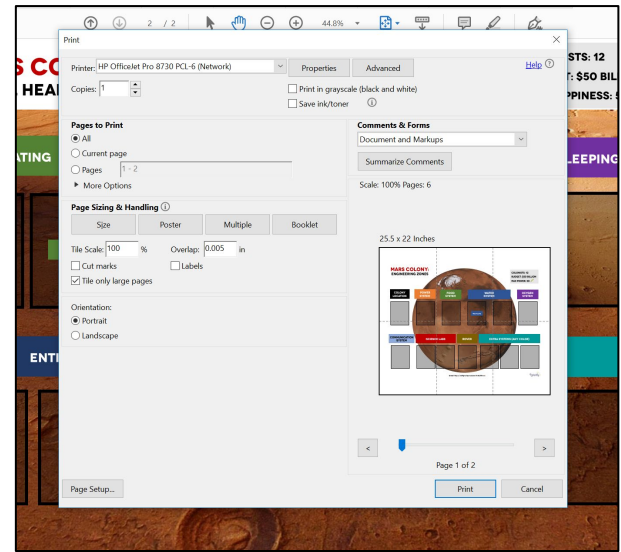
TEACHER INSTRUCTIONS

- Engage:** Show a real-world example of the engineering design process related to the journey to Mars (videos links on Resources and Taking it Further page).
 - Introduce the engineering design process as described in the handout.
 - Read “Mission to Mars” sheet describing NASA’s Journey to Mars.
- 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 Mars and develop a solution for a possible habitat on Mars. 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 Mars 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 Mars:** Before planning a colony on Mars, students need to understand the environment of Mars. A one-pager handout is provided as background information.
- Planning Game:** Students complete the Mission to Mars: Planning Game to determine design components of a colony on Mars. 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).



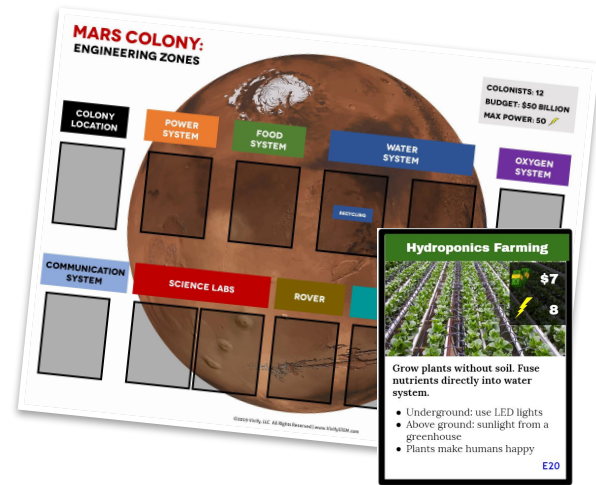
Part 1: Prep Game

- [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 comments
- Gameboard is included in PDF file.
- Prep the game by printing the two gameboards: 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.



Part 2: Play Game

- **Explain:** Introduce the game with the provided Mars 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.

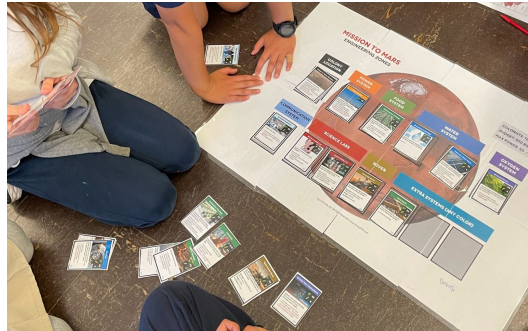


Activity Instructions

- **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.

Engineering Zones: Budget Tracking
Habitat maximum budget is \$50 billion.

System	Name	Budget (Mill. \$)	Notes
Colony Location			
Power			
Food			
Water			
Oxygen	Recycling		
Communication			
Science Labs			
Rover			
Extras Pick from any color			
Total Budget			



Test → Evaluate → Improve

Time to put your colony to the test! Read each scenario below, describe which zones will be affected by this scenario. Does your colony 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
Current water source has become contaminated and is no longer usable.		
A large meteor shower is penetrating the thin Martian atmosphere. Anything above-ground is at-risk for damage.		
A massive dust storm has hit your colony, and meteorologists predict it may last for months. The dust storm blocks out most sunlight.		
A strong solar storm is forecast to hit Mars. Meteorologists predict it will last for 24 hours, advising to shut down power for all electronics and communications during the storm.		
A large meteor shower is penetrating the thin Martian atmosphere. Anything above-ground is at-risk for destruction.		
After eating the same food for months, colonists are getting bored and depressed because of limited food options.		

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6. **Layout Design:** Once students have finalized all the engineering and mental health zones, teams create a layout of their design that incorporates the colony location.
 - **Plan Overall Layout:** Students will think about their overall colony design. Show examples of Mars colony designs using links in the resource section. Have each student on the team sketch an idea for the overall colony layout. Bring ideas together to finalize one overall colony layout and draw on provided handout.
 - **Plan Zone Placement:** Provide each team with a standard poster board to represent the area for their colony. 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 ¼ refers to folding a sheet of paper in half twice.



Activity Instructions

Colony Layout Example 1

This layout is one large dome built inside a crater with a few zones at higher elevation along the crater edge.

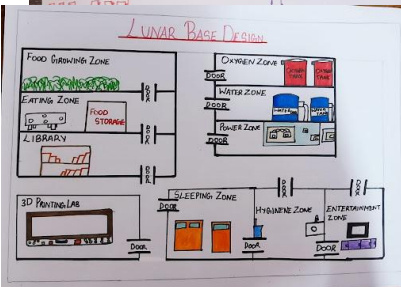
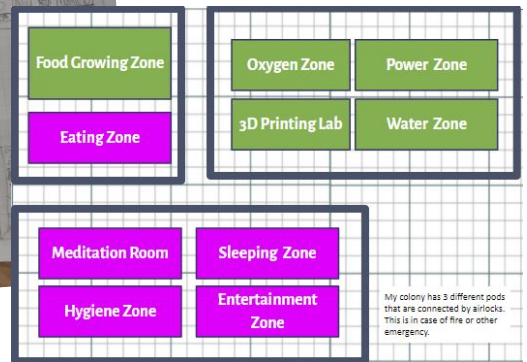
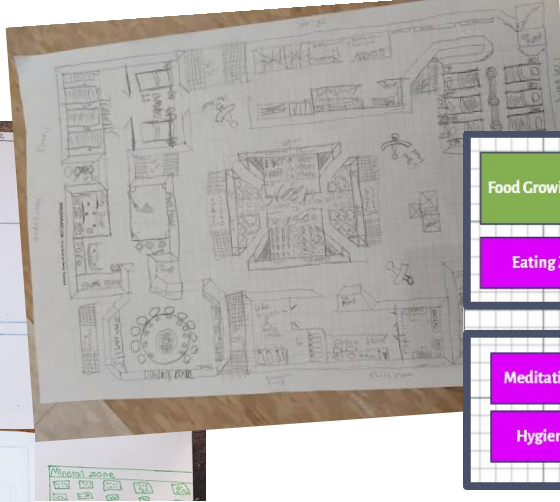
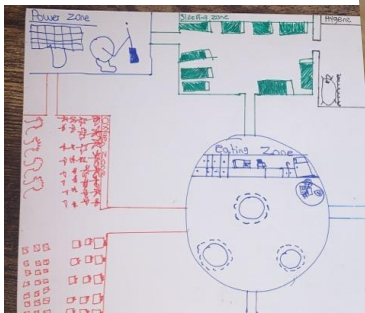
- Orange = Mental Health Zones
- Blue = Engineering Zones
- Red = Higher elevation due to crater wall



Colony Layout Example 2

This layout is built on a flat plain and separated into 3 separate structures or pods.

- Orange = Mental Health Zones
- Blue = Engineering Zones
- Red = The “Atmospheric Lab” is built above the hidden “Hydroponics” food area. (Red paper taped on one edge and can be lifted to reveal the hydroponics area below)



Teacher Tips: Students often struggle with drawing a habitat from scratch, so the zones allow them to focus on the layout without worrying about the details. They can also describe if the zones are placed in pods, all in one dome, underground, etc.

More advanced students can then take this initial layout and create a more detailed drawing.

RESOURCES FOR TAKING IT FURTHER

Mars Video Resources & Current Events

- [Journey to Mars](#)
- [Could We Live on Mars?](#)
- [We Brake for Mars](#)
- [Mars In A Minute: Getting to Mars](#)
- [How do you land on Mars?](#)
- [Could we live on Mars?](#)
- [Life In a Mars Colony](#)
- [How do Rovers drive on Mars?](#)
- [Mars City Design](#)
- [Marstopia](#)
- [Insight Lander](#)
- [NASA Journey to Mars](#)

Math Connections:

- Compare scale models of Earth, Sun, and Mars
- Draw scale model of colony design
- Build scale model of prototype with length scale defined

Science Connections:

- Space sciences
- Energy Sources (solar, wind, battery)
- [Science Behind the Martian Movie](#)
- Live Binder Resource - All About Mars Colonization:
[http://www.livebinders.com/play/play?id=1966714.](http://www.livebinders.com/play/play?id=1966714)

Engineering and Technology Connections:

- Engineering design process: https://www.youtube.com/watch?v=wE-z_TJyzil
- Recognize the importance of materials, environment, and constraints of the design process

History Connections:

- History of exploration of Mars
- Curiosity Rover Landing: <https://www.youtube.com/watch?v=OHwUrxzrvtg>

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!](#)

