

**EARTH SCIENCE**

GRADES 6-8

*Image credit: NASA/JPL/USGS*

# MARS MISSION OPERATIONS MANUAL



**Cutting edge science lessons co-developed by teachers and NASA scientists**





**The first Martians are in school on Earth today, and NASA seeks students who are ready to start their Mars Colonist training today!**

**Mars Base Eagle, a simulated Mars colony, provides NASA Researchers' our most current understanding of how families will live, work and go to school on Mars. Life on this alien planet will be hard, and will require the skill of being able to figure out how to solve problems with the tools and supplies you already have on hand.**

**Have you ever solved a problem in a creative way, using only what you had available? That is what the first Martians must be able to do.**

**These lessons will give you a chance to start learning how to solve the kinds of problems families may face on Mars. Best wishes on your training and this important Mission.**



## **MARS BASE EAGLE**

**Integrating Students, Teachers and Families in the Engineering Process of Building NASA-Themed STEM Museum Displays: A pilot project for US Science Museums**





## **Mars Base Eagle Missions**

### **Innovative Science Lessons Designed for Middle-level Students**

Each Mars Base Eagle Mission is a set of compelling science lessons that are designed to engage all students in learning key disciplinary content with an engaging Mars context. Our collaborative teams combined expertise in typical middle school student interests, cutting-edge scientific knowledge and innovation associated with exploring Mars, and a commitment to engaging students firsthand in rigorous practices of science and engineering. Our vision is that all students who engage in Mars Base Eagle Missions--even those students who are typically underserved in schools--may become inspired to consider further science academics and careers. In addition, Mars Base Eagle Missions are designed with high rigor, so that students can learn through experience the satisfaction of figuring out plausible solutions to the barely-imaginable--in this case, sending humans to explore Mars.

#### *Mars Base Eagle Interactive Exhibit at Wings of Eagles Discovery Center*

Wings of Eagles Discovery Center teaches aviation history and space science through the lens of how situations with limited resources lead to human innovation. Notably, the NASA grant that made the Mars Base Eagle Project possible, simultaneously supported curriculum development and the design and development of a Mars exhibit at the Wings of Eagles Discovery Center in Horseheads, NY. Also collaboratively developed, this interactive exhibit was explicitly designed to support teachers and learners who engage in Mars Base Eagle Mission science lessons (as well as exhibit visitors of all ages and backgrounds). Therefore, students engaging in any of the three Mars Base Eagle Missions can use experiences with the Mars Base Eagle exhibit to develop appreciation for the Mars environment and the human ingenuity required to travel to and explore Mars. The Mars Base Eagle exhibit at Wings of Eagles can help students grasp how scientists and engineers rely upon creativity and extensive knowledge to anticipate and find solutions for challenges. Further, students can discover how challenges facing those working to put humans on Mars can be sometimes similar to and sometimes entirely unlike those challenges we face on Earth.

#### *Science Standards Alignment*

In addition, the design of the lessons in Mars Base Eagle Missions aligns with the *Next Generation Science Standards* and *New York State Science Education Standards*. This includes close alignment with the vision that science teaching and learning should reflect the interconnected nature of science by integrating learning of Disciplinary Core Ideas Crosscutting Concepts, and Practices of Science and Engineering.

#### *Expertise Behind the Mission Ops Manual*

Design and development of the three Mars Base Eagle Missions was a collaborative effort, involving highly-qualified educators and noteworthy scientists and engineers. The outpouring of assistance from NASA researchers and engineers--both retired and current--as well as numerous experts in Mars exploration and exploration in remote Earth locations was phenomenal. As one collaborator noted, students who have the opportunity to learn with all three Mars Base Eagle Missions will be some of the very most knowledgeable individuals about Mars exploration because of the multidisciplinary input that went into designing the Missions. Perhaps those students will be some of the first to explore Mars...



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Mars Base Eagle's exhibit and curriculum focus on the many aspects of NASA science and engineering that are working on ways to support humans living on Mars. This includes Mars transit technology, Mars environmental research, and NASA Advanced Life Support (including plant growth, food production, biomedical, geology, and water & resource recovery topics). Without the contributions of NASA scientists and engineers--who donated time and valuable expertise--design and development of the Mars Base Eagle Missions would not have been possible. Similarly, these Missions are a reflection of the expertise and classroom testing conducted by Mars Base Eagle Curriculum Design Team members.

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## Earth Science Mission Standards Alignment

<b>MS-ESS2-6</b>	Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
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### Science and Engineering Practices

<b>Practice 1: Asking Questions and Defining Problems</b>	Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.
<b>Practice 2: Developing and Using Models</b>	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
<b>MS-ETS1-1</b>	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.
<b>MS-ETS1-2</b>	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

### Crosscutting Concepts:

**System and System Models:** Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems. (MS-PS3-2)

**Cause and Effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)

### Navigating the Mission

Each lesson in this Mission includes the following components:

***Mission Snapshot Page:*** Pertinent information at a glance: driving questions, learning targets, preparations, materials needed, approximate timing, and basic implementation steps ("Mission Brief")

***Lesson Outline:*** Detailed, step-by-step suggestions for implementing the lesson

Where applicable, lessons also include:

***Teacher Spec Sheets:*** Background information, materials for the whole class, etc.

***Student Spec Sheets:*** Master pages to be printed or copied for student use.

### Printing the Mission

The PDF file for each Mission is formatted professionally to be printed **double-sided**. There are blank pages inserted that will cause the printed pages to orient correctly.

### Mission Cumulative Assessment

Mars Base Eagle Missions include an assessment that was designed, piloted, and refined to assess key understandings related to the learning targets. Using the assessment for both pre- and post-assessment can reveal a combination of impact on students' attitudes about science academics and careers, as well as insights into what new disciplinary content they were exposed to and how it thoroughly it was understood. Both assessment and key are included at the end of this Mission Ops Manual.



# MARS BASE EAGLE MISSION OVERVIEW

## EARTH SCIENCE

### MARS EXHIBIT CONNECTIONS



Mars Base Eagle Exhibit  
at Wings of Eagles Discovery Center



Engaging students' prior knowledge.  
Connecting the Mission to students' lives and interests.



Exploration experiences provide students with a shared experience and opportunities to question, wonder, and conduct preliminary investigations.



Explanations in science include relevant evidence that is linked directly to claims by sound reasoning. Students have opportunities to defend their explanations with guidance from the teacher, additional research, and/or a trip to the Mars Base Eagle exhibit.



Elaboration provides an opportunity for students to apply the explanation learned (above) to a slightly different situation. This may also include applying science practices learned during this Mission to a new experience.



Students reflect on their own learning, and teachers conduct a summative evaluation to evaluate students' progress towards the target learning objectives.



- A field trip to the Mars Base Eagle exhibit will greatly enhance this mission.
- Students gather Mars geology, weather & climate information and compare to Earth.
- Students need to grasp an overall understanding of how challenging it is to transport supplies to Mars and how infrequently supplies from Earth can be delivered.

### ENGAGE



- Students collaboratively define "recreation" and develop a list of students' favorites.
- Students connect different types of recreation with geography, weather & climate.

### EXPLORE



- Introduce the Mission: If humans colonized Mars, what kinds of recreational activities could they engage in safely with others to lessen the effects of isolation and confinement?
- Explore Mars' geography, weather, climate, lighting.
- Students give Mars weather forecasts connected to recreation.

### EXPLAIN



- Students develop explanations for how conditions on Mars would affect general life supports needed for humans to live there and colonize Mars.
- Students explain how conditions on Mars would affect human access to recreational activities.

### ELABORATE



- Students explore how isolation and confinement can affect physical and mental health.
- Students then design a recreational activity that is plausible for Mars explorers to engage in for their physical & mental health.

### EVALUATE



- Students evaluate their own and others' design solutions for recreational activities that take into account the geography, weather, climate, and human needs on Mars.



## **Navigating and Printing This Mission**

### ***Navigating the Mission***

Each lesson in this Mission includes the following components:

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*Lesson Outline*: Detailed, step-by-step suggestions for implementing the lesson

Where applicable, lessons also include:

*Teacher Spec Sheets*: Background information, materials for the whole class, etc.  
(varies)

*Student Spec Sheets*: Master pages to be printed or copied for student use  
(varies)

### ***Printing the Mission***

The PDF file for each Mission is formatted professionally to be printed **double-sided**. There are blank pages inserted that will cause the printed pages to orient correctly.

### ***Mission Cumulative assessment***

Mars Base Eagle Missions include an assessment that was designed, piloted, and refined to assess key understandings related to the learning targets. During field-testing, the assessment was used prior to instruction and again after the Mission was completed. Using the assessment for both pre- and post-assessment can reveal a combination of impact on students' attitudes about science academics and careers, as well as insights into what new disciplinary content they were exposed to and how it thoroughly it was understood.

The assessment and key are included at the end of this Mission Ops Manual.



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# MISSION 1

ENGAGING WITH RECREATION AND GEOGRAPHY

## MISSION QUESTIONS



- What does "recreation" mean?
- Does one's location geographically make a difference in what kinds of things they do for fun?

## LEARNING TARGETS



- I can define the meaning of the word "recreation".
- I can give examples about how geography and climate can affect recreation.
- I can identify three different things I like to do for recreation.



Approximate Time Needed: 45-60 min

## PREPARATIONS



- Gather and prepare to project images of recreational activities (lots of varieties) that students will use as clues to the word "recreation."
- Notice while prepping for this lesson that the focus is on recreation to start; Mars conditions are only introduced after a "need-to-know" is established.

## MATERIALS



- Projector or Promethean/Smart Board
- images of a wide variety of recreational activities to project.
- Copies of "Geography and Climate Comparison Chart" Student Spec Sheet (1 per student)

## MISSION BRIEF



1. To start the Mission, engage students in guessing the a word that would best describe a wide variety of projected images (all are images that depict "recreation"). Students work in pairs or teams as the images are shown, guessing what they represent and citing evidence from the images to support their guesses.

2. Hold a whole-class discussion to refine students' guesses and guide the class to agree upon the word "recreation" as a word that describes all of the images.

3. Students work together to define "recreation."

4. Students decide if they agree or disagree with the statement: "Geography, weather and climate do not affect the types of recreational activities humans enjoy around the world."

5. Using the the "Geography and Climate Comparison Chart" Student Spec Sheet as a resource and an appropriate cooperative learning strategy: students consider how the geography and climate in 4 very different locations might affect the recreational activities enjoyed there. (Greenland, Jamaica, North Sudan, Vancouver)

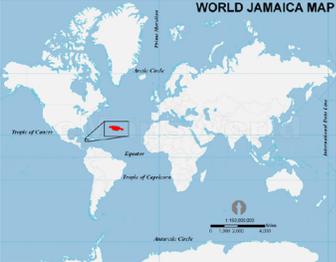
6. Introduce the question: "How might Mars geography and climate affect recreational options for humans who travel to and colonize the planet?" as a transition to Mission 2.



# STUDENT SPEC SHEET



## MISSION 1

Country	Geography	Climate
<p><b>Greenland</b></p> 	<ul style="list-style-type: none"> <li>• Ice sheet covers 84% of the country all year round</li> <li>• 40 glaciers cover the country</li> <li>• World's largest island</li> <li>• Coastline is rugged, mountainous and barren</li> <li>• Land not along the coastline is mostly flat</li> <li>• 20 rivers</li> <li>• Many thermal pools(hot springs)</li> </ul>	<ul style="list-style-type: none"> <li>• Artic to subarctic</li> <li>• Cold winters (January low of 14 degrees Fahrenheit)</li> <li>• Cool summers (July high of 50 degrees Fahrenheit)</li> </ul>
<p><b>Jamaica</b></p> 	<ul style="list-style-type: none"> <li>• Island with smaller islands off the coast</li> <li>• Mountainous</li> <li>• White sand beaches</li> <li>• Bays</li> <li>• Many small rivers--some unexplored and not navigable</li> <li>• Caves, caverns and underground rivers</li> </ul>	<ul style="list-style-type: none"> <li>• Rainfall heaviest from May to October</li> <li>• At lower elevations, fairly constant temperatures (77-86 degrees Fahrenheit)</li> <li>• At higher elevations the temperature is between 59 and 71 degrees Fahrenheit</li> <li>• Coasts receive refreshing breezes during the day and cooling breezes in the evening</li> <li>• Lies in the "hurricane belt"</li> </ul>
<p><b>Vancouver British Columbia, Canada</b></p> 	<ul style="list-style-type: none"> <li>• Surrounded by water on 3 sides</li> <li>• Lies on the coast of the Pacific Ocean</li> <li>• Some mountains</li> <li>• Forest regions</li> </ul>	<ul style="list-style-type: none"> <li>• Oceanic – mild weather year-round</li> <li>• Inland summer temperatures are warmer</li> <li>• Coastal summer temperatures are cooler (average 72 degrees Fahrenheit)</li> <li>• Summer months are dry</li> <li>• Half of the days between March and April get rain</li> <li>• On average, snow falls on 11 days per year</li> <li>• Average snowfall totals 15 inches</li> </ul> <p>Vancouver is not excessively cold or snowy</p>
<p><b>North Sudan</b></p> 	<ul style="list-style-type: none"> <li>• Landlocked</li> <li>• Largest country in Africa</li> <li>• Mostly desert</li> <li>• Only 5% of Sudan has water</li> <li>• Relatively flat with few mountains</li> </ul>	<ul style="list-style-type: none"> <li>• Arid</li> <li>• Hot and dry</li> <li>• Almost no precipitation</li> <li>• Frequent dust storms</li> <li>• Summer temperatures exceed 110 degrees Fahrenheit</li> </ul>



## TEACHING PROMPTS

1. To start the lesson, the teacher explains that students will attempt to guess the name of a word when given images depicting that word.
  - a. Teacher will display various images of recreational activities onto a Smart Board or Promethean Board for students to view.
  - b. Allow 15-20 seconds for students to chat with a shoulder partner about what word they think the viewed pictures represent.
  - c. On a student whiteboard, pairings will record up to 3 words they think the picture may depict and will “show their board” once teacher gives the signal to hold their board up for teacher and others to see.
  - d. Teacher requests that students keep the 3 guesses on the student whiteboard for now.
2. On a whiteboard, chart paper, Smart Board or Promethean Board, the teacher will draw 10 lines to symbolize the number of letters that make up the mystery word depicting in the images. The teacher will explain the meaning of the 10 drawn lines.
  - a. Students will now look at their guesses and will eliminate any guesses that don't contain 10 letters.
  - b. Teacher will reveal 2 random letters at a time to help students either narrow down their guess or to identify new guesses.
  - c. After 4-5 letters have been revealed by the teacher, ask students to now identify 1 guess and again, write their guess on the student whiteboard. Students will hold up their whiteboards for the teacher to see.
  - d. The teacher will eventually reveal the word “recreation” to students.
  - e. Teacher will post the first learning target for students – **I can define the meaning of the word “recreation.”** Teacher will unpack the learning target with students asking students to identify what it means to “define” something and to repeat the word “recreation” aloud.
  - f. Teacher will ask students to discuss with their shoulder partners what they think the word “recreation” means. Student pairs will record their definition on their whiteboard.
  - g. Teacher will cold call student pairings to share their definition of the word “recreation.” Teacher will provide feedback as pairings share out definitions.
  - h. Teacher will then provide students with the definition of recreation – “an activity done for fun or relaxation when not working.”
  - i. Teacher will ask students the question “What experiences have you had with recreation?” Teacher will generate a list of students’ responses.
3. Teacher then shares the following statement with students:

***Geography, weather and climate do not affect the types of recreational activities humans enjoy around the world.***

  - a. On a 3 x 5 index card, students will write “agree” or “disagree” after reflecting on the shared statement.
  - b. Teacher will ask students to stand up, and “mix”- students will move about the classroom holding their index card “disagree” or “agree” for others to see.

c. Teacher will call out “link” – students will find a classmate with the same “agree” or “disagree” index card.

d. In linked pairs, students will discuss their thinking in relation to the statement and their stance.

e. Teacher will cold call students from both the “agree” stance and the “disagree” stance to share their thinking.

**4. Without revealing much, the teacher will share the next learning target – I can give examples about how geography and climate can affect recreation.**

a. Teacher will unpack the learning target with students, making sure they understand the meaning of the word “affect” and “climate”.

- He or she should use this as an opportunity to discuss the meaning of the word “geography,” pointing of the prefix “geo-“ and suffix “-graphy.” The prefix geo- is related to the word “earth” and the suffix –graphy means “field of study” or “writing.”

b. Teacher explains to students that they will engage in the “four corners” protocol to generate examples of how geography and even weather and climate can affect the types of recreational activities enjoyed by humans living in that area or visiting that area.

c. Teacher will split the class into 4 groups. Each group will be provided with a marker and each group member will receive a “Geography and Climate comparison chart” to assist in brainstorming ideas. The comparison chart compares the geography and climate of 4 different locations: Greenland, North Sudan, Vancouver, and Jamaica.

d. When the teacher gives the signal to begin, each group will start at one of the 4 corners. In each corner will be a chart paper with the name of that designated location at the top (either Jamaica, North Sudan, Vancouver, or Greenland) and pictures of that region will be taped or glued to the chart. Students will examine the pictures and the comparison chart to identify types of recreational activities that could be enjoyed in that location. Provided is a PowerPoint example displaying images you could possibly use on the charts.

- Students will use the empty chart paper space below the pictures to record their recreational examples using the provided marker.
- Teacher will provide the signal when it’s time for students to rotate as a group clock-wise.

**5. After rotating among the 4 corners, the teacher will direct students back to their seats. He or she will ask for students to write on the back of the original index card on which they had already written “agree” or “disagree”.**

a. The teacher will ask the students to complete the following when given the sentence stem:

***Geography and climate can affect recreational activities. I know this because...***

**Possible Extension:** each group could research the culture of groups living in one of the 4 corners’ geographical locations.



# MISSION 2

## EXPLORING EARTH AND MARS

### MISSION QUESTIONS



- How are conditions on Mars and Earth alike and different?
- How do the geography and climate on Mars compare to geography and climate on Earth?

### LEARNING TARGETS



- I can give examples of similarities between geography and climate on Mars and Earth.
- I can give examples of differences between geography and climate on Mars and Earth.



Approximate Time Needed: 2-3 forty minute sessions

### PREPARATIONS



Prepare copies as described in Materials section

- Copy Mars/Earth fact strips, cut apart, place in envelopes
- Copy Compare and Contrast graphic organizers
- Plan for computer access to NASA website or make print copies
- Write out sentence starters for use with exit tickets

### MATERIALS



- Copies of cardstock-printed Mars and Earth fact strips, cut apart and placed in envelope (one envelope per pair of students)
- Copies "Compare and Contrast" table graphic organizer (1/student)
- Computer access and/or field trip to Mars Base Eagle Exhibit to research & gather information about Mars.
- Lesson exit ticket (1 per student)

### MISSION BRIEF



1. Activate students' prior knowledge about Mars: Students briefly sketch what they think the surface of Mars looks like and list things they think they already know about Mars environmental conditions.

2. In pairs, students sort a set of cardstock paper strips containing various facts about Mars and Earth.

3. Using a graphic organizer for recording, expert student groups research assigned conditions (atmospheric composition, air temperature, air pressure, gravity, travel time, surface composition, and topography) using NASA websites & resources:

<https://mars.nasa.gov/allaboutmars/facts/#infographic>

4. Following adequate research time, jigsaw groups are formed, so that each group has an expert from each of the researched conditions. Each expert within a group teaches the other group members, who record newly learning information on a "Compare and Contrast Table."

5. Bring students back as a whole class to confirm that students have an accurate understanding of what the environmental conditions on Mars are like and how they compare with conditions on Earth. At this time, check for accurate information recorded on their compare/contrast table.

6. Conclude with exit ticket self-assessment sentence starters:

- The environmental conditions on Mars are different than I expected because. . .
- The Mars environmental conditions that I think will make human life most challenging are. . . because. . .
- These environmental conditions would affect recreation for Mars explorers because. . .



## TEACHING PROMPTS

1. To activate students' prior knowledge about Mars, the teacher will ask students to briefly sketch what they think the surface of Mars looks like and to list off to the side things they think they already know about the environmental conditions of Mars.
2. Assign students into groups of two.
  - a. The teacher will distribute an envelope to pairs. Inside the envelope are cardstock strips. Typed on each strip is a fact about Mars or Earth.
  - b. Student pairs will review each cardstock strip and will attempt to sort the cards based on their own categories. At this point in the lesson, the teacher will not identify the sort headings.
  - c. After students have spent a few minutes sorting based on their own category headings, the teacher will ask students to share what they think is being compared in the sort.
  - d. At this point, if no students have identified the sort headings as Earth and Mars, the teacher will share the headings.
  - e. With the headings identified, students can modify their sort if they choose. Then, the teacher can distribute images of both Earth and Mars for students to add to their sort (see <https://mars.nasa.gov/allaboutmars/facts/-infographic> for images with accurate relative sizes).
  - f. The teacher will share the teacher version of the sort for students to check their accuracy.
  - g. The teacher will then share and unpack the first learning target with students: **I can compare and contrast the conditions on Earth and on Mars.** Students will define the meanings of “compare,” “contrast” and “conditions.”
3. Share and unpack the second learning target: **I can predict what conditions on Mars may have to be avoided or compensated to support human life.** Teacher and students should discuss and define “predict” and “compensated.”
  - h. Teacher will ask students to discuss in pairs: What do you expect the conditions of Mars to be like?
4. Teacher will place students into expert groups of 3 students. Assign each group one of the conditions listed on the Compare and Contrast graphic organizer to learn about Mars and compare to Earth.
  - a. **Ideally, at this time students could take a field trip to the Mars Base Eagle exhibit at Wings of Eagles Discovery Center (Horseheads, NY) for**

**hands-on experiences "on Mars" and engaging sources of Mars information.**

b. NASA online resources, designed for students to learn about Mars are freely available, reliably accurate, and interactive. If computers are not available for student research during class time, resources from the NASA site can be printed and copied for educational use.

<https://mars.nasa.gov/allaboutmars/facts/> - infographic

5. Once students have adequate time to gather information about their assigned Mars conditions, the teacher will place students into jigsaw groups so that each group has an expert from each Mars condition.

a. Expert students will take turns sharing out the information they obtained. Experts are expected to answer questions from jigsaw group members. All students are expected to record newly obtained information in their graphic organizer.

6. Teacher will bring students back as a whole class to confirm that students have an accurate understanding of what the environmental conditions on Mars are like and how they differ from the conditions on Earth. During this time, students will ensure that they have accurate information recorded on their compare/contrast table.

7. To conclude the lesson students will self-assess their current level of understanding in relation to the first learning target by completing an exit ticket. The exit ticket will ask students to identify their comfort so far and to complete three sentence starters:

- **The environmental conditions on Mars are different than I expected because . . .**
- **The Mars environmental conditions that I think will make human life most challenging are . . . because . . .**
- **These environmental conditions would affect recreation for Mars explorers because . . .**

# TEACHER SPEC SHEET

## MARS VS. EARTH FACT SORT



During the summer giant dust storms can blanket the planet and can last for months.

Atmosphere is 95% carbon dioxide.

Average temperature is -81 degrees Fahrenheit.

No liquid water at the surface. Below the surface may be large quantities of water.

Snowflakes are made of carbon dioxide.

The atmosphere is paper thin so it can't store heat from the sun.

Has polar ice caps.

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### Summary instructions

Copy on cardstock the fact statements on this and the next pages, cut into strips and place in an envelope for pairs of students to receive and sort into those they believe to be true of Mars or Earth.

One full year is 687 days.

One full year is 356 days.

There is no rain because the low temperatures and low air pressure cause water to exist only as vapor or ice.

A full day is 24.6 hours.

A full day is 24 hours.

The surface is covered in craters from asteroids and meteors hitting the planet's surface.

The surface of the planet is covered in red dust and rocks made from iron oxide (rust).

Has 4 seasons.

The sky is blue because when light from the sun enters the atmosphere it collides with molecules in the air.

Has volcanoes and canyons

Almost 70% of the surface is covered by water.

93 million miles from the sun

142 million miles from the sun

Atmosphere contains mostly nitrogen and oxygen.

Has 2 moons.

Has 1 moon.

Has a diameter of 4,222 miles.

Average temperature is 61 degrees Fahrenheit.

Snowflakes are made out of water.

Has a diameter of 7,915 miles.

Does not have a magnetic field.

Has a magnetic field that extends from its core out into space

## Teacher Spec Sheet: Mars vs Earth Fact Sort Key

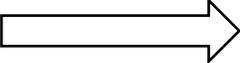
Earth	Mars
One full year is 356 days.	One full year is 687 days.
A full day is 24 hours.	A full day is 24.6 hours.
Average temperature is 61 degrees Fahrenheit.	Average temperature is -81 degrees Fahrenheit.
Has polar ice caps	The surface of the planet is covered in red dust and rocks made from iron oxide (rust).
Almost 70% of the surface is covered by water.	No liquid water at the surface. Below the surface may be large quantities of water.
The sky is blue because when light from the sun enters the atmosphere it collides with molecules in the air.	The atmosphere is paper thin so it can't store heat from the sun.
Has volcanoes and canyons	Surface is covered in craters from asteroids and meteors hitting the planet's surface.
Has 4 seasons	During the summer giant dust storms can blanket the planet and can last for months.
Snowflakes are made out of water.	Snowflakes are made of carbon dioxide.
Has a diameter of 7,915 miles.	Has a diameter of 4,222 miles
93 million miles from the sun	142 million miles from the sun
Has 1 moon	Has 2 moons
Has a magnetic field that extends from its core out into space	Does not have a magnetic field.
Atmosphere contains mostly nitrogen and oxygen.	Atmosphere is 95% carbon dioxide.
	There is no rain because the low temperatures and air pressure cause water to exist only as vapor or ice.

**STUDENT SPEC SHEET**

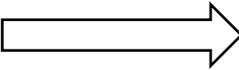
**EARTH VS. MARS COMPARE AND CONTRAST**



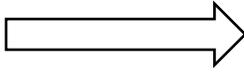
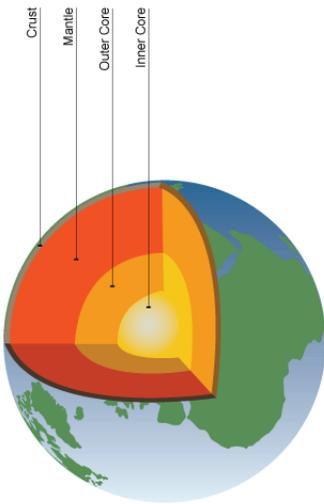
Conditions	Earth	Mars	So, what's the big deal? What will have to be avoided or compensated for?
<p style="text-align: center;"><b>Atmosphere Composition</b></p> <p style="text-align: center;">↓</p> <p>The formation or makeup of the gases surrounding Earth or another planet</p>	<p>Earth's atmosphere is about 300 miles thick, but most of it is within 10 miles of the surface.</p> <p>Near the surface, Earth has an atmosphere that consists of 78 percent nitrogen, 21 percent oxygen, and 1 percent other gases such as argon, carbon dioxide and neon.</p> <p>The atmosphere affects Earth's long-term climate and short-term local weather and shields us from much of the harmful radiation coming from the sun.</p> <p>It also protects us from meteoroids, most of which burn up in the atmosphere, seen as meteors in the night sky, before they can strike the surface as meteorites.</p> <p>Modified from <a href="http://www.space.com">www.space.com</a> and <a href="http://www.nasa.gov">www.nasa.gov</a></p>		

<p><b>Conditions</b></p>	<p><b>Earth</b></p>	<p><b>Mars</b></p>	<p><b>So, what's the big deal? What will have to be avoided or compensated for?</b></p>
<p><b>Air Pressure</b></p>  <p>The force exerted on a surface by the air above it as gravity pulls it to Earth</p>	<p>Air pressure is the weight of air molecules pressing down on the Earth. The pressure of the air molecules changes as you move upward from sea level into the atmosphere.</p> <p>Earth's atmosphere is similar to a sponge in that it can be compressed, or squished up.</p> <p>The weight of the air above compresses the air below tighter and tighter.</p> <p>The lower we travel down into the atmosphere, the more weight there is above, and so the tighter the air is squished or compacted.</p> <p>The higher we travel into the atmosphere, the less air there is above and so the less weight there is pushing down, and as a result, the less squished up, or the less compact the air.</p> <p>Atmospheric pressure is an indicator of weather.</p> <ul style="list-style-type: none"> <li>• When a low-pressure system moves into an area, it usually leads to cloudiness, wind, and precipitation.</li> <li>• High-pressure systems usually lead to fair, calm weather</li> </ul> <p>Modified from <a href="http://www.nationalgeographic.org">www.nationalgeographic.org</a> and <a href="http://www.kidsgeo.com">www.kidsgeo.com</a></p>		

<p><b>Conditions</b></p>	<p><b>Earth</b></p>	<p><b>Mars</b></p>	<p><b>So, what's the big deal? What will have to be avoided or compensated for?</b></p>
<p><b>Size</b></p>	<ul style="list-style-type: none"> <li>• Fifth largest planet</li> <li>• Earth has a diameter of 8,000 miles</li> <li>• It's shape is round because gravity pulls matter into a ball</li> <li>• Earth bulges at the equator and is flat at the polar regions</li> <li>• Earth's core is about 4,400 miles wide</li> </ul> <p>Modified from <a href="http://www.nasa.gov">www.nasa.gov</a></p>		

Conditions	Earth	Mars	So, what's the big deal? What will have to be avoided or compensated for?
<p style="text-align: center;"><b>Gravity</b></p>  <p>An invisible force that pulls objects toward each other. Earth's gravity is what keeps you on the ground and what makes things fall.</p> <p>The force of gravity keeps all of the planets in orbit around the sun.</p>	<p>Anything that has mass also has gravity. Objects with more mass have more gravity.</p> <p>Gravity also gets weaker with distance. So, the closer objects are to each other, the stronger their gravitational pull is.</p> <p>Earth's gravity comes from all its mass. All its mass makes a combined gravitational pull on all the mass in your body. That's what gives you weight. And if you were on a planet with less mass than Earth, you would weigh less than you do here.</p> <p>Gravity is very important to us. We could not live on Earth without it. The sun's gravity keeps Earth in orbit around it, keeping us at a comfortable distance to enjoy the sun's light and warmth.</p> <p>It holds down our atmosphere and the air we need to breathe. Gravity is what holds our world together.</p> <p>However, gravity isn't the same everywhere on Earth.</p> <p>Gravity is slightly stronger over places with more mass underground than over places with less mass.</p> <p>Modified from <a href="http://www.nasa.gov">www.nasa.gov</a></p>		

<p><b>So, what's the big deal? What will have to be avoided or compensated for?</b></p>	<p><b>Mars</b></p>	<p><b>Earth</b></p>	<p><b>Conditions</b></p>
		<p>Some landforms found on Earth's surface:</p> <ul style="list-style-type: none"> <li>• Archipelago</li> <li>• Bay</li> <li>• Beach</li> <li>• Bayou</li> <li>• Bluff</li> <li>• Canyon</li> <li>• Cape</li> <li>• Cave</li> <li>• Cliff</li> <li>• Desert</li> <li>• Forest</li> <li>• Geyser</li> <li>• Gulf</li> <li>• Hill</li> <li>• Island</li> <li>• Lake</li> <li>• Mountain</li> <li>• Ocean</li> <li>• Peninsula</li> <li>• Plateau</li> <li>• Prairie</li> <li>• River</li> <li>• Valley</li> <li>• Volcano</li> <li>• Waterfall</li> </ul> <p>Modified from <a href="http://www.bbc.co.uk">www.bbc.co.uk</a> and <a href="http://www.worldlandforms.com">www.worldlandforms.com</a></p>	<p><b>Topography &amp; Geography</b></p>  <p>Geography is the study of the description of the Earth. It includes the study of land features, climate, inhabitants, etc. of the Earth.</p> <p>On the other hand, topography is the study and mapping of the shapes and features of the places. Unlike Geography, it is not limited to the study of the Earth.</p>

<p><b>Conditions</b></p> <p><b>Surface Composition</b></p>  <p>The formation or makeup of the outermost layer of something</p>	<p><b>Earth</b></p> <p>The Earth has 4 layers:</p>  <p>Earth's crust is made up of several elements: oxygen, 47 percent; silicon, 27 percent; aluminum, 8 percent; iron, 5 percent; calcium, 4 percent; magnesium, potassium and sodium, 2 percent.</p> <p>The crust is divided into huge plates that float on the mantle, the next layer</p> <p>Earth's oceans cover about 70 percent of the planet's surface with an average depth of 2.5 miles (4 kilometers).</p> <p>Fresh water exists in liquid form in lakes and rivers and as water vapor in the atmosphere, which causes much of Earth's weather.</p> <p>Modified from <a href="http://www.nasa.gov">www.nasa.gov</a> and <a href="http://www.space.com">www.space.com</a></p>	<p><b>Mars</b></p>	<p><b>So, what's the big deal? What will have to be avoided or compensated for?</b></p>
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# MISSION 3

## WEATHER & GEOGRAPHY ON EARTH AND MARS

### MISSION QUESTIONS



- How are weather patterns on Mars and Earth alike and different?
- How does the geography on Mars and Earth effect each planet's weather?

### LEARNING TARGETS



- I can give plausible weather forecasts for specific locations on Earth and Mars, based on the geography of those locations.
- I can compare and contrast geography and weather on Earth and Mars.



Approximate Time Needed: 3-4 forty minute sessions

### PREPARATIONS



Prepare copies as described in Materials section

- Review the detailed NASA lesson on Geographical Influences on Climate, developed by the Global Precipitation Measurement Mission (a NASA resource). The NASA lessons will prepare students to make their forecasts (see Mission 3 Teacher Prompts for NASA lesson links).

### MATERIALS



- Projector or Promethian/Smartboard for showing the instructional slides and maps during weather forecasts.
- Copies of Student Capture Sheet from NASA lesson (one per student)
- Copies of the Task Card and Rubric for each weather group (see Instructional Slides)

### MISSION BRIEF



1. Review the previous day's learning by sharing a sample exit ticket response, then discuss.
2. Pose the question below for students to turn-and-talk about with another student. Discuss the meaning of "compensate" before starting the student-to-student discussion:  
HOW WOULD WE NEED TO COMPENSATE FOR THE CONDITIONS ON MARS TO MAKE IT POSSIBLE FOR HUMANS TO LIVE THERE?
3. Unpack with students the learning target.
4. Introduce the "Mars Forecast of the Day" and "Earth Forecast of the Day" activity in which teams will present a Mars forecast, advising citizens about the attire needed and what recreation can be safely completed. You may wish to use YouTube video, "Weather on other Planets? The Martian Movie."  
[https://youtu.be/DZfpLsx\\_xAE](https://youtu.be/DZfpLsx_xAE)
5. To prepare for the forecast, students predict which conditions may need to be avoided or compensated to support human life on Mars. Students research and record this info in the Compare and Contrast Student Spec Sheet from Lesson 2.
6. Form student forecast teams, including a meteorologist/broadcaster, scriptwriter and graphic designer.
7. Use NASA resources to teach the relationships between geography and weather on Earth. Then, students investigate weather on Mars and relate it to Mars geography and conditions (see Teacher Prompts for details).
8. Following instructions on the Task Card (see Instructional Slides) teams construct a Mars and Earth Forecast of the Day broadcast to present to classmates. Use the rubric included in the Instructional Slides to guide expectations.
9. Forecast teams take turns presenting to the whole class. Assign self-assessment of presentations, using the rubric.
10. Conclude the lesson by having students mark an X on a chart paper continuum that ranges from super important to not important at all in response to the question below.  
HOW IMPORTANT DO YOU THINK RECREATION PLANNING IS TO NASA SCIENTISTS AND ENGINEERS?
10. Assign students to write on a Post-it their predictions about how recreation could be important to astronauts and Mars explorers (other than as physical exercise). Post student responses on the same chart paper as the continuum.



## TEACHING PROMPTS

1. Teacher will summarize what students learned the previous day – researching the conditions of Mars and Earth.
  - a. On the whiteboard for students to see, teacher will share out various responses from the previous day’s exit ticket sentence starter (*The Mars environmental conditions that I think will make human life most difficult are...because...*) plus the question: *How would we have to compensate for these conditions for life to be possible on Mars?* Students will engage in turn-and-talk discussions with a shoulder partner.
2. To draw on the previous lesson’s content, the teacher will ask students to write and share a “Mars Forecast of the Day” and “Earth Forecast of the Day.” Each forecast should cite a specific geographical location, what type of attire is needed and what kinds of recreational activities can be safely enjoyed at that location.
3. Before students can do this, they must predict what Mars’ conditions may have to be avoided or compensated so that humans can survive on the planet.
  - a. The teacher and students will unpack and discuss the learning target: **I can predict what conditions on Mars may have to be avoided or compensated for to support human life on Mars.**
  - b. Students will work with a partner to complete the last column “What Does This Mean for Human Life?” from the previous lesson’s table graphic organizer (*Student Spec Sheet: Earth vs. Mars Compare and Contrast*).
4. To build the weather forecast, students work in groups of three. Each group needs a scriptwriter, meteorologist/broadcaster and graphic designer.
  - a. Each group will receive a task card (print out of the instructional slide) identifying the weather forecast expectations, materials, and individual roles.
  - b. Provide each group with the rubric as a guide and for self-assessment during the presentation (print out of the instructional slide).
5. Students work in assigned forecast trios to plan and create two forecasts for humans living on Mars and on Earth.
  - a. Students should access computers or laptops and should utilize the provided rubric upon completion to assess their forecast before the presentation.
  - b. A sample script is included in the Teacher Spec Sheet: Mission Slides for students to either use or to modify.
6. Use the detailed lesson on *Geographical Influences on Climate* lesson developed by the Global Precipitation Measurement Mission (a NASA resource) to support students’ to include disciplinary core ideas and scientific reasoning in their forecasts. Complete lessons and links to data are available online:  
[https://pmm.nasa.gov/education/sites/default/files/lesson\\_plan\\_files/geographical\\_influences/Geographical Influences - TG.pdf](https://pmm.nasa.gov/education/sites/default/files/lesson_plan_files/geographical_influences/Geographical%20Influences%20-%20TG.pdf)

7. Introduce sources of information for student-groups to research and learn about weather and climate on Mars. This information will be used in creating Mars forecasts: <https://www.weather.gov/fsd/mars> <https://mars.nasa.gov/weather/storm-watch-2018/>

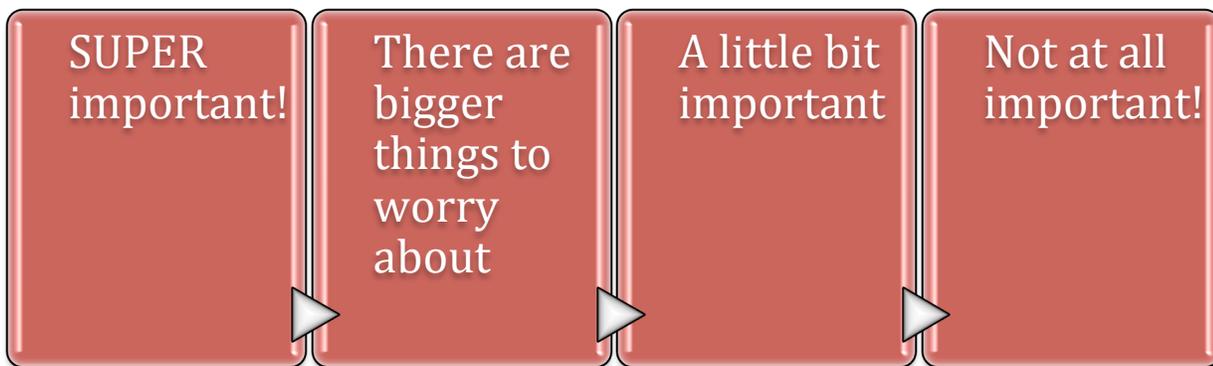
8. Student teams present their forecasts, using projected maps, simulating a typical television weather forecast.

a. On that same chart paper, students will predict why recreation (other than physical fitness) would be important to astronauts and Mars explorers.

9. To conclude the lesson, students will mark an X on a chart paper continuum to record their response to the question:

***How important do you think recreation planning is to NASA scientists and engineers?***

Sample continuum:



10. Assign students to write on a Post-it their predictions about how recreation could be important to astronauts and Mars explorers (other than as physical exercise). Post student responses on the same chart paper as the continuum.



## Lesson 3: Exploring Earth and Mars (Part 1)

- I can predict what Mars' conditions must be avoided or compensated to ensure the physical protection of human life.

## Mars Forecast of the Day Task Card

Your Task:

NASA has recently constructed a small, experimental colony of humans on the planet Mars. Your job as a NASA scientist is to provide those colonists with an accurate and thorough 1 day environmental conditions/weather forecast for Mars. With each condition discussed, you must provide the audience with precautions, adaptations or supports that could protect human life.

Accessible Materials:

- Earth and Mars Compare/Contrast Table
- Mars research materials
- Microsoft PowerPoint
- Student laptops
- Sample weather forecast script
- Samples of weather forecasts online

Student Roles:

- *Scriptwriter* – individual who writes/types the on-air script that the broadcaster will read aloud to the viewing audience
- *Graphic designer* – individual who will design the visual presentation the audience will view as the broadcaster reads the forecast aloud
- *Meteorologist/Broadcaster* – individual who will present the forecast to the viewing audience using both a written script and weather/conditions graphics and images



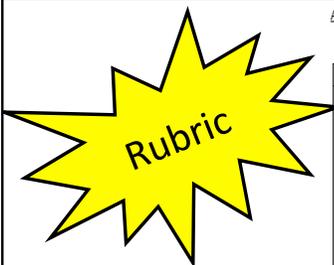
Use the “Student Capture Sheet” to gather information about the effects of geography on climate.

Apply this information to develop your team’s weather forecasts.



Research weather and geography on Mars.

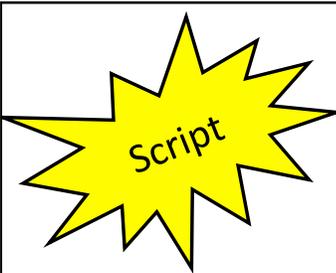
Apply this information to develop your team's weather forecasts.



Assessment:

- Groups will be assessed using the rubric below.

Criteria	2 points	1 points	0 points
<b>Human Life Impact</b> – Did the broadcaster provide recommendations on how to dress and what recreational activities could be enjoyed safely?	<u>Both</u> dress and recreational activities were addressed in the broadcast.	<u>Only 1</u> (either dress or recreational activities) were addressed during the broadcast.	<u>None</u> were addressed (neither dress or recreational activities) during the broadcast.
<b>Scientific Understanding</b> – 1) did the broadcasting team use scientific terminology in their presentation 2) did they display a solid understanding of the environmental conditions of Mars?	<u>Most</u> of the broadcast was accurate, using appropriate scientific terminology.	<u>Some</u> of the broadcast was accurate and students used some scientific terminology.	<u>Little or none</u> of the broadcast was accurate and little or no scientific terminology was included.
<b>Graphics</b> – did the chosen graphics connect to the environmental condition(s) discussed?	<u>All or most</u> of the graphics utilized connected to the environmental conditions, attire and recreational activities.	<u>Some</u> of the graphics utilized connected to the environmental conditions, attire and recreational activities.	<u>Little to no</u> graphics connected to the environmental conditions, attire and recreational activities.
<b>Script Writing</b> – did the written script flow appropriately when read aloud?	<u>All or most</u> of the script was easy to understand and made sense to listeners.	<u>Some</u> of the script was difficult to understand and only some of the script made sense to listeners.	<u>Little to none</u> of the script was easy to understand and little to none of the script made sense to listeners.
<b>Overall Presentation</b> – would Mars colonists understand your forecast and be able to utilize it to make decisions about what to wear and what activities they could engage in safely?	<u>All or most</u> of the presentation provided information about the environmental conditions of Mars and provided advice about attire and recreation.	<u>Some</u> of the presentation provided information about the environmental conditions of Mars and provided advice about attire and recreation.	<u>Little or none</u> of the presentation provided information about the environmental conditions of Mars and provided advice about attire and recreation.



### Sample Weather Forecast Script

Good morning Earthlings and Martians!

My name is \_\_\_\_\_ and on behalf of my weather team including \_\_\_\_\_ and \_\_\_\_\_, we're here to tell you about the conditions you'll see on Mars today.

(broadcaster's name) (team member name) (team member name)

On Mars, at \_\_\_\_\_, the current temperature is \_\_\_\_\_ and the atmospheric conditions are \_\_\_\_\_.

(specific Mars location) (specific degrees) (atmosphere composition, air pressure, gravity, surface composition and topography)

Martians should wear \_\_\_\_\_ because \_\_\_\_\_.

(type of clothing, footwear, head gear) (reason for wearing that clothing)

The following recreational activities are safe to enjoy: \_\_\_\_\_. You'll need to avoid \_\_\_\_\_.

(activities human enjoy for relaxation and fun) (something dangerous for humans)

because of \_\_\_\_\_.

(why it's dangerous or how it would impact humans)

That's the weather here and we hope that you have a day that's out of this world!

Lesson 3 – Sample Script for Forecast







# MISSION 4

## HUMAN SURVIVAL ON MARS

### MISSION QUESTIONS



- How might humans be able to live with the weather and geography on Mars?
- How might confinement and isolation like would be necessary to travel to and live on Mars affect people?

### LEARNING TARGETS



- I can describe what a Martian habitat that protects humans from the harsh environment needs to include.
- I can describe some of the ways isolation and confinement can affect humans.
- I can design an recreational activity that could be used to help the mental health of space explorers.



Approximate Time Needed: 4-5 forty minute sessions

### PREPARATIONS



- Locate and prepare TedTalk video, "Your kids might live on Mars."
- Tape "confinement" squares on the floor as described in the Teacher Prompts section.
- Gather objects and materials for use in the isolation & confinement task, weighing activity, and recreation design.

### MATERIALS



- Projector or Promethian/Smartboard for showing the TedTalk
- Tape, spaghetti, string, and marshmallows for isolation task.
- Materials to weigh and digital scale (see Instructional Slides)
- Materials for the final recreational activity challenge (see Instructional Slides).

### MISSION BRIEF



1. Direct student pairs to talk for 2 minutes in preparation for reporting out a summary of the learning from Missions 2 and 3.
2. Watch and discuss the short TedTalk video, "Your kids might live on Mars." as a way of confirming that human exploration of Mars likely will take place in the future (see Teacher Prompts for hyperlink and URL).
3. Use a think-pair-share strategy to develop a class list of challenges for human life on Mars that will need to be solved by building human-friendly Mars Habitats.
4. Discuss what types of solutions may be used or engineered to meet those challenges. Conclude this discussion by highlighting those solutions suggested that would require confinement to smaller spaces than what humans are accustomed to, living on Earth.
5. Engage students in the isolation and confinement experiment as explained in the Teacher Spec Sheet: Instructional Slides and Teacher Prompts section.
6. Conduct the weighing activity as described in the Instructional Slides to familiarize students with the strong limitations on available materials for use on Mars related to shipping weight.
7. Conclude by having students design a recreational activity, using only the materials provided, that is fun and could help the mental health of space explorers (see instructions in the Teacher Spec Sheet: Instructional Slides).



## TEACHING PROMPTS

Note that before starting Mission 4, taped areas on the floor must be prepared for the isolation and confinement activities that are explained in the Teacher Spec Sheet: Instructional Slides.

Use painters tape or masking tape (remove at the end of the day) to outline spaces approximately 4'x4' - the tape serves as a boundary. If class size makes it impractical to make enough confinement spaces for every student to begin with, the first challenge (working alone) can be limited to students' desks. For the second confinement task, you will need either one ~4'x4' confinement space for every 2 students or one ~4'x5' confinement space outlined for every 3 students.

1. To begin, students will link up with a partner. The teacher directs pairs to take two minutes to develop a brief summary of Missions 2 and 3. The teacher will call randomly for student pairs to briefly share their summaries.

2. Transition to Mission 4 by watching and discussing the TED2015 video, "Your kids might live on Mars. Here's how they'll survive."

[https://www.ted.com/talks/stephen\\_petranek\\_your\\_kids\\_might\\_live\\_on\\_mars\\_here\\_s\\_how\\_they\\_ll\\_survive?utm\\_campaign=tedsread&utm\\_medium=referral&utm\\_source=tedcomshare](https://www.ted.com/talks/stephen_petranek_your_kids_might_live_on_mars_here_s_how_they_ll_survive?utm_campaign=tedsread&utm_medium=referral&utm_source=tedcomshare)

Use this video to confirm that human travel to and exploration of Mars is plausible and being actively pursued. The video also serves as an additional source of information about challenges that will need to be resolved for humans to survive and thrive on Mars.

3. Use a think-pair-share strategy to develop a class list of challenges for human life on Mars that will need to be solved by building human-friendly Mars Habitats.

4. The teacher and students unpack the first learning target; specifically focus on the words "habitat," "harsh," and "environment."

*- I can describe what needs to be included in a Martian habitat that could protect humans from the harsh environment.*

- Discuss what types of solutions may be used or engineered to meet the challenges described in the class list.
- Conclude this discussion by highlighting those solutions suggested that would require confinement to smaller spaces than what humans are accustomed to, living on Earth.

5. Engage students in the isolation and confinement experiment as explained in the Teacher Spec Sheet: Instructional Slides.

6. The teacher introduces the culminating design challenge: Design a recreational activity that could be used to help the mental health of space explorers as explained in the Teacher Spec Sheet: Instructional Slides.

7. Begin the transition to the final Mission with an exit slip that asks: "How will we know if the design of your recreational activity is successful?"

# TEACHER SPEC SHEET



## INSTRUCTIONAL SLIDES

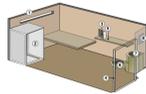
Guiding Questions:  

 How does isolation affect people's feelings?

 How does confinement affect people's feelings when put into groups?

Learning Targets: 

I can describe how isolation and confinement affect human feelings.



I can describe how confinement affects human behavior when placed in groups with others.



Imagine driving in a packed van for six months straight. You can't stop at all to stretch or pick up snacks. You can't open the window for fresh air. You don't have much privacy or personal space in the crowded van.

How would you feel on a trip like that?

Write down a few words to describe how you would feel:

---

---

Now share your answers with the others around you.

That's similar to the trip that the first astronauts who head to Mars will face. The trip to Mars is at least 6 months in a small spaceship, and the stay on Mars is up to 2 years before they can come home. (and another 6 months in a spaceship!)

## Your task: on your own first

Build the tallest free-standing structure out of 20 sticks of spaghetti, one yard of tape, one yard of string, and a marshmallow. The marshmallow needs to be on top.

**You must:**

**Stay in the space marked on the floor.**

No talking or asking questions – do your best

Please give your best serious effort.

## Your task: now with a team

Build the tallest free-standing structure out of 20 sticks of spaghetti, one yard of tape, one yard of string, and a marshmallow. The marshmallow needs to be on top.

**You must:**

Stay in the space marked on the floor.

Cooperate, share materials, work together.

Please give your best serious effort.

### Questions to Discuss:

- What feelings did you have when you worked on the task alone?
- What feelings did you have as you worked on the task with your team?
- How does this activity relate to what astronauts may experience in an underground lab on Mars?
- Do you think this would be stressful for the Mars team of scientists?

## Who can go on mission to Mars? Studies will help pick the best team

By Baltimore Sun, adapted by Newsela staff  
02/25/2016

BALTIMORE, Md. — NASA runs the U.S. space program. It will be choosing astronauts to travel to Mars sometime after 2030. **The astronauts must be smart and be able to get along with others.**

The space trip is almost 70 million miles. It could take three years. **The astronauts will need to work well together in a lonely, faraway ship. Scientists got money from NASA to help find the best astronauts. They must be friendly, too. Grouchy, moody people would not be good. Chatty people could also be a problem.**

One project will study workers in a lonely, faraway place in Antarctica. They will use cycling and video games to keep themselves calm. **The study will show how people learn to live if they are alone and unable to move around for a long time.**

### Astronauts Must Get Along

Being in space can lead to illnesses. Other scientists will study the blood of today's astronauts. They will study how future crews can fight off disease.

**Another group will study astronauts from different countries. They grew up in different ways. Some might like a strong leader. Others might like everyone to be the same and equal. This will help make the best team that can work together.**

Each astronaut will have special skills. Each skill will be needed to make the best team to go to Mars.

## What is the main idea of the article?

The main idea of the article is that it will be important for astronauts to be able to work with others in an unfamiliar, confined environment.

\*Astronauts will be doing experiments, working on construction and maintenance of the habitat, assisting with food production and a variety of other projects during the day. They will be part of a team that was chosen by NASA.

\*Although the team was chosen carefully, the astronauts must get along and be tolerant and respectful of each other. During the 2 year period, that might cause stress from time to time.

The astronauts will need to relax and unwind and take their mind off work in order to stay emotionally and mentally healthy. They will also need to socialize with each other in a relaxed situation to build relationships and learn to understand each other better.

We have determined that the astronauts will need some way to relax, have fun, relieve stress, and build relationships outside of their work time.



We have determined that participating in traditional sports such as football, baseball, soccer, hockey, basketball, and any other sport that requires lots of space and equipment will not be possible for a number of reasons including:

- \*Surface radiation
- \*Lack of adequate space in underground 'pods'
- \*Extreme cost of payload (\$2,600 per pound)
- \*Limited space on the transport vehicle



Which leaves us with the question of :

"What can astronauts do for fun that doesn't require much space, can be adapted to 1/3 gravity, and uses materials that are small and light?"

Brainstorm a list of simple activities that you could use to relax that don't require lots of equipment or space:

Make your own list and be ready to share your

- ideas.
- |                    |                                 |
|--------------------|---------------------------------|
| Reading            | Doing puzzles                   |
| Drawing            | Playing cards                   |
| Painting           | Playing video games             |
| Listening to music | Playing other board games       |
| Exercising         | Writing (in a journal or diary) |
| Yoga               |                                 |
| Meditation         |                                 |

## Which activities on the list would you enjoy ?

- **Make a list** of the materials that you would need to bring with you on the spacecraft in order to participate in that activity.
- **Share your lists** with classmates that like the same activities.
- Think about the weights of the materials that you would need to bring. **Cost of transport to Mars: \$2,600 per pound** 

The materials needed for the recreation activities that we listed last week are on your tables along with a digital scale.

Your tasks for today are:

- \*weigh the objects and write down the weight
- \*put the objects in order from lightest to heaviest
- \*present your findings to the whole group



Materials to weigh:

Paperback book	Hardcover book	Box of colored pencils	Box of crayons	Small paint brushes
Watercolor paints	Pieces of paper	iPod	Pencils	Deck of cards
Monopoly game	Journal/diary	100 piece puzzle	Crossword puzzle book	
Yoga mat	Video game materials		Dice	

Based on our results, explain: Are there any materials that you think might be too heavy (and costly) to bring to Mars?

## The final challenge:

In your basket, there is a collection of the lightest materials available to you:

1 paper plate	1 die
1 Styrofoam cup	2 small pieces of sponge
8 paperclips	8 pieces of cut-up drinking straw
1 pencil	
4 index cards	

You and your partner will use these materials to create a game that would be fun for you to play when you are living on Mars.

Share and demonstrate your game!

\*You and your partner (and others if the game is played with more than 2 people) will explain and demonstrate the game that you created.

\*Include an explanation of “why” you think it would be fun and “how” it can help you to relax and get to know your fellow astronauts!



Your classmates will evaluate the “fun factor”!



# MISSION 5

## DESIGN CRITERIA & EVALUATION

### MISSION QUESTIONS



- Which recreational activities designed by our class most closely meet the criteria and constraints that we identified for recreation on Mars that might best support both physical and mental health?

### LEARNING TARGETS



- I can evaluate design solutions using a systematic process to determine how well they meet the criteria and constraints that we established as a class.



Approximate Time Needed: 1-2 forty minute sessions

### PREPARATIONS



Prepare copies as described in Materials section

- Prepare to show the online video, "The Engineering Design Process: A Taco Party" (URL in Teacher Prompts section).

### MATERIALS



- Projector or Smart Board or Promethean Board and ability to show an online video
- Copies of the Student Spec Sheet, "Engineering Design Process: one per student

### MISSION BRIEF



1. Transition to Mission 5 by collecting students' exit slip responses from the end of Mission 4: "How will we know if the design of your recreational activity is successful?" Randomly choose several exit slips to read aloud without judgment
2. Show the video "Engineering Design Process: A Taco Party" on YouTube to provide a quick overview of the engineering design process: [https://www.youtube.com/watch?v=MAhpfFT\\_mWM](https://www.youtube.com/watch?v=MAhpfFT_mWM)
3. Distribute the Student Spec Sheet: "Engineering Design Process" for students to use as a guide.
4. Use a think-pair-share strategy to guide students to collectively develop a list of the criteria that all their activities need to meet for success on Mars or during travel to Mars. Record these criteria on chart paper or other media as students record them on their Spec Sheet.
5. In a whole class discussion, randomly call on students to give examples from experiences designing their recreational activity that align with stages in the design process.
6. Provide ~10 minutes for teams to discuss how their activities do and do not meet the criteria for a successful recreational activity. Check for understanding as student groups discuss to be sure they are referring explicitly to the class criteria list and the engineering design process when evaluating their activity.
7. Direct students to work individually and respond to the reflection questions on the Student Spec sheet.
8. Hold a whole-class, concluding discussion about what students learned through their Mars Missions experiences and what was most powerful and/or challenging in the learning.



## TEACHING PROMPTS

1. The teacher transitions to Mission 5 by collecting students' exit slip responses from the end of Mission 4: "How will we know if the design of your recreational activity is successful?"

Randomly choose several exit slips to read aloud and discuss without judgment.

2. The teacher explains to students that the process of making a recreational activity that could be successfully used by Mars explorers can be carried out as an engineering design challenge.

Share the short video "Engineering Design Process: A Taco Party" on YouTube for an overview of engineering design processes:

[https://www.youtube.com/watch?v=MAhpfFt\\_mWM](https://www.youtube.com/watch?v=MAhpfFt_mWM)

3. The teacher will distribute the Student Spec Sheet: "Engineering Design Process" for students to use as a guide during discussion and reflection.

- The teacher will remind students of the design challenge from Mission 4:

***Design a recreational activity that will help combat the challenges that space travelers and Mars explorers face, including isolation and confinement.***

4. The teacher will use a think-pair-share strategy to lead the whole class in the identification of criteria for a good solution design. The teacher must keep in mind that they must hold students accountable to cite evidence from what they learned in the explore/explain about the environment on Mars and the way humans will likely have to live on Mars. The teacher will also use this as an opportunity to share and unpack the learning target:

- I can evaluate design solutions using a systematic process to determine how well they meet the criteria and constraints that we established as a class.

5. In a whole class discussion, randomly call on students to give examples from experiences designing their recreational activity that align with design stages (shown on the Student Spec Sheet).

6. Provide ~10 minutes for teams to discuss how their activities do and do not meet the criteria for a successful recreational activity. Check for understanding as student groups discuss to be sure they are referring explicitly to the class criteria list and the engineering design process when evaluating their activity.

7. Direct students to work individually and respond to the reflection questions on the Student Spec sheet:

- What changes could you make to the design of your recreational activity to make it better and why?
- What do you think are the strongest features of your design? Explain.

8. Hold a whole-class, concluding discussion about what students learned through their Mars Missions experiences and what was most powerful and/or challenging in the learning.







# Mars Base Eagle Mission Assessment

Name: \_\_\_\_\_

1. I enjoy science activities and classes.

Mark only one oval.

Yes

No

2. I enjoy research.

Mark only one oval.

Yes

No

3. By the time I'm an adult, many people from Earth will be traveling to Mars.

Mark only one oval.

Agree

Disagree

4. Have you ever heard of NASA?

Mark only one oval.

Yes

No

5. If yes, what do you know about NASA

6. NASA has sent robotic research equipment to Mars.

Mark only one oval.

- True
- False

7. NASA has sent a person to Mars.

Mark only one oval.

- True
- False

8. Would you want to travel to Mars some day?

Mark only one oval.

- Yes
- No

9. Why or Why not?

10. When you think about your future career, what do you think you would like to be?

Check all that apply.

- Farmer
- Firefighter
- Forester
- Inventor/Entrepreneur
- Journalist
- Lawyer
- Librarian
- Marine Biologis
- Mechanic
- Medical/Health Care(Doctor, Nurse, Technician)
- Musician Park
- Ranger Pilot
- Police Officer
- Politician
- Teacher
- Veterianarian
- Video Game Developer
- Writer
- Zoologist/Zookeeper
- Other: \_\_\_\_\_

11. From the careers you checked, which are your top 3 choices?

- 1. \_\_\_\_\_
- 2. \_\_\_\_\_
- 3. \_\_\_\_\_

## Physical Science Mission Questions

12. Which of the following would be a challenge on Mars when using solar panels to convert energy in light into electrical energy?

Mark only one oval.

- Mars receives less intense light from the Sun than we receive on Earth.
- Dust carried in frequent dust storms on Mars will often shade the solar panels.
- High levels of radiation on the surface of Mars will make constructing solar panels there challenging.
- All of the above

## Wind Turbines



13. The wind turbines shown in the photo do not run on batteries. They are operated by wind blowing against and turning the blades. Which sequence best identifies the energy transfers that take place:

Mark only one oval.

- Chemical energy in wind--->Energy transformation by a generator---?electrical energy and heat
- Energy transported in sunlight--->Energy transformation--->Electrical energy and heat
- Kinetic energy in wind--->Energy transformation by a generator--->Electrical energy and heat
- Kinetic energy in wind--->Chemical energy transformation--->Energy in light

14. What is an advantage to relying on electrical energy generated using solar on Mars?

15. What is a disadvantage to relying on electrical energy generated using solar on Mars?

16. What is an advantage to relying on electrical energy generated using wind on Mars?

17. What is a disadvantage to relying on electrical energy generated using wind on Mars?

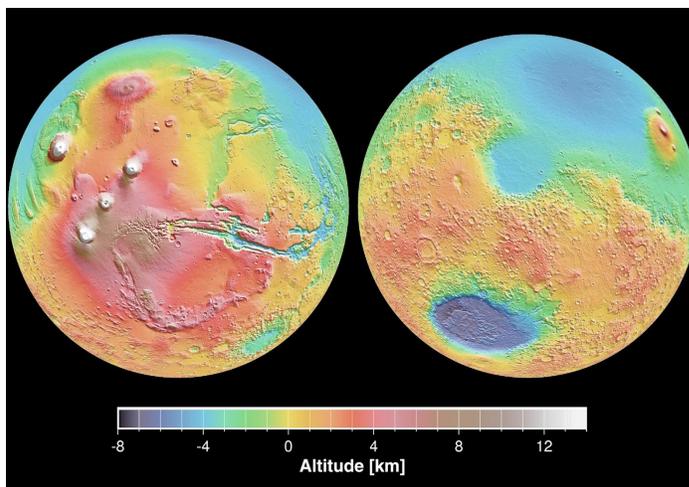
## Earth Science Mission Questions

18. Why would humans on Mars need to use Oxygen tanks to help them breathe?

Mark only one oval.

- At high elevations on Mars the ozone layer draws oxygen out of the atmosphere.
- The atmosphere is less dense on Mars so there is less oxygen available.
- Oxygen is heavier than the other gases in the atmosphere and sinks to lower elevations.
- The atmosphere on Mars is made up primarily of carbon dioxide, with only traces of oxygen.

### Mars Craters



19. The surface of Mars is covered with craters, as shown. How are most of these craters formed? **Mark only one oval.**

- By eruptions of active volcanoes.
- By impacts of many meteoroids.
- By shifting rock on Mar's surface (Marsquakes).
- By tidal forces caused by Earth and the Sun.

20. Which of these are reasons why scientists think a human colony on Mars most likely will live underground? **Mark only one oval.**

- The Sun will be too bright on Mars to live on the surface.
- Radiation levels will be too high on Mars to live on the surface.
- The surface of Mars will be too hot for humans to live there.
- The easiest way to build housing for humans on Mars will be to dig buildings underground.
- None of the above.

## Life Sciences Mission Questions

21. What parts of the food web are currently missing on Mars?

Mark only one oval.

- Producers
- Consumers
- Decomposers
- All of the above
- None of the above

22. What will a human colony on Mars need to get from plants that they grow on Mars?

Mark only one oval.

- Oxygen
- Food
- Shelter
- Both A and B
- None of the above

23. When humans bring seeds of plants to Mars, will the plants they grow have the same environmental requirements plants on Earth? (light, carbon dioxide, water, minerals)

Mark only one oval.

- Yes
- No

24. Why or Why not?

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# Mars Base Eagle Mission Disciplinary Content Assessment Keys

## Physical Science Mission Questions

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- Kinetic energy in wind--->Chemical energy transformation--->Energy in light

14. What is an advantage to relying on electrical energy generated using solar on Mars?

**The intensity of sunlight on Mars is less, and there are frequent dust storms, and dust could shade solar panels. Given our current technologies, it would be too expensive and probably not possible to transport the number and size of solar panels and batteries necessary to support human explorers on Mars.**

15. What is a disadvantage to relying on electrical energy generated using solar on Mars?

**If we could develop a way to capture and use the energy in wind on Mars, it would be a form of energy that is already available on Mars, so we wouldn't have to transport that energy source.**

16. What is an advantage to relying on electrical energy generated using wind on Mars?

**If we could develop a way to capture and use the energy in wind on Mars, it would be a form of energy that is already available on Mars, so we wouldn't have to transport that energy source.**

17. What is a disadvantage to relying on electrical energy generated using wind on Mars?

**Wind on Mars is too light to move the blades on any windmills or power wind turbines that we currently have available. Although wind--including large wind storms--are common on Mars, the atmosphere is extremely thin, so winds there are very light.**

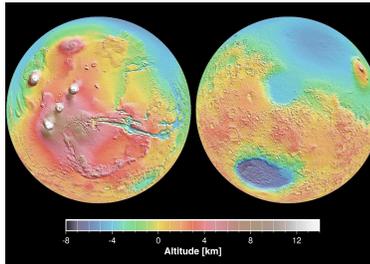
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- Both A and B**
- None of the above

23. When humans bring seeds of plants to Mars, will the plants they grow have the same environmental requirements plants on Earth? (light, carbon dioxide, water, minerals)

Mark only one oval.

- Yes**
- No

24. Why or Why not?

**Plants have needs that must be met for them to survive and grow, wherever they may live (like other living things). If any one of those environmental requirements is missing, the plants will die.**