Pre-Mission

Teacher's Guide

EXPEDITION MARS™

Expedition Mars Teacher's Guide Outline

The Teacher's Guide will include lessons to support the Challenger Center Mission: Expedition Mars. Teachers will choose a lesson path to follow to allow for maximum flexibility, while still engaging and preparing students for their visit to a Challenger Learning Center. All lessons will include the basic concepts of Mars and expose students to the various roles available during their mission experience. The format will include the Crew Manifest at the end of the sequence of lessons, to allow students to gain information about the content included in their roles before making a choice. Longer sequences will include a general description of the roles being highlighted in each lesson to help students rank the job options available.

Each lesson will include hands-on components and will be mindful of student and teacher choice.

Paths:

1 day – this path will include a general overview of Earth vs. Mars and touch on many general concepts that will be necessary for completing the mission at the Challenger Learning Center. Students will go through the Crew Manifest at the end of this session to ensure everyone is prepared when entering the Challenger Learning Center.

3 days- this path will also use the Earth vs. Mars lesson as an introduction to the unit. Students will learn of each job role but will not choose a job until the end of day 3. Day 2 will focus on Biology and Physiology, while day 3 will focus on the moon, Phobos, and landing on Mars along with the Crew Manifest.

5 days- the 5-day path allows for maximum impact of concepts taught. Each day will focus on a different concept, while highlighting the roles that focus on the content being taught. These concepts include: planetary science, geology, biology, human physiology, and landing on Mars. The Crew Manifest will be completed at the end of day 5.

<u>Reasoning:</u>

Challenger Center has chosen to format the Teacher's Guide to include different paths. This allows teachers flexibility and choice when preparing for a mission with their class. Using a path system will ensure all students are prepared and have an adequate overview of basic concepts needed to be successful in their mission. We know that teachers are often pressed for time in their classrooms and appreciate options and flexibility whenever possible. We also know that classes who are prepared through thoughtful and meaningful lessons are more successful and achieve larger gains from a mission experience. The content in the different paths is designed to deliver as much background knowledge and buy-in for students as possible in the time allotted by the teacher for preparation before visiting a Challenger Learning Center.

Single Day Track

<table>
<tr><td>Day 1 (of 1)</td><td>Objective: SWBAT explain how characteristics of Mars differ from the characteristics of Earth.</td><td rowspan="3"><u>Activity</u>:
Create class venn diagram/Four Corners activity</td></tr>
<tr><td rowspan="2">Earth vs. Mars</td><td>Standards and Skills:
Analyze and interpret data to determine similarities and differences in findings. (MS-ESS1-3)
The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)
CCSS.ELA-Literacy.RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
CCSS.ELA-Literacy.RST.6-8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.</td></tr>
<tr><td>Description:
In this overview lesson students will compare properties of Mars to properties of Earth. Topics will include: location in solar system, gravity, length of day, core (lack of ionosphere), weather (temperature, pressure, and storms), communication with earth, surface characteristics (color, water), life on each, moons and the atmosphere.

Students will also learn about the different mission roles, select their top three and explain why they would be a good fit.</td></tr>
</table>

Three and Five-Day Tracks

Day 1 (of 5)	Objective: SWBAT compare and contrast characteristics of Mars and Earth.	Activity: Create class Venn Diagram/Four Corners activity
Earth vs. Mars	Standards and Skills: Analyze and interpret data to determine similarities and differences in findings. (MS-ESS1-3) The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2) CCSS.ELA-Literacy.RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue. CCSS.ELA-Literacy.RST.6-8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	
	Description: In this overview lesson students will compare properties of Mars to properties of Earth. Topics will include: location in solar system, gravity, length of day, core (lack of ionosphere), weather (temperature, pressure, and storms), communication with earth, surface characteristics (color, water), life on each, and the atmosphere.	
Day 2 (of 5)	Objective: SWBAT explain how the existence of extremophiles hints at the possibility of life on Mars.	Activity: Extremophile study, matching game
Biology & Physiology	Standards and Skills: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment (MS-LS4-4).	
	Description: This lesson will touch on all aspects of life on Mars. Topics will include: what is needed for life on Mars, evidence of water on Mars, and extremophiles. (If teaching 3 days, include brief discussion on humans on Mars, specifically why they cannot live on Mars without accommodations.)	

Day 3 (of 5)	Objective: SWBAT describe how to take off from and land on Mars.	Activity: Cannon demo/game
Landing on Mars/Phobos	Standards and Skills: CCSS.ELA-Literacy.RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue. The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2) Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. (MS-PS2-4)	
	Description: This lesson will go more in depth about Phobos and why it is a good candidate for exploration. It will also touch on how to land on Mars from Phobos, with an explanation of Newton's cannon, delta v, and escape velocity. Students will also go through the crew manifest more in depth. ***Classes teaching 3 lessons will apply for roles. 5 day classes will learn about advantages and disadvantages of rovers.***	
Day 4 (of 5)	Objective: SWBAT identify and analyze evidence of water on Mars.	Activity: Water race demo, sorting photos of Mars vs Earth
Mars Geology	Standards and Skills: In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1) CCSS.ELA-Literacy.RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.	
	Description: Students will go more in depth on the geology of Mars. Topics will include: why Mars is red, evidence of water on Mars, the lack of tectonic plates, what could be under the surface of Mars.	

Day 5 (of 5)	Objective: SWBAT use their knowledge of the effects of Mars on humans to design a safe space station to support human life on Mars.	Activity: Design a space station, health on Mars lab
Humans on Mars	Standards and Skills: 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. (3-5-ETS1-3)	
	Description: This concluding lesson will discuss human life on Mars. Topics will include: conditions needed for human life, effects of low gravity environments, radiation, and adaptations/accommodations that need to be made for human survival. Students will apply for their roles.	

Optional Extension Activity

Day 6	Objective: SWBAT write a position piece on whether or not are worth using for Mars exploration.	Activity: Rover game
Rovers on Mars	Standards and Skills:	
	Description: Students will learn about Mars exploration using rovers, specifically Curiosity. Topics will include: landing on Mars, communicating with a rover, and its ability to gather data.	

Lesson References

Day 1: Four-corners, Create a Venn-Diagram with partner/group -

Day 2: Extremophiles - https://marsed.mars.asu.edu/content/xtreme-o-philes

Day 3: Landing Process jigsaw

Day 4: Water race - https://www.nasa.gov/pdf/168049main_Follow_the_Water.pdf

Day 5a: Human bodies in Space stations—
http://www.lpi.usra.edu/education/explore/space_health/space_stations/

Day 5b: Design your own space station

Day 6: Rover Races:
https://marsed.mars.asu.edu/sites/default/files/stem_resources/Rover%20Races%206th%20-%2012th%20Grade%20Lesson.pdf

Expedition Mars – Single Day Track – Earth vs. Mars

Prep Time: 10 minutes	**Lesson Time:** 45 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT explain how characteristics of Mars differ from the characteristics of Earth.

Standards:

- Analyze and interpret data to determine similarities and differences in findings. (MS-ESS1-3)
- The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)
- CCSS.ELA-Literacy.RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
- CCSS.ELA-Literacy.RST.6-8.9: Compare and contrast the information gained from experiments.

Teacher Prep:

- Create a KWL chart and Venn Diagram on chart paper
- Have video cued and ready to play
- Print a copy of the 3-2-1 sheet for each student
- Set up 4 corners game by printing statement cards and labeling corners

Teacher Notes/Background:

- It will be helpful to read through all lesson materials, including handouts, before the lesson begins.
- Students who need extra assistance can be paired during any portion of the lesson. If room does not allow for the 4 corners game, you can modify by printing the 4 options and having individuals or small groups hold up their answer as you read the statements.
- Load the video: How does Mars compare to Earth?
- https://www.youtube.com/watch?v=VvqANiuGcyo

Engage	"Today we are going to talk about Mars to help get us ready for our trip to the Challenger Learning Center. Let's talk about what we already know about Mars…" Draw a KWL chart on the board or on a piece of chart paper (chart paper preferred so that it can remain in the classroom for reference) Ask students to contribute what they "know" about Mars. Complete the "k" section of the chart. When answers have been exhausted, ask students what they "want" to learn about Mars–complete the "W" section of the chart.	**Materials:** • Chart Paper

K	W	L
What we know	What we want to know	What we learned

Explore	"Now that we have some good ideas about what we already know and what we'd like to learn, we're going to watch a short video that highlights the differences between our plant, Earth, and the planet Mars. At the end of the video, you will be writing down 3 things you found interesting, 2 things you learned, and 1 question you still have." Pass out the 3-2-1 sheet before the video so students can write things down as they watch if desired. Play the video. Give students a few minutes after the video to complete the sheet. Have students share out their 3-2-1 sheets in a turn and talk with a neighbor or small surrounding group. Circulate to check for understanding	**Materials:** • Video • 3-2-1 sheet

3 interesting facts
2 things I learned
1 question I still have

Explain

"We've learned a lot of new facts about Mars already, let's test our knowledge about the differences between Earth and Mars. We're going to play a game called 4 corners. I'll read a fact and you need to safely, with walking feet, travel to the corner that you think the statement belongs to. Our corner choices are Earth, if what I say only happens on Earth; Mars, if what I say only happens on Mars; Both, if it happens on both Earth and Mars; or Neither, if my statement does NOT happen on Earth or Mars"

** Have the Venn Diagram chart posted on the board**

Have students stand behind desks with the chairs pushed in for ease of movement.

Read a statement from the 4 corner cards.

Students will move to the correct corner. If students get and answer incorrect, either have a student at the correct answer share why or read the reasoning on the bottom of the statement card.

After reading each card and having students move, TAPE the statement card to the correct place on the Venn Diagram chart.

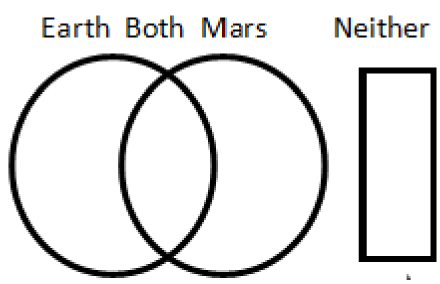
When all cards have been read, gather students to go over the statements that are now recorded in the Venn Diagram.

Check for understanding and answer any questions during this review.

Materials:

- 4 corner statement cards
- [Tip: you may want to put cards in a certain order before starting this lesson to ensure that students are moving around the room]
- 4 corner labels
- Venn Diagram

View of Board or Chart Paper



Elaborate	All these facts we have learned today are going to help us complete our mission at the Challenger Learning Center. When we go, everyone will have a different job to do to help us complete our mission to Mars." During our mission, we will be working together to get to Mars's surface from its moon, Phobos. Read the Mission description to the students: "The year is 2076. A handful of facilities have been established on Mars, including a greenhouse, a mobile geological survey base, and a centralized research habitat. The primary human habitat is not on Mars, but on one of its moons, Phobos. A large shuttle regularly ferries astronauts and scientists between the base on Phobos and the surface of Mars. This shuttle, or Mars Transport Vehicle (MTV), carries parts to build a remotely operated vehicle (ROV) to continue the search for the evidence of life and water. However, when crew members discover an imminent threat to their MTV and the Martian surface facilities, they must act quickly to save their stations, their research, and their lives." Use the PowerPoint to show students each job with its logo and description. This will help them make an informed decision about their job choice. Leave the final summary slide on the screen for students to reference during their job application process or print the summary sheet.	**Materials:** • PowerPoint (can be projected or printed) https://drive.google.com/file/d/1SrM_PcjvydgIN8Uly-8y7bzQIzK4zGRT/view?usp=sharing

Evaluate

After introducing students to all the possible jobs available during the mission, have them think about which jobs sound the most interesting.

Project or pass out printed copies of the job descriptions summary sheet for students to reference during the exit ticket activity.

Students complete the job application.

Materials:

- Job summary sheet (paper or projected)
- Job applications


Job Application

The 3 jobs I am most interested in at the Challenger Center are...

Write a 1 next to your first choice, 2 for second, 3 for third.

☐ BIO ☐ GEO ☐ NAV
☐ BOT ☐ LS ☐ ROV
☐ COM ☐ MED ☐ WEATHER

Please fill out the application below ONLY for your first choice.

Why do you want to do this job?

What skills do you have that will help you be successful in this position?

Name

Extensions and Enrichment:

- If more time allows, increase the number of 4 corners cards you use.
- Have students create their own statements to use for the 4 corners game, based on the video or their own research.

Additional Resources:

NASA Earth vs Mars Lesson:

http://www.nasa.gov/offices/education/programs/national/summer/education_resources/earthspacescience_grades7-9/ESS_earth-vs-mars.html#.V7seX4WcE2w

NASA Mars Education Lessons:

https://marsed.mars.asu.edu/stem-lesson-plans

You would weigh more on this planet.

Earth

This planet has less gravity.

Mars

It takes this planet over 24 hours to rotate once.

Mars

This planet has at least one orbiting moon.

Both

This planet is found in the Milky Way Galaxy.

Both

This planet is the fourth from the sun.

Mars

This planet has an average temperature of 57°F.

Earth

The atmosphere on this planet is mostly CO_2.

Mars

This planet has a magnetosphere that protects it from the sun.

Earth

This planet experiences four seasons.

Both

This planet takes 687 days to orbit the sun.

Mars

This planet has a denser atmosphere.

Earth

This planet experiences weather.

Both

This planet contains the highest peak in the galaxy, reaching 13.2 miles above sea level.

Mars

This planet is the smaller of the two planets.

Mars

This planet has polar ice caps.

Both

This planet has a lot of iron in the soil.

Mars

This planet experiences significant dust storms that can last for months.

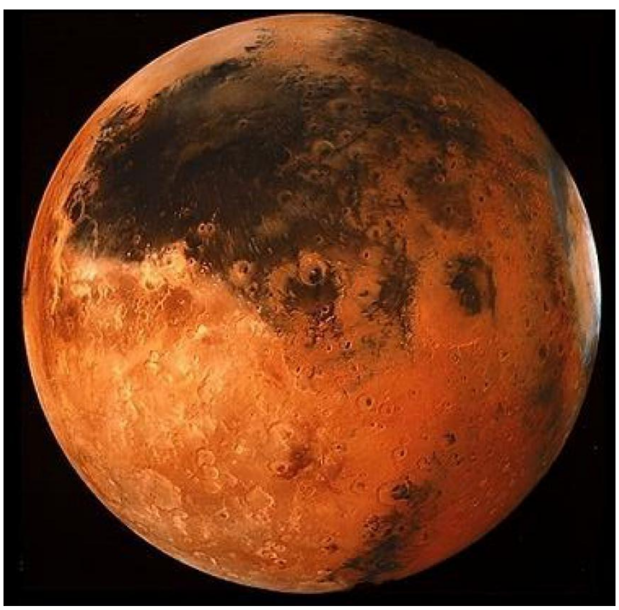
Mars

Little green men live here.

Neither

This planet is the farthest known planet from the sun.

Neither



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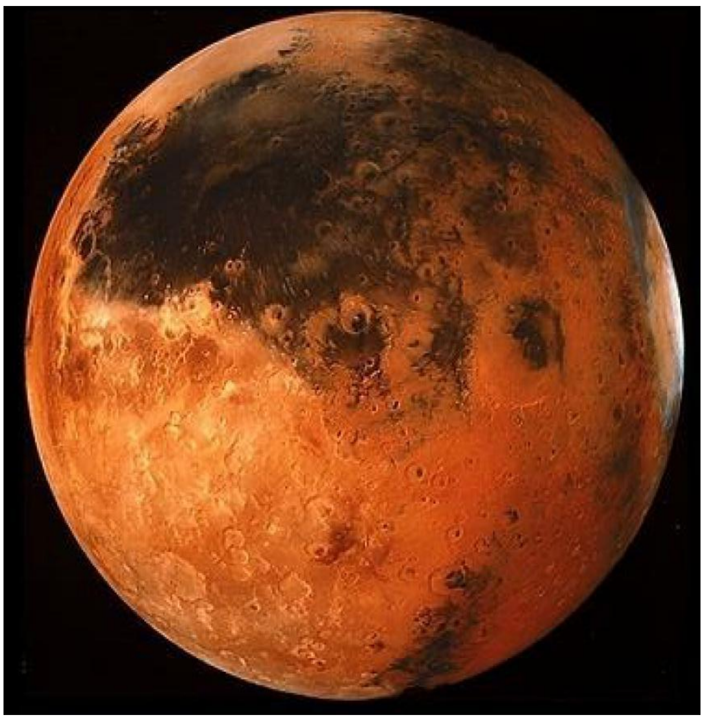
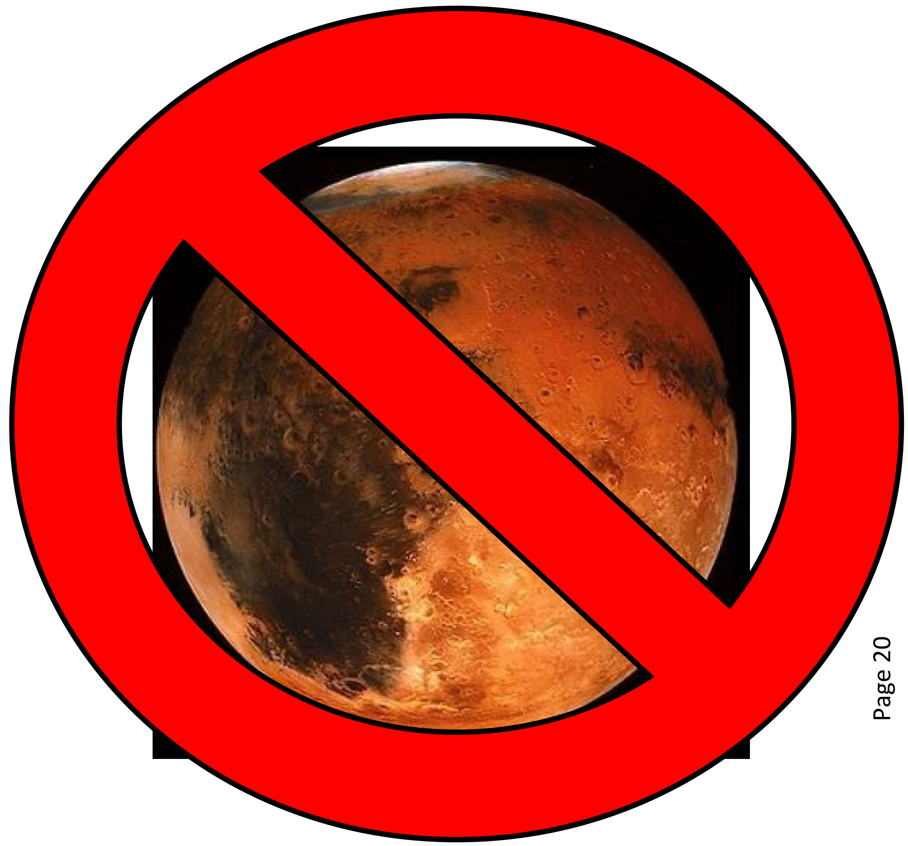


Mars

Earth

Neither



3 DAY TRACK

Expedition Mars – Three Day Track – Day 1 – Earth vs. Mars

Prep Time: 10 minutes	**Lesson Time:** 45 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT explain how characteristics of Mars differ from the characteristics of Earth.

Standards:

- Analyze and interpret data to determine similarities and differences in findings. (MS-ESS1-3)
- The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)
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Teacher Prep:

- Create a KWL chart and Venn Diagram on chart paper
- Have video cued and ready to play
- Print a copy of the 3-2-1 sheet for each student
- Set up 4 corners game by printing statement cards and labeling corners

Teacher Notes/Background:

- It will be helpful to read through all lesson materials, including handouts, before the lesson begins.
- Students who need extra assistance can be paired during any portion of the lesson. If room does not allow for the 4 corners game, you can modify by printing the 4 options and having individuals or small groups hold up their answer as you read the statements.
- Load the video: How does Mars compare to Earth?
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Engage

"Today we are going to talk about Mars to help get us ready for our trip to the Challenger Learning Center. Let's talk about what we already know about Mars…"

Draw a KWL chart on the board or on a piece of chart paper (chart paper preferred so that it can remain in the classroom for reference) Ask students to contribute what they "know" about Mars. Complete the "k" section of the chart. When answers have been exhausted, ask students what they "want" to learn about Mars– complete the "W" section of the chart.

Materials:

- Chart Paper

K	W	L
What we know	What we want to know	What we learned

Explore

"Now that we have some good ideas about what we already know and what we'd like to learn, we're going to watch a short video that highlights the differences between our plant, Earth, and the planet Mars. At the end of the video, you will be writing down 3 things you found interesting, 2 things you learned, and 1 question you still have."

Pass out the 3-2-1 sheet before the video so students can write things down as they watch if desired.
Play the video.

Give students a few minutes after the video to complete the sheet.

Have students share out their 3-2-1 sheets in a turn and talk with a neighbor or small surrounding group. Circulate to check for understanding

Materials:

- Video
- 3-2-1 sheet

3 interesting facts
2 things I learned
1 question I still have

Explain

"We've learned a lot of new facts about Mars already, let's test our knowledge about the differences between Earth and Mars. We're going to play a game called 4 corners. I'll read a fact and you need to safely, with walking feet, travel to the corner that you think the statement belongs to. Our corner choices are Earth, if what I say only happens on Earth; Mars, if what I say only happens on Mars; Both, if it happens on both Earth and Mars; or Neither, if my statement does NOT happen on Earth or Mars"

** Have the Venn Diagram chart posted on the board**

Have students stand behind desks with the chairs pushed in for ease of movement.

Read a statement from the 4 corner cards.

Students will move to the correct corner. If students get and answer incorrect, either have a student at the correct answer share why or read the reasoning on the bottom of the statement card.

After reading each card and having students move, TAPE the statement card to the correct place on the Venn Diagram chart.

When all cards have been read, gather students to go over the statements that are now recorded in the Venn Diagram.

Check for understanding and answer any questions during this review.

Materials:

- 4 corner statement cards
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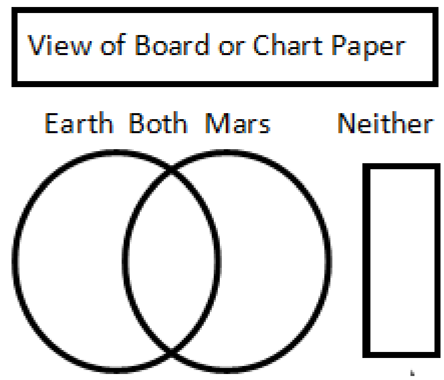
- 4 corner labels
- Venn Diagram



Elaborate	All these facts we have learned today are going to help us complete our mission at the Challenger Learning Center. When we go, everyone will have a different job to do to help us complete our mission to Mars." During our mission, we will be working together to get to Mars's surface from its moon, Phobos. Read the Mission description to the students: "The year is 2076. A handful of facilities have been established on Mars, including a greenhouse, a mobile geological survey base, and a centralized research habitat. The primary human habitat is not on Mars, but on one of its moons, Phobos. A large shuttle regularly ferries astronauts and scientists between the base on Phobos and the surface of Mars. This shuttle, or Mars Transport Vehicle (MTV), carries parts to build a remotely operated vehicle (ROV) to continue the search for the evidence of life and water. However, when crew members discover an imminent threat to their MTV and the Martian surface facilities, they must act quickly to save their stations, their research, and their lives." Use the PowerPoint to show students each job with its logo and description. This will help them make an informed decision about their job choice. Leave the final summary slide on the screen for students to reference during their job application process or print the summary sheet.	**Materials:** • PowerPoint (can be projected or printed) https://drive.google.com/file/d/1SrM_PcjvydgIN8Uly-8y7bzQIzK4zGRT/view?usp=sharing

Evaluate

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Students complete the job application.

Materials:

- Job summary sheet (paper or projected)
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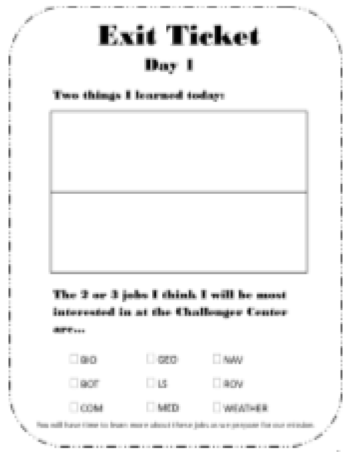


Extensions and Enrichment:

- If more time allows, increase the number of 4 corners cards you use.
- Have students create their own statements to use for the 4 corners game, based on the video or their own research.

Additional Resources:

NASA Earth vs Mars Lesson:

http://www.nasa.gov/offices/education/programs/national/summer/education_resources/earthspacescience_grades7-9/ESS_earth-vs-mars.html#.V7seX4WcE2w

NASA Mars Education Lessons:

https://marsed.mars.asu.edu/stem-lesson-plans

This planet is the fourth from the sun.

Mars

This planet has an average temperature of 57°F.

Earth

The atmosphere on this planet is mostly CO_2.

Mars

This planet has a magnetosphere that protects it from the sun.

Earth

This planet experiences four seasons.

Both

This planet takes 687 days to orbit the sun.

Mars

This planet has a denser atmosphere.

Earth

This planet experiences weather.

Both

This planet contains the highest peak in the galaxy, reaching 13.2 miles above sea level.

Mars

This planet is the smaller of the two planets.

Mars

This planet has polar ice caps.

Both

This planet has a lot of iron in the soil.

Mars

This planet experiences significant dust storms that can last for months.

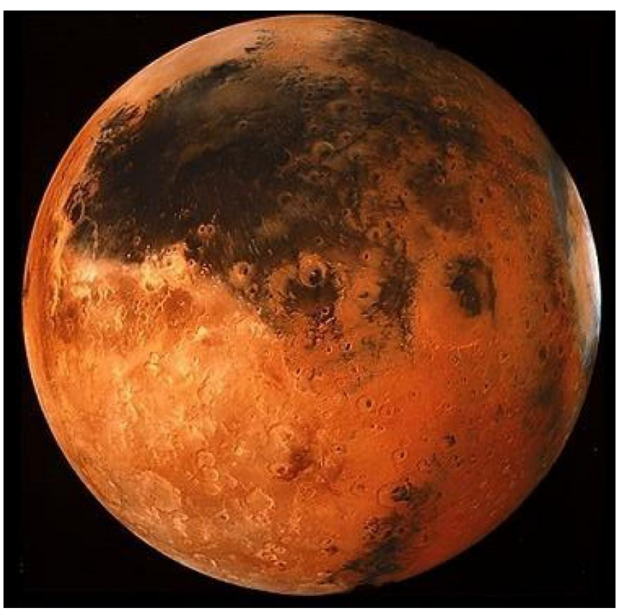
Mars

Little green men live here.

Neither

This planet is the farthest known planet from the sun.

Neither



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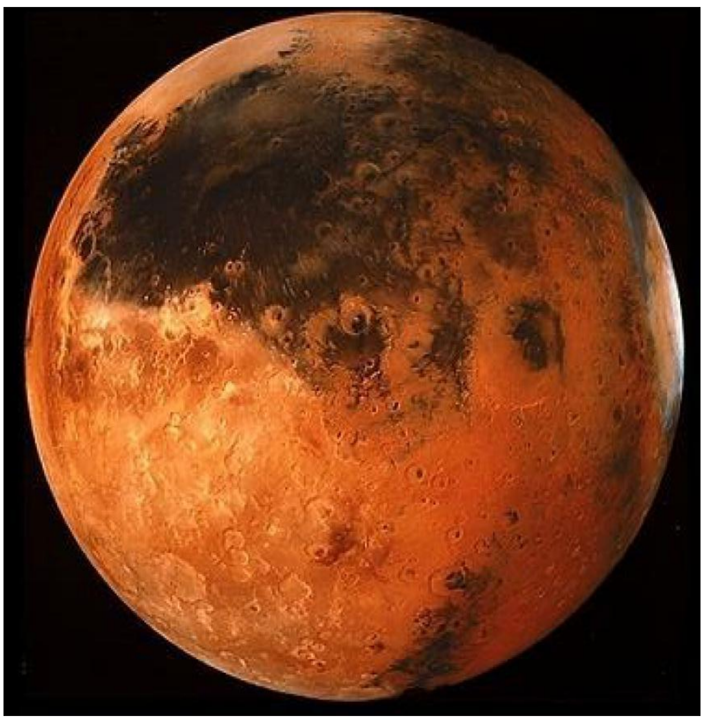


Mars

Earth

Neither

Exit Ticket

Day 1

Two things I learned today:

The 2 or 3 jobs I think I will be most interested in at the Challenger Learning Center are...

☐ BIO	☐ GEO	☐ NAV
☐ BOT	☐ LS	☐ ROV
☐ COM	☐ MED	☐ WX

You will have time to learn more about these jobs as we prepare for our mission.

Expedition Mars – Three Day Track – Day 2 – Extremophiles

Prep Time: 20 minutes	**Lesson Time:** 45 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Learning Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT explain how the existence of extremophiles hints at the possibility of life on Mars.

Standards:

- Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment (MS-LS4-4).

Teacher Prep:

- Create Do Now/Exit Slips
- Print water pictures or put in PowerPoint
- Create enough decks of cards for each group of 2-3 students. Either print on different color paper or differentiate the decks in some way. Put in zip top bag for easy distribution and collection.
- Print enough Put an Extremophile on Mars handouts for class.

Teacher Notes/Background:

- Mars environment cards: https://marsed.mars.asu.edu/sites/default/files/stem_resources/mars-cards.pdf
- Extremophile cards: https://marsed.mars.asu.edu/sites/default/files/stem_resources/cards_0.pdf
- For students who need additional reading support, highlight/underline important information on the cards. The number of options can also be reduced (put in 4 of each instead of 8 of each).
- Load the Video: Why extremophiles bode well for life beyond Earth https://www.youtube.com/watch?v=Bsp5JYNMAQE

Engage	For a warm-up/Do Now, have students list out different things that organisms need to live. Students share out answers, while teacher compiles a list on the board.	**Materials:** • Do Now 
Explore	Living organisms need water to live. Some need a lot, some need a little, some need hot water, some need salt water, but all need water. Because of this, evidence of water would prove that life COULD be on Mars. (Show picture of evidence of water on Mars, compared with a similar photo from Earth.) By looking at this picture, we can see that water is present on Mars. This leads us to believe that life at one point, or still today, potentially is on Mars. No life has been found, but this says it **could**. Today will be spent looking at the type of life that **could** live on Mars. As we learned yesterday, there is very little oxygen, low pressures, and extreme temperatures. Because of that, we will be looking at **extremophiles** to see which could live on Mars. Extremophiles are organisms that live in extreme environments. Let's watch a video to explain more about extremophiles.	**Materials:** • Photograph of canyons on Mars and Earth • Video

Explain

Give students attached chart with Earth vs. Mars characteristics as reference sheet. They will also receive two sets of cards: extremophiles (found on Earth) and environments on Mars. In groups of 3, they will select an extremophile that they believe could survive on Mars and a Mars environment in which it could live. They will explain why they chose that extremophile and environment and will present their findings to the class.

Go through one example. Show using the cards.

"This card says that Endoliths do not need a lot of water and can survive in extreme temperatures—very hot and very cold. Let's find an environment on Mars that is similar. The Desert Meridiani Planum does not have a lot of water and has temperatures ranging from very cold to very hot. This would be a good match for the Endoliths."

Materials:

- Earth vs. Mars chart (1 per group)
- Mars Environment cards
- Extremophile cards
- "Put an Extremophile on Mars" handout

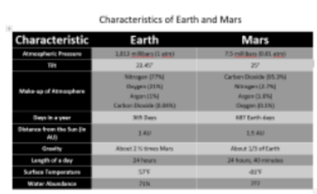
Elaborate

Students work for 10 minutes on this activity. Each group has 1 min to present their findings.

After presentations, reiterate that these extremophiles have not been found on Mars, but since Mars has more extreme conditions, scientists believe these are the key to finding life.

Similar investigations will be done by the **BIO team** during the Challenger Learning Center mission.

Materials:



Characteristics of Earth and Mars

Characteristic	Earth	Mars
Atmospheric Pressure	1,013 millibars (1 atm)	7.5 millibars (0.01 atm)
Tilt	23.45°	25°
Make-up of Atmosphere	Nitrogen (77%) Oxygen (21%) Argon (1%) Carbon Dioxide (0.04%)	Carbon Dioxide (95.3%) Nitrogen (2.7%) Argon (1.6%) Oxygen (0.1%)
Days in a year	365 Days	687 Earth days
Distance from the Sun (in AU)	1 AU	1.5 AU
Gravity	About 2 ½ times Mars	About 1/3 of Earth
Length of a day	24 hours	24 hours, 40 minutes
Surface Temperature	57°F	-81°F
Water Abundance	71%	???

Put an Extremophile on Mars

Directions: Using the cards, select an extremophile that your group thinks could (or could have in the past) survived on Mars. Select a location on Mars where you think it could have lived. Explain your choice and why the extremophile could live in that location.

Your group will share your choice with the class.

Group Members: ______________________

Extremophile: ______________ Mars Location: ______________

In complete sentences, justify your answer. What evidence supports your claim?

Evaluate

Have students turn in an Exit Slip answering the question: "Why are scientists studying extremophiles?"

Materials:

- Exit Slip

Name: ______________ Class: ______

Exit Ticket
Day 2

Why is it important for scientists at NASA to study extremophiles? Write 2-3 complete sentences.

Extensions and Enrichment:
• Students can match the rest of the extremophiles to the Mars environment in which they could live. Students could also create a more formal presentation if time and resources allow.
Additional Resources: Lesson adapted from: https://marsed.mars.asu.edu/content/xtreme-o-philes

Challenger CENTER

Put an Extremophile on Mars

Directions: Using the cards, select an extremophile that your group thinks could (or could have in the past) survived on Mars. Select a location on Mars where you think it could have lived. Explain your choice and why the extremophile could live in that location.

Your group will share your choice with the class.

Group Members: ____

Extremophile: ________________________________ Mars Location: ________________________________

In complete sentences, justify your answer. What evidence supports your claim?

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Characteristic	Earth	Mars
Atmospheric Pressure	1,013 millibars (1 atm)	7.5 millibars (0.01 atm)
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Make-up of Atmosphere	Nitrogen (77%) Oxygen (21%) Argon (1%) Carbon Dioxide (0.04%)	Carbon Dioxide (95.3%) Nitrogen (2.7%) Argon (1.6%) Oxygen (0.1%)
Days in a Year	365 Days	687 Earth days
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Gravity	About 2 ½ times Mars	About 1/3 of Earth
Length of a Day	24 hours	24 hours, 40 minutes
Surface Temperature	57°F	-81°F
Water Abundance	71%	present

Characteristic	Earth	Mars
Atmospheric Pressure	1,013 millibars (1 atm)	7.5 millibars (0.01 atm)
Tilt	23.45°	25°
Make-up of Atmosphere	Nitrogen (77%) Oxygen (21%) Argon (1%) Carbon Dioxide (0.04%)	Carbon Dioxide (95.3%) Nitrogen (2.7%) Argon (1.6%) Oxygen (0.1%)
Days in a Year	365 Days	687 Earth days
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Gravity	About 2 ½ times Mars	About 1/3 of Earth
Length of a Day	24 hours	24 hours, 40 minutes
Surface Temperature	57°F	-81°F
Water Abundance	71%	present

Name: ______________________________ Class: ____________

Do Now
Day 2

What do organisms (living things) need to survive? Use humans and plants to help you get started.

____

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____

____

____

Name: ______________________________ Class: ____________

Do Now
Day 2

What do organisms (living things) need to survive? Use humans and plants to help you get started.

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Name: ________________________ Class: __________

Exit Ticket
Day 2

Why is it important for scientists at NASA to study extremophiles? Write 2-3 complete sentences.

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Name: ________________________ Class: __________

Exit Ticket
Day 2

Why is it important for scientists at NASA to study extremophiles? Write 2-3 complete sentences.

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Expedition Mars – Three Day Track – Day 3 – The Journey of the Inspiration Rover

Prep Time: 10 minutes	**Lesson Time:** 45 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Learning Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT describe how to take off from and land on Mars.

Standards:

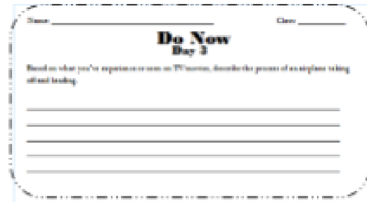
- CCSS.ELA-Literacy.RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both objects have large mass—e.g., Earth and the sun. (MS-PS2-4)

Teacher Prep:

- Print articles (laminate if you want to reuse for class periods)
- Make copies of graphic organizer, Do Now, Crew Manifest/application
- Load video

Teacher Notes/Background:

- Review all pieces of the launch and landing process. The videos can be useful. This is also a helpful animation (Can also be shared with students): http://mars.jpl.nasa.gov/multimedia/interactives/edlcuriosity/index-2.html
- If your class does not evenly split into groups of 3, keep a group or two of 2 and provide them with the article they are missing during the sharing time.
- Load video: Curiosity Has Landed https://www.youtube.com/watch?v=N9hXqzkH7YA

Engage	Students will complete the Do Now at the beginning of class to get them thinking about the take-off/landing process of aircrafts.	**Materials:** • Do Now 

Explore		
Explore	"When we go to the Challenger Learning Center, we are going to be traveling from one of Mars's moons, Phobos, to Mars. Today we will be going through a similar journey with our own Inspiration Rover. Here is a video about landing a rover on Mars. **[show video]** Now for our launch from Phobos to Mars. You've seen spacecrafts take off from Earth. What do you know about it? How does it leave? Could a regular plane go into space? [prompt students to talk about speed] In order to "break free" from something's gravity, it must go faster than the **escape velocity**. The escape velocity of Earth is 25,000 mph. Mars's is 11,000 mph, while Phobos's is about 25 mph, so it is much easier to go to Phobos and take off again from there. Now, our rover has reached the escape velocity and is officially launched to Mars, the next step will be landing. This is challenging because the rover will be going very fast and will need to slow down quickly to be able to land safely. With rovers, this must be programmed/planned ahead of time since no one is in the spacecraft. When rovers have been launched from Earth, because of the distance, there is a radio delay in communication with the rover. By the time Mission Control gets word that the rover has entered the atmosphere, it will have already reached the ground. This means Mission Control must wait anxiously to know whether or not it was	**Materials:** • Method for watching YouTube video https://www.youtube.com/watch?v=N9hXqzkH7YA

	successful. This waiting period is called the '**seven-minutes of terror**.'" The seven minutes of terror refer to the time that the ROV needs to go from full speed to a full stop. Radio delay varies depending on the planets distances from each other, so the signal delay may be much longer than 7 minutes depending on where the ROV is landing.	

Explain		
	"We're going to look into what happens during those 7 minutes of terror, during the **descent** of the spacecraft." [Facilitate jigsaw. Break students into teams of 3 and set multiple copies of each article around the room (or distribute directly to students' desks). 1's go to aerobraking station, 2's go to parachute station, and 3's go to rocket thrusters station—have students distribute themselves evenly.] "In groups, each of you will be responsible for reading an article and learning about one of the section of the landing. Write down notes in your graphic organizer and you will report back to your group. You will be the expert on this for your group, so they are depending on you for high-quality information. Your team will also be finding the velocity of Inspiration Rover as it lands. Each article has the change in velocity of the rover from that section, so don't forget to write that down for your team. Your final task as a team will be to find the final velocity of the rover after it goes through the three steps of landing." [Tip: Break these down into 4-5 steps that you write on the board for students to reference during the activity. This will help strengthen their ability to follow written directions, which is necessary for the Challenger Learning Center mission.]	**Materials:** • Articles printed for Aerobraking, Parachute, and Rocket Thrusters stations—enough of each so that only 2-3 students are reading off one article  Landing on Mars: The Seven Minutes of Terror Initial Rover Velocity: 4200 m/s Aerobraking Parachute Rocket Thrusters Final Velocity =

Elaborate	Students complete jigsaw. Suggested schedule: 5 minutes for students at station, 10 minutes to report back to group and finish calculation. Bring group back together to reflect on activity. Ask students what they thought about the jigsaw activity. What would happen if someone didn't do their job? How might this relate to a crew in space? Crews in spacecrafts usually have one expert on many different topics that they rely on for information. You will see this at the CLC, with each person being on a different team. You will count on each other for information and its important you do your part. The work you did today is related to the work the **NAV team** will be doing at the CLC.	**Materials:** • Jigsaw Graphic Organizer • Calculators available for students who need them
Evaluate	[Distribute "Job Application" to students.] "You will now read more about the roles we mentioned two days ago. These are the teams for the mission tomorrow. Read through the roles silently. Select three teams you are interested in and complete the job application. These will help decide which team you are on during the mission." Complete job application.1	**Materials:** • Expedition Mars Crew Manifest • Job Application

Extensions and Enrichment:

- If time allows, show this 5-min video after going through the process of descent: https://www.youtube.com/watch?v=Ki_Af_o9Q9s
- Students who struggle with math might need more in-depth instruction on what to do with delta v.

Landing on Mars: The Seven Minutes of Terror

The journey to Mars is a long one. Scientists follow the path of the spacecraft carefully to make sure everything is working correctly, but because Mars is so far away from Earth, there is a delay in communication. Scientist call the 7 minutes from the time they know the spacecraft has entered Mars's atmosphere, to the time they know it is safely on the ground, "the seven minutes of terror." During this time, the spacecraft using three main techniques to land: aerobraking, parachutes, and rocket thrusters.

Directions: Have each member of your group complete their section of the graphic organizer to land your spacecraft safely. Then, use your values for Δv to find the **final velocity** of the Inspiration Rover as it lands.

Initial Rover Velocity: **4200 m/s**

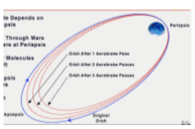
Summarize your section of the landing process. How does it work? Why is this important?

Aerobraking

____
____
____

__________ — __________ = __________

(initial velocity) (Δv1) (aerobrake velocity)



Δv1 from aerobraking: __________

Parachute

____
____
____

__________ — __________ = __________

(aerobrake velocity) (Δv2) (parachute velocity)

Δv2 from a parachute: __________

Rocket Thrusters

____
____
____

__________ — __________ = __________

(parachute velocity) (Δv3) (final velocity)

Δv3 from thrusters: __________

Congratulations! You have found the final velocity of the Inspiration Rover. Your spacecraft has landed successfully on the surface of Mars. It is now ready to help collect data from the red planet.

Name: ______________________________ Class: __________

Do Now

Day 3

Based on what you've experience or seen on TV/movies, describe the process of an airplane taking off and landing.

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Name: ______________________________ Class: __________

Do Now

Day 3

Based on what you've experience or seen on TV/movies, describe the process of an airplane taking off and landing.

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Name: ______________________________ Class: ____________

Exit Ticket

Day 3

In complete sentences, summarize the landing process on Mars.

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Name: ______________________________ Class: ____________

Exit Ticket

Day 3

In complete sentences, summarize the landing process on Mars.

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Rocket Thrusters: The Last Stop

Rocket thrusters help slow the spacecraft by powering the rocket in the opposite direction, taking away some of its falling velocity. This helps slow the spacecraft.

How do you slow a spacecraft down to land on the surface of Mars? Very carefully! The last step in the multistep approach to landing on Mars is using **rocket thrusters**. After the parachute is **deployed**, the rocket turns on the thrusters to slow the spacecraft. By lifting the rocket upwards, it balances out the spacecraft's fall and decreases the velocity. This also stops the spacecraft from spinning, making it a safer landing. This whole landing process is called a **powered descent**.

This chart shows a rover in a powered descent. The final step is using rocket thrusters.

With the creation of every new rover, NASA has to find a way to get the billions of dollars worth of equipment to the surface of Mars safely. Engineers spend years planning and building prototypes of solutions to slow the spacecraft delivering the rover. To successfully land a rover on Mars without damaging any of the sophisticated lab equipment on board, scientists and engineers have developed a multi-step approach.

Slowing down the spacecraft requires a **change in velocity** (v), or speed. In science, change is represented by a delta symbol (Δ), so this is often called **delta v.** The symbol for delta v is Δv.

In the descent of the Inspiration Rover to the red planet, rocket thrusters will provide a 100 m/s change in velocity.

Rocket thrusters – used to move a rocket forward

Deployed – to bring into action and make useable

Powered Descent – a multi-step process that allows a safe landing

Velocity – the speed of something traveling in a given direction

Delta v – a change in velocity

SCIENCE NEWS DAILY

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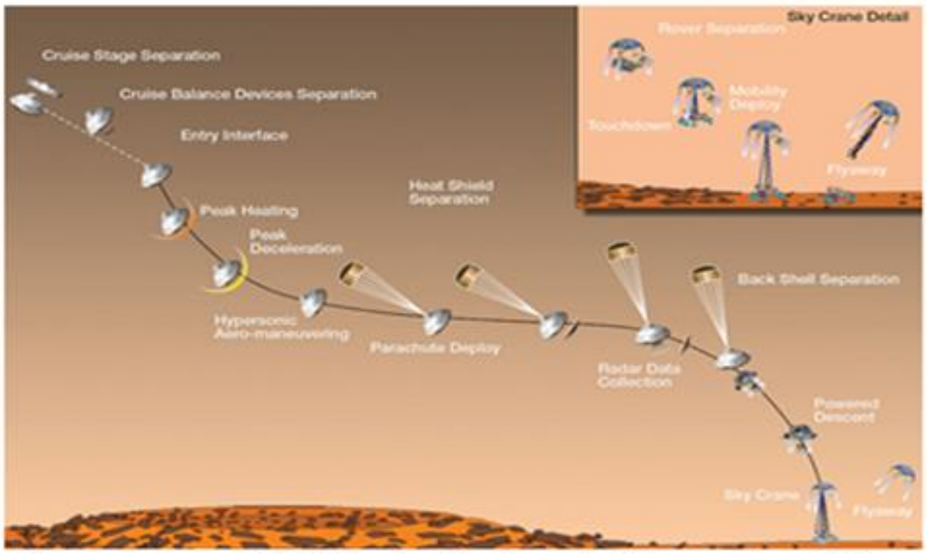
August 2016 | Science News Daily

The Power of the Parachute



The massive parachute helps slow the descent of the rover towards the surface of Mars.

How do you slow a spacecraft down to land on the surface of Mars? Very carefully! Scientists use several steps to ensure a smooth landing. The second step in the process is deploying a large **parachute**. The parachute traps air to create **drag** and slow the **descent** of the rover. Because Mars has a thinner atmosphere than Earth, the parachute must be much larger to catch enough drag to slow it down. Scientists perform many tests to make sure the parachute is perfect before launch.

With the creation of every new rover, NASA has to find a way to get the billions of dollars worth of equipment to the surface of Mars safely. Engineers spend years planning and building prototypes of solutions to slow the spacecraft delivering the rover. To successfully land a rover on Mars without damaging any of the sophisticated lab equipment on board, scientists and engineers have developed a multi-step approach. The slowing occurs through the use of aerobraking, a parachute, and rocket thrusters.

Slowing down the spacecraft requires a change in **velocity** (v), or speed. In science, change is represented by a delta symbol (Δ), so this change in velocity is often called **delta v.** The symbol for delta v is **Δv.**

In the descent of the Inspiration Rover to the red planet the parachute will provide a 350 m/s change in velocity.

A scientist at NASA checks a model of a parachute that is being tested.

Parachute – a cloth canopy that fills with air to slow down a falling object

Descent – the action of moving downward

Drag – something that makes an action or progress slower

Velocity – the speed of something traveling in a given direction

Delta v – a change in velocity

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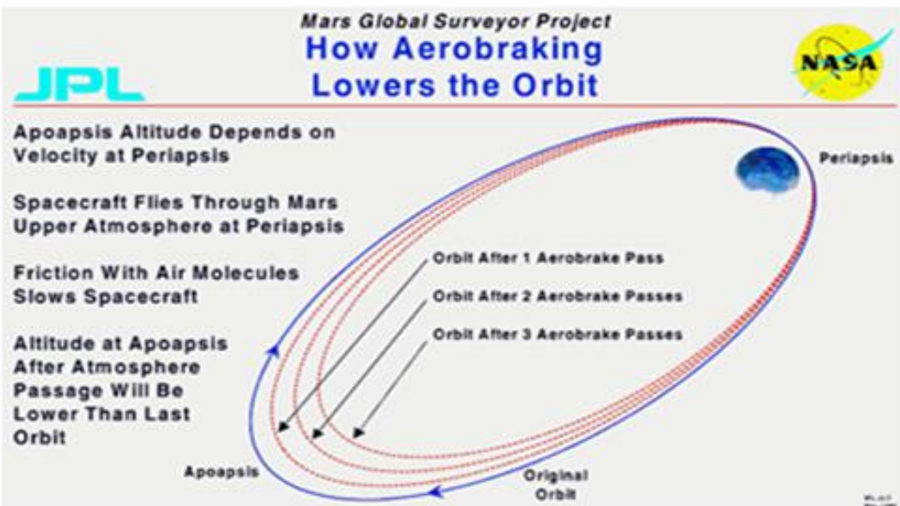
August 2016 Science News Daily

Aerobraking: The First Stop



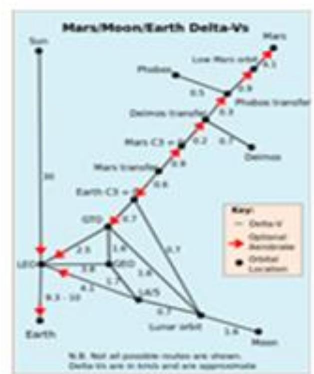
Aerobraking helps slow the spacecraft by entering Mars's atmosphere at the low point (periapsis) of orbit. The drag created helps slow the spacecraft.

How do you slow a spacecraft down to land on the surface of Mars? Very carefully! The first step in the multistep approach to landing on Mars is **aerobraking.** Aerobraking is using a planet's atmosphere to slow down a spacecraft. When the spacecraft hits Mars's atmosphere, the friction will create **drag**, which slows the spacecraft. This happens many times, making a smaller **orbit** each time, until the spacecraft is ready for the next landing phase.

With the creation of every new rover, NASA has to find a way to get the billions of dollars worth of equipment to the surface of Mars safely. Engineers spend years planning and building prototypes of solutions to slow the spacecraft delivering the rover. To successfully land a rover on Mars without damaging any of the sophisticated lab equipment on board, scientists and engineers have developed a multi-step approach. The initial slowing happens through the use of aerobraking.

Slowing down the spacecraft requires a **change in velocity** (v), or speed. In science, change is represented by a delta symbol (Δ), so this is often called **delta v.** The symbol for delta v is **Δv.**

In the descent of the Inspiration Rover to the red planet aerobraking will provide a 3750 m/s change in velocity.



This chart shows the rate of aerobraking and Δv necessary to land on Mars.

Aerobraking – the slowing of a spacecraft by entering a planet's atmosphere to create drag.

Drag – something that makes an action or progress slower

Orbit – the curved path around a planet or other object

Velocity – the speed of something traveling in a given direction

Delta v – a change in velocity

5 DAY TRACK

Expedition Mars – Five Day Track – Day 1 – Earth vs. Mars

Prep Time: 10 minutes	**Lesson Time:** 45 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT explain how characteristics of Mars differ from the characteristics of Earth.

Standards:

- Analyze and interpret data to determine similarities and differences in findings. (MS-ESS1-3)
- The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)
- CCSS.ELA-Literacy.RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
- CCSS.ELA-Literacy.RST.6-8.9: Compare and contrast the information gained from experiments.

Teacher Prep:

- Create a KWL chart and Venn Diagram on chart paper
- Have video cued and ready to play
- Print a copy of the 3-2-1 sheet for each student
- Set up 4 corners game by printing statement cards and labeling corners

Teacher Notes/Background:

- It will be helpful to read through all lesson materials, including handouts, before the lesson begins.
- Students who need extra assistance can be paired during any portion of the lesson. If room does not allow for the 4 corners game, you can modify by printing the 4 options and having individuals or small groups hold up their answer as you read the statements.
- Load the video: How does Mars compare to Earth?
- https://www.youtube.com/watch?v=VvqANiuGcyo

Engage

"Today we are going to talk about Mars to help get us ready for our trip to the Challenger Learning Center. Let's talk about what we already know about Mars…"

Draw a KWL chart on the board or on a piece of chart paper (chart paper preferred so that it can remain in the classroom for reference) Ask students to contribute what they "know" about Mars. Complete the "k" section of the chart. When answers have been exhausted, ask students what they "want" to learn about Mars– complete the "W" section of the chart.

Materials:
- Chart Paper

K	W	L
What we know	What we want to know	What we learned

Explore

"Now that we have some good ideas about what we already know and what we'd like to learn, we're going to watch a short video that highlights the differences between our plant, Earth, and the planet Mars. At the end of the video, you will be writing down 3 things you found interesting, 2 things you learned, and 1 question you still have."

Pass out the 3-2-1 sheet before the video so students can write things down as they watch if desired.
Play the video.

Give students a few minutes after the video to complete the sheet.

Have students share out their 3-2-1 sheets in a turn and talk with a neighbor or small surrounding group. Circulate to check for understanding

Materials:
- Video
- 3-2-1 sheet

3 interesting facts
2 things I learned
1 question I still have

Explain

"We've learned a lot of new facts about Mars already, let's test our knowledge about the differences between Earth and Mars. We're going to play a game called 4 corners. I'll read a fact and you need to safely, with walking feet, travel to the corner that you think the statement belongs to. Our corner choices are Earth, if what I say only happens on Earth; Mars, if what I say only happens on Mars; Both, if it happens on both Earth and Mars; or Neither, if my statement does NOT happen on Earth or Mars"

** Have the Venn Diagram chart posted on the board**

Have students stand behind desks with the chairs pushed in for ease of movement.

Read a statement from the 4 corner cards.

Students will move to the correct corner. If students get and answer incorrect, either have a student at the correct answer share why or read the reasoning on the bottom of the statement card.

After reading each card and having students move, TAPE the statement card to the correct place on the Venn Diagram chart.

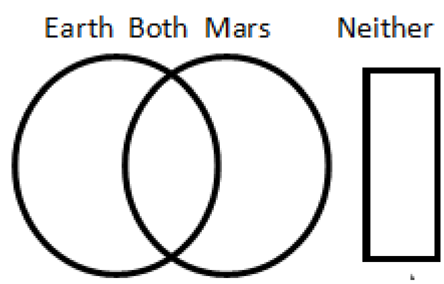
When all cards have been read, gather students to go over the statements that are now recorded in the Venn Diagram.

Check for understanding and answer any questions during this review.

Materials:

- 4 corner statement cards
- [Tip: you may want to put cards in a certain order before starting this lesson to ensure that students are moving around the room]
- 4 corner labels
- Venn Diagram

View of Board or Chart Paper



Elaborate	All these facts we have learned today are going to help us complete our mission at the Challenger Learning Center. When we go, everyone will have a different job to do to help us complete our mission to Mars." During our mission, we will be working together to get to Mars's surface from its moon, Phobos. Read the Mission description to the students: "The year is 2076. A handful of facilities have been established on Mars, including a greenhouse, a mobile geological survey base, and a centralized research habitat. The primary human habitat is not on Mars, but on one of its moons, Phobos. A large shuttle regularly ferries astronauts and scientists between the base on Phobos and the surface of Mars. This shuttle, or Mars Transport Vehicle (MTV), carries parts to build a remotely operated vehicle (ROV) to continue the search for the evidence of life and water. However, when crew members discover an imminent threat to their MTV and the Martian surface facilities, they must act quickly to save their stations, their research, and their lives." Use the PowerPoint to show students each job with its logo and description. This will help them make an informed decision about their job choice. Leave the final summary slide on the screen for students to reference during their job application process or print the summary sheet.	**Materials:** • PowerPoint (can be projected or printed) https://drive.google.com/file/d/1SrM_PcjvydgIN8Uly-8y7bzQIzK4zGRT/view?usp=sharing

Evaluate

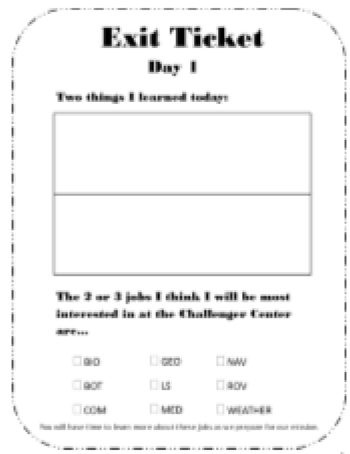
After introducing students to all the possible jobs available during the mission, have them think about which jobs sound the most interesting.

Project or pass out printed copies of the job descriptions summary sheet for students to reference during the exit ticket activity.

Students complete the job application.

Materials:

- Job summary sheet (paper or projected)
- Job applications



Exit Ticket

Day 1

Two things I learned today:

The 2 or 3 jobs I think I will be most interested in at the Challenger Center are...

☐ BIO ☐ GEO ☐ NAV

☐ BOT ☐ LS ☐ ROV

☐ COM ☐ MED ☐ WEATHER

Extensions and Enrichment:

- If more time allows, increase the number of 4 corners cards you use.
- Have students create their own statements to use for the 4 corners game, based on the video or their own research.

Additional Resources:

NASA Earth vs Mars Lesson:

http://www.nasa.gov/offices/education/programs/national/summer/education_resources/earthspacescience_grades7-9/ESS_earth-vs-mars.html#.V7seX4WcE2w

NASA Mars Education Lessons:

https://marsed.mars.asu.edu/stem-lesson-plans

This planet is the fourth from the sun.

Mars

This planet has an average temperature of 57°F.

Earth

The atmosphere on this planet is mostly CO_2.

Mars

This planet has a magnetosphere that protects it from the sun.

Earth

This planet experiences four seasons.

Both

This planet takes 687 days to orbit the sun.

Mars

This planet has a denser atmosphere.

Earth

This planet experiences weather.

Both

This planet contains the highest peak in the galaxy, reaching 13.2 miles above sea level.

Mars

This planet is the smaller of the two planets.

Mars

This planet has polar ice caps.

Both

This planet has a lot of iron in the soil.

Mars

This planet experiences significant dust storms that can last for months.

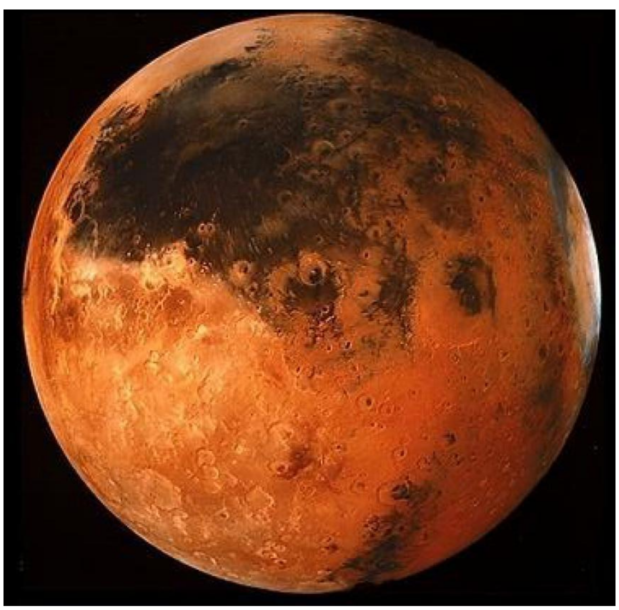
Mars

Little green men live here.

Neither

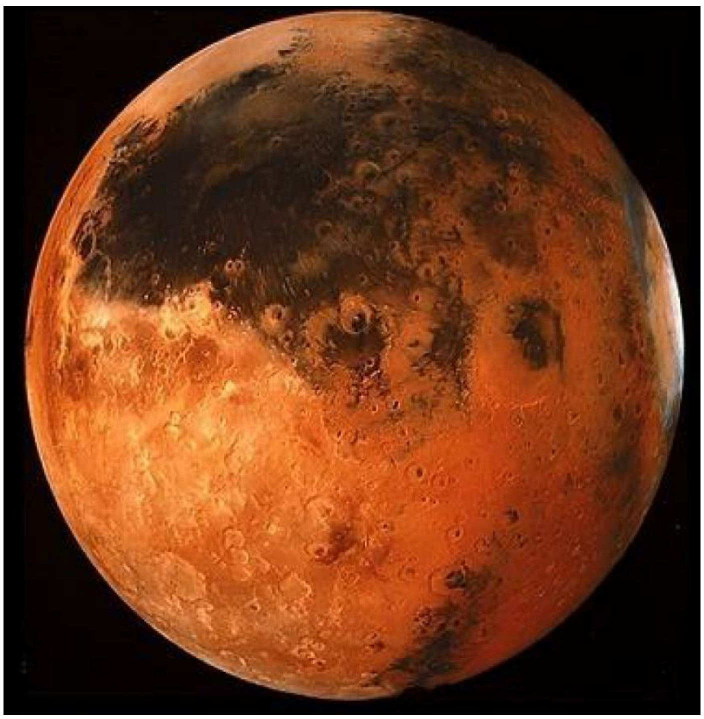
This planet is the farthest known planet from the sun.

Neither



Both

Mars



Earth

Neither

Exit Ticket

Day 1

Two things I learned today:

The 2 or 3 jobs I think I will be most interested in at the Challenger Learning Center are...

- ☐ BIO
- ☐ GEO
- ☐ NAV
- ☐ BOT
- ☐ LS
- ☐ ROV
- ☐ COM
- ☐ MED
- ☐ WX

You will have time to learn more about these jobs as we prepare for our mission.

Expedition Mars – Five Day Track – Day 2 – Extremophiles

Prep Time: 20 minutes	**Lesson Time:** 45 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Learning Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT explain how the existence of extremophiles hints at the possibility of life on Mars.

Standards:

- Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment (MS-LS4-4).

Teacher Prep:

- Create Do Now/Exit Slips
- Print water pictures or put in PowerPoint
- Create enough decks of cards for each group of 2-3 students. Either print on different color paper or differentiate the decks in some way. Put in zip top bag for easy distribution and collection.
- Print enough Put an Extremophile on Mars handouts for class.

Teacher Notes/Background:

- Mars environment cards: https://marsed.mars.asu.edu/sites/default/files/stem_resources/mars-cards.pdf
- Extremophile cards: https://marsed.mars.asu.edu/sites/default/files/stem_resources/cards_0.pdf
- For students who need additional reading support, highlight/underline important information on the cards. The number of options can also be reduced (put in 4 of each instead of 8 of each).
- Load the Video: Why extremophiles bode well for life beyond Earth https://www.youtube.com/watch?v=Bsp5JYNMAQE

Engage	For a warm-up/Do Now, have students list out different things that organisms need to live. Students share out answers, while teacher compiles a list on the board.	**Materials:** • Do Now  Do Now Day 2

Explore	Living organisms need water to live. Some need a lot, some need a little, some need hot water, some need salt water, but all need water. Because of this, evidence of water would prove that life COULD be on Mars. (Show picture of evidence of water on Mars, compared with a similar photo from Earth.) By looking at this picture, we can see that water is present on Mars. This leads us to believe that life at one point, or still today, potentially is on Mars. No life has been found, but this says it **could**. Today will be spent looking at the type of life that **could** live on Mars. As we learned yesterday, there is very little oxygen, low pressures, and extreme temperatures. Because of that, we will be looking at **extremophiles** to see which could live on Mars. Extremophiles are organisms that live in extreme environments. Let's watch a video to explain more about extremophiles.	**Materials:** • Photograph of canyons on Mars and Earth • Video

Explain

Give students attached chart with Earth vs. Mars characteristics as reference sheet. They will also receive two sets of cards: extremophiles (found on Earth) and environments on Mars. In groups of 3, they will select an extremophile that they believe could survive on Mars and a Mars environment in which it could live. They will explain why they chose that extremophile and environment and will present their findings to the class.

Go through one example. Show using the cards.

"This card says that Endoliths do not need a lot of water and can survive in extreme temperatures—very hot and very cold. Let's find an environment on Mars that is similar. The Desert Meridiani Planum does not have a lot of water and has temperatures ranging from very cold to very hot. This would be a good match for the Endoliths."

Materials:

- Earth vs. Mars chart (1 per group)
- Mars Environment cards
- Extremophile cards
- "Put an Extremophile on Mars" handout

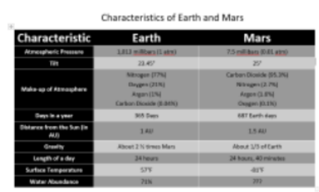
Elaborate

Students work for 10 minutes on this activity. Each group has 1 min to present their findings.

After presentations, reiterate that these extremophiles have not been found on Mars, but since Mars has more extreme conditions, scientists believe these are the key to finding life.

Similar investigations will be done by the **BIO team** during the Challenger Learning Center mission.

Materials:


Characteristics of Earth and Mars

Characteristic	Earth	Mars
Atmospheric Pressure	1,013 millibars (1 atm)	7.5 millibars (0.01 atm)
Tilt	23.45°	25°
Make-up of Atmosphere	Nitrogen (77%) Oxygen (21%) Argon (1%) Carbon Dioxide (0.04%)	Carbon Dioxide (95.3%) Nitrogen (2.7%) Argon (1.6%) Oxygen (0.1%)
Days in a year	365 Days	687 Earth days
Distance from the Sun (in AU)	1 AU	1.5 AU
Gravity	About 2 ½ times Mars	About 1/3 of Earth
Length of a day	24 hours	24 hours, 40 minutes
Surface Temperature	57°F	-81°F
Water Abundance	71%	???


Put an Extremophile on Mars

Directions: Using the cards, select an extremophile that your group thinks could (or could have in the past) survived on Mars. Select a location on Mars where you think it could have lived. Explain your choice and why the extremophile could live in that location.

Your group will share your choice with the class.

Group Members: ____________________

Extremophile: ____________ Mars Location: ____________

In complete sentences, justify your answer. What evidence supports your claim?

Evaluate

Have students turn in an Exit Slip answering the question: "Why are scientists studying extremophiles?"

Materials:

- Exit Slip


Name: ____________ Class: ________

Exit Ticket
Day 2

Why is it important for scientists at NASA to study extremophiles? Write 2-3 complete sentences.

Extensions and Enrichment:
• Students can match the rest of the extremophiles to the Mars environment in which they could live. Students could also create a more formal presentation if time and resources allow.
Additional Resources: Lesson adapted from: https://marsed.mars.asu.edu/content/xtreme-o-philes

Put an Extremophile on Mars

Directions: Using the cards, select an extremophile that your group thinks could (or could have in the past) survived on Mars. Select a location on Mars where you think it could have lived. Explain your choice and why the extremophile could live in that location.

Your group will share your choice with the class.

Group Members: ____

Extremophile: _________________________________ Mars Location: _________________________________

In complete sentences, justify your answer. What evidence supports your claim?

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Characteristic	Earth	Mars
Atmospheric Pressure	1,013 millibars (1 atm)	7.5 millibars (0.01 atm)
Tilt	23.45°	25°
Make-up of Atmosphere	Nitrogen (77%) Oxygen (21%) Argon (1%) Carbon Dioxide (0.04%)	Carbon Dioxide (95.3%) Nitrogen (2.7%) Argon (1.6%) Oxygen (0.1%)
Days in a Year	365 Days	687 Earth days
Distance from the Sun (in AU)	1 AU	1.5 AU
Gravity	About 2 ½ times Mars	About 1/3 of Earth
Length of a Day	24 hours	24 hours, 40 minutes
Surface Temperature	57°F	-81°F
Water Abundance	71%	present

Characteristic	Earth	Mars
Atmospheric Pressure	1,013 millibars (1 atm)	7.5 millibars (0.01 atm)
Tilt	23.45°	25°
Make-up of Atmosphere	Nitrogen (77%) Oxygen (21%) Argon (1%) Carbon Dioxide (0.04%)	Carbon Dioxide (95.3%) Nitrogen (2.7%) Argon (1.6%) Oxygen (0.1%)
Days in a Year	365 Days	687 Earth days
Distance from the Sun (in AU)	1 AU	1.5 AU
Gravity	About 2 ½ times Mars	About 1/3 of Earth
Length of a Day	24 hours	24 hours, 40 minutes
Surface Temperature	57°F	-81°F
Water Abundance	71%	present

Name: ____ Class: ____________

Do Now
Day 2

What do organisms (living things) need to survive? Use humans and plants to help you get started.

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Name: ____ Class: ____________

Do Now
Day 2

What do organisms (living things) need to survive? Use humans and plants to help you get started.

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Name: ____ Class: _____________

Exit Ticket

Day 2

Why is it important for scientists at NASA to study extremophiles? Write 2-3 complete sentences.

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Name: ____ Class: _____________

Exit Ticket

Day 2

Why is it important for scientists at NASA to study extremophiles? Write 2-3 complete sentences.

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Expedition Mars – Five Day Track – Day 3 – The Journey of the Inspiration Rover

Prep Time: 10 minutes	**Lesson Time:** 45 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Learning Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT describe how to take off from and land on Mars.

Standards:

- CCSS.ELA-Literacy.RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both objects have large mass—e.g., Earth and the sun. (MS-PS2-4)

Teacher Prep:

- Print articles (laminate if you want to reuse for class periods)
- Make copies of graphic organizer, Do Now, Crew Manifest/application
- Load video

Teacher Notes/Background:

- Review all pieces of the launch and landing process. The videos can be useful. This is also a helpful animation (Can also be shared with students): http://mars.jpl.nasa.gov/multimedia/interactives/edlcuriosity/index-2.html
- If your class does not evenly split into groups of 3, keep a group or two of 2 and provide them with the article they are missing during the sharing time.
- Load video: Curiosity Has Landed https://www.youtube.com/watch?v=N9hXqzkH7YA

Engage	Students will complete the Do Now at the beginning of class to get them thinking about the take-off/landing process of aircrafts.	**Materials:** • Do Now 

Explore		Materials:
Explore	"When we go to the Challenger Learning Center, we are going to be traveling from one of Mars's moons, Phobos, to Mars. Today we will be going through a similar journey with our own Inspiration Rover. Here is a video with more information about landing a rover on Mars **[show video]** Now for our launch from Phobos to Mars. You've seen spacecrafts take off from Earth. What do you know about it? How does it leave? Could a regular plane go into space? [prompt students to talk about speed] In order to "break free" from something's gravity, it must go faster than the **escape velocity**. The escape velocity of Earth is 25,000 mph. Mars's is 11,000 mph, while Phobos's is about 25 mph, so it is much easier to go to Phobos and take off again from there. Now, our rover has reached the escape velocity and is officially launched to Mars, the next step will be landing. This is challenging because the rover will be going very fast and will need to slow down quickly to be able to land safely. With rovers, this must be programmed/planned ahead of time since no one is in the spacecraft. When rovers have been launched from Earth, because of the distance, there is a radio delay in communication with the rover. By the time Mission Control gets word that the rover has entered the atmosphere, it will have already reached the ground. This means Mission Control must wait anxiously	**Materials:** • Method for watching YouTube video https://www.youtube.com/watch?v=N9hXqzkH7YA

	to know whether or not it was successful. This waiting period is called the ‘**seven-minutes of terror**.’” The seven minutes of terror refer to the time that the ROV needs to go from full speed to a full stop. Radio delay varies depending on the planets distances from each other, so the signal delay may be much longer than 7 minutes depending on where the ROV is landing.	

Explain		
Explain	“We’re going to look into what happens during those 7 minutes of terror, during the **descent** of the spacecraft.” [Facilitate jigsaw. Break students into teams of 3 and set multiple copies of each article around the room (or distribute directly to students’ desks). 1’s go to aerobraking station, 2’s go to parachute station, and 3’s go to rocket thrusters station—have students distribute themselves evenly.] “In groups, each of you will be responsible for reading an article and learning about one of the section of the landing. Write down notes in your graphic organizer and you will report back to your group. You will be the expert on this for your group, so they are depending on you for high-quality information. Your team will also be finding the velocity of Inspiration Rover as it lands. Each article has the change in velocity of the rover from that section, so don’t forget to write that down for your team. Your final task as a team will be to find the final velocity of the rover after it goes through the three steps of landing.” [Tip: Break these down into 4-5 steps that you write on the board for students to reference during the activity. This will help strengthen their ability to follow written directions, which is necessary for the Challenger Learning Center mission.]	**Materials:** • Articles printed for Aerobraking, Parachute, and Rocket Thrusters stations—enough of each so that only 2-3 students are reading off one article 

Elaborate	Students complete jigsaw. Suggested schedule: 5 minutes for students at station, 10 minutes to report back to group and finish calculation. Bring group back together to reflect on activity. Ask students what they thought about the jigsaw activity. What would happen if someone didn't do their job? How might this relate to a crew in space? Crews in spacecrafts usually have one expert on many different topics that they rely on for information. You will see this at the CLC, with each person being on a different team. You will count on each other for information and its important you do your part. The work you did today is related to the work the **NAV team** will be doing at the CLC.	**Materials:** • Jigsaw Graphic Organizer • Calculators available for students who need them
Evaluate	[Distribute "Job Application" to students.] "You will now read more about the roles we mentioned two days ago. These are the teams for the mission tomorrow. Read through the roles silently. Select three teams you are interested in and complete the job application. These will help decide which team you are on during the mission." Complete job application.	**Materials:** • Expedition Mars Crew Manifest • Job Application

Extensions and Enrichment:

- If time allows, show this 5-min video after going through the process of descent: https://www.youtube.com/watch?v=Ki_Af_o9Q9s
- Students who struggle with math might need more in-depth instruction on what to do with delta v.

Landing on Mars: The Seven Minutes of Terror

The journey to Mars is a long one. Scientists follow the path of the spacecraft carefully to make sure everything is working correctly, but because Mars is so far away from Earth, there is a delay in communication. Scientist call the 7 minutes from the time they know the spacecraft has entered Mars's atmosphere, to the time they know it is safely on the ground, "the seven minutes of terror." During this time, the spacecraft using three main techniques to land: aerobraking, parachutes, and rocket thrusters.

Directions: Have each member of your group complete their section of the graphic organizer to land your spacecraft safely. Then, use your values for Δv to find the **final velocity** of the Inspiration Rover as it lands.

Initial Rover Velocity: **4200 m/s**

Summarize your section of the landing process. How does it work? Why is this important?

Aerobraking

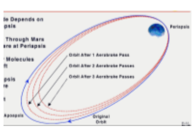
____

____

____

__________ — __________ = __________

(initial velocity) (Δv1) (aerobrake velocity)



Δv1 from aerobraking: ___________

Parachute

____

____

____

__________ — __________ = __________

(aerobrake velocity) (Δv2) (parachute velocity)

Δv2 from a parachute: ___________

Rocket Thrusters

____

____

____

__________ — __________ = __________

(parachute velocity) (Δv3) (final velocity)

Δv3 from thrusters: ___________

Congratulations! You have found the final velocity of the Inspiration Rover. Your spacecraft has landed successfully on the surface of Mars. It is now ready to help collect data from the red planet.

Name: ______________________________________ Class: ___________

Do Now

Day 3

Based on what you've experience or seen on TV/movies, describe the process of an airplane taking off and landing.

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Name: ______________________________________ Class: ___________

Do Now

Day 3

Based on what you've experience or seen on TV/movies, describe the process of an airplane taking off and landing.

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Name: ______________________________________ Class: ___________

Exit Ticket
Day 3

In complete sentences, summarize the landing process on Mars.

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Name: ______________________________________ Class: ___________

Exit Ticket
Day 3

In complete sentences, summarize the landing process on Mars.

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Rocket Thrusters: The Last Stop

Rocket thrusters help slow the spacecraft by powering the rocket in the opposite direction, taking away some of its falling velocity. This helps slow the spacecraft.

How do you slow a spacecraft down to land on the surface of Mars? Very carefully! The last step in the multistep approach to landing on Mars is using **rocket thrusters**. After the parachute is **deployed**, the rocket turns on the thrusters to slow the spacecraft. By lifting the rocket upwards, it balances out the spacecraft's fall and decreases the velocity. This also stops the spacecraft from spinning, making it a safer landing. This whole landing process is called a **powered descent.**

This chart shows a rover in a powered descent. The final step is using rocket thrusters.

With the creation of every new rover, NASA has to find a way to get the billions of dollars worth of equipment to the surface of Mars safely. Engineers spend years planning and building prototypes of solutions to slow the spacecraft delivering the rover. To successfully land a rover on Mars without damaging any of the sophisticated lab equipment on board, scientists and engineers have developed a multi-step approach.

Slowing down the spacecraft requires a **change in velocity** (v), or speed. In science, change is represented by a delta symbol (Δ), so this is often called **delta v.** The symbol for delta v is **Δv.**

In the descent of the Inspiration Rover to the red planet, rocket thrusters will provide a 100 m/s change in velocity.

Rocket thrusters – used to move a rocket forward

Deployed – to bring into action and make useable

Powered Descent – a multi-step process that allows a safe landing

Velocity – the speed of something traveling in a given direction

Delta v – a change in velocity

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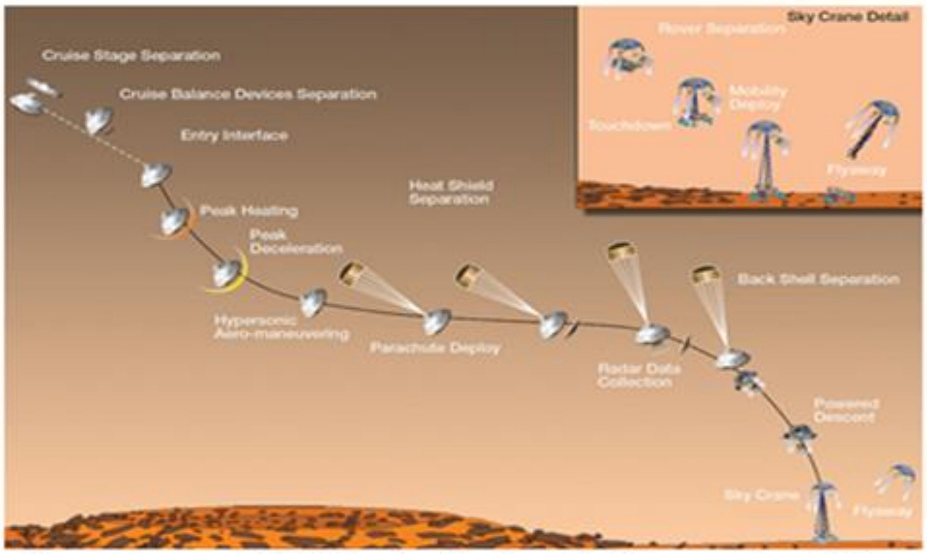
The Power of the Parachute



The massive parachute helps slow the descent of the rover towards the surface of Mars.

How do you slow a spacecraft down to land on the surface of Mars? Very carefully! Scientists use several steps to ensure a smooth landing. The second step in the process is deploying a large **parachute**. The parachute traps air to create **drag** and slow the **descent** of the rover. Because Mars has a thinner atmosphere than Earth, the parachute must be much larger to catch enough drag to slow it down. Scientists perform many tests to make sure the parachute is perfect before launch.

With the creation of every new rover, NASA has to find a way to get the billions of dollars worth of equipment to the surface of Mars safely. Engineers spend years planning and building prototypes of solutions to slow the spacecraft delivering the rover. To successfully land a rover on Mars without damaging any of the sophisticated lab equipment on board, scientists and engineers have developed a multi-step approach. The slowing occurs through the use of aerobraking, a parachute, and rocket thrusters.

A scientist at NASA checks a model of a parachute that is being tested.

Slowing down the spacecraft requires a change in **velocity** (v), or speed. In science, change is represented by a delta symbol (Δ), so this change in velocity is often called **delta v.** The symbol for delta v is **Δv.**

In the descent of the Inspiration Rover to the red planet the parachute will provide a 350 m/s change in velocity.

Parachute – a cloth canopy that fills with air to slow down a falling object

Descent – the action of moving downward

Drag – something that makes an action or progress slower

Velocity – the speed of something traveling in a given direction

Delta v – a change in velocity

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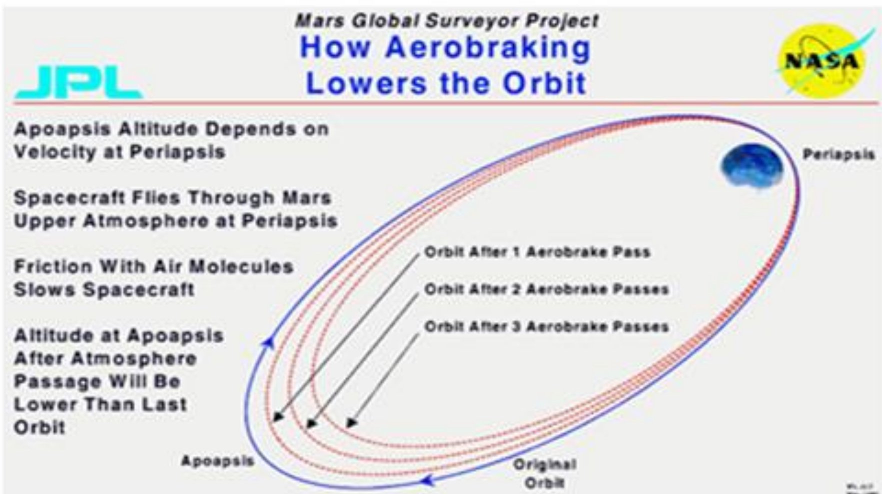
Aerobraking: The First Stop



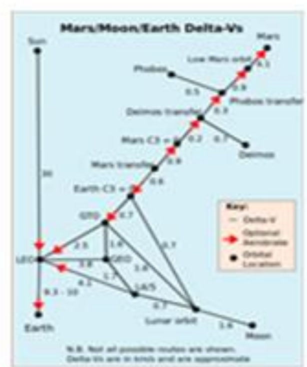
Aerobraking helps slow the spacecraft by entering Mars's atmosphere at the low point (periapsis) of orbit. The drag created helps slow the spacecraft.

How do you slow a spacecraft down to land on the surface of Mars? Very carefully! The first step in the multistep approach to landing on Mars is **aerobraking**. Aerobraking is using a planet's atmosphere to slow down a spacecraft. When the spacecraft hits Mars's atmosphere, the friction will create **drag**, which slows the spacecraft. This happens many times, making a smaller **orbit** each time, until the spacecraft is ready for the next landing phase.

With the creation of every new rover, NASA has to find a way to get the billions of dollars worth of equipment to the surface of Mars safely. Engineers spend years planning and building prototypes of solutions to slow the spacecraft delivering the rover. To successfully land a rover on Mars without damaging any of the sophisticated lab equipment on board, scientists and engineers have developed a multi-step approach. The initial slowing happens through the use of aerobraking.

Slowing down the spacecraft requires a **change in velocity** (v), or speed. In science, change is represented by a delta symbol (Δ), so this is often called **delta v**. The symbol for delta v is **Δv**.

In the descent of the Inspiration Rover to the red planet aerobraking will provide a 3750 m/s change in velocity.



This chart shows the rate of aerobraking and Δv necessary to land on Mars.

Aerobraking – the slowing of a spacecraft by entering a planet's atmosphere to create drag.

Drag – something that makes an action or progress slower

Orbit – the curved path around a planet or other object

Velocity – the speed of something traveling in a given direction

Delta v – a change in velocity

Expedition Mars – Five Day Track – Day 4 – The Geology of Mars

Prep Time: 25 minutes	**Lesson Time:** 45 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Learning Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT identify and analyze evidence of water on Mars.

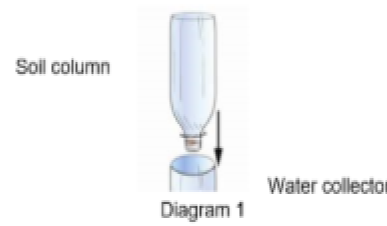
Standards:

- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1)
- CCSS.ELA-Literacy.RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.

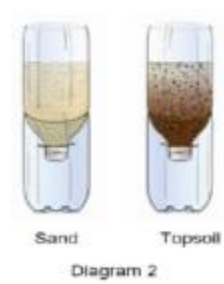
Teacher Prep:

You will need to prepare a bottle for the soil demonstration ahead of time. For this you will need two bottles. You could also use one 2L bottle, but you will need to use less soil.

1. Cut off the base of one bottle to make the container for the soil column.
2. Cut the top off the spout of the other bottle to make a water collector. See Diagram 1.



3. Place a piece of gauze or cheesecloth over the spout of the bottle, securing the cloth with a rubber band.
4. Add the soil or sand to the bottle. You can make one with each and have students compare the result. See Diagram 2.



- You will also need to print the picture cards and the investigation logs for each small group.

Teacher Notes/Background:

- Portions of this lesson were adapted from the NASA Lessons: “What similar physical processes occur on both Earth and Mars?” and “Follow the Water.”
- One theory of the formation of rocky planets like Earth and Mars states that both were formed from the debris of an exploded star that was once near the location of our current Sun. Over a period of millions of years, the debris accumulated into many larger “clumps” of debris that then formed into some of the planets, moons, asteroids, and comets that now make up our present solar system. According to this theory, it would seem logical that since Earth and Mars formed from similar processes, both planets would also have similar features.
- Understanding Mars is an important task because NASA is currently investigating plans that will send the first humans to Mars within the next two decades to explore our planetary neighbor and possible future home for explorers. If this timeline works out, the first persons sent to Mars are in a middle school/junior high school classroom at this time. Could it be one of your students?

Engage	Today we're going to talk about Geology on Mars. Geology is the study of a planet's physical structure and properties. We're going to investigate the rocks on Mars and discover whether Mars has water. Water is a good clue that there are building blocks of life on Mars. Watch the **video**: https://www.youtube.com/watch?v=leNAkb1W4H0 Have students share out one thing they learned in the video. Record answers on the board.	**Materials:** • Video- NASA Now: Geology: Curiosity -- Main Science Goals • Board, dry erase markers

Explore		Materials:
Explore	One of the things that scientists are investigating on Mars is if there is water, or if there has ever been water on Mars. Water is an important building block of life and also can shape the landforms on a planet, so it would be a great clue that life might be able to survive there. Do you think there is, or ever was, water on Mars? Why or why not? [Students may say how there aren't lakes/oceans. Prompt by asking what they DO see? Sand.] Today we're going to look at soil/sand. I'm going to pour 50 mL of water into this bottle of soil/sand. What do you think will happen? Do you think 50 mL will come out the other end? If not, where will it go? Pour 50 mL of water into the container. If doing two bottles, set it up as a race and have the students predict which will come out first and explain why. As it is draining, ask students for observations. Once it goes through, measure the amount of water in the collection cup. Ask a student to come up and tell you how much water is there. Did it all come out? Only some? Knowing this, why do you think scientists are looking at soil on Mars? We know that there are no lakes or oceans on Mars, but we also know that water can be stored underground, so scientists are looking there now. Think about when it rains, a lot of the water gets absorbed into the soil of grass, or when you water a plant, you don't see a pool of water (unless you give it too much), it goes into the soil. Scientists are drilling underground and looking at rock samples to see if they were exposed to water. The geology can be a great tip on whether there was water on Mars. This is related to the work the **GEO team** will do at the Challenger Learning Center.	**Materials:** • 1-2 prepared soil bottles (directions in the prep page) • 50 mL of water for each bottle

Explain	Now that we know how water travels through different types of soil and how it can have stored, let's think about how water can affect physical properties of a planet, such as landforms. The best example of water affecting land on Earth is the Grand Canyon. It was formed over millions of years as water eroded the Earth. Pictures of a planet or landform can tell a lot about the history of that place. We're going to explore a little more into the geology of Mars. You will get 10 pictures—5 from Mars and 5 from Earth. You are going to match a picture from Mars that is similar to a picture from Earth. You will then determine which picture is from which planet.	**Materials:**

Elaborate		Materials:
	This portion of the lesson is adapted from the NASA lesson: What similar physical processes occur on both Earth and Mars? Students will look at several pictures and match the two pictures of similar landforms. One will be a picture from Earth, one from Mars. Pair students or create small groups of 3-4 to complete this activity. Give each grouping a picture card set. Ask students to study the cards and find two cards that they feel go together. Tape or glue them to the Investigation Log (one per group). Have them write 1-2 sentences about what the pictures have in common. Once they've done that, have them predict which photograph is Mars and which is Earth. Go through one example—Figure 1 pairs with Figure 2. Show students the similarities and write Mars on Figure 1 (Olympus Mons, Mars) and Earth (Island of Maui) on Figure 2. After students have completed the activity, have each small group share one of their picture matches if time allows. If you are running short on time, give students the answers to the matches. **Students should match the figures as indicated below**: • Figure 3—Arres Valles "Twin Peaks," Mars Figure 7—Lavic Lake Desert, Earth Wind erosion are important in arid (dry) environments. There is little vegetation to hold material down, so wind action causes most erosion. • Figure 4—Yuty Crater, Mars Figure 6—Meteor Crater, Earth Meteor impacts produce unique landforms on both Earth and Mars. Vegetation obscures some craters on Earth. • Figure 5—Warrego Valles, Mars Figure 11—Yemen, Earth	• Picture cards (1 set per group) • Investigation Log (1 per group) • Tape/Glue

	Running water produces the distinctive branching pattern of streams evident in both images. Yemen, like Mars, was once a much wetter environment than it is today. • Figure 8—Grand Canyon, Earth Figure 9—South Candor Chasma, Mars Running water can be powerful enough to create canyons. The processes illustrated in these images though producing the same result, may not be the same.	
Evaluate	Why is studying the geology of a planet important for learning about it? As we have learned, water can play an important role in how many physical properties, such as landforms, occur on Earth. Why is water on Mars significant? Recap that water is also a building block of life as we know it and is a good clue that life COULD exist on Mars, either in the past or now. Have students complete the exit ticket.	**Materials:** • Exit Ticket 

Extensions and Enrichment:

Students can explore more about Geology on Mars, play games, and learn about the Mars rover here
http://www.nasa.gov/audience/forstudents/5-8/index.html

Additional Resources:

Links the full lessons adapted for this lesson:

http://www.missiongeography.org/II-2-3.pdf

https://www.nasa.gov/pdf/168049main_Follow_the_Water.pdf

The video can be found at:
https://www.youtube.com/watch?v=leNAkb1W4H0

Exit Ticket

Day 4

Two things I learned today:

Why is finding water on Mars significant?

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EARTH AND MARS: IT'S A MATCH!

Directions: Pick two pictures that have similar characteristics. Attach them in the boxes and circle whether you think it is from Mars or Earth. Then, answer the questions about the pair.

Mars or Earth Mars or Earth

What are the similarities between these images?

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____

How do you think these were formed? (Water, wind, meteor, etc.) Why?

____

____

Mars or Earth Mars or Earth

What are the similarities between these images?

____

____

How do you think these were formed? (Water, wind, meteor, etc.) Why?

____

____

Lesson adapted from http://www.missiongeography.org/II-2-3.pdf.

EARTH AND MARS: IT'S A MATCH!

Mars or Earth   Mars or Earth

What are the similarities between these images?

____

____

How do you think these were formed? (Water, wind, meteor, etc.) Why?

____

____

Mars or Earth   Mars or Earth

What are the similarities between these images?

____

____

How do you think these were formed? (Water, wind, meteor, etc.) Why?

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Lesson adapted from http://www.missiongeography.org/II-2-3.pdf.

EXAMPLE MATCH

Figure 1

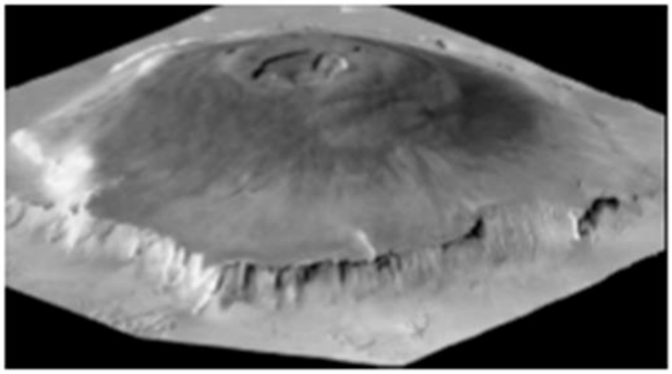

Figure 2

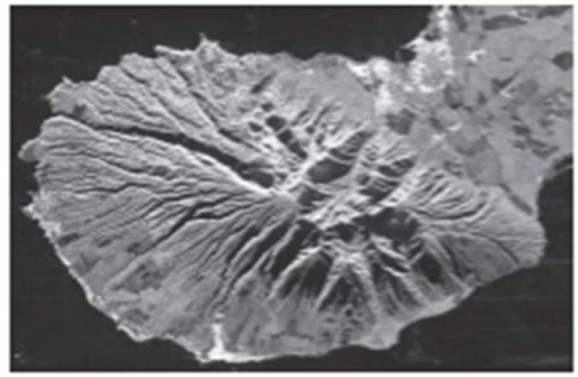

Figure 1 (Mars) and Figure 2 (Earth) are a match. They both mountains, with a volcano and cliffs. They are probably formed by volcanic activity and erosion.

Lesson adapted from http://www.missiongeography.org/II-2-3.pdf.

STUDENT CARDS

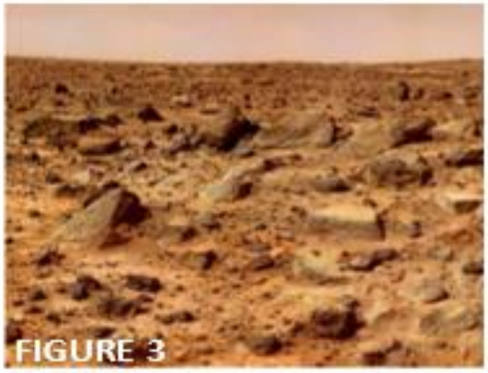
FIGURE 3

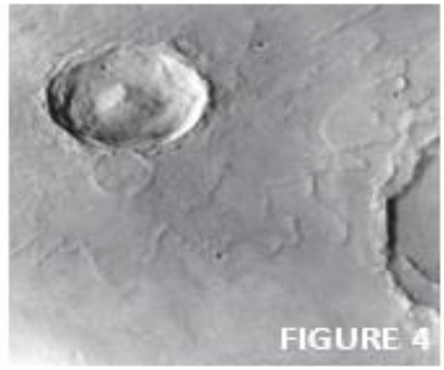
FIGURE 4

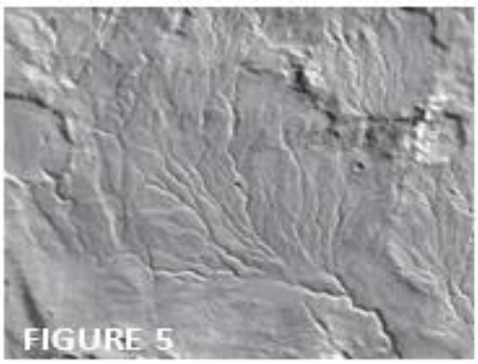
FIGURE 5


FIGURE 6


FIGURE 7


FIGURE 8

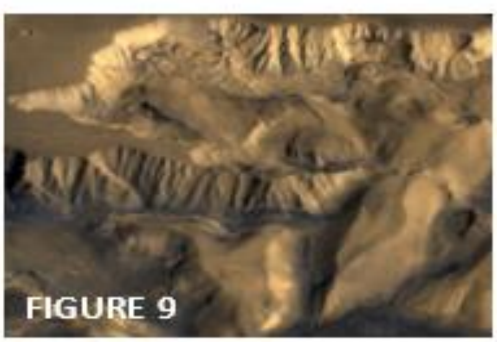
FIGURE 9

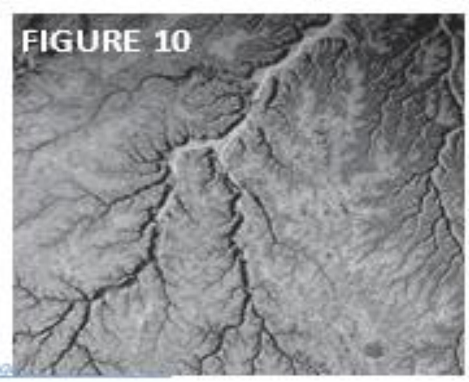
FIGURE 10

Lesson adapted from http://www.missiongeog

Day Five Lessons

Please note that there are 2 choices for day 5:

Lesson 5a - requires a 60-minute class period. This lesson features hands-on learning stations. These stations require teacher preparation and materials.

Lesson 5b - requires a 45-minute class period. Students will be participating in a space habitat design challenge.

Expedition Mars – Five Day Track – Day 5a – Human Bodies on Mars

Prep Time: 30 minutes	**Lesson Time:** 55 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Learning Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT use their knowledge of the effects of Mars on humans to design a safe space station to support human life on Mars.

Standards:

- 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. (3-5-ETS1-3)

Teacher Prep:
Print copies of Lab Observation Sheet, Do Nows, Job Descriptions, and Job Applications.
Prepare all stations:

Sponge Spine:

1. Cut a dry sponge into three pieces, 1-2 in. squares and use a hole-puncher to put a circular hole in the middle.
2. On your pipe cleaner alternate pieces of sponge and wooden spool.
3. Use pipe cleaner to add arms and legs to the spine.
4. Make sure you leave space at the bottom between the “spine” and “legs” for then the spine expands.
5. Have a container of water ready for the demonstration.

Station 1—Beans in Space:

1. Line two coffee cans (or another opaque container) with padding materials, such as newspaper or packing peanuts. This will keep the beans from rattling.
2. Label one can “EARTH” and pour 3 cups of dried beans into it. Add more packing if needed to prevent rattling.
3. Label the other can “MARS” and pour 1 cup of dried beans into it. Add more packing if needed to prevent rattling.

(Note: You can increase or decrease the amount of beans in each one but keep the 3:1 weight ratio.)

4. Tape lids on to secure both.

Station 2—Measuring Up:

1. Cut enough string for all student pairs to use one, at least 1-foot long.

(Note: The length is not important, so you can cut a model string and have pairs cut their own at the station.)

Station 3—Bones:

1. Get enough Styrofoam cups for each pair to have.
2. Label half “EARTH (or BONE ON EARTH)” and poke 5 holes around the sides using a sharp pencil.
3. Label the other half “MARS (or BONE ON MARS)” and poke ~25 holes around the sides.

Teacher Notes/Background:
You will be doing a demo of an experiment at the beginning of this lesson. It is necessary to read through and prepare this lesson in advance.

You will also be setting up 3 stations in your room. You will need to plan some space for students to move around the room, as well.

This lesson cannot be done in full in 45 minutes. If needed, cut the initial Sponge-Spine demonstration to allow enough time for students to pick Mission roles. **This is related to the MED and Life Support (LS) teams for the CLC Mission.**

Engage	What would happen to your body on Mars? Today we're going to explore how our bodies would react to being on the red planet. What do we know about Mars? How does the gravity on Mars compare to the gravity on Earth? We talked on Day 1 about how you would weigh less on Mars, but would your height change? Why or why not? Here we have a model of a human. This is the spine on Earth; the sponges are the discs and wooden spools are the vertebrae. On Earth, our bodies are always experience gravity. It is constantly pulling us down towards the Earth. Let's compare Earth to Mars. [Measure the "spine" or ask for students to help.] When we are on Mars, our bodies no longer experience the same gravity as on Earth. In space we experience microgravity. This means there is less gravity pushing down on us. Let's see what happens if there is less gravity pushing on us. This pool of water will represent space/Mars. [Put the spine model into the water. Allow a minute for the sponges to absorb water. Pull it out and measure the "spine" again. It should have expanded.] This is how our bodies would react on Mars where there is less gravity then on Earth. So, what would happen to your height on Mars? If your spine gets longer, what do you think would happen? We're going to try a few more experiments to help us learn about our bodies in space. Explain the stations students will be rotating though (explanations and directions below). Break students in to 3 groups. You may choose to partner students within the 3 groups. Send students to stations. Rotate every 7 minutes.	**Materials:** • Sponge-spine model • Container of water • Lab Observation Packet • Ruler

Explore

Students will be rotating through 4 stations:

Station 1 - Beans in Space

Students will do 20 curls with each of the containers and compare which used more effort and helped build muscles faster.

** Students will be testing out how much more you need to exercise to get a workout in space because of the lower gravity.

Station 2– Measuring up

Measure the same changes that astronauts experience in space. Each pair of students will take turns with the following steps:

While they are standing up, wrap the string once around your partner's ankle. Make a mark where the end of the string comes back into contact with the rest of the string. Measure the distance from the end of the string to the mark and record your measurement.

Have your partner lay on the floor near a wall with his or her legs in the air leaning against the wall for one minute. After one minute, measure his or her ankle again — while his or her legs still are propped against the wall —with a different color, and record that measurement. Be sure to measure the ankle at the same place.

What do you notice? Predict why that might happen, based on what you know about gravity and blood flow.

Station 3- Bones

Compare the models of the bone on Earth with the bone in space.

Stand each of the "bones" (cups) upright on a flat surface.

Place your hand, palm down, on top of the Earth

Materials:

- Two cans labeled EARTH and MARS. (See "Prep" for instructions on making these)
- Lab Sheet
- Lab Station Directions

Measuring up:

For each group of 2 children you will need:

- 2 different colors of markers
- 1 (12–18-inch) length of string that will not stretch
- A writing utensil and scrap paper
- Timer or watch

Bones:

- Styrofoam cups labeled EARTH and MARS

	bone. Gently press down and observe whether it is difficult or easy to crumple. Gently press down on the "space bone" and observe how difficult or easy it is to crumple. What do they notice? Predict why you think that happened	

Explain	**Debrief on stations** Gather students back together as a whole group. Discuss each of the centers, what happened at each and the key takeaway from each station. A thorough explanation is listed for each station. Use as much of this as you see fit with your students. **Station 1—Beans in Space** On Mars (a microgravity environment), astronauts' muscles **become smaller and weaker because** their muscles don't have to work hard to lift their bodies or the equipment that the astronauts use. In space, where there is no gravity for their muscles to pull against, their muscles become weaker. Imagine if all you had to lift was something as heavy as the MARS can of beans. Astronauts work out almost two hours every day while they are in space and even *then,* they *still* lose muscle mass. Kids and adults on Earth also lose muscle mass if we don't exercise enough! There are many challenges astronauts face as they live and work in space. Daily life in space is different than life on Earth, but in both environments, humans have the same basic needs. **Station 2—Measuring Up** Note: It will be challenging for students to make the connection on their own, so you may just have to explain this one to them. Blood and water are constantly circulating throughout the body. You don't feel it, but on Earth gravity is pulling your blood down. When there is less gravity, like on Mars, fluids, like blood and water in your body, float. They aren't getting pushed down anymore so they will move higher up in your body. This is why when astronauts first get to space the top half of their body will look bigger and their face will look puffy, while their legs and ankles will be smaller. This is what happened to your ankles in this station. The blood left your ankles and they got smaller.	**Materials:**

	Their body will go back to normal when they return to Earth. **Station 3– Bones** **Explain that in space (a microgravity environment), astronauts' bones become weak.** Their muscles don't have to work as hard, and the muscles don't have to pull as hard on the bones to support the astronauts' bodies, just like we learned in the CAN Station. The "space bone" hadn't gotten enough exercise, and it lost minerals and became weak. Astronauts must exercise almost two hours each day and get a diet rich in calcium to help keep their bones from getting too weak until they return to Earth. It is important to emphasize that being in space does not put holes in your bones. This activity uses models of bones (cups) to demonstrate the effects of mineral loss in bones as a result of being in space. The "bone" (cup) with more holes models a bone that is less healthy than the "bone" (cup) with fewer holes.	
Elaborate	Now that we know about how Mars affects humans, other living items, how it compares to Earth, how to launch and land a rover, and how to search for water—we are ready for our mission at the Challenger Learning Center. The last step is to pick your role on the Mission Crew. Let's review the roles we talked about on the first day.	**Materials:** • Crew Manifest
Evaluate	Students will turn in their Job Application	**Materials:** • Job Application

Extensions and Enrichment:

- Students can research more about humans in space. Create a poster or Power Point presentation to share with younger grades or community members during a science night or fair.
- Students can create their own habitat for Mars that would include ways for astronauts to keep their bodies healthy.
- Students can create a Healthy Human plan to combat the effects of Mars.

Additional Resources:

Parts of this lesson are adapted from The Lunar and Planetary Institute *Health in Space*

http://www.lpi.usra.edu/education/explore/space_health/space_stations/

Name: ____ Class: ____________

Do Now
Day 5

What do you think happens to your height on Mars? Do you grow, shrink, or stay the same? Explain your answer.

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Name: ____ Class: ____________

Do Now
Day 5

What do you think happens to your height on Mars? Do you grow, shrink, or stay the same? Explain your answer.

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Beans in Space

Do 20 curls with Earth container. Record the effort it took.

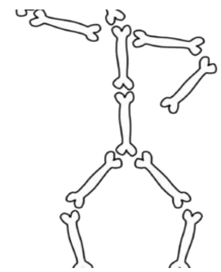
Do 20 curls with Mars container. Record the effort it took.

Compare which used more effort and helped build muscles faster.

Bones!

Compare the models of the bone on Earth with the bone in space.

- Stand each of the "bones" (cups) upright on a flat surface.
- Place your hand, palm down, on top of the Earth bone. Gently press down and observe whether it is difficult or easy to crumple.



- Gently press down on the "space bone" and observe how difficult or easy it is to crumple.
- What do you notice? Why do you think that happened?

Measure Up

Measure the same changes that astronauts experience in space.

- While they are standing up, wrap the string once around your partner's ankle. Make a mark where the end of the string comes back into contact with the rest of the string. Measure the distance from the end of the string to the mark and record your measurement.
- Have your partner lay on the floor near a wall with his or her legs in the air leaning against the wall for one minute. After one minute, measure his or her ankle again — while his or her legs still are propped against the wall —with a different color, and record that measurement. Be sure to measure the ankle at the same place.

Name ____

Bodies in Space Lab Sheet

Directions: Record what happens at each station in the correct box below.

Remember, scientists write down information, so they can share it with others. You will need to share your results with the class. At the Challenger Learning Center, you will need these recording skills to complete your mission successfully!

Beans in Space

Directions: Do 20 curls with the Earth can. Then, do 20 curls with the Mars can. Which one took more effort? Why?

Measuring Up

Directions: Follow the center directions to measure your partner. What happened? Why? Hint: Think about gravity and blood flow.

Bones

Directions: Put your hand flat on the top of the cup and gently push down. What happens? Why?

Earth:

Mars:

Keeping Your Body Healthy on Mars

Write about an activity you could do to maintain a healthy body while living on Mars.

Quick Sketch– Draw and label how your activity keeps a human body healthy on Mars.

Expedition Mars – Five Day Track – Day 5b – Living in Space

Prep Time: 20 minutes	**Lesson Time:** 45 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Learning Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT use their knowledge of the effects of Mars on humans to design a safe space station to support human life on Mars.

Standards:

- 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. (3-5-ETS1-3)

Teacher Prep:

- Set up the "spine experiment"- build the spine and have a container of water ready.
- Cue up videos.
- Print copies of "Create a Space Habitat," Mission Role Sheet, Job Application, and Do Now.

Teacher Notes/Background:

- This lesson can easily be adapted to different class lengths. Choose the number of videos that best fits the length of your class.

Engage		
Engage	What would happen to your body on Mars? Today we're going to explore how our bodies would react to being on the red planet. What do we know about Mars? How does the gravity on Mars compare to the gravity on Earth? We talked on Day 1 about how you would weigh less on Mars, but would your height change? Why or why not? Here we have a model of a human. This is the spine on Earth; the sponges are the discs and wooden spools are the vertebrae. On Earth, our bodies are always experience gravity. It is constantly pulling us down towards the Earth. Let's compare Earth to Mars. [Measure the "spine" or ask for students to help.] When we are on Mars, our bodies no longer experience the same gravity as on Earth. In space we experience microgravity. This means there is less gravity pushing down on us. Let's see what happens if there is less gravity pushing on us. This pool of water will represent space/Mars. [Put the spine model into the water. Allow a minute for the sponges to absorb water. Pull it out and measure the "spine" again. It should have expanded.] This is how our bodies would react on Mars where there is less gravity then on Earth. So, what would happen to your height on Mars? If your spine gets longer, what do you think would happen? Right now, there are astronauts dealing with these effects living on the International Space Station. Astronauts from all over the world go for 6 months at a time to do research and experiments. Let's watch a few videos as a NASA astronaut gives a tour of their home for these months.	**Materials:** • Sponge-spine model • Container of water • Ruler

Explore	Play videos of the different parts of the International Space Station. Play as many or as few as you see fit or have time for. These are in order of interest/importance, with their running time. • https://www.youtube.com/watch?v=tBVUTFPate0_ Explores living on ISS, sleeping quarters, bathroom, food, etc. (8:41) • https://www.youtube.com/watch?v=ntYP7cRozhk_ Tours the laboratory modules, discusses need of exercise (5:10) • https://www.youtube.com/watch?v=jbZ7lDlVelo_ Shows observation window, more exercise equipment, etc. (6:07) • https://www.youtube.com/watch?v=IJT0FMN_Ua0 Tours the Russian segment (the oldest), how the Spacecraft is docked at the ISS (9:39)	**Materials:** • Videos

Explain	"Based on the video and what you have learned about Mars all week, what do you think are the biggest issues for humans in Space, or specifically Mars?" Suggested answers: Low gravity, lack of oxygen, cold, needing to find water and make it safe for humans, no food, getting sick, psychological effects, danger of launching/landing/travel, the unknown—who knows what's out there and what could happen? Radiation hasn't been discussed yet but is an important human risk; without the ionosphere the planet is not protected again radiation from the Sun, this high energy getting into bodies can change your DNA and cause cancer. "What we have studied today is similar to what the **MED and Life Support (LS) teams** will do at the CLC. " "You will be working with a partner to design a space habitat. This will live on Mars and will house astronauts for long periods of time (or forever). You will want to have places in your habitat that addresses those concerns and needs of humans but be creative! This doesn't exist yet, so you can make it whatever you want—as long as it's scientifically accurate!" [Distribute Create a Space Habitat handout. Students work for 10 minutes. If time allows, have them present their habitats or set up a Gallery Walk for students to look at other creations.]	**Materials:** • Create a Space Habitat handout • Markers/Crayons/Colored Pencils
Elaborate	"After talking about Mars for the last 5 days, we are going on our Mission at the Challenger Learning Center tomorrow. As we talked about on the first day, each of you will have an individual role on the Mission team. Let's review the roles again and then you will pick your top three choices and show why you are the best fit for the role."	**Materials:** • Crew Manifest

Evaluate	Students will turn in their Job Application	**Materials:** • Job Application

Extensions and Enrichment:

- Students can research more about humans in space. Create a poster or Power Point presentation to share with younger grades or community members during a science night or fair.
- Students can create a Healthy Human plan to combat the effects of Mars.

Additional Resources:

Parts of this lesson are adapted from The Lunar and Planetary Institute *Health in Space*

http://www.lpi.usra.edu/education/explore/space_health/space_stations/

Name: ______________________________ Class: ____________

Do Now
Day 5

What do you think happens to your height on Mars? Do you grow, shrink, or stay the same? Explain your answer.

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Name: ______________________________ Class: ____________

Do Now
Day 5

What do you think happens to your height on Mars? Do you grow, shrink, or stay the same? Explain your answer.

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Name: ____ Class: _____________

Create a Space Habitat

Your task today is to design a space habitat for the first humans to live on Mars. Make sure you address all the needs of humans and the effects that being in space can have on humans. Be scientifically accurate but be creative. You can draw it from above or make a floorplan or any other way you want to show you creation.

Directions: Draw your space habitat in the space below. Explain four components of the habitat on the back. Label your picture so that when you explain your creation on the back, it is clear what you are referencing.

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(Choose a name for your space habitat)

Scientific Explanation:

In complete sentences, explain at least **FOUR** main components of your space habitat. Why did you create that aspect of the habitat? What human concern were you addressing? Why is it necessary for your space habitat?

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Expedition Mars – Optional – Day 6 – Rover Race

Prep Time: 30 minutes	**Lesson Time:** 45 minutes

Essential Questions:

- What characteristics of the planet Mars are most important to know to be able to successfully complete a Challenger Learning Center mission?
- What would the human experience be on Mars, and how does it affect or limit exploration?

Objectives:

- SWBAT analyze results of a Rover race and improve upon the race.

Standards:

- 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-ETS1-3. 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.

Teacher Prep:

- Print job cards.
- Create groups of 6 (it might help to have them seated together at the beginning to save time).
- Create at least two obstacle courses (same path) and up to the number of groups you have depending on space, using pieces of paper for the boundaries, and cones (or other small items that can be upright). See example.

Teacher Notes/Background:

- This lesson and its resources were adapted from:

  https://www.nasa.gov/pdf/392975main_Rover_Races_Activity.pdf

Engage	Do Now: Write directions from the school to your house. Be specific! Have students share out.	**Materials:** • Do Now  Name: Class: **Do Now** **Day 6** Write directions from the school to your house. You can make a list.
Explore	Imagine you gave those directions to a someone who was delivering something to your house. Do you think they could get there using only your directions with no address? What about if they couldn't contact you along the way? This is how rovers on Mars work. While there are many advantages to using rovers for exploration, just as its helpful to have someone deliver something to your house for you, but there are some drawbacks. Today we will be going investigating more into rovers. Because of the delay in communication in reaching Mars, the mission team will program a series of commands for the rover ahead of time.	**Materials:**

Explain

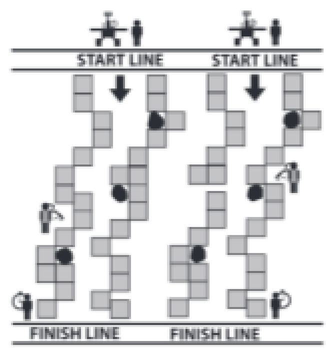
[Separate students into their rover teams.] Your team will be competing against the other teams to win a Rover Race. You will be judged based on your rover's completion of the obstacle course with regards to time, accuracy, and collection of "rocks." The job roles are as follows [put these on the board for their reference]: **1 Rover Driver** (will "program the rover" by going through the obstacle course first, writing directions on the *Command and Information Sheet*, then reading the directions to the Rover), **1 Timer** (will record official start and end time of the rover using a stopwatch), **1 Official** (will record any time either foot of the first Rover Student goes off course/touches a tile for a foot fault on *Official's Record*), **3 Rover Students** (<u>1st Student</u> "steers" the rover using the directions, <u>2nd student</u> carries the "rocks" that are passed to them from 3rd student, and <u>3rd student</u> retrieves the rocks when instructed by sweeping their arm when the Driver says "rock retrieval left/right"). The Rover Students are all blindfolded throughout. The Driver must read the directions **exactly** how they were written.

[Distribute group roles. You can randomly assign roles or select based on student strengths. If assigning, try putting students with different heights as the driver and rover student 1 to highlight the different lengths of a "step" based on strides/height].

Give the Drivers 3 min to go through the course and record their directions on the *Command and Information Sheet.* Remind them to include rock retrievals. While this is happening, have the rest of the team come up with a Rover name. Then, call two Rover teams (or as many groups as courses there are) to do their course. Reiterate their roles and that the Driver cannot change what they wrote down. Even if there is a mistake they must continue on. Set expectations: All other teams must be in a certain location (seated or standing in one place, No Yelling at the Rover and No Touching the Rover. <u>Tell them accuracy, not speed is most important</u>.

Materials:

- Rover Role cards
- Obstacle course
- *Command & Info Sheet*
- *Official's Record*
- Stopwatch (or method for timing)
- Blindfolds for each Rover Student



	The Rover Students should be blindfolded and standing in a line (in order) with hands on each other's shoulders. Once they are ready, the Timer begins the stopwatch, and the Driver can begin reading the directions. Make sure the Official is writing down any foot faults on the *Official's Record*.	
Elaborate	Repeat until all teams have gone. Record results on the board. If you want to pick a winner, consider the rocks collected to "erase" a foot fault, and whichever group has the fewest foot faults wins. Use the fastest time if there is a tie. Give students 3 minutes to complete a quick *Rover Evaluation*. Have students share out things that worked well, things that did not work well, and what they would change if they could go again.	**Materials:** • Rover Evaluation Sheet
Evaluate	Exit Ticket: What do you think is the biggest disadvantage/limitation for using rovers and how can a mission team fix it?	**Materials:** • Exit Ticket

Extensions and Enrichment:

- If time allows, give the teams a second chance to go through the course. Give them time to discuss a new strategy and re-run the process again. Allow time for a discussion afterwards about what they improved and how well their changes worked. Is there anything they would still change again?

Name: ______________________________ Class: __________

Do Now
Day 6

Write directions from the school to your house. You can make a list.

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Name: ______________________________ Class: __________

Do Now
Day 6

Write directions from the school to your house. You can make a list.

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Name: ______________________________ Class: __________

Exit Ticket

Day 6

What do you think is the biggest limitation (or struggle) of using rovers on Mars? How can a mission team make it better?

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Name: ______________________________ Class: __________

Exit Ticket

Day 6

What do you think is the biggest limitation (or struggle) of using rovers on Mars? How can a mission team make it better?

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Rover Driver

You are responsible for "programming" the Rover. You will go through the course, write the directions for the Rover, and read the directions aloud during the Rover mission.

Rover Official

You are responsible for tracking the accuracy of the Rover. Each time the Rover goes off the course, you will make a record of it. You will also keep track of the Rock Sample retrievals.

Rover Timer

You are responsible for keeping track of the accurate time it takes for the Rover to go from start to finish in the Rover course.

Rover Student 1

You are at the front of the Rover. You are responsible for following the Rover Driver's exact directions to go through the course.

Rover Student 2

You are in the middle of the Rover. You are responsible for keeping the Rover together and storing Rock Samples collecting.

Rover Student 3

You are in the back of the Rover. You are responsible for collecting Rock Samples when the Rover Driver tell you to. When instructed, put your hand down and swipe to be able to pick up a Rock Sample. Then, pass it to Rover Student 2 for storage.

Name: ____ Class: ___________

Rover Race Evaluation and Reflection

1. What are some challenges you and your group experienced during your Rover Race?

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2. What do you think were the potential causes of these challenges?

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3. What would you change in a second drive?

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OFFICIAL'S RECORD

Name of Rover Team Official: ____

Name of Rover Team Driver: ____

Name of Rover Team Timer: ____

Names of Rover Team:

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Directions: As your Rover Team is completing the course, put a tally mark (I I I) every time the first student in the Rover touches a tile.

Total Foot Faults (steps on tiles by first person in the Rover):

Total Time for the Rover Team to Complete the Course: _______________

Total Rock Samples Collected: ___________

Total Rover Team Score (Foot Faults - Rock Samples Collected): _____________

Lesson adapted from ASU Mars Education Program at https://marsed.mars.asu.edu/lesson-plans-rover-races

Rover Driver Command and Information Sheet

Rover Name: ____

Directions:

1. Walk through the Mars surface obstacle course. Write down the commands the rover should follow. Count your steps and be sure to list where the rover needs to make a turn on the course.
2. When the rover is in the correct position to collect a rock, use the command "Rock Sample Retrieval Left/Right" to earn bonus points. The last person in the Rover will pick it up.
3. The rover can only follow your written set of commands. Giving the rover commands that are different than what you have written will result in an automatic disqualification.

Rover Commands:

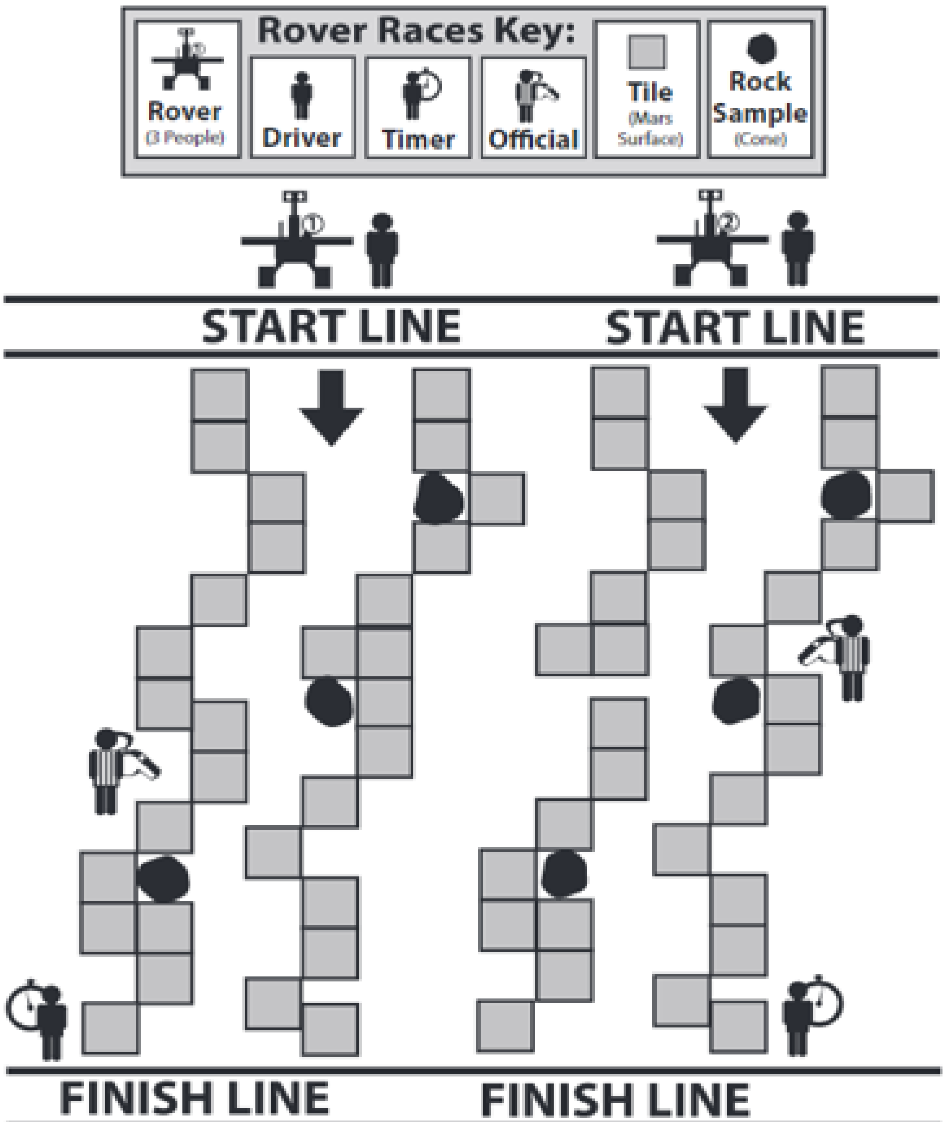
Right (R)	Left (L)
Backward (B)	Forward (F)
Stop (S	Rock Sample Retrieval (RSR) Left or Right

Commands: (Example 1. Forward 3 Steps. Stop. 2. Turn left 1 step. Stop… etc.

1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.
13.	14.
15.	16.
17.	18.
19.	20.

Lesson adapted from ASU Mars Education Program at https://marsed.mars.asu.edu/lesson-plans-rover-races

Sample Rover Course:



Lesson adapted from ASU Mars Education Program at https://marsed.mars.asu.edu/lesson-plans-rover-races.

MISSION

RANK

DATA

SKILLS

Expedition Mars Crew Application

EXPEDITION MARS™

Please review all the avaliable positions and list your top three choices.

1st Choice ______________________________

2nd Choice ______________________________

3rd Choice ______________________________

Personal Data

Last Name______________________________

First Name______________________________

Middle Initial______________________________

Why do you want this position?

What experiences and skills make you the best candidate for this position?

List any interests, hobbies or personal achievements.

List memberships in any organizations or civic clubs. (Girl Scouts, Boy Scouts, Sports Teams, etc)