PHYSICAL SCIENCE

Grades 6-8

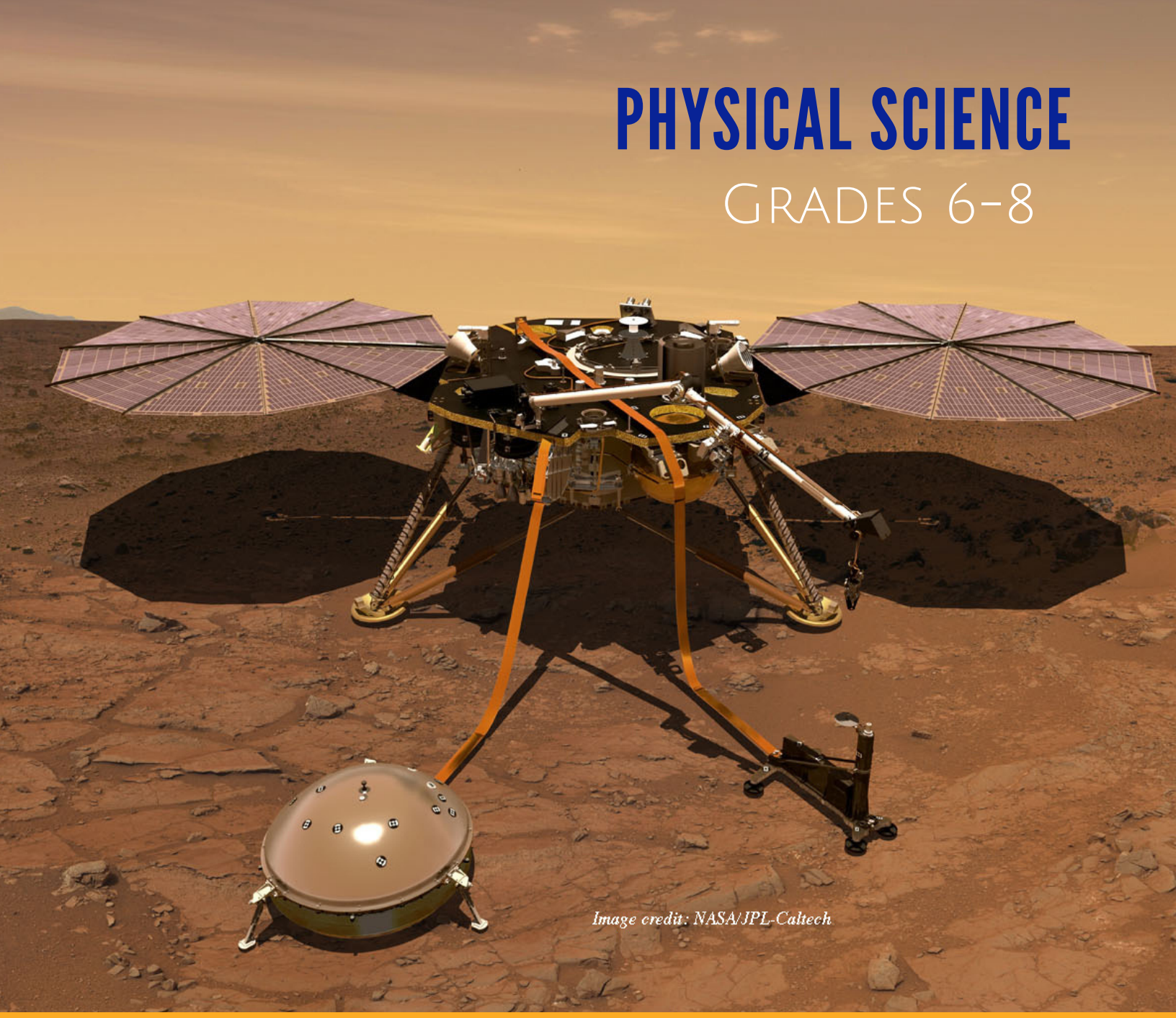
Image credit: NASA/JPL-Caltech

MARS MISSION OPERATIONS MANUAL

MARS BASE EAGLE

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

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

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

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

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

WINGS *of* EAGLES
DISCOVERY CENTER
...imagine the possibilities

MARS BASE EAGLE

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

Mars Base Eagle Missions

Innovative Science Lessons Designed for Middle-level Students

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

Mars Base Eagle Interactive Exhibit at Wings of Eagles Discovery Center

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

Science Standards Alignment

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

Expertise Behind the Mission Ops Manual

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

Contributors Curriculum Design Pilot Program

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

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Physical Science Mission Standards Alignment

MS-PS3-5	Construct, use, and present an argument to support the claim that when work is done on or by a system, the energy of the system changes as energy is transferred to or from the system.

Science and Engineering Practices

Practice 1: Asking Questions and Defining Problems	Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.
Practice 2: Developing and Using Models	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Crosscutting Concepts:

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

Energy and Matter: Energy may take different forms (energy in fields, thermal energy, energy of motion) (MS-PS3-5)

Navigating the Mission

Each lesson in this Mission includes the following components:

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

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

Where applicable, lessons also include:

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

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

Printing the Mission

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

Mission Cumulative Assessment

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

MARS BASE EAGLE MISSION OVERVIEW

PHYSICAL SCIENCE

MARS EXHIBIT CONNECTIONS

Mars Base Eagle Exhibit
at Wings of Eagles Discovery Center

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

ENGAGE

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

- Students collaboratively define "evidence" and "inference."
- Students consider different meanings of the word "energy" and learn what "energy" means in ence.

EXPLORE

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

- Introduce the Mission: If humans colonized Mars, how might they be able to charge personal electronic devices like cell phones?
- Explore wind and solar energy sources, forms, and transformations .

EXPLAIN

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

- Students develop explanations for how conditions on Mars would affect wind and solar energy machines and their effectiveness for transforming energy in wind and sun to electrical energy on Mars.

ELABORATE

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

- Students design plausible solutions for transforming energy from the sun or wind on Mars to electricity for charging an electric personal device like a cell phone on Mars.

EVALUATE

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

- Students evaluate their own and others' design solutions for an electricity solution that takes into account the conditions on Mars.

Navigating and Printing This Mission

Navigating the Mission

Each lesson in this Mission includes the following components:

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

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

Where applicable, lessons also include:

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

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

Printing the Mission

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

Mission Cumulative assessment

Mars Base Eagle Missions include an assessment that was designed, piloted, and refined to assess key understandings related to the learning targets.
The test is included in the pages that follow this description and is followed by an answer key.

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MISSION 1

EVIDENCE VS INFERENCE

MISSION QUESTIONS

- What is the difference between evidence and inference?

LEARNING TARGETS

- I can explain what is happening in a picture using evidence to support my story.
- I can explain the difference between evidence and inference.

Approximate Time Needed: 45-55 min

PREPARATIONS

- Make copies of the Student Spec Sheet Photographs--one photograph per student group.
- **Notice while prepping for this lesson that the focus is only subtly about Mars at this point; Mars environmental conditions are only introduced after a "need-to-know" is established.**

MATERIALS

- **Sticky notes and one Student Spec Sheet Photograph for each student group (3-4 students/group)**
- **Chart paper for each student group to record notes about the photos in two columns: "What you see" and "What you think."**
- **Individual science journals for each student (optional)**

MISSION BRIEF

1. To start the Mission, engage student groups in observing and thinking about one assigned Student Spec Sheet Photo. Elicit and connect students' prior knowledge with probing questions, including:
• What do you recognize in the photo? What don't you recognize in the photo? What can you actually see with your eyes, looking at the photo?
• What do you think or guess is happening in the photo, and what makes you think that?
Students work in small groups, with each student writing ideas on on sticky notes.

2. Direct each student group to make a chart that is divided in two columns: "What you see" and "What you think." Every student group member needs to post at least one sticky note in each column.

3. Explain that each student group will now create a story about the photo, using a minimum of 3 pieces of supporting evidence observed in the photo.

4. Have student groups share their stories, and follow up with questions about what evidence and reasoning were used in developing the stories.

5. Facilitate a whole-class discussion, using examples from students stories to define "evidence" and "inference."

6. Conclude this lesson with a brief description of this Mars Mission and an explanation for how evidence-based inferences will be a critical component of their work.

Exit Slip: Why is evidence and inference important when we conduct science investigations?

TEACHING PROMPTS

1. Create student groups by counting off by 3's or 4's or use a similar grouping strategy. To start the Mission, engage student groups in observing and thinking about one assigned *Student Spec Sheet Photo*. Elicit and connect students' prior knowledge with probing questions, including:

• What do you recognize in the photo? What don't you recognize in the photo? What can you actually see with your eyes, looking at the photo?

• What do you think or guess is happening in the photo, and what makes you think that?

2. In their assigned groups, observing their assigned photo, students will record ideas on sticky notes that will be posted in one of 2 columns labeled "*What you see*" and "*What you Think*" on a group chart paper. Each student will need to put at least 1 sticky note in each column (-5minutes).

3. Each group member will then do a share-out with the group with what they could see and what they think is going on and why.

4. Groups will then have to create a story about the photo with supporting evidence from the photo (-5-10 minutes).

5. Project or show a copy of the photo from each group as they share their story with the entire class. Ask group members to elaborate on their stories in response to questions like: *How did your group decide on the story for that picture? What evidence did they use from the photo?*

6. Facilitae a class discussion about how *what can we see* in the photos (evidence) influences our inferences. Prompt students to create a list of what else (in addition to what is directly observable) can affect *what we infer*.

1. How would we define evidence? Generate a class definition—anything we see, hear, touch, smell, measure, or count that is helpful in forming a conclusion.

8. Prompt the lesson's driving question: ***What is the difference between evidence and inference?*** Facilitate a whole-class discussion about which column on their chart paper (***What we see*** vs. ***What we think***) could be accurately labeled ***evidence*** and ***inference***.

> Hold a whole-class discussion to generate a class definition for *evidence*— and *inference*—a conclusion or opinion that is reasoned from facts and evidence we think we know.

9. Explain to students your expectations for organizing and taking notes, observations, definitions during this Mission. If you opt for having students keep science journals, this is the time to introduce how they are a tool for keeping track and referring to

information. You may choose to have students transfer the information recorded on groups' chart paper into their journals.

Record for the class and/or have students individually write the class definitions in their science journals for future use.

10. Conclude the discussion with what the unit is about: You will investigate some of the ways that we get energy through electricity on Earth and also gather evidence about what human life on Mars may look like, so that you can design a power source for charging personal devices like cell phones on Mars.

Reflection prompt/exit slip: Why is evidence and inference important when we conduct science investigations?

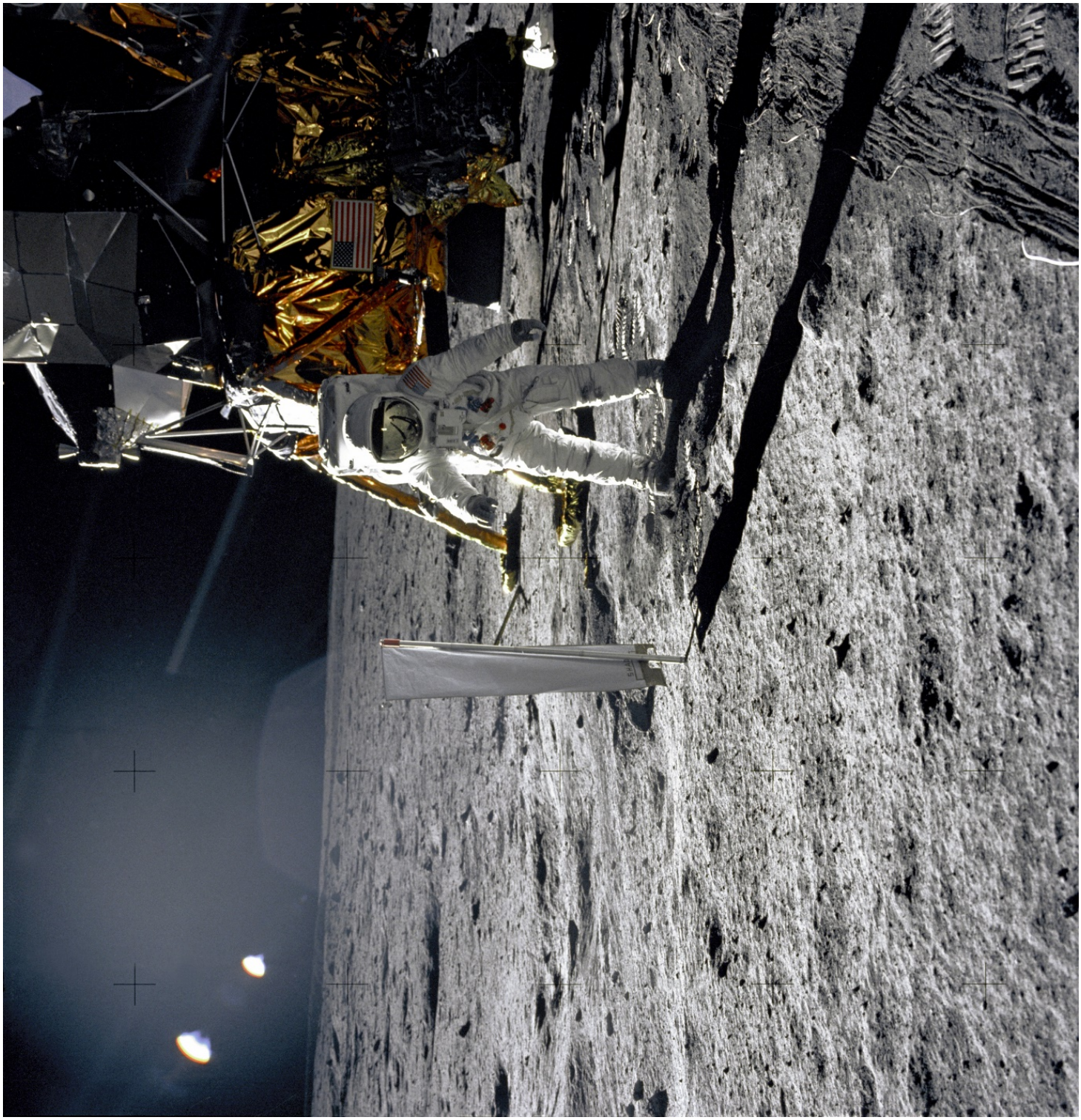
TEACHER SPEC SHEET

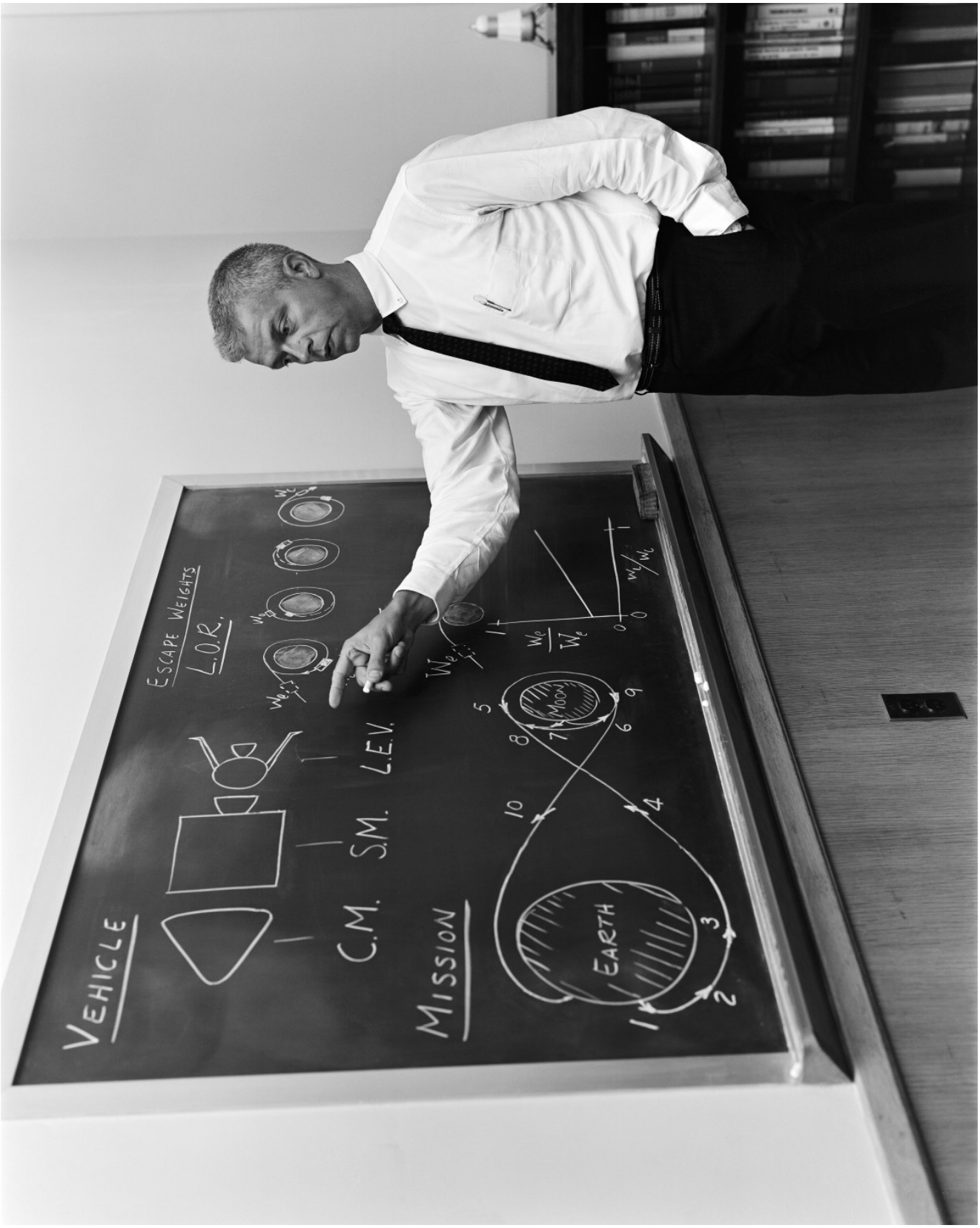
MISSION 1 PHOTOGRAPH INFORMATION & SOURCES

	This view of the Space Shuttle Atlantis still connected to Russia's Mir Space Station was photographed by the Mir-19 crew on July 4, 1995. Cosmonauts Anatoliy Y. Solovyev and Nikolai M. Budarin, Mir-19 Commander and Flight Engineer, respectively, temporarily undocked the Soyuz spacecraft from the cluster of Mir elements to perform a brief fly-around. They took pictures while the STS-71 crew, with Mir-18's three crew members aboard, undocked Atlantis for the completion of this leg of the joint activities. Solovyev and Budarin had been taxied to the Mir Space Station by the STS-71 ascent trip of Atlantis. https://www.flickr.com/photos/nasacommons/9461048636/in/photostream/
	Pathfinder photographed the Martian surface and the Sojourner Rover during its mission in 1997. In the picture, the rover is taking a APXS measurement of Yogi rock on Sol 17-18 of the mission. Image #: 81696 Date: July 21, 1997 https://www.flickr.com/photos/nasacommons/18647779303/in/photostream/
	Interior view of a Mobile Quarantine Facility (MQF), showing the Apollo 11 crewmen soon after they arrived at Ellington Air Force Base after a flight from Hawaii aboard a U.S. Air Force C141 jet transport. Neil Armstrong is strumming on a ukelele. Michael Collins (right foreground) and Edwin E. Aldrin Jr. (right background) are looking out the window. The other people in the picture are MQF support personnel. This picture was taken during brief welcome home ceremonies. The crew (and the support staff) remained in quarantine until August 11, 1969. https://www.flickr.com/photos/nasacommons/7944968778/
	After achieving the goal of landing on the moon, the crew of Apollo 11 (Neil Armstrong, Mike Collins and Buzz Aldrin) returned home to Earth on July 24th, 1969. Upon splashing down, the Apollo 11 crew underwent a 21 day quarantine. The purpose of this was to protect against the small possibility of lunar contagion. This procedure was discontinued after Apollo 14. https://www.flickr.com/photos/nasacommons/36003146311/in/photostream/
	Astronaut Edwin E. Aldrin, Jr., Lunar Module pilot, is photographed during the Apollo 11 extravehicular activity (EVA) on the lunar surface. In the right background is the Lunar Module "Eagle." On Aldrin's right is the Solar Wind Composition (SWC) experiment already deployed. This photograph was taken by Neil A. Armstrong with a 70mm lunar surface camera. 1969 https://www.flickr.com/photos/nasacommons/9457418179/in/photostream/
	Astronaut Christopher Cassidy, STS-127 mission specialist, is pictured in the center of this wide shot photographed during Endeavour's third space walk of a scheduled five overall for this flight. Cassidy is near The Japanese Experiment Module - Exposed Facility (JEF.) This was Cassidy's first of a scheduled three sessions for him. Astronaut Dave Wolf, Cassidy's EVA colleague, is out of frame. STS-127 launched on Space Shuttle Endeavor on July 15, 2009. The mission ended on July 31, 2009. Image # : S127-E-007801 Date: July 22, 2009 https://www.flickr.com/photos/nasacommons/19732870479/in/photostream/
	John C. Houbolt at blackboard, showing his space rendezvous concept for lunar landings. Lunar Orbital Rendezvous (LOR) would be used in the Apollo program. Although Houbolt did not invent the idea of LOR, he was the person most responsible for pushing it at NASA. On July 11, 1962, Seamans and NASA Administrator James Webb announced during a press conference that LOR had been chosen as the primary mission mode for manned moon landing. https://www.flickr.com/photos/nasacommons/9460191434/in/photostream/

Summary instructions

Assign one photo per student group. Background information provided here is solely for your use, and optional sharing only AFTER student groups have shared their stories.




VEHICLE
C.M.
S.M.
L.E.V.
ESCAPE WEIGHTS
L.O.R.
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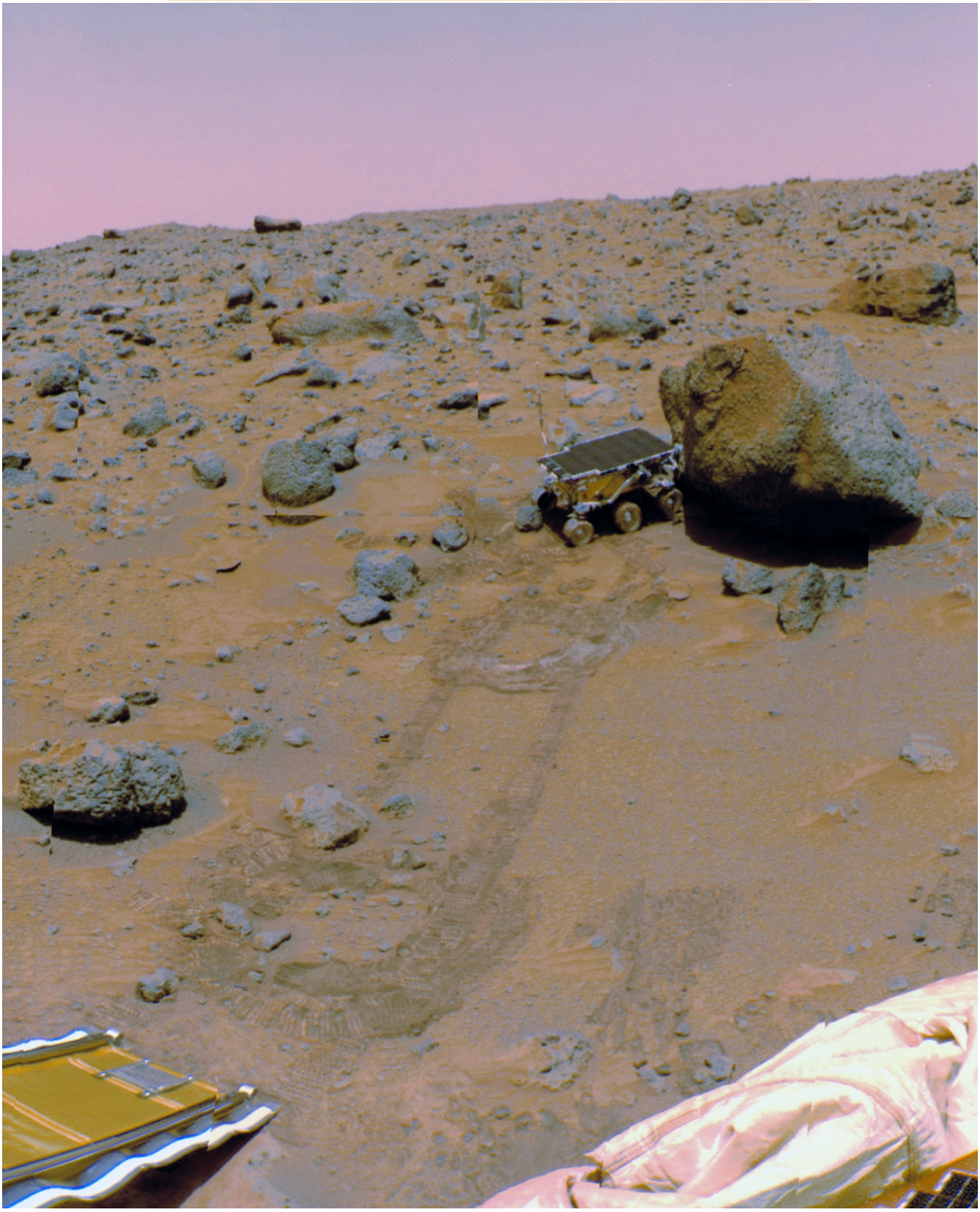
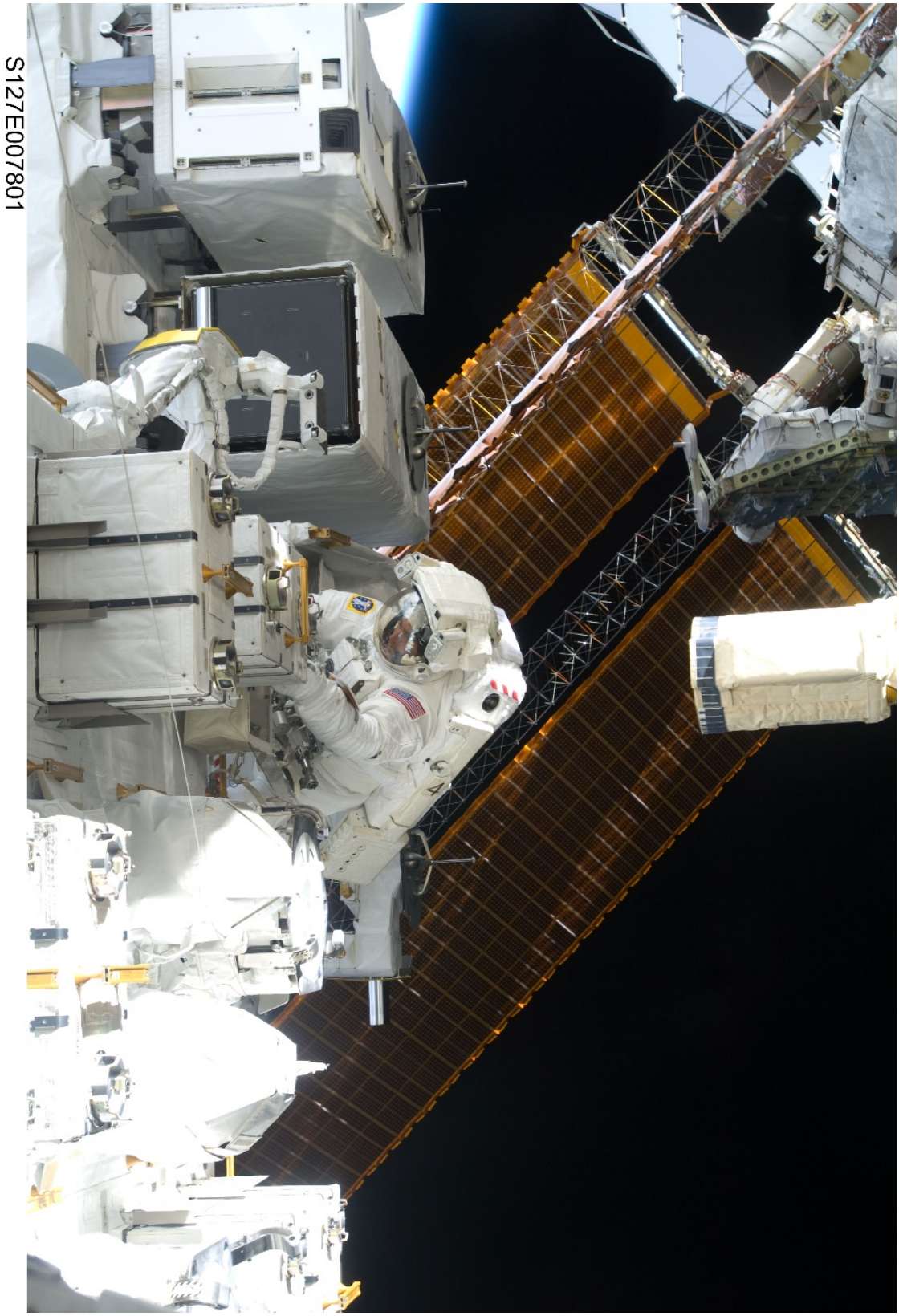
STUDENT SPEC SHEET

MISSION 1



STUDENT SPEC SHEET

MISSION 1



MISSION 2

EXPLORING ENERGY

MISSION QUESTIONS

- How does the use and supply of energy in our classroom compare to that in outer space?
- What is the difference between the meaning of "energy" in every-day use and in science?

LEARNING TARGETS

- I can describe some sources and forms of energy that astronauts use and compare/contrast them to some sources and forms of energy that I use.
- I can explain the differences/similarities between my every-day use of the word "energy" and the meaning of the word "energy" in science.

Approximate Time Needed: 45-55 min

PREPARATIONS

- Make copies of the Student Spec Sheet: Energy in Science--one per student group.
- Arrange for showing the YouTube video tour of the International Space Station or a similar video that shows evidence of energy use by astronauts: **https://youtu.be/SGP6YOPnhe4**

MATERIALS

- Smartboard or projector and screen with Internet/YouTube access to show International Space Station video: https://youtu.be/SGP6YOPnhe4
- 1 copy per student: **Student Spec Sheet: Energy in Science**

MISSION BRIEF

.1. Use a turn-and-talk strategy: one partner explains what evidence is, and the other explains what inference is. Summarize as a class.

2. Introduce how this Mars Misison is about figuring out solutions for getting energy to use on Mars. Have students individually write a brainstorm-list of evidence of energy use in this classroom.

3. Assign students the task of looking for evidence of energy use by astronauts, and show the video tour of the International Space Station.

4. Have students turn-and-talk with their nearby partner: compare the two lists (evidence of energy use in the classroom and energy use by astronauts). Then, hold a whole-class discussion: collect and combine all evidence students observed into two class lists (energy use in the classroom and energy use by astronauts).

5. Use a think-pair-share strategy for students to develop one inference about the energy source for each piece of evidence on the class lists. Then, ask students to further explain their ideas as needed to eliminate any inferences (e.g. electricity is not likely visible evidence, but we can infer its use from evidence).

6. Repeat step #5, now looking for evidence in the International Space Station.

7. Pose the question: How is the way that we talk about energy in every-day life--for example, when we say, "I just don't have the energy to do that!"--different from the way we talk about energy in science?
Hold an interactive discussion to teach students that energy in science can be described as "forms of energy" and "sources of energy." Use *Student Spec Sheet: Energy in Science* to help explain:
- Sources of energy can include a battery (source for electrical energy), the sun (source for energy in light), or windmill (source for electrical or mechanical energy).
- Forms of energy that can be described scientifically include energy of motion (kinetic), heat (thermal), chemical, mechanical energy, and energy in light.
- Scientists adopted the word energy centuries ago to refer to mathematically predictable relationships among measurable energy forms that are useful to do work.

8. Summarize that "Energy" refers to many things in every-day and cultural contexts. In science class, we focus on types of energy and especially energy transformations that are studied in science.

9. Exit slip: **Describe in your own words what energy means in science.**

TEACHING PROMPTS

Transitioning from the introduction to evidence and inference to connecting students use of energy to uses of energy by a NASA astronaut.

1. Ask students to turn-and-talk with a nearby partner: one partner explains what evidence is, and the other explains what inference is. Summarize as a class.

2. Introduce to students how this Mars Misison is about figuring out solutions for getting energy to use on Mars, then have students connect the Mission to their prior knowledge by individually writing a list of **evidence of energy use** in this classroom.

3. Assign students the task of looking for evidence of energy use by astronauts, and show the video tour of the International Space Station: https://youtu.be/SGP6Y0Pnhe4

4. Have students turn-and-talk with their nearby partner: compare the two lists (evidence of energy use in the classroom and energy use by astronauts).

5. Hold a whole-class discussion: collect all evidence students observed into two class lists (energy use in the classroom and energy use by astronauts). After the lists are generated, reduce the sizes of the lists as needed by combining similar items and pushing for reasoning where needed so that only examples of evidence are included. For example, students may think to list computers, light fixtures and lamps, electric sockets, windows, speakers, and any visible electric appliances.

If students mention as evidence such things as people moving about, excited chatter, or other observable evidence of "energy" that fit with every-day use of the word "energy," but not with the scientific definition of energy, accept the ideas, and be ready to revisit them at the end of this lesson.

6. Use a think-pair-share strategy for students to develop one inference about the energy source for each piece of evidence on the class lists. During the whole-class sharing of students' ideas, chart all of students ideas without judgement. Once the list is complete, then ask students to further explain their ideas as needed to eliminate any inferences (e.g. electricity is not likely visible evidence, but we can infer from evidence--seeing sockets and devices that typically require electricity to run--that there is electricity available in the classroom).

7. Transition to focusing on energy needs for space exploration: repeat the think-pair-share exercise of looking for evidence of energy use (steps described in #6) this time looking for evidence in the International Space Station, instead of the classroom.

8. Pose the following question:

How is the way that we talk about energy in every-day life--for example, when we say, "I just don't have the energy to do that!"--different from the way we talk about energy in science?

Facilitate a discussion that leads students to recognize that there are lots of ways we talk about energy in common language; however, in science "energy" means something very specific. Guide the discussion and use *Student Spec Sheet: Energy in Science* to help explain the following concepts:

- Energy in science can be described as "forms of energy" and "sources of energy" For example, a battery is a source for electrical energy, the sun is a source for energy in light, and a windmill can be a source for electrical (if it has an alternator) or mechanical energy (if it pumps water, for example).
- Forms of energy that can be described scientifically include energy of motion (kinetic), heat (thermal), chemical, mechanical energy, and energy in light.
- Scientists adopted the word energy centuries ago to refer to mathematically predictable relationships among measurable energy forms that are useful to do work.
- On the other hand, types that we might refer to in every-day experiences include energy transformation processes (e.g. photosynthesis, metabolism, etc.) and feelings (e.g. feeling energetic).

You may wish to use the Nova resources online yourself or to help students define and differentiate between the way the term "energy" is used in science and every-day life:
World's Most Asked Questions: Defining Energy
http://www.pbs.org/wgbh/nova/labs/lab/energy/1/2/

9. Conclude the discussion the big idea from this lesson: “Energy” refers to many things in every-day and cultural contexts. In science class, we focus on types of energy and especially energy transformations that are studied in science.

10. Provide 2-3 minutes for students to write in their own words in their science journal or on an exit slip a description of what energy means in science.

Forms of Energy fall under two categories:

POTENTIAL

Stored energy and the energy of position (gravitational).

CHEMICAL ENERGY is the energy stored in the bonds of atoms and molecules. Gasoline and a piece of pizza are examples.

NUCLEAR ENERGY is the energy stored in the nucleus of an atom – the energy that holds the nucleus together. The energy in the nucleus of a plutonium atom is an example.

ELASTIC ENERGY is energy stored in objects by the application of force. Compressed springs and stretched rubber bands are examples.

GRAVITATIONAL POTENTIAL ENERGY is the energy of place or position. A child at the top of a slide is an example.

KINETIC

The motion of waves, electrons, atoms, molecules, and substances.

RADIANT ENERGY is electromagnetic energy that travels in transverse waves. Light and x-rays are examples.

THERMAL ENERGY or heat is the internal energy in substances – the vibration or movement of atoms and molecules in substances. The heat from a fire is an example.

MOTION is the movement of a substance from one place to another. Wind and moving water are examples.

SOUND is the movement of energy through substances in longitudinal waves. Echoes and music are examples.

ELECTRICAL ENERGY is the movement of electrons. Lightning and electricity are examples.

Source: National Energy Education Development Project: need.org

MISSION 3

EXPLORING ENERGY IN WIND & SUN

MISSION QUESTIONS

- How is electrical energy generated by solar cells and wind turbines?
- In science, what does a model of energy transformations look like, and how are energy inputs and outputs represented?

LEARNING TARGETS

- I can assemble a solar cell / wind turbine, make thoughtful observations, gather evidence of energy transformations, and make logical inferences about energy inputs and outputs.
- I can draw a model that includes sources and forms of energy inputs and outputs, and note where energy transformations take place for both a solar cell and wind turbine.

Approximate Time Needed:
2-3 class periods

PREPARATIONS

- Arrange to have sets of the EV3 Lego solar and wind turbine sets for teams of 3-4 students to work with. Decide if you will have all student teams work with the same EV3 set at once or divide the class and half using solar while the other uses wind, then switch.
- Make copies of the 4 Student Spec Sheets (1 per student)
- Arrange for a field trip to the Mars Base Eagle exhibit at Wings of Eagles to follow this Mission, if possible.

MATERIALS

One copy per student::
- Student Spec Sheet: Energy in Science
- Student Spec Sheet: Example model of energy flows
- Student Spec Sheet: Modeling solar cell energy flows
- Student Spec Sheet: Modeling wind turbine energy flows

MISSION BRIEF

1. Pose the Mission's scenario and questions: ***Imagine yourself on Mars; would having a personal device like a cell phone for playing your own music and games or taking pictures be important to you? What might be a way that Mars explorers could charge their personal electronic devices on Mars?***

2. Explain that students will assemble a solar cell and wind turbine, while gathering evidence and making inferences to look for possible Mars energy solutions.

3. Describe the model that students will draw to communicate their inferences about energy inputs, outputs, and transformations for both the solar cell and the wind turbine.

4. Hand out and discuss copies of Student Spec Sheet: Energy flows model for running a car (combustion engine).

5. Hold a whole-class discussion and construction of a model for lamp lighting (see #5 Teaching Prompt)6. Pose the questions: ***Where does the electrical energy come from for lighting fixtures in our classroom? Where could it possibly come from on Mars?***

6. Explain the Student Spec sheets for energy flow in solar panels and wind turbines.

7. Demonstrate your expectations for how students will assemble, experiment with, and gather evidence from the EV3 solar panel / wind turbine.

8. After all students have explored both wind turbines and solar panels, revisit the question posed at the start of this lesson.

9. Generate a class list of all students still need to know about Mars, to answer suggest with confidence if solar panels or a wind turbine might be a workable solution on Mars for charging a personal electronic device.

10. If possible, visit the Mars Base Eagle exhibit and/or provide access to resources for students to research and learn key information about the Mars atmosphere, sunlight conditions, and dust storms.

TEACHING PROMPTS

1. Pose the Mission's scenario and questions: *Imagine yourself on Mars; would having a personal device like a cell phone for playing your own music and games or taking pictures be important to you? What might be a way that Mars explorers could charge their personal electronic devices on Mars?*

2. Explain the goals for this exploration: Students will assemble a solar cell and wind turbine, making thoughtful observations, gathering evidence of energy transformations, and making logical inferences about energy inputs and outputs. Emphasize the role of evidence and inference in this exploration.

3. Describe the model that students will draw to communicate their inferences about energy inputs, outputs, and transformations for both the solar cell and the wind turbine.

- Scientific models include diagrams and other representations that are used to predict or explain phenomena (according to the Next Generation Science Standards). In this Mission, students models will be two dimensional drawings with arrows and written explanations that show the evidence and inferences they're using to explain how the solar cell and wind turbine can make electricity available to do work.

4. Hand out and discuss copies of *Student Spec Sheet: Energy flows model for running a car (combustion engine).*

5. Using the sample model for energy flows in running a car as a guide, use a think-pair-share strategy for students to draw a model for energy flows in lighting a lamp. Finish with a whole-class discussion and construction of a model that looks similar to the one pictured below *(Source: CarbonTIME)*.

6. Pose the questions: *Where does the electrical energy come from for lighting fixtures in our classroom? Where could it possibly come from on Mars?*

- Explain how students will investigate two different types of "power machines" that can convert two different energy sources into electrical energy.
- For each of the two machines, students will:
    a. draw an energy flow model that represents your prediction for energy inputs, outputs and transformations for that machine (see *Student Spec Sheets: Modeling solar cell / wind turbine energy flows*,
    b. construct and observe the machine at work,
    c. add to and revise your energy flow model to include evidence you observed, and
    d. add a written explanation for what evidence you observed and learned and your inferences about what it would take for the machine to work on Mars.

7. Demonstrate to students how to assemble the EV3 solar panel / wind turbine, keeping in mind they only need to assemble it so far as necessary to experiment with different light sources and intensities and low or high levels of wind to learn that:

a. Sunlight has energy. Solar power panels use the energy in sunlight to generate electricity. The greater the intensity of light, the greater the amount of electricity generated by the panel.
    - Logical inference: For solar panels to work on Mars, they must be able to receive a level of light intensity necessary to generate electricity.
b. Wind is moving air, so wind has energy. Wind turbines use the energy of wind to generate electricity.
    - Logical inference: For wind turbines to work on Mars, there must be sufficient wind to generate electricity.

See sample energy flow models on the next page.

Sample flow diagrams:

8. After all students have explored both wind turbines and solar panels, revisit the question posed at the start of this lesson:

Imagine yourself on Mars; would having a personal device like a cell phone for playing your own music and games or taking pictures be important to you? What might be a way that Mars explorers could charge their personal electronic devices on Mars?

9. Generate a class list of all students still need to know about Mars, to answer suggest with confidence if solar panels or a wind turbine might be a workable solution on Mars for charging a personal electronic device.

10. If possible, visit the Mars Base Eagle exhibit to gather the additional information about the Mars atmospheric pressure, sunlight intensity, and dust storms that need to be taken into consideration.

If a field trip is not possible, provide resources for students to learn through research about these important conditions on Mars. Students will need sufficient opportunities for learning about Mars to determine that solar panels can function on Mars, but there is likely insufficient air pressure in most cases for Mars' winds to turn a wind turbine.

Two relevant resources for research could include:

Huge planet-wide dust storm on Mars knocks out NASA's 'Opportunity' rover – scientists worried

https://wattsupwiththat.com/2018/06/13/huge-planet-wide-dust-storm-on-mars-knocks-out-nasas-opportunity-rover-scientists-worried/

The Fact and Fiction of Martian Dust Storms

https://www.nasa.gov/feature/goddard/the-fact-and-fiction-of-martian-dust-storms

For more in-depth lessons about energy and energy transformations, we recommend (and have adapted materials for this Mission from) the National Energy Education Development Project (NEED Project): www.NEED.org and the CarbonTIME Project: http://carbontime.bscs.org.

STUDENT SPEC SHEET

MISSION 3

Energy Flows Model for Running a Car (combustion engine)

Evidence we can observe

- Cars need gasoline to run.
- Car engines get hot when tFuels such as gasoline contain chemical energy.

Evidence we can learn

- Fuels such as gasoline contain chemical energy.
- When fuels are burning in cars, the chemical energy stored in fuels transforms into energy of motion and heat.
- Fuels like gasoline require oxygen (O2) to burn, and burning produces carbon dioxide (CO2) and water (H2O)

Logical inference we can make

- If there is sufficient oxygen on Mars AND we could transport fuel to Mars, a combustion engine might be one way to get the energy needed to do work.

Source: Adapted from CarbonTIME Project: carbontime.bscs.org

Energy Flows Model for Wind Turbine

Evidence we can observe

Evidence we can learn

Logical inference we can make

Source: Adapted from CarbonTIME Project: carbontime.bscs.org

Energy Flows Model for Solar Panel

Evidence we can observe

Evidence we can learn

Logical inference we can make

Source: Adapted from CarbonTIME Project: carbontime.bscs.org

MISSION 4

ENGINEERING AN ENERGY SOLUTION

MISSION QUESTIONS

- How could we get the energy needed to charge personal electronic devices like cell phones on Mars?
- What factors in the Mars environment do scientists know or infer would be challenging for obtaining electricity energy?

LEARNING TARGETS

- I can describe what needs to be included in a Martian energy solution that could allow humans to charge a personal electronic device in the harsh Mars environment.
- I can use what we have learned about energy sources and forms and the Mars environment to develop a list of challenges that are likely to be faced by humans planning for life on Mars.
- I can use evidence and inferences from the wind and solar investigations to design a plausible solution for charging cell phones on Mars.

08:30 Approximate Time Needed:
2 class periods

PREPARATIONS

- Determine How long you wish to give student-groups to present their engineered solutions (done in Mission 5) and prepare any rubrics you may wish to use for evaluating teamwork, written components of the project, or oral presentation skills.
- Make copies of the Student Spec Sheet and Energy Sources handout.
- Plan ahead as needed to show the TED2015 video, "Your kids might live on Mars" https://tinyurl.com/y75yy5nh

MATERIALS

One copy per student::
- Student Spec Sheet: Engineering Design Process
- Handout: 10 Energy Sources

Each students' Spec Sheets from the previous lesson (important that students have these materials plus notes).

MISSION BRIEF

1. Assign students to partner groups and give pairs two minutes to summarize the previous lessons. Call randomly for student pairs to briefly share.

2. Show and briefly discuss the TED2015 video, "Your kids might live on Mars. Here's how they'll survive." **https://tinyurl.com/y75yy5nh**

3. Give each student a copy of the 10 Energy Sources handout. Have students individually write explanations--using evidence and inferences--which sources might work for generating electricity on Mars (or not) and why.
Collect the responses, and randomly draw one to read aloud anonymously for each of the 10 energy sources. Discuss as a class whether others agree or not and why.

4. Work as a class to develop a list of all the challenges that will need to be addressed for humans to live on Mars, including energy-specific challenges.

5. Restate the original challenge from the last lesson about charging a personal electronic device on Mars. Make a two-column, two-row chart for students to sign up for wind or sun. Have students sign up under the energy source they choose for designing a solution, then form teams of 2-3 students who chose the same energy source.

6. Unpack the first learning target; specifically focus on the words "solution" and "environment."
- I can describe what needs to be included in a Martian energy solution that could allow humans to charge a personal electronic device in the harsh Mars environment.
Discuss how student-team solutions must be designed, using the evidence we currently have about Mars and transforming energy from wind or sun to electrical energy. In addition the solution must address the challenges described in the class list.

7. Explain, using Student Spec Sheet: Engineering Design Process, the design steps students are following to engineer an energy solution.

8. Guide students to record a summary of the list made by the class in Teacher Prompt #3 as the criterea for their designed solutions.

9. Give a minimum of 40 minutes for teams to design their solution, draw an energy flow model on chart paper, and prepare a presentation for the class.

10. Exit slip: "***How will we know if the design of your energy solution is successful?***"

TEACHING PROMPTS

1. Begin by assigning students to partner groups. Direct pairs to take two minutes to develop a brief summary of Missions 2 and 3. Then, call randomly for student pairs to briefly share their summaries.

2. Transition to Mission 4 by watching and discussing the TED2015 video, "Your kids might live on Mars. Here's how they'll survive."
https://www.ted.com/talks/stephen_petranek_your_kids_might_live_on_mars_here_s_how_they_ll_survive?utm_campaign=tedspread&utm_medium=referral&utm_source=tedcomshare

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

3. Provide each student with a copy of the *10 Energy Sources handout,* and assign students to work individually to explain, using evidence and inferences, which of those sources are likely to be viable sources for generating electricity on Mars.

When students are done writing individual explanations, collect their responses, and randomly draw one to read aloud anonymously for each of the 10 energy sources. Facilitate a whole-class discussion about whether other students agree or disagree with the response that was read, and prompt for students to thoroughly explain why or why not.

4. Work as a whole class to develop a list of all the challenges that will need to be addressed for humans to live on Mars. As needed, prompt students to include energy-specific challenges, such as the lack of power plants and grid system to transmit energy, energy demands associated with life underground, and the environmental conditions learned about in lesson 3 (e.g. low atmospheric pressure, less intense sunlight, cold temperatures, etc.).

5. Restate the original challenge from the last lesson about charging a personal electronic device on Mars.

Make a two-column, two-row chart for students to sign up for ***wind*** or ***sun***. Have students sign up under the energy source they would most like to use to design a plausible solution for charging a personal electronic device on Mars.

Note: If some students choose "wind" as their energy source, assign them to work together, and allow them to change to "sun" as their source later. Wait until all student groups are busy working, then prompt any group that chose "wind" to explain how the atmospheric pressure on Mars differs from that on Earth and how that, in turn, effects the potential energy in wind on Mars.

Use your best judgment to assign working groups of two or three students.

6. Unpack the first learning target; specifically focus on the words “solution" and "environment."

- *I can describe what needs to be included in a Martian energy solution that could allow humans to charge a personal electronic device in the harsh Mars environment.*

Discuss how student-team solutions must be designed, using the evidence we currently have about Mars and transforming energy from wind or sun to electrical energy. In addition the solution must address the challenges described in the class list.

7. Explain, using *Student Spec Sheet: Engineering Design Process,* the design steps they are following to engineer an energy solution.

8. Guide students to record a list of the criterion their solution needs to meet; this list can be recorded in a science journal or on their copy of *Student Spec Sheet: Engineering Design Process*. The list should be a summary of the list made by the class in Teacher Prompt #3.

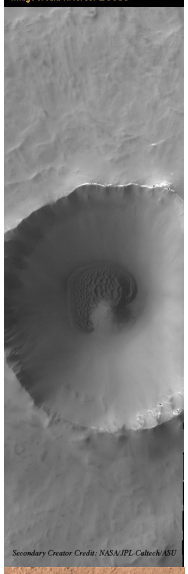
9. Assign teams to work for a minimum of 40 minutes, designing their energy solution, drawing on chart paper an energy flow model of their solution, and preparing to present their solution to the class.

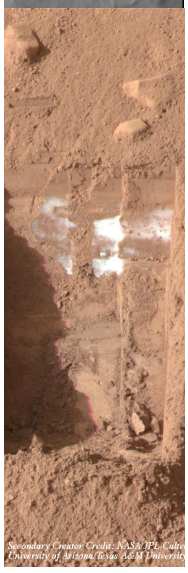
Use professional judgment to set milestones that student-groups must complete, holding them accountable to producing their solution with explicit references to evidence and explanations.

10. Begin the transition to the final Mission with an exit slip that asks: “How will we know if the design of your energy solution is successful?”

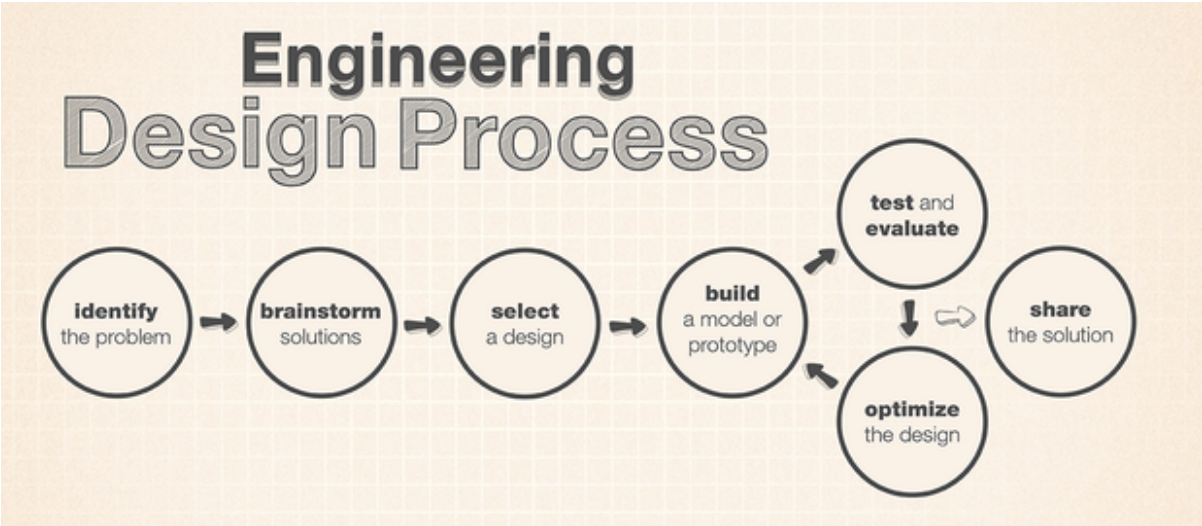
STUDENT SPEC SHEET

ENGINEERING DESIGN PROCESS





Use the engineering design process to design and evaluate your energy solution. How well does it meet the criteria for a successful energy solution for Mars explorers?



Our design criteria for a successful energy solution:

Reflections

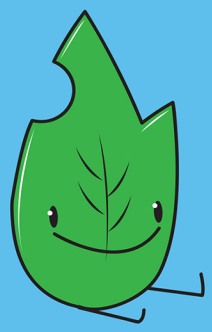
- What changes could you make to the design of your energy solution to make it better and why?

- What do you think are the strongest features of your design? Explain.

10 ENERGY SOURCES

RENEWABLE

Fuels that can be easily made or replenished; we can never use up renewable fuels.

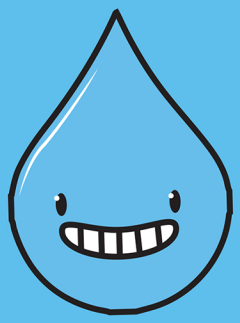


BIOMASS

Anything that is alive, or anything that was alive a short time ago is called biomass. Trees, crops, garbage, and animal waste are all biomass. Most of the biomass we use for energy today is wood.

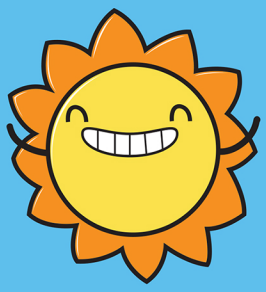
GEOTHERMAL

Geothermal energy is heat from inside the Earth. The inside of the Earth is very hot. Sometimes this heat comes near the surface. We can use this heat to warm our houses. We can generate electricity with it.



HYDROPOWER

Hydropower is energy created by moving water. Moving water has a lot of energy. We use that energy to generate electricity.



SOLAR

The sun provides lots of energy to the Earth. We call it solar energy. It travels from the sun to the Earth in rays. The energy from the sun makes rain fall, wind blow, and plants grow.

WIND

Wind is moving air. We can use the energy in wind to do work.

NONRENEWABLE

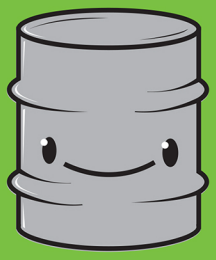
Fuels that cannot be easily made or replenished; we can use up nonrenewable fuels.

COAL

Coal was formed millions to hundreds of millions of years ago from plants. Coal is often shiny, black rock. Coal is a fossil fuel that we burn for energy.*

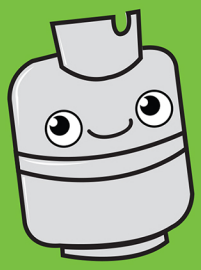
NATURAL GAS

Natural gas is a mixture of gases you can't see, smell, or taste. We often add an odor to it so we can smell it. It has a lot of energy in it. You can burn it to make heat. Natural gas is a fossil fuel.*



PETROLEUM

Petroleum is a liquid that is found underground. Sometimes we call it oil. Oil can be as thick and black as tar or as thin as water. Petroleum is a fossil fuel* that has a lot of energy we release when we burn it.



PROPANE

Propane is the gas we use to fuel our backyard grills and operate machines in warehouses. You cannot see it, smell it, or taste it, but you can burn it to produce heat energy. Propane is fossil fuel.*

URANIUM

Uranium is a mineral found in rocks in the ground. We split uranium atoms to release energy in nuclear power plants.

MISSION 5

EVALUATING ENERGY DESIGNS

MISSION QUESTIONS

- How well do our proposed energy solutions meet the criteria we developed for a successful solution for charging a personal electric device on Mars?

LEARNING TARGETS

- I can evaluate design proposals, using the criteria developed by the class and the guidelines for engineering processes to determine a proposal's strengths and recommend improvements.

Approximate Time Needed:
1 class period

PREPARATIONS

- Plan the timing for this lesson in advance to allow each team sufficient presentation time and follow-up discussion about their proposed energy solution.
- If your students are not accustomed to this type of interactive discussion and critique, you may wish to post sample sentence stems that are appropriate for questioning, agreeing, and disagreeing with ideas.
- Plan for showing a video **https://www/youtube.com/watch?v-MAhpfFt_mWM**

MATERIALS

- All students need to bring the ***Student Spec Sheet: Engineering Design Process*** from the previous lesson. Plan to have a few extra on hand for students who were absent or forget.
- Smartboard or projector to show "Engineering Design Process: A Taco Party"

MISSION BRIEF

1. Transition to Mission 5 by collecting students' exit slip responses from the end of Mission 4: "How will we know if the design of your energy solution is successful?" Randomly choose several exit slips to read aloud without judgment.

2. Show the video "Engineering Design Process: A Taco Party" on YouTube to provide a quick review of the engineering design process: https://www.youtube.com/watch?v=MAhpfFt_mWM

3. From the previous lesson, have students retrieve Student Spec Sheet: "Engineering Design Process" to use as a guide.

4. Use a think-pair-share strategy to lead the class in reviewing the criteria for a good solution design.

5. In a whole class discussion, randomly call on students to give examples from experiences designing their energy solution that align with stages in the design process.

6. Provide ~1 minute per team for presentations, followed by class discussion. Check for understanding during discussion time, and hold students accountable for referring explicitly to the class criterion and the engineering design process.

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

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

TEACHING PROMPTS

1. Transition to Mission 5 by collecting students' exit slip responses from the end of Mission 4: “How will we know if the design of your energy solution is successful?”

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

2. Revisit how the process of designing an energy solution that could be successfully used by Mars explorers is a good example of an engineering design challenge.

> Share the short video “Engineering Design Process: A Taco Party” on YouTube for an overview of engineering design processes: https://www.youtube.com/watch?v=MAhpfFt_mWM

3. Have students retrieve their individual copies from the previous lesson of Student Spec Sheet: "Engineering Design Process" to use as a guide while reflecting on their group's design process.

4. Use a think-pair-share strategy to lead the whole class in reviewing the criteria for a good solution design. Hold students accountable to cite evidence from what they have learned about the environment on Mars, the way humans will likely have to live on Mars, and energy sources, forms and transformations. Unpack the learning target:

- I can evaluate design proposals using the criteria developed by the class and engineering processes to determine its strengths and recommend improvements.

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

6. Provide ~1 minute per team for presentations, followed by class discussion. Check for understanding as students discuss to be sure they are referring explicitly to the class criterion list, what is known about energy sources, forms, and transformations, and the engineering design process.

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

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

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

Mars Base Eagle Mission Assessment

Name: _____

1. I enjoy science activities and classes.
   Mark only one oval.

   - Yes
   - No

2. I enjoy research.
   Mark only one oval.

   - Yes
   - No

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

   - Agree
   - Disagree

4. Have you ever heard of NASA?
   Mark only one oval.

   - Yes
   - No

5. If yes, what do you know about NASA

6. NASA has sent robotic research equipment to Mars.
   Mark only one oval.

   - True
   - False

7. NASA has sent a person to Mars.
   Mark only one oval.

   - True
   - False

8. Would you want to travel to Mars some day?
   Mark only one oval.

   - Yes
   - No

9. Why or Why not?

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

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

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

1. _____

2. _____

3. _____

Physical Science Mission Questions

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

    Mark only one oval.

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

Wind Turbines

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

    Mark only one oval.

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

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

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

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

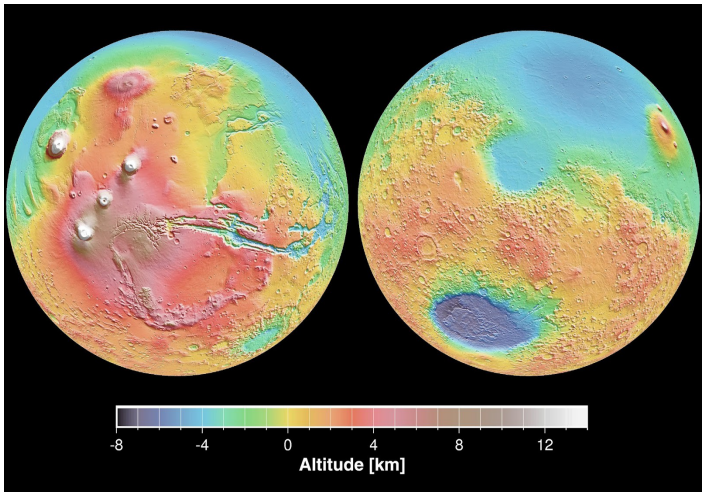
17. What is a disadvantage to relying on electrical energy generated using wind on Mars?

Earth Science Mission Questions

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

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

Mars Craters



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

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

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

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

Life Sciences Mission Questions

21. What parts of the food web are currently missing on Mars?
    Mark only one oval.

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

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

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

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

    - Yes
    - No

24. Why or Why not?

Mars Base Eagle Mission Disciplinary Content Assessment Keys

Physical Science Mission Questions

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

    Mark only one oval.

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

Wind Turbines

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

    Mark only one oval.

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

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

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

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

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

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

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

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

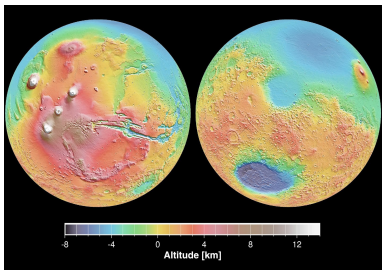
Wind on Mars is too light to move the blades on any windmills or power wind turbines that we currently have available. Although wind--including large wind storms--are common on Mars, the atmosphere is extremely thin, so winds there are very light.

Earth Science Mission Questions

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

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

Mars Craters



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

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

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

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

Life Sciences Mission Questions

21. What parts of the food web are currently missing on Mars?
    Mark only one oval.

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

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

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

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

    - **Yes**
    - No

24. Why or Why not?

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