Exploring Mars: Packing for the Trip as Astronauts!

Lesson Plan for Grades: Middle School (Science or Math)
Length of Lesson: 90 minutes

Authored by: UT Environmental Science Institute
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Subject area/course:
- General Science/Astronomy/Earth Sciences (Middle and/or High School)
- Mathematics/Algebra I (Middle/High School)

Materials:
- For Teacher use:
  - Doc cam/projector, access to internet if showing slide, or printed color copy of slide (if no internet access) and/or for showing the video clips.
  - Pre-made cardboard (open) boxes, of 1 cubic meter volume, enough for each group in classroom to use as reference
- For Students:
  - Small sticky notes (1 per student)
  - Calculator (1 per student)
  - Rulers (1 per student or at least 2-3 per Explore group)
  - Masking tape (not sticky like scotch tape) (1 per Explore group)
  - Access to technology (1 laptop/computer/phone/tablet per student)
  - Student worksheets for Explore (1 per student)
  - Student worksheets for Elaborate (1 per student)
  - Evaluate Exit Tickets (1 per student)
  - Index cards as optional resource for student presentations (10-20 per Explore group)

TEKS/SEs:
§112.18. Science, Grade 6, Adopted 2017.
(b) Knowledge and skills.
(4) Scientific investigation and reasoning. The student knows how to use a variety of tools and safety equipment to conduct science inquiry. The student is expected to:

(A) use appropriate tools, including journals/notebooks, beakers, Petri dishes, meter sticks, graduated cylinders, hot plates, test tubes, balances, microscopes, thermometers, calculators, computers, timing devices, and other necessary equipment to collect, record, and analyze information;

(11) Earth and space. The student understands the organization of our solar system and the relationships among the various bodies that comprise it. The student is expected to:

(C) describe the history and future of space exploration, including the types of equipment and transportation needed for space travel.

§112.19. Science, Grade 7, Adopted 2017.
(b) Knowledge and skills.
(4) Science investigation and reasoning. The student knows how to use a variety of tools and safety equipment to conduct science inquiry. The student is expected to:

(A) use appropriate tools, including life science models, hand lenses, stereoscopes, microscopes, beakers, Petri dishes, microscope slides, graduated cylinders, test tubes, meter sticks, metric rulers, metric tape measures, timing devices, hot plates, balances, thermometers, calculators, water test kits, computers, temperature and pH probes, collecting nets, insect traps, globes, digital cameras, journals/notebooks, and other necessary equipment to collect, record, and analyze information;

§112.20. Science, Grade 8, Adopted 2017.

(b) Knowledge and skills.

(4) Scientific investigation and reasoning. The student knows how to use a variety of tools and safety equipment to conduct science inquiry. The student is expected to:

(A) use appropriate tools, including lab journals/notebooks, beakers, meter sticks, graduated cylinders, anemometers, psychrometers, hot plates, test tubes, spring scales, balances, microscopes, thermometers, calculators, computers, spectroscopes, timing devices, and other necessary equipment to collect, record, and analyze information;

§112.33. Astronomy, Beginning with School Year 2010-2011 (One Credit).

(2) Scientific processes. The student uses scientific methods during laboratory and field investigations. The student is expected to:

(H) communicate valid conclusions in writing, oral presentations, and through collaborative projects

§112.36. Earth and Space Science, Beginning with School Year 2010-2011 (One Credit).

(c) Knowledge and skills.

(2) Scientific processes. The student uses scientific methods during laboratory and field investigations. The student is expected to:

(H) use mathematical procedures such as algebra, statistics, scientific notation, and significant figures to analyze data using the International System (SI) units; and

(I) communicate valid conclusions supported by data using several formats such as technical reports, lab reports, labeled drawings, graphic organizers, journals, presentations, and technical posters.

§111.26. Mathematics, Grade 6, Adopted 2012.

(b) Knowledge and skills.

(1) Mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to:

(A) apply mathematics to problems arising in everyday life, society, and the workplace;

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution;

(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems;

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate;

§111.27. Mathematics, Grade 7, Adopted 2012.

(b) Knowledge and skills.

(1) Mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to:

(A) apply mathematics to problems arising in everyday life, society, and the workplace;

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution;

(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems;

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate;

(9) Expressions, equations, and relationships. The student applies mathematical process standards to solve geometric problems. The student is expected to:

(A) solve problems involving the volume of rectangular prisms, triangular prisms, rectangular pyramids, and triangular pyramids;

§111.28. Mathematics, Grade 8, Adopted 2012.

(b) Knowledge and skills.

(1) Mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to:

(A) apply mathematics to problems arising in everyday life, society, and the workplace;

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution;

(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems;

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate;

§111.39. Mathematics, Algebra I, Adopted 2012 (One Credit).

(c) Knowledge and skills.

(1) Mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to:

(A) apply mathematics to problems arising in everyday life, society, and the workplace;

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution;

(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems;

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate;

Lesson objective(s): Students will be able to (SWBAT):

- Assess different pictures showing environments on Earth and Mars using observable characteristics and prior knowledge in order to determine the location of the picture shown
- Synthesize a team packing list of essentials for a trip to Mars based on mathematical calculations of item dimensions

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- Present and explain the reasoning of their chosen packing items

Differentiation strategies to meet diverse learner needs:

- The teacher should ask students whether they prefer to read or watch videos to learn about concepts; then have students learn in their preferred learning style. However, the teacher may assign students certain methods to improve their skills. For example, if a student prefers reading, teachers may have them watch a video and take notes to improve their listening skills.
- ELL students and students with learning disabilities should have multiple forms of instruction including visual and written instruction sheets as well as a verbal instruction and demonstration.

ENGAGEMENT (5 minutes):
ACTIVITY #!: A Look at the Environment

- Teacher will have a slide pulled up (or a printed color copy of the slide) on the doc cam/projector at the front of the classroom with the slide showing two different images (with no labels).
- Teacher will pass out small sticky notes to each student and ask them to place their sticky note on the picture that is showing a place not on Earth. (1-2 minutes will be allocated for students to observe the pictures, think, and stand up to place their sticky note).
- Teacher will then give 1 minute for students to discuss in small groups (with table partners or seat neighbors) what they think and why they think their picture is not from Earth.
- Teacher will ask for raise of hands (as final voting system) for which picture students think is not from Earth. (30 seconds)
- Teacher will then state which is from Earth and which is not. Teacher will also state that the non-Earth picture is specifically from Mars.

- Possible Student Guiding Questions that should be asked by the Teacher:
  1. What could you look for to see if the picture is not from Earth?
     - *Could look for whether there's a blue sky, water, clouds (Earth's atmosphere), animals/plants/organisms, buildings, cars, etc.*
  2. Do you think these pictures look similar or different?
     - *Student answers will vary (this question serves as more of an icebreaker to get students talking)*
- Possible Student Questions that may be asked to the Teacher:
- Are both of these pictures/photos real? Or are they photo-shopped/edited?
  - *They're both real.*
- If something isn't shown in the photo (ex: car), does that mean we can assume it doesn't exist for the environment shown in the photo?
  - *No, you can't assume that, you can only be 100% sure if you see something (ex: car) in the photo (which shows it exists), not the opposite.*

- *Expected Student Responses to main concept questions:*
  1. *Student responses will vary (based on observations and students' own personal experiences for what can be used to differ between an Earth and non-Earth place)*
  2. *These pictures look similar because (student observations) / They look different because (student observations).*

TRANSITION: "Now, we're going to be doing a fun activity where all of you will be astronauts and scientists in NASA trying to pack for a trip to Mars."

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POSSIBLE ALTERNATE ACTIVITY #2: (5 minutes)

Another Engage activity is playing a short clip of the HSCT video (https://youtu.be/QE9limGhntI?t=455 see URL listed under resources for the first source listed below under "Sources"), from 7:35 to 9:08. After playing this short clip, the teacher will ask students to describe how they felt about the story that was told.

Possible questions include:

1. What kind of trip was this? Does it seem similar to any trip you've ever been on?
2. What sort of things do you think the explorer brought with her on her trip?
3. Where do you think this trip took place? Why (Explain your reasoning)?

Teachers should get students thinking about both that this trip could be happening on Mars and that it could be happening on Earth.

To illustrate how a place in Antarctica has similar conditions to Mars in terms of environment (and not including the presence of air), the teacher can show the same video, just from 9:08 to 9:35. This would show how different people can go on trips, from astronauts to Mars, to microbiologists to Antarctica. The teacher would then pose the following question as a transition to the Explore:

ALTERNATE TRANSITION (FOR ACTIVITY #2): What items would you bring with you, if you were told by NASA that you are going to be sent as one of their best astronauts to a trip to Mars?

EXPLORATION (30 minutes): Packing for a Long Trip to Mars

https://spaceplace.nasa.gov/classroom-activities/en/ (Packing for a Long Trip to Mars Lesson Plan)

- "Ok everyone! I will place you in groups of 4 students and you will be working together with your group members to come up with what you should pack for a 2.5-year trip to Mars."
- Teacher should hand out calculators, Worksheets, 1 box per group, masking tape, and rulers.
- Teacher should assign group roles as follows:
    - *Organizer:* Organizes information that the group discusses (by writing it down/taking notes on a group-accessible Google Doc)
    - *Time Manager:* Keeps track of time and makes sure group is moving according to time without skipping any important steps, is a point of contact to discuss any important group issues/questions with teacher
    - *Encourager:* Makes sure each member speaks up, discusses the ideas, and contributes to the group; Keeps the mood positive, helps diffuse any conflicts that may arise
    - *Checker/Questioner:* Asks fellow members any questions (regarding ideas, presentation method, etc.) to help push for elaborate responses; Checks over group responses for presentation to make sure each member will have something to report and speak about and that all the information is present/answered
    - These groups are designed to help with group collaboration and organization (as well as time management). In addition to the group roles, each student should contribute to the process of coming up with ideas for packing and calculating to make sure the proposed group list works out mathematically. Each student should come up with at least 1 school-appropriate item (that must be approved of by the other members of the group) as well as their dimensions (googled from online with the website link written

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out as a source). Each student should do mathematical calculations and speak during the presentation.
- If groups are 3 or 5 students, then student roles will be Organizer, Time Manager/Encourager, and Checker/Questioner (for 3), and Organizer, Time Manager, Encourager, Checker, and Questioner (for 5 students).

- "Think about the following questions (which will be written on the board, or under the doc cam, and try to find a way to answer them through your presentations."
  1. "Mars has no native people, no Wi-Fi, no outlets, and no social events. Keeping morale up can be difficult, and trying to stay happy while in a close proximity to only your team for 2.5 years can be challenging. In order to keep your team mentally and emotionally stable, you should all bring things with you to help when things get slow or tiring. So, what things should you pack for yourselves? Remember, you have a limited amount of packing space that you have to completely use up?"
  2. "Is it possible to bring everything? Should you try to bring everything? Or do you, as a team, have to compromise on a lot of items?"
- Teacher will first have students read over the above 2 questions (on the board/under the doc cam) as a class, and then instruct students in their groups to
- Teachers will instruct students to google the dimensions of their items (as they choose what item they want to bring). Once they know the dimensions of all their items, they need to calculate whether each item can fit in a 1 cubic meter space. The cardboard boxes can be used to help students visualize how much space that is. If they can't fit everything, they need to decide what they should cut from the packing list.
  - Teacher will run through an example:
    - Teacher wants to bring phone and headphones (to listen to music (with no Wi-Fi required)): an iPhone X is 143.6mm (height) x 70.9mm (width) x 7.7mm (depth) and headphones (air pods and charging case) is 16.5 by 18.0 by 40.5 mm (each) while the charging case is: 44.3 by 21.3 by 53.5 mm. In order to save space, the air pods can be packed into the charging case (so as not to take up more space) and the dimensions of the charging case + the iPhone should be subtracted from the total packing space of 1 cubic meter.
  - Students can use math to manually subtract the items from the total dimension
  - Students can draw out their own diagram showing each item and the space it takes up for the 1 cubic meter amount (using rulers for accuracy).
  - Or, to help students visualize, teachers can instruct students to use a ruler and tape to mark how much space each item takes up in the box.
  - Teachers should also run through a mini checklist of possible items (student-led) where the teacher can give deeper ideas on why a certain item works/doesn't work.
    - Example of List:
      - Phone (doesn't work b/c no outlets, service, or Wi-Fi)
      - Sketch pad and pencil (does work, but think about whether you'd need a sharpener or extra eraser, and also consider the size of sketch pad)
      - Basketball (does work, but think about how the gravity on Mars is less than Earth's and how that might affect how you can play with the ball)
  - Teachers should maintain "checkpoints" every 5-10 minutes for the whole class (with one at the first 5 minutes of the activity) and have groups first come up with a group list of items and justifications for why these items would work (no size dimensions at this point) that the teacher would approve (for each group). As items are approved,

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students can look up size dimensions and reflect on what else they can fit into the 1 cubic meter sized "box."

- The exploration activity or activities will be described *in detail* in pages behind this table if necessary, as well as in the directions on the Student Handout.
  - The activity or activities should produce a shared common experience for the students.
  - Teachers should allow for student-directed learning during this time, but should also be highly engaged while students are performing activities, asking questions of the students' one-on-one or while they are working in groups (see example questions under Evaluation)

TRANSITION: "Ok. Let's begin presenting your group's plans for what you can take with you."

EXPLANATION (23 minutes)

- The teacher will call the groups to present their responses and findings. The students will all present as astronauts, explaining how they decided on the items they plan on bringing, and what made them decide on those items. The presentations will be student-directed and will be process-focused, rather than result-focused. The teacher will state that there is no "singular, correct" way to pick and pack the items, rather it is the process that is significant, as it can be repeated over and over again, providing new information through repetition.
- The students will conclude their presentations by sharing their responses to the 2 higher order-thinking questions (that were given prior to the Exploration activity, written either on the board or under the doc cam). The other students will ask questions if they have any, or elaborate on alternative ways the packing could have been done. *[Time for all presentations should be 12 minutes total +/- 2 minutes]*
- As the students present in their groups, the teacher will write down each item the group decides they want to pack (on a separate poster board, or separate whiteboard away from the presenting group).
- After all the groups have presented, the teacher will show the students how many different things astronauts try to accommodate for (pointing to the complete list) and how astronauts have to make the same decisions as the students on deciding which items should be prioritized.
- Some higher order thinking questions, which teachers will use to **solicit *student* explanations** and help them to justify their explanations are listed below:
  1. "How do we decide what's the most important versus least important when packing for a trip to Mars?"
  2. "What types of packing-related items change depending on who is going on the trip/where the trip is/how many people are going on the trip?"
     a. How would these types of circumstances (that often occur in real life) change your packing list?
     b. What are some things you packed to fit the needs of your specific group?

TRANSITION: "Alright, now let's do this packing while considering the real-life dilemma of working with NASA's budget. As astronauts, you need to carefully pack in a way that saves weight while maintaining enough items for your team. The problem is, however, each pound costs $10,000 to send to space."
[Source of cost statistic: https://www.nasa.gov/centers/marshall/news/background/facts/astp.html]

ELABORATION (30 minutes): Public Policy on Space Exploration

- Students that were in groups of 4 for the Explore activity will work together to come up with a "new" list of items that are the most cost-effective for a trip to Mars. There is a separate

handout for the Elaborate to scaffold the new extension of thinking about how the items relate to cost to transport through Space. Students will be given this Handout at this time, and the Teacher will go through the procedures and goal (listed below).
   - GOAL given to students (and written on board as visual reminder): To bring as many possible items (or as many versatile ones) as possible, without costing a lot of money.
- Students will use the URLs that they should have saved as sources besides each item, to find the weight. If the weight is not given, students can no longer use that item. Teachers will instruct students to try using up all the given volume (as in the Explore), as 2.5 years is a long trip and packing "empty space" isn't likely to help with the astronaut's morale.
- First 15 minutes will be spent calculating the cost for the packing as well as the "new and updated" list of items. No group presentations will be done, however the costs per item and total need to be added to the Handout (under the final column, which students will categorize as "Cost") and these Handouts will be turned in to the Teacher at the end of the activity.
- For reference, Teacher will write 1 lb. costs $10,000 to transport through Space on the board for students to use as well as the conversion of 1 kg = 2.2 lbs.
- The last 15 minutes will be spent discussing as a class what items (using the mega-list that the Teacher wrote out on the board during the Explain) were removed by one or several groups as well as what the students may have noted (differences in prices versus items across all the groups, as well as a class decision on which method(s) of packing they liked the best and the reasoning on their opinion). Teacher should stress this as an opinion-based discussion, where the answers can be evaluated on many different aspects, and that there is no one, right answer.

TRANSITION: "Now that we have finished this activity, please turn in your student handouts to me, while I pass everyone an index card."

EVALUATION (throughout entire lesson and 2 minutes at end)

- The teacher will walk around the classroom during the exploration portion of the lesson, and ask critical questions regarding how students can ration their needed supplies and what they should bring as astronauts (who are going to Mars as part of their job!) and what would be important to help them be able to relax during down-time, as well as what limitations to keep in mind (no Wi-Fi, no service, no outlets/electricity, etc.). Teacher would do this formative assessment during the Engage, Explore, Explain, and Elaborate.
- Teachers also assess student responses from the Handout that will be collected at the end of the lesson (summative assessment) as well as how students shared their responses during the Explanation portion of the lesson (the presentations).
- For the last 2 minutes of class, teachers will instruct students to complete an "Exit Ticket" on a half sheet of paper (see Evaluate section listed below). Students will need to fill out and turn in their ticket before dismissal from the class.

SOURCES AND RESOURCES

- Dr. Joe Levy's *Hot Science – Cool Talks #113,* "Will We Really Live on Mars? Investigating the Amazing Red Planet", http://www.esi.utexas.edu/talk/live-on-mars/
- "Packing for a Long Trip to Mars," https://spaceplace.nasa.gov/classroom-activities/en/
- Picture 1 (Engage): https://marsmobile.jpl.nasa.gov/msl/multimedia/images/?ImageID=7539
- Picture 2 (Engage): https://commons.wikimedia.org/wiki/File:A_Section_of_the_McMurdo_Dry_Valleys_Seen_by_Secretary_Kerry_While_he_Conducted_a_Helicopter_Tour_in_Antarctica_(30877662966).jpg
- Cost of $10,000/lb. payload (Elaborate): https://www.nasa.gov/centers/marshall/news/background/facts/astp.html

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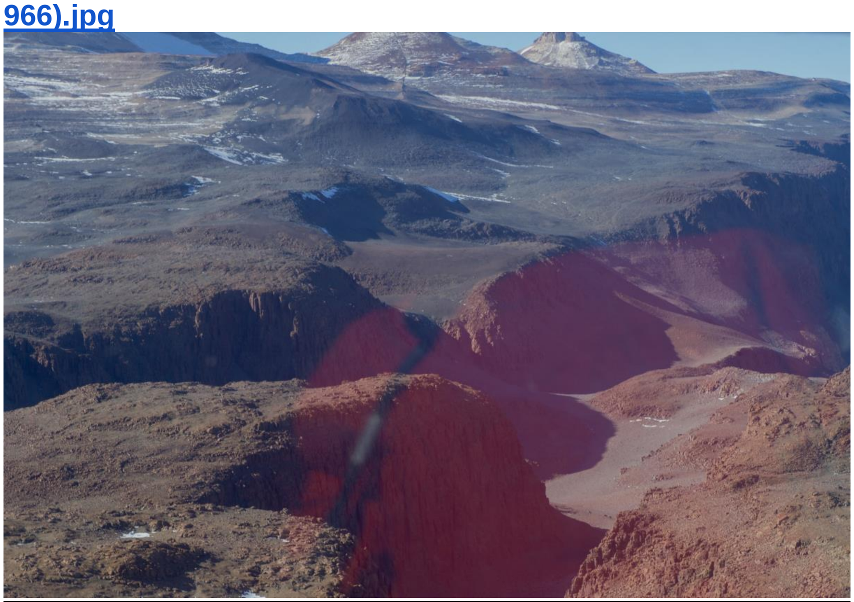
<u>ENGAGE:</u>
FOR TEACHER USE:
Picture 1: Mars, source:
https://marsmobile.jpl.nasa.gov/msl/multimedia/images/?ImageID=7539

Picture 2: Mcmurdo Dry Valleys, Antarctica, source:
https://commons.wikimedia.org/wiki/File:A_Section_of_the_McMurdo_Dry_Valleys_Seen_by_Secretary_Kerry_While_he_Conducted_a_Helicopter_Tour_in_Antarctica_(30877662966).jpg



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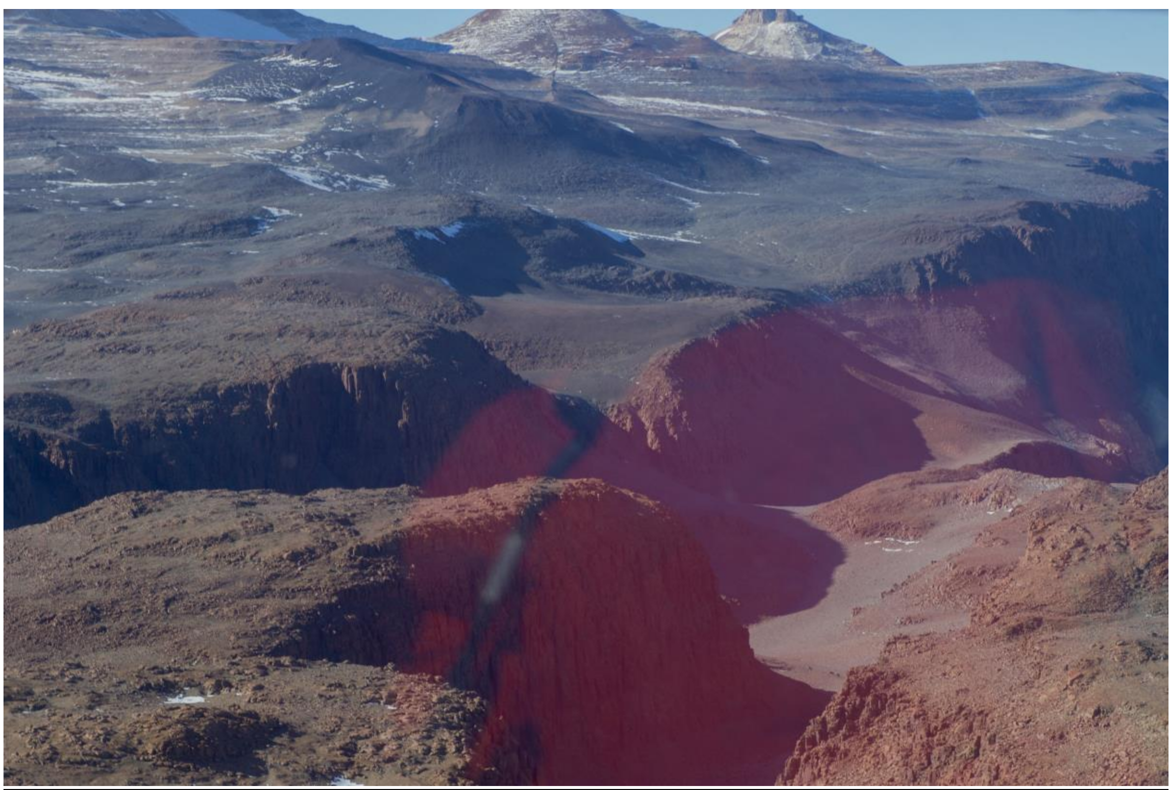
FOR CLASS USE:
How these images should be shown to the class:



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EXPLORATION ACTIVITY

Purpose: To encourage students to work together in small groups to solve a real-life problem astronauts face; To help students use and realize the importance of math in solving real-life challenges; To motivate students to present group collaborative work to the rest of the class

Materials: Student Handout, pencil, rulers, “example 1 cubic meter boxes,” tape, Handout, and student laptops/tablets

Safety Information: N/A for Physical Safety; Emotional Safety for group conflicts or peer-to-peer conflict with students is described as follows: Students should be reminded of class rules and school/classroom policy on being respectful and kind towards peers; Teacher should also instruct students to bring any conflicts to Teacher’s attention so they can resolve it in a fair manner.

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STUDENT HANDOUT:
Name:
Group Member Names:

Worksheet

1. Fill in the table:
   *Remember you have a total of **1 cubic meter of space** and there needs to be **at least one item that each member likes/wants to pack.**
   *Possible needed conversions:
   1 inch = 2.54 cm 3 ft. = 1 yd.
   1000mm = 1m 100cm = 1m

Item name	URL/ Website	Length (units)	Width (units)	Height (units)	Volume (units^3)

Use the back side of the Handout and other scratch paper to do calculations and conversions (remember, show and turn in your work for credit!). Any group collaborative Google Docs should also be emailed and shared to receive credit. (Hint: Formula for volume of rectangular prism is length*width*height).

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1. Start by **finding your item,** and the **website** (that should contain **length, width, and height**). If a website only has the volume listed but not the individual l, w, h parts, then find another website that does include those 3 things instead.
2. Now, **use a Volume formula** to solve for the volume. Remember, different shapes use different formulas! (Hint: Try to make your object fit one of the standard geometric shapes such as rectangular prism, sphere, pyramid, cube, cylinder, etc.).

Calculations and Conversions:

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ELABORATE: (Scaffolding Handout for Elaborate)

Name:______________________________

Calculating the Total Cost of Your Trip (Just the Packing!):

Oh no! NASA is experiencing some budget cuts! They just told you that you have to carefully check that your packed items don't cost too much! You have a mission goal to bring as many possible items (or as many versatile ones) as possible, without costing a lot of money. NASA didn't exactly give you a budget (Do they want you to read their mind?) so you should get creative and discuss with your group what items you want to keep versus keeping the total cost reasonable.

1. Looking back at the chart with all the items you previously decided to pack, go the websites for each item and **find the listed weight.** Write each item's weight in the Weight column on the table below. If the website doesn't show the weight, find another website and write out it's URL on the table below.
2. Now that you have the weights, **use the rate conversion of 1 lb. costs $10,000 to transport through Space and 1 kg = 2.2 lbs.** Write down the **costs for each item below and add them up to find your total.** See if you can decrease your total cost somehow, while still packing a good number of items *(Hint: you can add or remove the items you previously had, just remember to update your calculations and tables!)*

Item name	New URL/ Website for Weight	Volume (units^3)	Weight (units)	Cost ($)

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Item name	New URL/ Website for Weight	Volume (units^3)	Weight (units)	Cost ($)

Total Cost: _______________
Number of Items Packed: ________
Did you leave empty packing space? (Circle one) Yes / No

1. Is your list the same as the one you started with? Why or why not?

____
____
____
____

2. You looked at amount of available space (volume) and cost in determining some tough packing decisions. What are some other possible variables that may affect what you can bring on your trip to Mars?

____
____
____
____

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EVALUATE: (2 Exit Tickets for this page are listed below)

Name: ______________________________

Exit Ticket:

1. Using what we learned and discussed today in class, in your opinion, what is the most important variable (cost or volume) to decide what items you can bring with you? Explain why.

Most important thing:

____
____
____
____

Reason why:

____
____
____
____

Name: ______________________________

Exit Ticket:

2. Using what we learned and discussed today in class, in your opinion, what is the most important variable (cost or volume) to decide what items you can bring with you? Explain why.

Most important thing:

____
____
____
____

Reason why:

____
____
____
____