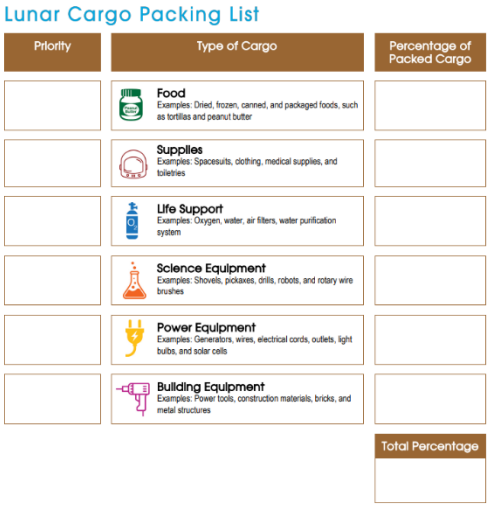
PRIORITY PACKING FOR THE MOON

BIG IDEA:

Participants will use the engineering design process to evaluate the importance of given objects based on basic human needs and availability of space on a lander in order to be successful on a mission to the Moon and optimize a given volume for packing items for space in the human landing system cargo bay.

AUDIENCE:

- Families
- Students, 6th–8th grade



WHAT YOU NEED:

- Printouts (one of each per group)
  - Packing List
  - Lunar Cargo: Food Polyominoes
  - Lunar Cargo: Supplies Polyominoes
  - Lunar Cargo: Life Support Polyominoes
  - Lunar Cargo: Science Equipment Polyominoes
  - Lunar Cargo: Power Equipment Polyominoes
  - Lunar Cargo: Building Equipment Polyominoes
  - (Optional) printed list of 12 items
  - (Optional) printed copy of NASA priority list
- Poster paper
- Rulers
- Pencils, pens or markers
- Glue or tape
- Scissors

SET-UP:

- Print the materials listed above.
- **Safety concerns:** Practice safety protocols for scissor use.

WHAT TO DO:

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1. Read the following scenario to the participants:
   The year is 2025 and you are part of a team traveling toward the Moon. As your spacecraft enters lunar orbit, you spot the base camp. It is located on a crater rim near the lunar South Pole, in near-constant sunlight. This location is not far from supplies of water ice that can be found in the cold, permanently shadowed part of the crater. As your spacecraft descends toward the lunar surface, you suddenly notice that there is a problem with the thrusters. You land safely, but off course, about 25 kilometers (approximately 15 miles) from the base camp. As you look across the charcoal-gray, dusty surface of the Moon, you realize your survival depends on reaching the base camp, finding a way to protect yourself until someone can reach your team, or meeting a rescue party somewhere between your landing site and the habitat. You know the Moon has basically no atmosphere or magnetosphere to protect you from space radiation. The environment is unlike any found on Earth. The regolith, or lunar soil, is a mixture of materials that includes sharp, glassy particles. The gravity field on the Moon is only one-sixth as strong as Earth's. More than 80 percent of the Moon is made up of heavily cratered highlands. Temperatures vary widely on the Moon. It can be as cold as 193 °C (–315 °F) at night at its poles and as hot as 111 °C (232 °F) during the day at its equator.

   Survival will depend on your mode of transportation and your ability to navigate. Your basic needs for food, shelter, water, and air must be considered. With the Moon's lower gravity, 25 kilometers (approximately 15 miles) is not too far to walk, but you are limited in what you can carry.

   You can only take seven items with you. What should you take with you and why? Of the 12 items available, strategize with your team and prioritize the 7 items your team will carry during your journey to the lunar base camp. Your survival depends on your ability to work with other team members to determine not only the value of these items, but how to use them as well.

   - **Box of matches**
   - **Oxygen**
   - **Food**
   - **Water**
   - **Lights with solar-powered rechargeable batteries**
   - **Magnetic compass**
   - **Solar powered receiver–transmitter**
   - **Life raft**
   - **First aid kit**

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- **Map of Moon's surface**
- **15 meters (approximately 50 feet) of nylon rope**
- **Signal mirror**

2. Ask participants to work with a partner or small group to decide which items to bring.
3. Once the teams have agreed on their seven essential items, facilitate a whole-group discussion on the reasoning behind each choice. Be open to all answers if participants have reasonable justifications for their order and reasoning. This activity helps to verify participants' understanding of the conditions on the Moon. This can also lead to identifying misconceptions about the Moon's environment.
    - For each of the teams' seven items, add the number of points from the NASA ranking in the priority table:
      3 – High priority
      2 – Medium priority
      1 – Low priority
    - Add up their points:
      20 or more: Excellent – Future Moon Explorers!
      19: Good
      18: Average
      17: Poor – Suggests use of Earthbound logic
      16 or fewer: Very poor – Need to go back to Basic Astronaut Moon Survival Training!
4. Take out the Lunar Cargo Packing List. Have teams prioritize six items for a mission to their landing site. This is the first step to prioritize the cargo they will bring to the Moon.
5. Have each team draw a 10- by 10-inch square on a large sheet of paper. This space represents the (500-kilogram-unit) cargo bay of their human landing system, which will transport the basic needs and science cargo for the mission.
6. Have each team cut out the six sets of shapes on the Lunar Cargo Polyominoes worksheets. Polyominoes are equal-sized squares joined together edge to edge to form a plane geometric figure. These shapes represent cargo that needs to be packed into the human landing system. The percentage shown on each item represents the percentage of volume it will occupy in the cargo bay.
7. Based on their team's original priority list, participants will fit the shapes in the cargo bay, beginning with the supplies they will need the most of. For example, if food is their number one priority, there should be a greater percentage of food packed in the cargo bay. Teams should try to pack the cargo so there are no empty spaces. Be sure participants use only the shapes given and do not cut them to make them fit in the cargo bay.

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8. Have participants compare their final decision with their original priority list. If necessary, instruct participants to repack the cargo bay until the priority list has been followed and space has been used to its maximum capacity.
9. Have participants justify their packing plans:
    - Defend your choices in the items your team picked.
    - What is a “high-priority” item and what determines it being a high priority?
    - Why did you not select certain items?
    - Did your final packing solution match your priority list?

TIPS & TRICKS:

- *If you are using this activity as part of a community event:*
    - Cut the Lunar Cargo Polyominoes before the event. Consider laminating them or printing them on heavier cardstock so they can survive multiple groups using them over the course of the event. If you choose to do it this way, do not have visitors glue or tape them down, but place them and explain their thinking before returning the polyominoes for the next visitor to use.
    - Provide pre-drawn cargo bays and consider laminating those as well.
- *If you are using this activity as part of an out-of-school time program:*
    - Add additional constraints to the challenge:
        - You must have enough basic life support for 7 days on the Moon for each team member astronaut
        - You may not leave out anything from your priority list: food, supplies, life support, science equipment, power equipment, and building equipment
    - For older students:
        - Have students follow the second step on the Lunar Cargo Packing List worksheet to calculate the percentages of each type of packed cargo. A fully packed cargo bay will equal 100 percent.
        - Assign or allow students to choose a specific landing site from this lunar map. Students can use the site information guides below to assess the site in case there are any existing resources that might influence what they pack.
            - Site Information: Cabeus
            - Site Information: Haworth
            - Site Information: Mons Malapert
            - Site information: Shackleton
            - Site information: Shoemaker
- See the Mission2Mars Additional Resources document for related videos, printable resources, and other activities.

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WHAT TO KNOW:

- The Apollo astronauts were on the lunar surface for just 2 days on average. For future Artemis missions, longer stays on the Moon are expected. Longer duration missions provide more data for human research, more time for scientific work, and more experience for future exploration missions. This is the proving ground that will refine our technologies to live and work in deep space, learn more about planetary processes and evolution, and establish the resources and infrastructure to support further scientific investigations.
- The objective of the Human Landing System program is to deliver humans to the surface of the Moon and return them safely back to lunar orbit. The lander will also carry equipment and supplies that will allow astronauts to spend time on the surface performing various tasks. These lunar landers will work together with the Space Launch System (SLS) rocket, the Orion spacecraft, and the Gateway outpost in lunar orbit to form a lunar architecture for long-term human exploration on and around the Moon.
- Humans—and all organisms—have specific requirements to live. Space and the surfaces of the Moon and Mars are harsh environments for humans. The average temperatures are well below 0°F; there are high levels of solar radiation, which can damage body tissues; there is little or no atmosphere; and there are no sources of food or water.
- Earth provides the conditions, resources, and systems to provide the requirements of life, and because those needs don't change when they are exploring the lunar surface, it's important to pack accordingly.
- Providing and maintaining the conditions, resources, and systems required to support human life in space is a complex, challenging task.
- On Earth, the average American uses about 132 liters (roughly equal to 35 gallons) of water every day. In contrast, the average astronaut on the International Space Station (ISS) uses 11 liters (3 gallons) of water. Water is heavy (1 kilogram per liter), so attempts are made to minimize the amount of water carried on board a spacecraft. An astronaut on the ISS uses about 0.83 kilograms (1.83 pounds) of food per meal each day. The average person (both on the ISS and on Earth) needs about 0.84 kilograms of oxygen per day.

SOURCE: NASA, Landing Humans on the Moon Educator Guide

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