TEACHER'S GUIDE

Spacesuit Design

Background

When traveling to a land of warmer or colder climates, one considers what clothes to pack for these environmental conditions. If the destination happens to be the top of Mt. Everest or the bottom of the ocean floor, the change in conditions must be accounted for. At the top of Mt. Everest, climbers bring oxygen to breathe, dress for extreme weather, and take weeks to acclimate to higher elevations. In the same way deep-sea divers must consider changes in environmental conditions as well. But what happens when a human leaves the Earth? What environmental needs must be brought along?

Space travelers wear a spacesuit in order to bring along elements of Earth's environment needed for survival: oxygen, appropriate air pressure, moderate temperatures, and protection against the Sun's rays. On Earth, our atmosphere absorbs much of the Sun's harmful rays. In space and on planets with thin atmospheres there is little protection from the Sun's harmful rays. The spacesuit provides this protection for astronauts, keeping them safe from radiation. Harmful radiation can result in skin damage, hair loss, vomiting, cataracts, infertility, cancers, birth defects, and death.

The vacuum of space is another harsh environmental condition. An unprotected body that is exposed to the vacuum of space quickly perishes. Fluids in the body quickly begin to boil from the lack of air pressure. Bubbles would form in the bloodstream and tissues. Capillaries and other fragile tissues would rupture, and newly formed gases would begin to diffuse out of the body into space. Skin and tissue would retain gases for a time, resulting in a condition that looks like swelling. As the gases exit the body it becomes "freeze-dried." The lack of oxygen would render the unfortunate individual unconscious in 15 seconds. Permanent brain damage would occur in as little as 4 minutes, and death would follow shortly thereafter.

Also the temperatures in space are extreme. At low temperatures, the human body suffers from hypothermia. In very warm environments, the body suffers heat exhaustion or heat stroke. Physical and mental abilities become impaired. Within the shade of a planet or a space structure, temperatures can drop below -100° C. On the sunlit side of objects in space (at Earth's distance) temperatures can climb to over 120° C. Debris from other space missions, as well as meteroids, travel at high enough speeds to damage spacesuits and spacecraft.

Topics

Spacesuit Design
Mars Environment
How spacesuits must be adapted depending on the planetary characteristics

Objectives

Students will:

- Research the environment of Mars.
- Identify necessary spacesuit features for Mars.
- Analyze necessary spacesuit features for Mars.
- Make decisions about necessary spacesuit features for Mars.
- Conceptualize necessary spacesuit features for Mars.
- Design a blueprint of a Martian spacesuit.
- Use criteria to determine whether a spacesuit offers enough protection on Mars.

Overview

Teams will analyze conditions on Mars to evaluate and establish criteria for designing spacesuit features and then draw and label a spacesuit design.

Key Question

What functions does a spacesuit need to have for a mission to Mars?

Key Concepts

- Space is a hostile environment that cannot support human life.
- Humans must have oxygen, air pressure, moderate temperatures, and protection from space debris and harmful radiation in space to survive.
- The spacesuit must also provide features to handle body functions and communicate with the crew on board the spaceship.
- Spacesuits function to bring part of Earth's atmosphere to space with the astronaut. They allow humans to survive in environments that have little or no air, extreme temperatures, little or no atmospheric pressure, harmful solar rays, and space debris. (See background for details.)

Materials & Preparation

- Student Sheets
- Assorted drawing materials

1. Use a thinking web for students to discuss harsh environments on Earth (e.g., the desert, at the top of Mt. Everest, the deep sea, Antarctica, etc.). Describe what makes each place inhospitable to humans, adding lines to the appropriate circles for each place. How do humans adapt to live in these harsh environments?
2. Use a thinking web to describe the harsh environment of space.
3. Compare and contrast harsh environments on Earth to those of space using a Venn diagram.
4. How does the Space Shuttle spacesuit allow astronauts to adapt to the harsh conditions of space? Discuss the Spacesuit Fact Sheet.
5. **Conditions on Mars:** Use the Mars Sheet at the beginning of the book to identify inhospitable conditions on the Red Planet. Students need to identify these conditions on Mars so they can plan spacesuit features to counteract these conditions. Use the *Conditions on Mars* chart on the Student Worksheet.
6. **Pick a Mission:** Students are now ready to design a team spacesuit to function on Mars. Organize students into teams. Tell them that each team needs to pick a mission where astronauts will perform specific tasks. Have them define the types of tasks they will need to do on their mission. Here are some suggested missions, but students can research and come up with their own:
   - Climbing and rappelling in the canyon Valles Marineris to do geological surveys.
   - Flying to the top of the giant volcano Olympus Mons to study the caldera.
   - Examining rocks and digging for fossils on what appears to be a dry river channel.
   - Going to the poles to cut ice and melt it for water.
   - Tinkering with Mars Sojourner or one of the Viking landers to get it to run again.
7. **Spacesuit Design Criteria:** Based on the mission each team chooses, they should design a spacesuit that will function safely on Mars and perform specific tasks. Spacesuits need to:
   - Function on Mars.
   - Have features needed to accommodate human body functions.
   - Take into account Mission Control needs.
   - Allow astronauts to perform mission tasks.
8. **Body Functions:** Have students focus on body functions that the spacesuit needs to accommodate using a thinking web to brainstorm. Then have them identify the most important spacesuit features needed to meet each body function using the *Spacesuit Features for Body Functions* chart.
9. **Mission Control:** Mission Control plays a critical role in keeping astronauts safe and helping them complete tasks during extra-vehicular activities (EVA's), or spacewalks. Spacesuits need to have special features so that Mission Control can be sure the suits are functioning well. They also need to communicate with and identify the astronauts. Note that if the astronauts are far away (e.g. Mars), there will be a substantial time delay between when communications are transmitted and when they are received. Depending on where Mars is in its orbit, the delay could be between 5 and 20 minutes. Have students make a thinking web of

interactions Mission Control must have with the astronauts and the conditions they need to monitor. Again, pick the most important features in the *Spacesuit Features for Mission Control* chart.

10. Have students go through the two charts for Body Functions and Mission Control. Circle the top ten functions their spacesuit designs need to accommodate. List the spacesuit features that will address them in the *Master Spacesuit Parts* chart. Do the items on the list address the inhospitable conditions on Mars completed in the first chart?
11. Now teams are ready to design their spacesuits. Have each team draw a blueprint of their spacesuit and label the parts.
12. Have the class discuss the appropriateness of each suit, giving positive feedback and suggesting any improvements needed. Compare and contrast their suits with the Space Shuttle spacesuits using a Venn diagram.

Management

This lesson can be done over two to five class periods, depending on how involved you want your students to be in the spacesuit design. Students should complete the spacesuit features for Mars in the first class and features for the body and Mission Control in the second. Use one to two classes to work on blueprint designs. The last session should have students share their designs and make comparisons to the Space Shuttle spacesuit.

Reflection & Discussion

1. Why do humans need to wear spacesuits on Mars? *Humans must have air, atmospheric pressure, moderate temperatures, and protection from Martian dust.*
2. How is movement in space different from movement on Earth? *It depends where you are in space. On the Space Shuttle, which feels like a gravity-free environment, everything seems to float, so you have to change the way you do things.*
3. What does a spacesuit have to include? *Spacesuits must have systems for breathing, air pressure, temperature control, walking, identification, and food storage, among others.*
4. How can a spacesuit make work harder to complete? *Spacesuits are bulky because of the many systems they carry. The pressure inside the suit can make the suit stiff and hard to bend.*
5. Why don't astronauts have to wear spacesuits inside of a spacecraft? *The spacecraft provides the necessary oxygen, temperature, and air pressure while astronauts travel inside it.*
6. How does a spacesuit worn in space differ from those needed for Mars? *Spacesuits for Mars must function in temperatures that do not rise above freezing. Fine dust particles could affect visibility and leak into suit joints. Mars has some atmosphere, but the suit will still need to supply oxygen.*

Transfer/Extension

1. Design spacesuits to accomplish specific activities on Mars: taking soil samples, climbing canyons, operating a Martian rover, and assembling habitats.
2. Spacesuits have similar features to the suits worn by deep-sea divers. Have students compare and contrast the components of deep-sea diving suits and spacesuits.
3. Take students to a local museum to see a real spacesuit, or surf the Internet for pictures of real spacesuits. See the websites listed at the end of the activity guide.
4. Have students research the history of the spacesuit and compare and contrast the first spacesuit to those worn by astronauts today.
5. Conduct spacesuit activities from "Suited for Spacewalking," by NASA, 8 from NASA Spacelink at: http://spacelink.nasa.gov.
6. Compare and contrast the differences between Russian and American spacesuit designs.

STUDENT FACT SHEET

Space Shuttle Spacesuit

Helmet
- has a hard shell to protect against space debris.
- has lamps for light to see in the dark.
- has special glass to keep out harmful solar rays.
- has a microphone and listening piece for communication.

Food Bar & Drink Bag
- are built in to the side of the helmet in case astronauts get hungry or thirsty. The food is wrapped in edible paper.

Gloves
- have layers to protect against space debris and keep astronaut warm or cold.
- are flexible for working.

Space Boots
- are airproof and insulated to protect feet.
- have special soles depending on where astronauts will walk.

Pressure Control Garment
- looks like long underwear.
- inflates to create pressure.

Temperature Control Garment
- looks like long underwear.
- has many layers for warmth.
- has tubes of flowing water to take away extra heat.

Hard Outer Torso
- has a top and bottom that connect to be airproof.
- is made of many layers to keep astronaut warm and safe from space debris.

Display and Control Module
- has buttons for power and to monitor all spacesuit functions.

Life Support System
- has oxygen tanks and power battery.
- can fasten to a mobility unit that lets astronauts move around.

STUDENT WORKSHEET

Martian Spacesuit

Student Procedures

1. Research the conditions on Mars and complete the chart below.

Conditions on Mars	
Condition Write a phrase to describe the conditions on Mars.	**Problem** Describe what the condition does to the human body.
Atmosphere?	
Space debris?	
Temperature?	
Pressure of Atmosphere?	

2. Brainstorm and create a thinking web for body functions that will need special spacesuit features.
3. List the body functions and spacesuit features in the chart *Spacesuit Features for Body Functions*.

Spacesuit Features for Body Functions	
Body Function Use an -ing word (For example: Seeing).	**Spacesuit Part** List the spacesuit part to take care of the function.

4. Brainstorm and create a thinking web for Mission Control spacesuit needs.

5. List the Mission Control needs and the spacesuit features on the *Spacesuit Features for Mission Control* chart.

Spacesuit Features for Mission Control	
Mission Control Issue List conditions Mission Control needs to monitor.	**Spacesuit Part** List a spacesuit part to take care of the function.

6. Look at all three charts. Go through each chart and put an "x" by each spacesuit feature that you list more then once. Complete the *Master Spacesuit Parts* chart.

Master Spacesuit Parts	
Spacesuit Part List at least ten spacesuit parts you will draw.	**Part Features** Describe the features and function of each part.

7. Draw a diagram of your spacesuit design. Be sure to label all the parts and explain their function. Attach a page with the name of your team members and the date. Describe your mission to Mars.