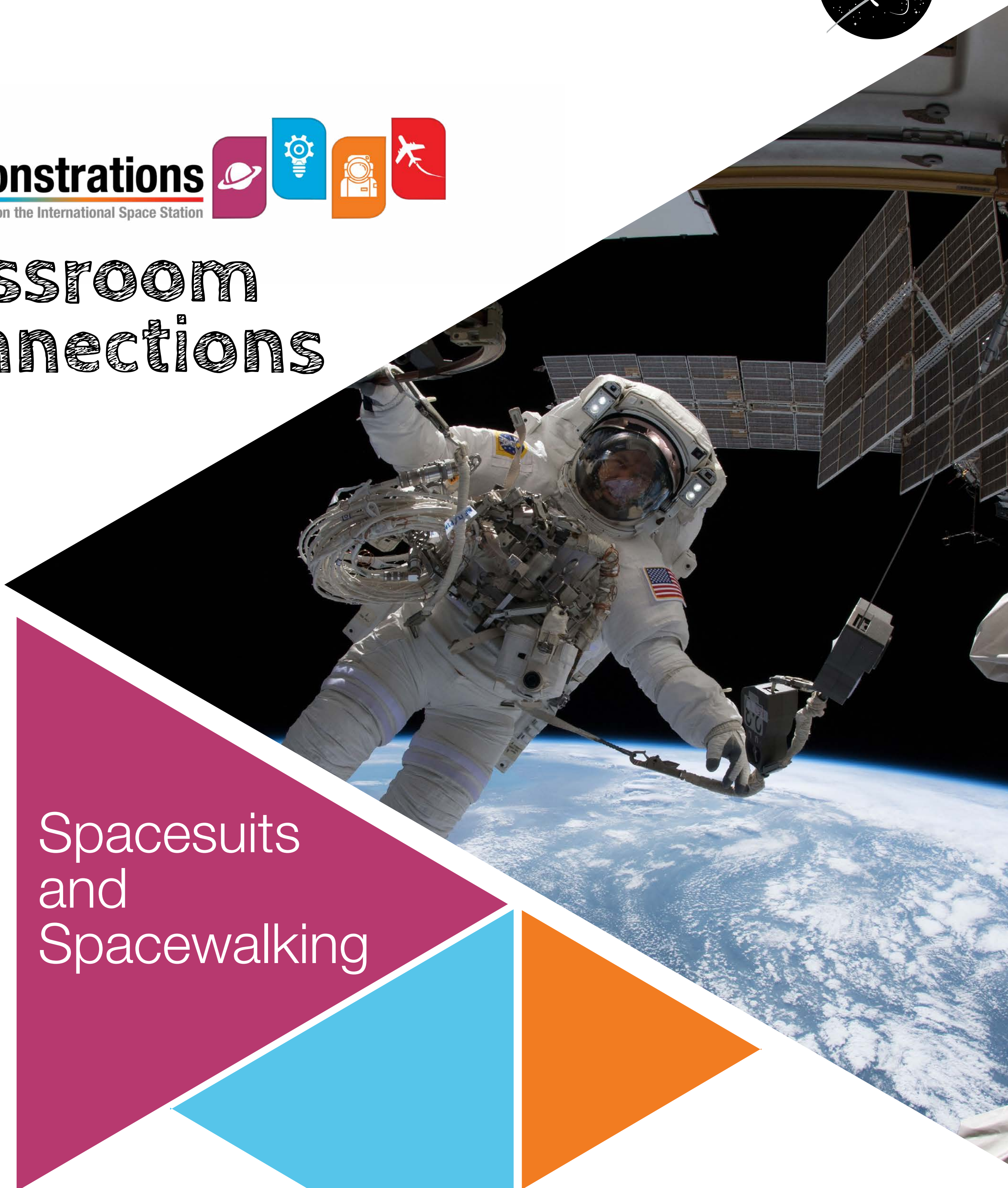
National Aeronautics and Space Administration

STEMonstrations

Education in Action on the International Space Station

Classroom Connections



Spacesuits and Spacewalking

For more STEMonstrations and Classroom Connections, visit www.nasa.gov/stemonstation.

Spacesuits & Spacewalking
Teacher Background

Grade Level: **6th-8th**

Suggested Time: **55 minutes**

Next Generation Science Standards (NGSS):

MS-PS1-3. Matter and its Interactions: *Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.*

MS-PS1-4. Matter and its Interactions: *Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.*

MS-PS2-1: Motion and Stability. Forces and Interactions: *Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*

MS-PS3-1. Energy: *Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.*

MS-PS3-3. Energy: *Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

MS-PS3-4. Energy: *Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.*

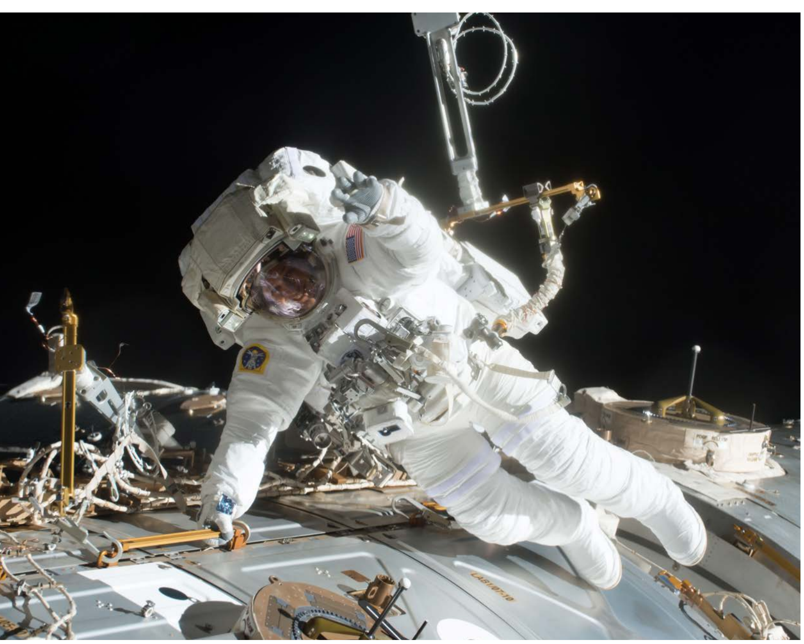
MS-ETS1-1. Engineering Design: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*

MS-ETS1-3. Engineering Design: *Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*

MS-ETS1-4. Engineering Design: *Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.*

Background

When astronauts execute an Extra Vehicular Activity (EVA) or spacewalk, they must be protected from the harsh environment of space and carry everything they need to survive for several hours with them. When they pass through the airlock and venture outside, they are protected by a smaller and specialized "spacecraft" called the Extravehicular Mobility Unit (EMU), commonly known as a spacesuit. This spacesuit includes a life-support system and protection against high-speed micrometeoroid impacts.



Spacesuits have multiple layers to support life and protect astronauts. The first two internal layers make up the liquid cooling and ventilation garment. These layers are made up of spandex fabric and plastic tubing. The next layer is a pressure bladder made of urethane-coated nylon followed by a pressure-restraining fabric layer. This is followed by seven layers of a thermal micrometeoroid garment. All of these specialized layers come together to form the spacesuit.

Vocabulary

- EVA: Extra Vehicular Activity; a spacewalk; an activity in which astronauts wear a full body spacesuit and exit the vehicle. Typically conducted to construct or repair part of a spacecraft/vehicle.
- EMU: Extravehicular Mobility Unit; the white spacesuit NASA and its partners use to keep astronauts alive while spacewalking.
- Micrometeoroid: a tiny meteoroid; a small particle of rock in space, usually weighing less than a gram. Orbital debris in the near-Earth space environment is made up of micrometeoroids and man-made debris. Can be potentially dangerous to a spacecraft or an astronaut spacewalking.

Objective

Following this activity, students will be able to:

- Explain the relationship between temperature change and the environment of space
- Understand the need for micrometeoroid protection in the environment of space
- Understand why astronauts conduct spacewalking on the International Space Station
- Experiment with different types of materials to use on spacesuits
- Identify most appropriate materials to use in a new spacesuit and how they could be used
- Explain how spacesuit materials can be used on Earth

Materials

Materials for Temperature Regulation Activity:

- Styrofoam, Mylar® sheets, cloth, brown paper bags, white copy paper, cardboard, foam, etc. (materials can be pre-cut, or students can cut needed amounts)
- Thermometer
- Heat lamp on low setting
- Stop watch or timer
- Temperature Regulation Data Table (included)
- Graph paper

Materials for Micrometeoroid Protection Activity:

- Styrofoam, Mylar® sheets, cloth, brown paper bags, white copy paper, cardboard, foam, etc. (materials can be pre-cut, or student can cut needed amounts)
- Phillips screwdriver
- Measure stick or measuring tape
- Micrometeoroid Protection Activity Data Table (included)
- Graph paper

Procedure

- Inquiry Discussion

Encourage discovery-based learning by hosting a class discussion using the guiding questions below. Use this discussion to segue into the activities, and incorporate background information when students reflect after completing the activities.

1. What is the most important factor to consider during spacewalking?
2. What is the purpose of spacewalking?
3. How do astronauts train for spacewalking?
4. How are spacesuits similar to the space station?
5. What functions does a spacesuit need to perform?

Let's check out a video from the space station to learn about spacesuits and spacewalking.

- Watch and Discuss Videos

Watch the STEMonstration videos:

1. Spacewalk Part 1: Safety and Training
2. Spacewalk Part 2: Spacesuits

Temperature Regulation
Activity One

The spacesuit is made up of several layers in order to provide temperature regulation to the astronauts. You will experiment with different materials and determine the most effective material combination to keep a thermometer as close to room temperature as possible when placed under a heat lamp.

Each trial will have a different number of layers and different combination of materials used. You will record the temperature at 30 second intervals for five minutes. The materials that are the most effective will regulate the temperature within a few degrees for the majority of the time.

Investigation Steps

1. Gather a set of materials you think will help keep a thermometer at room temperature for five minutes. You can create layers using the same or different materials. Use at least three and no more than 10 total layers in your design.
2. Record the number of layers and the type of materials used on the Temperature Regulation Data Table.
3. Record your prediction of how the materials will perform on the Temperature Regulation Data Table.
4. Place the first set of materials under the heat lamp.
5. Place the thermometer under the layers and begin the timer. Make sure the thermometer is completely covered by the layers.
6. Record the temperature on the Temperature Regulation Data Table every 30 seconds.
7. Repeat steps 1-6 with a different set of materials two more times. Can you improve your results with a new set of materials?
8. Create a scatter plot that shows the relationship between temperature and time for each set of materials.
9. Make sure your graph has the following components:
    - Graph title
    - Appropriate scale on axes
    - Labels on both axes
    - Different color line for each set of materials (three total)
    - Legend

Final Discussion

1. What was the most effective set of materials for temperature regulation?

2. How can you tell?

3. Did the number of layers contribute to the effectiveness of the materials? Why or why not?

4. What are other materials that could help keep temperature steady that you didn't have access to today?

Trial	Number of Layers	Materials Used for Layers	Prediction of How Effective Materials Will Be
1			
2			
3			

Trial	Time (seconds)	Temperature (^{o}F)
1	30	
	60	
	90	
	120	
	150	
	180	
	210	
	240	
	270	
	300	
2	30	
	60	
	90	
	120	
	150	
	180	
	210	
	240	
	270	
	300	
3	30	
	60	
	90	
	120	
	150	
	180	
	210	
	240	
	270	
	300	

______________________________ vs. ____________ __________________

Micrometeoroid Protection
Activity Two

The spacesuit is made up of several layers in order to provide micrometeoroid protection to the astronauts. Today you will experiment with different materials and determine the most effective combination of materials to protect an astronaut from a fast-moving object.

Investigation Steps

1. Gather a set of materials you think will provide micrometeoroid protection (simulated by a dropping a screwdriver). You can create your layers using the same or different materials. Use at least five and no more than 25 layers in your design.
2. Record the number of layers and the type of materials used on the Micrometeoroid Protection Data Table.
3. Record your prediction of how the materials will perform on the Micrometeoroid Protection Data Table.
4. Place the first set of materials on a flat surface next to a wall or door.
5. Using the measuring stick or tape measure, measure three feet up and mark the spot on the vertical wall/door.
6. Hold the screwdriver with the pointed end facing down, even with the mark on the wall.
7. Drop the screwdriver so it impacts the layers of materials.
8. Sort through the layers and count how many layers have a visible impact mark on them.
9. Record the number of layers that are impacted (do NOT include any layers that do not have evidence of impact) on the Micrometeoroid Protection Data Table.
10. Repeat steps 1-9 with a different set of materials two more times. Can you improve your results with a new set of materials?
11. Create a bar graph that shows the relationship between the trials you performed and the number of layers impacted. Make sure your graph has the following components:
    - Graph title
    - Appropriate scale on axes
    - Labels on both axes
    - Different color bar for each set of materials (three total)
    - Legend

Final Discussion

1. What was the most effective set of materials for micrometeoroid protection?

2. How can you tell?

3. Did the number of layers contribute to the effectiveness of the materials? Why or why not?

4. What is the relationship between the number of layers and micrometeoroid protection?

Micrometeoroid Protection Data Table — Activity Two (continued)

Trial	Number of Layers	Materials Used for Layers	Prediction of How Effective Materials Will Be	Number of Impacted Layers
1				
2				
3				

______________________________ vs. ____________ _________________

Resources

https://www.nasa.gov/centers/johnson/pdf/584725main_Wings-ch3d-pgs110-129.pdf

https://www.nasa.gov/pdf/143159main_Suited_for_Spacewalking.pdf

https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-spacewalk-58.html

https://www.nasa.gov/audience/foreducators/spacesuits/home/index.html

https://www.nasa.gov/audience/foreducators/spacesuits/home/clickable_suit.html

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For more STEMonstrations and Classroom Connections, along with other resources and opportunities, visit **www.nasa.gov/stemonstation**.