Science and Innovation

A Boeing/Teaching Channel Partnership

MISSION TO MARS

Teacher Handbook

Teaching Channel

Mission to Mars

Day 4: Mission #3—Temperature Control

Grade Level	Middle School
Lesson Length	One 50-minute session

Lesson Overview

Students learn how knowledge about simple physics (energy transfer) can help provide for human needs on Mars. They build a simple device to demonstrate how spacesuits help keep astronauts alive at temperatures and in environments that are not suitable for humans. As an optional extension, students build and demonstrate a simple gas collection device for propellant and oxygen.

Connecting to the Next Generation Science Standards

On Day 4, students make progress toward developing understanding across the following three dimensions:

- Science and Engineering Practices: Constructing Explanations and Designing Solutions
- Disciplinary Core Ideas: PS3.B Conservation of Energy and Energy Transfer
- Crosscutting Concepts: Energy and Matter

Day 4 is best taught in tandem with other lessons relating to PS3.B.

In the following table, the specific components addressed in this lesson are underlined and italicized. The specific connections to classroom activity are stated.

Performance Expectations		
This can be used to enhance the development of the following *physical science* performance expectation: MS-PS3-3. *Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*		
Specific Connections to Classroom Activity In this lesson, students use their understanding of how energy can be spontaneously transferred from hot regions to cold regions to design a cooling device for space suits. Students consider the transfer of energy in the designed system.		
Dimension	**NGSS Element**	**Connections to Classroom Activity**
Science and Engineering Practices	**Constructing Explanations and Designing Solutions** • *Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system.*	Students use their knowledge of energy transfer to design a device to keep astronauts cool. Students justify their design using science ideas.
Disciplinary Core Ideas	**PS3.B: Conservation of Energy and Energy Transfer**	In other lessons relating to PS3.B, students should have already developed the idea that energy can be transferred from hotter

	• *Energy is spontaneously transferred out of hotter regions or objects and into colder ones.*	regions into cooler regions. In this lesson, students use this science idea to design a device to keep astronauts cool.
Crosscutting Concepts	Energy and Matter • *The transfer of energy can be tracked as energy flow through a designed or natural system.*	As students design a device to cool astronauts, they consider the idea that energy can be transferred from humans to the designed cooling device in the space suit.

Basic Teacher Preparation

Make copies of the needed photos, or locate and share them with the class online. Be sure to familiarize yourself with the passive gas collection process beforehand if you choose to do the optional Oxygen on Mars activity. If you are going to acquire and use dry ice in this lesson, familiarize yourself with safety procedures.

The Heating and Cooling activity can be very messy. Prepare appropriate measures to help students pour water into tubes or to collect any spilled water. Practice the Heating and Cooling activity prior to engaging in the activity with students.

Required Preparation	Links/Additional Information
❑ Gather or purchase the required materials for the lesson	Refer to the Materials List below
❑ Ensure technology is available to project or allow students to access the recommended websites	Refer to the Suggested Teacher Resources at the end of this lesson
❑ Familiarize yourself with the processes for the heating/cooling device and the optional gas collection device	Refer to the Heating/Cooling Device and the Gas Property sections in this lesson
❑ Review suggested teacher preparation resources in advance	Refer to the Suggested Teacher Resources at the end of this lesson

Materials List

Item	Description/Additional Information	Quantity	Where to Locate/Buy
Computer (or computers) with Internet access and a projector		1 per class for projecting to entire class, or access to a computer lab	Available in most schools
Heating/cooling device	Each set includes: • 2 buckets • Hot and cold water • Funnel	1 set per team	Items available at most hardware or aquarium/pet stores, or online: • Buckets [Web Link]

	• 4–6 feet of flexible aquarium tubing (.25–.5 inches in diameter) • Thermometer		• Funnel [Web Link] • Flexible aquarium tubing [Web Link] • Thermometer [Web Link]
Gas collection device (Optional)	Each set includes: • 2 buckets • Cold and very warm water • Clean and empty 2-liter soda bottle • Large balloon • Dry ice (if available) • Tongs and gloves (if using dry ice)	1 set per team	Items available at most hardware stores, at home, or online: • Buckets [Web Link] • Large balloons Web Link] • Dry ice [Web Link]

Day 4: Mission #3 - Temperature Control

Introduction (15 minutes)

Ask students to explain how they dress differently in summer and winter. *What else do people do to stay comfortable in different types of weather?* Discuss the different heating and air conditioning methods currently in use. *Why do people use these inventions?*

Ask students which locations on Earth require special equipment for people to live there. Some examples include life in submarines, polar regions, deserts, underwater, and at extremely high altitudes. Discuss how the special equipment used in these extreme environments on Earth might relate to life on Mars.

Let students use Space.com to look up the most extreme temperatures on Earth. Discuss whether people live in these places and, if so, what they need to survive there. Then, have students look up the temperature ranges on Mars at NASA Quest. Discuss what people need to do to survive there.

Humans can live comfortably in temperature ranges of approximately 10–30° Celsius. Ask students if this temperature range is found on Mars. Give students a few minutes to talk to their teams about how they might protect astronauts from extreme temperatures.

Web Resources

- Space.com: What Is the Temperature of Earth [Web Link]
- NASA Quest Mars Facts [Web Link]

NGSS Key Moment

Listening to student discussions about keeping astronauts protected from extreme temperatures will help inform you of current student conceptions of PS3.B. Use student ideas to guide the amount support provided throughout the lesson.

Design Work: Heating and Cooling on Mars (30 minutes)

Give each team a length of tubing, a bucket of cold water, and an empty bucket. Challenge them to use the materials to devise a method of cooling astronauts while they work in sunlight on Mars.

If after a few minutes students have not come up with a method, show them how to wrap tubing around their arm, and pour cold water in the upper end with a bucket and a funnel, collecting it at the lower end with the empty bucket. Give them a few minutes so they can all experience the results.

Give students the warm water to try warming themselves with the device. Discuss the

Important Note

This activity can be messy. To minimize the mess, help students carefully pour the water into the tubing. Provide buckets or baby pools to catch spilled water.

advantages and disadvantages of a water cooling system in the spacesuits. Access Space.com to show the class a diagram of how space suits work, pointing out the heating/cooling system.

Revisit student letters to NASA. Have students add their ideas about temperature control to their letters. Students should include a justification for *how* and *why* the design helps to keep astronauts cool (or warm).

Students should build on ideas from previous lessons (not included in this module).

Students should comment on energy transfer in the system.

Students should recognize that energy is spontaneously transferred from warm areas to cold areas.

Web Resource

- Space.com: How NASA Spacesuits Work (infographic) [Web Link]

NGSS Key Moment

This activity can be used as a formative assessment of a student's ability to design a system that maximizes thermal energy transfer. Simply *doing* the activity, however, is not enough. Students must justify their ideas about *how* and *why* the design worked.

Whole Group Discussion: Oxygen on Mars (Optional) (10 minutes)

Remind students that astronauts also need to breathe on Mars. Ask students what they think they will need to fill the Mars habitat with oxygen.

Where will this oxygen come from? Are there any resources on Mars that might provide astronauts with oxygen?

Introduce the term **in situ**. Access the Phoenix Mars Mission website. Discuss the gas composition of Earth's atmosphere and Mars' atmosphere.

Review with students the contraction and expansion properties of matter, including gases. Tell them that Mars' gases can be collected passively though the heating and cooling cycles of the planet's surface. Review how the heating and cooling cycles happen on Earth in the day/night cycle, which also helps account for weather events.

Web Resource

- Phoenix Mars Mission [Web Link]

Helpful Tip

If you are short on time, consider showing students the videos included in this activity rather than completing the entire activity.

Show the Gas Property Demonstration video created by one of the module's engineer contributors. This video and the activity demonstrates expansion and contraction of gases. Emphasize the idea that warmer molecules move faster, thus increasing the volume of their container (if the material of the container is flexible). Allow students to try this in their teams with the warm and cold water.

If desired, demonstrate this process in front of the class, using the dry ice (frozen carbon dioxide) to achieve greater temperature differences and greater inflation rates for the balloon. Dry ice safety information can be found at Safe Handling of Dry Ice.

Video Link

- Gas Property Demonstration [YouTube Link]

Web Resources

- Safe Handling of Dry Ice [Web Link]

Discuss why space pioneers (or humans on Earth) might want to use a passive system using in situ resources over a mechanized system to meet their needs for warmth, fuel, and so forth. *What are the advantages and disadvantages of this type of passive system?*

Lesson Close (5 minutes)

End the class with a review of the properties of heat, reminding students that knowing about these properties helps to determine how resources are used in space. As an exit ticket, ask students to identify one new fact they learned today and to think of one question they have about the lesson's experiences. Have them record this information in their science notebooks.

Assessment Opportunities

Use student justifications for the heating and cooling device to gather data regarding student progress on MS-PS3-3. Provide appropriate supports or extensions as needed. Reference Appendix B for suggestions for meeting the needs of all learners.

Community Connections

Many new companies—particularly solar-oriented firms—now use passive heating and cooling technologies. Identify and research a few companies in your region to share with students.

Suggested Teacher Resources

Meeting the Needs of All Learners	Mission to Mars Teacher Handbook, Appendix B
Space.com: What Is the Temperature of Earth	[Web Link]
NASA Quest Mars Facts	[Web Link]
Space.com: How NASA Spacesuits Work (infographic)	[Web Link]
Phoenix Mars Mission	[Web Link]
In situ (definition)	[Web Link]
Gas Property Demonstration	[YouTube Link]
Safe Handling of Dry Ice	[Web Link]