

**Lesson Title:** Mars Thermos

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**Topic:** Thermal Energy

**Targeted Grade Level:** 6<sup>th</sup> Grade

**Time Needed:** 7-10 days (50 minute periods)

**Subject Integration:** Science, Engineering, Math

**Justification:** As we study energy, we will learn about the different forms of energy and how energy is never lost but can be transferred. In this 5E lesson plan, we will focus on thermal energy. Student teams use everyday materials to design an insulator that will keep a small amount of water from rapidly changing temperature. This activity incorporates both science and engineering process skills. Students will design and build an insulator and use it to conduct a scientific experiment, complete with control. Students will learn the application of heat transfer and basic thermodynamics, while practicing their data collection and analysis mathematics skills.

**Standards:** NGSS Science Standards

<p>Students who demonstrate understanding can:  <b>MS-PS1-4.</b> <b>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.</b> [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]</p>		
<p>The performance expectation above was developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i>:</p>		
<p><b>Science and Engineering Practices</b></p> <p><b>Developing and Using Models</b>        Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.</p> <ul style="list-style-type: none"> <li>Develop a model to predict and/or describe phenomena.</li> </ul>	<p><b>Disciplinary Core Ideas</b></p> <p><b>PS1.A: Structure and Properties of Matter</b></p> <ul style="list-style-type: none"> <li>Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.</li> <li>In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.</li> <li>The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.</li> </ul> <p><b>PS3.A: Definitions of Energy</b></p> <ul style="list-style-type: none"> <li>The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (<i>secondary</i>)</li> <li>The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system’s total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (<i>secondary</i>)</li> </ul>	<p><b>Crosscutting Concepts</b></p> <p><b>Cause and Effect</b></p> <ul style="list-style-type: none"> <li>Cause and effect relationships may be used to predict phenomena in natural or designed systems.</li> </ul>
<p><b>Connections to other DCIs in this grade-band:</b>  <b>MS.ESS2.C</b></p>		
<p><b>Articulation of DCIs across grade-bands:</b>  <b>HS.PS1.A ; HS.PS1.B ; HS.PS3.A</b></p>		
<p><b>Common Core State Standards Connections:</b></p> <p><b>ELA/Literacy -</b>  <b>RST.6-8.7</b> Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (<i>MS-PS1-4</i>)</p> <p><b>Mathematics -</b>  <b>6.NS.C.5</b> Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (<i>MS-PS1-4</i>)</p>		

Students who demonstrate understanding can: <b>MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*</b> [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]		
The performance expectation above was developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> :		
<b>Science and Engineering Practices</b> <b>Constructing Explanations and Designing Solutions</b> Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. <ul style="list-style-type: none"> <li>Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.</li> </ul>	<b>Disciplinary Core Ideas</b> <b>PS3.A: Definitions of Energy</b> <ul style="list-style-type: none"> <li>Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.</li> </ul> <b>PS3.B: Conservation of Energy and Energy Transfer</b> <ul style="list-style-type: none"> <li>Energy is spontaneously transferred out of hotter regions or objects and into colder ones.</li> </ul> <b>ETS1.A: Defining and Delimiting an Engineering Problem</b> <ul style="list-style-type: none"> <li>The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (<i>secondary</i>)</li> </ul> <b>ETS1.B: Developing Possible Solutions</b> <ul style="list-style-type: none"> <li>A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (<i>secondary</i>).</li> </ul>	<b>Crosscutting Concepts</b> <b>Energy and Matter</b> <ul style="list-style-type: none"> <li>The transfer of energy can be tracked as energy flows through a designed or natural system.</li> </ul>
Connections to other DCIs in this grade-band: <b>MS.PS1.B ; MS.ESS2.A ; MS.ESS2.C ; MS.ESS2.D</b>		
Articulation of DCIs across grade-bands: <b>4.PS3.B ; HS.PS3.B</b>		
Common Core State Standards Connections: ELA/Literacy - <b>RST.6-8.3</b> Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. ( <i>MS-PS3-3</i> ) <b>WHST.6-8.7</b> Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. ( <i>MS-PS3-3</i> )		

## NGSS Engineering Standards

Students who demonstrate understanding can: <b>MS-ETS1-1. 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.</b>		
The performance expectation above was developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> :		
<b>Science and Engineering Practices</b> <b>Asking Questions and Defining Problems</b> Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. <ul style="list-style-type: none"> <li>Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.</li> </ul>	<b>Disciplinary Core Ideas</b> <b>ETS1.A: Defining and Delimiting Engineering Problems</b> <ul style="list-style-type: none"> <li>The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.</li> </ul>	<b>Crosscutting Concepts</b> <b>Influence of Science, Engineering, and Technology on Society and the Natural World</b> <ul style="list-style-type: none"> <li>All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.</li> <li>The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.</li> </ul>
Connections to MS-ETS1.A: Defining and Delimiting Engineering Problems include: <b>Physical Science: MS-PS3-3</b>		
Articulation of DCIs across grade-bands: <b>3-5.ETS1.A ; 3-5.ETS1.C ; HS.ETS1.A ; HS.ETS1.B</b>		
Common Core State Standards Connections: ELA/Literacy - <b>RST.6-8.1</b> Cite specific textual evidence to support analysis of science and technical texts. ( <i>MS-ETS1-1</i> ) <b>WHST.6-8.8</b> Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. ( <i>MS-ETS1-1</i> ) Mathematics - <b>MP.2</b> Reason abstractly and quantitatively. ( <i>MS-ETS1-1</i> ) <b>7.EE.3</b> Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. ( <i>MS-ETS1-1</i> )		

Students who demonstrate understanding can: <b>MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.</b>		
The performance expectation above was developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> :		
<b>Science and Engineering Practices</b> <b>Engaging in Argument from Evidence</b> Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. <ul style="list-style-type: none"> <li>Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.</li> </ul>	<b>Disciplinary Core Ideas</b> <b>ETS1.B: Developing Possible Solutions</b> <ul style="list-style-type: none"> <li>There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.</li> </ul>	<b>Crosscutting Concepts</b>
Connections to MS-ETS1.B: Developing Possible Solutions Problems include: <b>Physical Science: MS-PS1-6, MS-PS3-3, Life Science: MS-LS2-5</b>		
Articulation of DCIs across grade-bands: <b>3-5.ETS1.A ; 3-5.ETS1.B ; 3-5.ETS1.C ; HS.ETS1.A ; HS.ETS1.B</b>		
Common Core State Standards Connections: <i>ELA/Literacy -</i> <b>RST.6-8.1</b> Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-2) <b>RST.6-8.9</b> Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2) <b>WHST.6-8.7</b> Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2) <b>WHST.6-8.9</b> Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2) <i>Mathematics -</i> <b>MP2</b> Reason abstractly and quantitatively. (MS-ETS1-2) <b>7.EE.3</b> Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-2)		

Students who demonstrate understanding can: <b>MS-ETS1-3. 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.</b>		
The performance expectation above was developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> :		
<b>Science and Engineering Practices</b> <b>Analyzing and Interpreting Data</b> Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. <ul style="list-style-type: none"> <li>Analyze and interpret data to determine similarities and differences in findings.</li> </ul>	<b>Disciplinary Core Ideas</b> <b>ETS1.B: Developing Possible Solutions</b> <ul style="list-style-type: none"> <li>There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.</li> <li>Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.</li> </ul> <b>ETS1.C: Optimizing the Design Solution</b> <ul style="list-style-type: none"> <li>Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.</li> </ul>	<b>Crosscutting Concepts</b>
Connections to MS-ETS1.B: Developing Possible Solutions Problems include: <b>Physical Science: MS-PS1-6, MS-PS3-3, Life Science: MS-LS2-5</b>		
Connections to MS-ETS1.C: Optimizing the Design Solution include: <b>Physical Science: MS-PS1-6</b>		
Articulation of DCIs across grade-bands: <b>3-5.ETS1.A ; 3-5.ETS1.B ; 3-5.ETS1.C ; HS.ETS1.B ; HS.ETS1.C</b>		
Common Core State Standards Connections: <i>ELA/Literacy -</i> <b>RST.6-8.1</b> Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-3) <b>RST.6-8.7</b> Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ETS1-3) <b>RST.6-8.9</b> Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-3) <i>Mathematics -</i> <b>MP2</b> Reason abstractly and quantitatively. (MS-ETS1-3) <b>7.EE.3</b> Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-3)		

**5.G.A.2 Graph points on the coordinate plane to solve real-world and mathematical problems.**

Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

**6.SP.B.4 Summarize and describe distributions**

Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

**8.SP.A.1 Investigate patterns of association in bivariate data**

Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

**CC ELA/ Literacy Standards**

**CCSS.ELA-LITERACY.RST.6-8.3**

Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

**Objectives:**

*Students will be able to:*

- design and build an insulator and use it to conduct a scientific experiment, complete with control.
- learn the application of heat transfer and basic thermodynamics
- practice their data collection and analysis mathematics skills.
- Practice engaging in scientific practices of explanation and argumentation

**Nature of STEM:**

In this lesson we will be addressing the Nature of Science in a variety of ways:

- Scientific Investigations Use a Variety of Methods
- Scientific Knowledge is Based on Empirical Evidence
- Scientific Knowledge is Open to Revision in Light of New Evidence
- Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Science Addresses Questions About the Natural and Material World

**Engaging Context/Phenomena:** How can containers keep stuff from warming up or cooling down?

The students will observe an iced drink in a regular cup warming up more quickly compared with an iced drink in a fancy cup. We will develop a systems models to explain what is happening in the two cups that leads one to be better than the other at maintaining the temperature of the drink. We will brainstorm why certain objects are better at keeping things cold or hot by considering features of each object's design. We will ask questions about design features and other factors that influence how well an object can keep something hot or cold.

**Data Integration:** After observing the anchoring phenomena, the students will be designing their own Thermos for Mars where they will be collecting data (temperature changes). They will also be graphing their data.

**Differentiation of Instruction:** The anchoring phenomenon is relatable and can connect to students on all levels. I would encourage students' models and designs to look different from those of their peers so that we can see there more than one way to view a problem or create a solution. Modification can be made for note taking. Some students may need help with brainstorming from peers. Student groups can be teacher chosen maximize student's potential.

**Real-life Connection:** This lesson is directly related to real-life since all of the students have experienced the warming or cooling of their drinks and/or food. The students should be able to identify which materials are better insulators than others.

**Possible Misconceptions:** A possible misconception that students can have is that heat transfer is from cold to hot. The opposite is true. Heat transfers from hot to cold.

## **5 E Lesson Plan**

**Engage: (Anchoring phenomena, facilitate student questions, discussions, learn about what students already know and want to know).**

In the engage part of this lesson, students will describe what happens to my cold plastic water bottle by the end of my workout. They will observe an iced drink in a regular cup warming up more quickly compared with an iced drink in a fancy cup. We will develop systems models to explain what is happening in the two cups that leads one to be better than the other at maintaining the temperature of the drink. We will brainstorm why certain objects are better at keeping things cold or hot by considering features of each object's design. We will ask questions about design features and other factors that influence how well an object can keep something hot or cold, and we generate a list of investigations to test these factors.

*Adapted from OpenSciEd Unit 6.2*

**Length:** 50 minutes

**Materials:**

- 2 thermometers
- 16-oz plastic cup with lid and straw
- 16-oz hard plastic cup with lid and straw (fancy cup)
- Pitcher of 800 mL iced cold water
- 500 mL beaker
- Timer
- Chart paper/whiteboard
- Markers
- Science Journal

**Procedure:**

1. Anchoring phenomena: Tell students that when I leave for the gym in the morning, I grab a plastic water bottle from the refrigerator but by the end of my workout, the water is warm. Discuss why they think this happens.
2. Introduce students to the plastic cup and fancy cup activity. Tell them that fancy cups ***claim*** to keep drinks colder longer.
3. Brainstorm with students how to test the two cups. Elicit students' ideas about how to test whether the fancy cup keeps a drink colder longer.
4. Based off of students' ideas, set up both cups where students can observe them so they can collect observational data and temperature data.
5. Have students work in teams to draw systems model on chart paper to explain why the water in regular cup warms up faster than the water in the fancy cup.
6. Have students return to the claim and write initial conclusions in Science Journal
7. Ask students to look for related phenomena at home for homework.

**Modifications:**

As students create their models, encourage students to have their models look different from those of their peers so that we can see there more than one way to view a problem or create a solution.

**Standards Addressed:**

MS-PS1-4: 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.

**Resources:**

<https://www.openscienced.org/6-2-thermal-energy-download/>

**Explore: (Plan for student to engage in hands-on activities that are designed to facilitate conceptual change)**

In the Explore part of this lesson, the students will review the activity from the previous day. We will then relate our findings to explore the planet Mars. Mars has extreme temperature changes and that can take a toll on robots, equipment and one day astronauts. The students will take what they've learned so far about thermal energy to design and build an insulator and use it to conduct a scientific experiment. The students will learn the application of heat transfer and basic thermodynamics. They will also practice their data collection and analysis of mathematic skills.

*Adapted from JPL's Mars Thermos Activity*

**Length:** 3-4 days (50 minute periods)

**Materials:**

- Thermometers (ideally 2 per team)
- Stopwatches (1 per team)
- Graduated cylinders (1 per team)
- Plastic cups (2 per team)
- Insulating material (bubble wrap, paper, cloth, sand, water, foil, Styrofoam, etc)
- Tape (masking, packing, duct)
- Paper towels (for cleaning up spills)
- Pitcher (for ice water)
- Ice
- Water
- Insulated thermos or carafe (for warm water)
- Electric tea kettle or hot plate and pot (for heating water)
- Copies of Mars Thermos Experiment Record  
[https://www.jpl.nasa.gov/edu/pdfs/marsthermos\\_worksheet.pdf](https://www.jpl.nasa.gov/edu/pdfs/marsthermos_worksheet.pdf)
- Pencils
- Science Journal

**Management**

- Suggested team size: two to three students

**Pre-Activity Set-Up**

1. Heat water to no warmer than 120°F and place it in a well-insulated commercial thermos or carafe. Keep it in a safe location away from student access.
2. Fill the pitcher with ice and pour water over the ice to fill the pitcher. Mix, and allow the water to become ice cold
3. Make sure paper towels are readily accessibly to all teams in case of spills.

4. To expedite the experiment, set up one control (un-insulated) set of cups for which you (or a designated student) will record temperatures.

#### **Cold Water Experiment Tips**

- This experiment works best when the temperature in your classroom is moderate (not on a cold winter day when the heater is broken).
- Use ice to pre-cool the water only. **DO NOT** transfer any ice to student cups.

#### **Hot Water Safety and Experiment Tips**

- Water used should **NEVER** be more than 120°F for students.

#### **Procedure:**

1. Have students review the activity from yesterday. Using a large model of the experiment on chart paper, facilitate a discussion with the students to gather information on:

- a. how the different parts of the cup system worked together to keep the water cool,
- b. identify structural features that helped maintain the temperature,
- c. that heat can enter the cup and/or cold can leave the cup system

2. Show students Mars in a Minute: Is Mars Red Hot? Video.

<https://www.youtube.com/watch?v=HfyyGCvVevc&list=PL9TFrgFq7557nWqmfuVngU22OhTpUE9gg#action=share>

\* Temperatures can fluctuate greatly on Mars because there is very little atmosphere to retain heat. The temperatures can be as low as -125 C (-195 F) to up to 20 C (70 F). \*

3. Explain to students that robots, scientific equipment, spacecrafts and humans are sensitive to these extreme temperature fluctuations. Humans need protective layers to keep them at a reasonably constant temperature. Engineers need to design spacesuits to prevent heat from being transferred to, or away from our spacecraft and bodies.

4. Ask, "How might we insulate a spacecraft and ourselves from the wide variations of temperature in the Martian environment?"

5. Introduce the activity by explaining the objective: Teams must keep water from changing temperature more than 5°F in 10 minutes.

**\*Emphasize hot water safety protocols. \***

6. Students will follow procedures on the Mars Thermos Experiment Record (also listed below).

7. Discuss the definitions and real-world applications of heat, temperature, equilibrium, and thermal energy transfer.

8. Have students write definitions of these terms on their copies of the Mars Thermos Experiment Record. (copy later into Science Journal).
9. Ask students to predict how the temperature will change in each cup of water and use the terms defined in Step 4 to write their hypotheses.
10. Instruct students on the use of thermometers and have them announce, compare and record the temperature of the room in degrees Fahrenheit.
11. Ask each group to decide how much water they should use in each cup. Ask them to write their justification for their chosen amount. Students should use their prior knowledge and thought processes to consider that a greater amount of water will change temperature slower than a smaller amount of water.
12. Ask each group to decide how often they will record the temperature for each cup of water. More frequent measurements will yield more accurate graphs, but may not be feasible. A reasonable compromise should be reached that will allow an accurate graph without undue burden of manual data collection.
13. Have student teams use graduated cylinders to obtain ice water (with no ice) and hot water (no warmer than 120°F) samples, place the samples in their control cups and perform the control experiment.
14. Have students investigate the insulative properties of the materials available and then design and build a Mars Thermos for the cold and hot cup. Remind them to make sure they are able to easily obtain temperature measurements. Design should be completed in Lab Notebook.
15. Have teams perform the experiment with their Mars Thermos designs, then graph their data.

**Modifications:** Some modifications that can be made during the experiment are:

- Pair students with a partner that will work well with them.
- Give different students different roles based on their strengths.
- Reduce the writing component of the lab work.
- Students may be given extended time if needed.

**Standards Addressed:**

**MS-ETS1-1:** 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-ETS1-2:** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**MS-ETS1-3:** 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-PS3-3:** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

**5.G.A.2** Graph points on the coordinate plane to solve real-world and mathematical problems.

**6.SP.B.4** Summarize and describe distributions

**8.SP.A.1** Investigate patterns of association in bivariate data

**CCSS.ELA-LITERACY.RST.6-8.3**

Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

**Resources:**

[https://www.jpl.nasa.gov/edu/pdfs/marsthermos\\_worksheet.pdf](https://www.jpl.nasa.gov/edu/pdfs/marsthermos_worksheet.pdf)

[https://www.youtube.com/watch?](https://www.youtube.com/watch?v=HfyyGCvVevc&list=PL9TFrgFq7557nWqmfuVngU22OhTpUE9gg#action=share)

[v=HfyyGCvVevc&list=PL9TFrgFq7557nWqmfuVngU22OhTpUE9gg#action=share](https://www.youtube.com/watch?v=HfyyGCvVevc&list=PL9TFrgFq7557nWqmfuVngU22OhTpUE9gg#action=share)

**Explain: (Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts)**

In this part of the lesson, students will use their data and observations to form a conclusion, based off our big question, *how might we insulate a spacecraft and ourselves from the wide variations of temperature in the Martian environment*, that is supported with evidence gathered during their investigation. During this dialogue, the teacher can address any misconceptions and introduce the concepts of convection, conduction and radiation of thermal energy.

**Length: 1-2 Days (50 minute period)**

**Materials:**

- Mars Thermos Experiment Record
- Science Journal

1. Students will use the data from their experiments to write a conclusion in their science notebook.
2. Have teams share their conclusions supported with evidence from their performance data with the class.
3. Using dialogue, challenge students practice engaging in the scientific practices of explanation and argumentation.
4. Discuss with students:
  - a. How did the temperature of the hot water change? Cold water?
  - b. How do your experiment's data compare to the control experiment?
  - c. Do you think the temperatures in the cup will reach equilibrium with the air in the room? If so, predict how long this would take.
4. Present Google Slides on Thermal Engineering and Heat Transfer.

[https://docs.google.com/presentation/d/1snfANZvfvu3sUAP4ZontLFDoQ\\_xkWWtrMQay4ucHqT8/edit?usp=sharing](https://docs.google.com/presentation/d/1snfANZvfvu3sUAP4ZontLFDoQ_xkWWtrMQay4ucHqT8/edit?usp=sharing)

5. Have students record notes in Science Journal.

**Modifications:** Some modifications that can be made during the experiment are:

- Practice argumentation and science dialogue
- Encourage positive feedback from peers and how to respectfully disagree
- Prompt students with sentence starters if they struggle
- Modify note taking with outlined (fill in the blank) notes

**Standards Addressed:**

MS-ETS1-2: Evaluate competing design solutions using systemic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3: Analyze data from test 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.

**Resources:**

<https://thewonderofscience.com/documents>

<https://static1.squarespace.com/static/59c3bad759cc68f757a465a3/t/5cf84ae6fbc9d70001158493/1559775974448/>

[Engaging+in+Argument+from+Evidence+Graphic+Organizer+%28%29.pdf](#)

<http://www.argumentationtoolkit.org/>

**Elaborate: (Provide applications of concepts and opportunities to challenge and deepen ideas; build on or extend understanding and skills)**

In this part of the lesson, students have the opportunity to extend their learning redesigning their thermoses or exploring deeper questions.

**Length: 1-2 days**

**Procedure Options:**

1. Have teams design a second set of Mars Thermoses, improving upon their original design, then redo the experiment.
2. Have students vary the amount of water used in the two designs to determine the impact the amount of water has on the experiment.
3. Research:
  - a. Would the water change temperature more slowly or more rapidly on Mars?
  - b. Does it matter whether the application of keeping my soup warm until lunch is as effective as keeping my body at roughly “body temperature” when on Mars?
  - c. In what situations on Earth are insulation and limiting thermal transfer important?

**Modifications:** Some modifications that can be made if they redesign is to allow students to report their findings in a variety of ways. They could choose from writing a description, drawing a diagram, or explaining findings to a peer. Provide students supplemental materials if needed. Students may be given extended time if needed.

**Standards Addressed:**

MS-ETS1-3: Analyze data from test 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.

**Evaluate: (Assess students knowledge, skills and abilities)**

**Procedure:**

1. Use the following rubrics as a formative assessment of the lesson.

**Formative Assessment/Rubric(s):**

Mars Thermos Rubric

<https://drive.google.com/file/d/1RiCQBcu3HetkCKVr90KYnKQwQIMwPaE7/view?usp=sharing>

STEM Reflection (see below)

# stem Lab Reflection

Name:

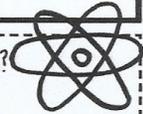
Date:



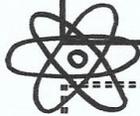
Describe your task:

What area of STEM did you work in today? (describe)

What field of science did you work in? Are there other fields where this activity / lesson applies?

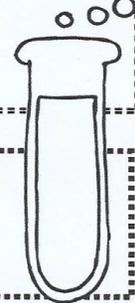


In what career field do today's activities connect?



How did you use mathematics today?

What did you do today that worked well? What did you do today that didn't work well?



If another student were to do this lab, what advice would you give?

**Modifications:** Some modifications that can be made are:

- Students to report their findings in a variety of ways. They could choose from writing a description, drawing a diagram, or explaining findings to a peer.
- Provide students supplemental materials if needed.
- Students may be given extended time if needed.

**Teacher Background:**

### **Mars**

Very little atmosphere exists on Mars, so temperatures fluctuate through a very wide range. In winter, near the poles, the temperature can be as low as  $-125^{\circ}\text{C}$  ( $-195^{\circ}\text{F}$ ). A summer day on Mars may get up to  $20^{\circ}\text{C}$  (or  $70^{\circ}\text{F}$ ) near the equator, but at night, the temperature can plummet to about  $-73^{\circ}\text{C}$  ( $-100^{\circ}\text{F}$ ). These are serious extremes for both robots and human beings!

Robots carry sensitive on-board science and computer equipment that must remain somewhat warm in order to properly function. Anyone living on Mars -- even for a short time -- will have to deal with this temperature variation and be protected properly from its damaging effects. Just think about the number of layers you wear when going outside on a very cold winter's day.

Spacecraft and humans traveling into extreme temperature environments must be surrounded by protective layers to keep them at a fairly constant temperature. Engineers need to design protective blankets and spacesuits to prevent heat from being transferred to, or transferred away, from our spacecraft and bodies. How might we insulate spacecraft and ourselves from the wide variations of temperature in the Martian environment?

**Thermal engineering** has to include important design elements so spacecraft can remain protected as temperatures rapidly change - at high speeds, day and night conditions, and on different surfaces.

<https://www.youtube.com/watch?v=aKrvKB3I79Q>

### **Thermal Energy and Heat Transfer**

[https://docs.google.com/presentation/d/1snfANZvfvu3sUAP4ZontLFDoQ\\_xkWWtrMQay4ucHqT8/edit?usp=sharing](https://docs.google.com/presentation/d/1snfANZvfvu3sUAP4ZontLFDoQ_xkWWtrMQay4ucHqT8/edit?usp=sharing)