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| **Task-level phenomenon:**  In this lesson, the specific phenomenon is an engineering design challenge to answer the question: Why do winter clothes keeps you warm?  **Synopsis of high-quality task:**  This task could be included in a unit on thermal energy. The goal of this task is to determine how thermal energy is transferred through conduction in order to construct a device that prevents the transfer of thermal energy by conduction. Students will develop an investigation to show how when warm objects and cool objects come into contact with one another, thermal energy moves from warm areas to cool areas. Students will use results of this investigation to create an effective tool to limit the transfer of thermal energy. Finally, students will explain why winter clothes keep you warm.  The task has three parts. Teachers can choose to use one or more of these parts in depth, while abbreviating the others. Keep in mind that explaining the phenomena of the ability of winter clothing to limit conduction, convection and radiation is the ultimate goal and should always be a part of the assessment of this lesson, as it is the most applicable to the standard.  **Anticipated student time spent on task:** 2 sessions, 55mins each.  **Type of Task (check one):**  \_X\_\_ 1. **Investigation/experimentation/design challenge**  \_\_\_\_ 2. Data representation, analysis, and interpretation  \_\_\_\_ 3. Explanation  **Student task structure(s):** Small group |
| **STE Standards and Science and Engineering Practices:**  Standard:  **7.MS-PS3-3.** Apply scientific principles of energy and heat transfer to design, construct, and test a device to minimize or maximize thermal energy transfer.\*  Clarification Statement:   * Examples of devices could include an insulated box, a solar cooker, and a vacuum flask.   State Assessment Boundary:   * Accounting for specific heat or calculations of the total amount of thermal energy transferred is not expected in state assessment.   **7.MS-PS3-6(MA).** Use a model to explain how thermal energy is transferred out of hotter regions or objects and into colder ones by convection, conduction, and radiation.  **Science and Engineering Practices:**   * Planning and Carrying out an investigation * Constructing explanations and designing solutions |
| **Prior Knowledge:**  Previous Standard from [Strand Map](http://www.doe.mass.edu/stem/standards/StrandMaps.html):  **4-PS3-2.** Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.  Clarification Statement:   * Evidence of energy being transferred can include vibrations felt a small distance from a source, a solar-powered toy that moves when placed in direct light, warming a metal object on one end and observing the other end getting warm, and a wire carrying electric energy from a battery to light a bulb.   State Assessment Boundary:   * Quantitative measurements of energy are not expected in state assessment.   **6.MS-PS1-7(MA).** Use a particulate model of matter to explain that density is the amount of matter (mass) in a given volume. Apply proportional reasoning to describe, calculate, and compare relative densities of different materials.  Previous Topics:   * Energy is the ability to do work. * Energy exists in different forms including, but not limited to potential, kinetic, thermal, electrical, chemical, and nuclear. * The particulate model of matter explains the properties of solids, liquids, and gases; most importantly it explains that particles of matter are always moving and thus, have energy. * Energy can be transferred from place to place by sound, light, heat, and electric currents. * Density is a characteristic property of a substance; it describes the relationship between the mass of the substance and how much space it takes up. * Light colors feel cool in sunlight, while dark colors feel warm in sunlight. |
| **Connections to the real-world**   * Winter clothing mimics nature to keep us warm. * Organisms with feathers stay warm because air pockets are created within these feathers and also among the different feathers. * Air acts as an insulator, which doesn’t allow for the movement of energy (e.g., electrical, thermal). * Clothing that purposefully integrates air spaces is very effective at limiting the transfer of thermal energy. * The industry demands for synthetic fibers that mimic natural feathers (e.g., Thinsulate, Primaloft) has never been greater. * At a time when overall fashion apparel trends are down, active apparel continues to grow with outdoor apparel leading the way. * Demands for picnic coolers and insulated, reusable drink containers are also thriving for similar reasons.   On winter days, our bodies oftentimes feel cold, but not because the cold is transferring into our bodies. We feel cold because thermal energy in our bodies is being transferred into the environment surrounding us.  Thermal energy moves from areas that are warmer to areas that are cooler. Therefore, a cold drink on a hot day is subject to the transfer of thermal energy from the environment to the drink. So oftentimes, in order to keep a drink cold on a hot day, different objects are used to prevent this transfer of thermal energy (e.g., insulated mug, picnic cooler). Materials that make up these objects share this quality, to prevent the transfer of thermal energy (e.g., styrofoam, plastic, air).  Picnic coolers can also be used to keep objects warm. In order to keep objects warm, coolers must prevent the transfer of thermal energy from the object into the environment. The same materials that prevent thermal energy from entering the cooler also prevent energy from transferring out of the cooler. Similar to picnic coolers, winter jackets, gloves, and hats limit thermal energy transfer from a person’s body to the air on cold days. |
| **Mastery Goals:**  Learning Objective:   * Carry out an investigation to determine how thermal energy is transferred through conduction * Construct an explanation for why winter clothes keep you warm   Performance Objective:   * Plan and carry out an investigation to determine the direction thermal energy moves (Part I) * Engineering design: Create a device that minimizes thermal energy transfer (Part II) * Analyze the effectiveness of the constructed device to determine how well it minimizes thermal energy transfer and recommend improvements to further minimize this transfer (Part II) * Construct an explanation for why winter clothes keep you warm, use evidence from your investigation to help support your claim (Part III)   Language Objective:   * Orally discuss the successes and challenges of designing your device and offer verbal feedback on how to further minimize thermal energy transfer for your classmates’ devices. * Construct a written explanation for why winter clothes keep you warm. |
| **Teacher Instructions:**  **INTRODUCTION (~20 min)**   1. As a large class, pose the following questions to students and discuss answers. Please note that when discussing, all ideas are acceptable, including those that are incorrect. The Look For points below are what students are working towards in this task. However, be prepared if students come with this prior knowledge.    1. Have you ever been cold? Describe what happens to your body when you are cold.    2. Why do we feel cold?   LOOK FOR: In this section you are eliciting student ideas and can collect them on the board.   * The heat in our bodies moves out of us * Energy moves from warmer to colder   1. What are some ways we keep drinks cold? Warm?   2. How do coolers work?   LOOK FOR: In this section you are eliciting student ideas and can collect them on the board.   * The food/drinks are protected by the cooler * The cooler limits energy from moving inside   1. Why do winter clothes keep us warm?   LOOK FOR: In this section you are eliciting student ideas and can collect them on the board.   * The clothing doesn’t let the heat move out of us * The clothing limits energy from leaving our bodies   1. Do coolers and winter clothes work the same way or differently?   **PART I (~45 min)**   1. Before starting this section, decide if students will work individually, in pairs, or in small groups. 2. Frame the activity by telling students they are going to design an investigation to determine how thermal energy moves and if it always moves the same way. 3. Show students the materials available (see supplies for thermal energy transfer investigation). 4. Inform students that in this case, the energy they are investigating is thermal energy. 5. Emphasize the importance of recording each step so that if a procedure was to be replicated/changed, the appropriate information could be provided.    1. Different approaches will likely be followed.    2. Students may begin with cold water or hot water.    3. If students are struggling to design an investigation, students may be given the fact that energy always travels from warm to cold and thus, instead of figuring it out, their investigation should prove this.    4. The goal of this part of the task is to see how thermal energy transfer occurs and that it always occurs in the same direction. The investigations students create may not be perfect, but they may include elements that will get them closer to determining how thermal energy moves. In collaborating with classmates, imperfect investigations together may help to develop more thorough understanding. 6. Sign off on investigations proposed by students that are safe and worthwhile. Ask probing questions, if necessary, to provide assistance. 7. Students should be allowed to experiment with materials provided while in the planning phase. This will allow for students to isolate variables, secure washers, in order to determine the best experimental setup. 8. LOOK FOR:    1. Hot and cold water need to be used    2. Washers need to be secured together    3. Thermometers need to be used for initial and final readings 9. As students are working, allow students to complete a gallery walk. Ask students to make improvements to their investigations as they deem necessary based on what they observed during their walk.    1. Depending on time, students may be allowed to completely redesign their investigation.    2. Students should be directed to notice differences among students’ investigations and whether these investigations are actually determining how energy moves.    3. Students should be further encouraged to make comparisons with their own investigations to determine possible ways to improve upon the results of their investigations. 10. Have students present their investigation, focusing on the results and direction that energy moves. 11. As a large group, compile a chart of student feedback.   Example  Student feedback chart   1. As a large group, make the determination that thermal energy always moves from warm to cold.   **PART II (~60 min)**   1. Before starting this section, decide if students will work individually, in pairs, or in small groups. 2. Frame the activity by telling students they are going to design a device that limits the transfer of thermal energy. Students may choose to keep something warm or cold. 3. Show students the materials available (see recycled materials for devices). 4. Emphasize the importance of recording each step so that if a device was to be replicated/changed, the appropriate information could be provided.    1. Different approaches will likely be followed.    2. If students are struggling to design a device, students may be reminded that energy always travels from warm to cold and thus, instead of figuring it out, their device should b e an example of this.    3. Sign off on devices proposed by students that are safe and worthwhile. Ask probing questions, if necessary, to provide assistance. 5. Students should be allowed to experiment with materials provided while in the planning phase. This will allow for students to isolate variables and choose the best materials, in order to construct the best functioning device. 6. As students are working, allow students to complete a gallery walk. Ask students to make improvements to their devices as they deem necessary based on what they observed during their walk.    1. Depending on time, students may be allowed to redesign their device.    2. Students should be directed to notice differences among students’ devices and whether these devices are minimizing the transfer of thermal energy.    3. Students should be further encouraged to make comparisons with their devices to determine possible ways to improve them. 7. Have students present their devices, focusing on the results and how the device minimizes thermal energy transfer.   **PART III (~20 min)**   1. Remind students of the original question - why do winter clothes keep you warm? 2. Students use the investigation, personal experiences, and the devices they constructed to discuss their findings in their groups. Students should take notes on their discussion. For support, teachers could provide:    1. Graphic organizers for writing       1. Possible example: CER - The claim might be that winter clothes keep us warm because they slow down the transfer of our thermal energy. The evidence may come from the device (e.g., the bag of air and the box I placed it in kept the ice from melting for 6 minutes, which was better than wrapping the ice cube in plastic wrap where the ice cube started melting in just 1 minute). The reasoning is that thermal energy always moves from warmer areas to colder areas. If materials are used to slow this process, then this transfer will be minimized. Some materials perform better in doing this than others (e.g., air versus plastic wrap).       2. Sentence frames/starters 3. Students write explanations about why do winter clothes keep you warm. |
| **Instructional Materials/Resources/Tools:**  Include:   * Student handout (included below) * Supplies for thermal energy transfer investigation (for each group):   + Hot plate\*   + Hot hands/silicone pot-holders   + Water   + Ice   + 2-500 mL beakers   + 2-250 mL beakers   + Metal washers   + String, approximately 12”   + Scissors   + 2 thermometers   Note: Materials selected for this section was purposeful; intention was on experimental design, not materials selection.   * Recycled materials for devices, including but not limited to:   + Plastic containers   + Aluminum foil   + Plastic wrap   + Styrofoam   + Packing peanuts   + Cardboard   + Wood   + Cellophane   + Tissue paper   + Paper towel   \*Hot plate safety - hot plates and the materials heated by hot plates can cause burns resulting in serious injury. Review with students, proper use of hot plates. |
| **Task Source:**  This is original work not based on any other source. |
| **Accessibility and Supports:**  Key academic vocabulary (tier 2 and 3): cold, design, device, energy, heat, improvement, maximize, minimize, purpose, temperature, thermal energy, thermometer, transfer, warm  Students should be provided with claim, evidence, and reasoning graphic organizer (included below) for Part III |
| **Sample Student Work:**  Not available. |

Why Do Winter Clothes Keep You Warm?

Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Objectives

* Plan and carry out an investigation to determine the direction thermal energy moves (Part I)
* Engineering design: Create a device that minimizes thermal energy transfer (Part II)
* Analyze the effectiveness of the constructed device to determine how well it minimizes thermal energy transfer and recommend improvements to further minimize this transfer (Part II)
* Construct an explanation for why winter clothes keep you warm, use evidence from your investigation to help support your claim (Part III)

Introduction

1. Have you ever been cold? Describe what happens to your body when you are cold.
2. What can you do to stay warm?
3. Why do we feel cold?
4. What are some ways we keep drinks cold? Warm?
5. How do coolers work?
6. Why do winter clothes keep us warm?
7. Do picnic coolers and winter clothes work the same way or differently? Explain your answer.

Part I

Thermal Energy Transfer Investigation

Materials available:

* Hot plate\*
* Hot hands/silicone pot holders
* Water
* Ice
* 2-500 mL beakers
* 2-250 mL beakers
* Metal washers
* String, approximately 12”
* Scissors
* 2 thermometers

\*Hot plate safety - hot plates and the materials heated by hot plates can cause burns resulting in serious injury. Use hot hands/silicone pot holders for protection when using hot plates and moving beakers heated on hot plates.

Draft an investigation for thermal energy transfer. Write the procedure below.

Teacher approval of drafted investigation\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| Brief Description/Illustration of Experimental Setup | Results |
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Complete a gallery walk. List two improvements that can be made to your investigation to produce better results.

Part II

Design a device that minimizes thermal energy transfer. Your device may keep things cold or warm. Provide an illustrated sketch below.

Teacher approval of device design\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| Brief Description/Labeled Illustration of Actual Device | Results |
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Complete a gallery walk. List two improvements that can be made to your device to produce better results.

Part III

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| **Question:** Why do winter clothes keep us warm? |
| **Claim:** |
| **Evidence:** |
| **Reasoning:** |