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| **Lesson Title: Thermos Challenge** | |  |
| **Grade Level: 8th** | **Quarter: 3rd** |
| **Standards:** *List relevant STEM – Science, Technology, & Math standards. Include ELA CCGPS if applicable.* | | |
| **S8P2. Students will be familiar with the forms and transformations of energy.**  a. Explain energy transformation in terms of the Law of Conservation of Energy.  d. Describe how heat can be transferred through matter by the collisions of atoms (conduction) or through space (radiation). In a liquid or gas, currents will facilitate the transfer of heat (convection). | | |
| **Science and Engineering Practices** | **Crosscutting Concepts** | |
| **Asking Questions and Defining Problems:**  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.  **Constructing Explanations and Designing**  **Solutions:**  Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.  **Engaging in Argument from Evidence:**  Construct, use, and present an oral and written  argument supported by empirical evidence and  scientific reasoning to support a solution to a problem. | **Cause and effects:** Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.  **Systems and system models:** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.  **Energy and matter:** Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations.  Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions. | |
| **Lesson Essential Question:**  How can I build a container that will prevent heat loss? | **Vocabulary:**  [*conduction:*](https://en.wikipedia.org/wiki/Special:Search?search=conduction) The transfer of heat through a solid object. When one part of an object is heated, the molecules within it begin to move faster and more vigorously; when these molecules hit other molecules within the object, they cause heat to be transferred through the entire object.  [*convection:*](https://en.wikipedia.org/wiki/Special:Search?search=convection) The transfer of heat by the movement of a fluid (water, air, etc.).  [*heat transfer:*](https://en.wikipedia.org/wiki/Special:Search?search=heat+transfer) The movement of heat from one body to another.  [*radiation:*](https://en.wikipedia.org/wiki/Special:Search?search=radiation) A direct transfer of heat from one object to another, without heating the air in between.  [*thermal conductivity:*](https://en.wikipedia.org/wiki/Special:Search?search=thermal+conductivity) A property of a material that describes the materials ability to conduct heat.  [*thermal conductor:*](https://en.wikipedia.org/wiki/Special:Search?search=thermal+conductor) A material that allows for easy transfer of thermal energy. Large values of thermal conductivity. The opposite of a thermal insulator.  [*thermal insulator:*](https://en.wikipedia.org/wiki/Special:Search?search=thermal+insulator) A material that impedes (blocks) the transfer of thermal energy. Small values of thermal conductivity. The opposite of a thermal conductor.  [*thermodynamics:*](https://en.wikipedia.org/wiki/Special:Search?search=thermodynamics) The study of heat and thermal energy, and how heat is transferred from one area to another. | |
| **Lesson Materials**   * calculator * thermometer * water * Thermos Challenge STEM Worksheet * beaker tongs or hot gloves * burner or hotplate or microwave for heating water * 200-ml beaker or graduated cylinder * assorted thermos construction materials (such as water, foil, cotton balls, paper cup, plastic cup, Styrofoam cup, foam insulation, masking tape, as listed on the worksheet) | **Lesson Assessment:**  Rubric to assess completed STEM worksheet and final design. | |
| **STEM Challenge Overview:**  Students will design a thermos that keeps hot liquids hot and is cost effective. The design must be made only of approved materials and cost $3.00 or less. | | |
| **Teacher Background:**  Begin by introducing the concepts of energy, temperature heat and thermodynamics. Include ample opportunities for students to give their own examples of the types of heat transfer they encounter in every day.  Review examples of the materials available to help the class relate to the materials while comparing thermal conductivities. Provide actual examples that students can touch and feel, which is especially helpful for unfamiliar materials.  When discussing the mechanisms of heat transfer (conduction, convection, radiation), explain that most systems do not rely on only one type of heat transfer. Therefore, it is important not to omit any from the design of a system.  Once students informally demonstrate understanding of the materials and concepts of heat transfer through class discussion, introduce the engineering design challenge: designing a thermos. Define "thermos" as applies to this challenge: a container used to hold a hot liquid with the goal that the liquid remain hot. As with all designed products, first a need and a purpose must be identified. For this activity, compare the performance and cost of containers created within the class. | | |
|  | | |
| 1. **Ask/Engage** | | |
| *How will you engage students? Introduce design challenge in general terms- what problem will students need to solve? Review any STEM Content that students will need to apply to solve design challenge.*  We're going to be discovering the role energy, temperature and heat play in engineering and our daily lives. Specifically, you will apply what you know about heat transfer and energy to solve an engineering design challenge: You want to design a thermos that keeps hot liquids hot. Your goal is to create the best heat retaining, cost-effective design with the materials available. | | |
| 1. **Imagine/Brainstorm** | | |
| *Introduce the constraints of the design plan. Define the criteria for success. Ask each student to work independently to come up with 1-2 possible design solutions. Students should draw/label their designs.*   * *Lukewarm Industries* is looking for a design for a container to hold 150 mL of hot water with minimum heat loss. * The winning prototype thermos must hold 150 mLwater, allow the least heat loss over 10 minutes (starting from boiling water), and cost the least (cost per degree loss, $/°C). * Each group has a $3 budget for the purchase of materials. * Any of the materials provided by teacher are available to be "purchased" for the design. * Students may bring in their own materials with the stipulation that the teacher must approve the materials and students must "purchase" them from the teacher, staying under the $3 maximum spending limit. * Each student will work independently to come up with 1-2 possible design solutions. Students should draw/label their designs. | | |
| 1. **Plan/Design** | | |
| *Each student presents their ideas to their team. Student teams collaborate to come up with final design plan. Students draw final design plan and make a list of needed supplies.*   * Engineering teams may design and test as many different thermos designs as class time allows. Students can re-use materials from one design to the next, while keeping track of the individual cost of each design. * Team members collaborate to choose a final design plan. | | |
| 1. **Create / Test** | | |
| *Student teams build their design according to their design plan. Students test their design plan and record data.*   * Student teams build a model of their thermos. * Student teams create a presentation to convince *Lukewarm Industries* that their design meets the criteria better than any other team. | | |
| 1. **Evaluate/Improve –** and repeat Steps 1-5 | | |
| *Students evaluate their design for success. Did it meet the established criteria? Did their final design match their planned design? How would students improve their design?*   * The class evaluates each group’s design for success. Did it meet the established criteria and constraints? * Was there any aspect the group failed to take into account? Was there any aspect particularly innovative? * ­­Student teams take feedback and make one-two redesign recommendations. * Student success will be evaluated through use of a rubric. | | |

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Thermos Challenge

**Challenge Overview:**

Students are challenged to create a container that will cost the least and allow the least amount of heat loss (as compared to their peers) after a ten minute time period.

**Constraints:**

* Constructed of only approved materials
* Cost less than $3 to build

**Materials:**

**Criteria:**

* Must hold 150 mL of hot water
* Prevent heat loss

|  |  |
| --- | --- |
| **Material** | **Cost** |
| Water (for insulation) | $0.25/ mL |
| Aluminum foil | $0.01/cm (minimum 5 cm) |
| Cotton balls | $0.15/ each |
| Paper cup | $0.55/each |
| Plastic cup | $0.15/each |
| Styrofoam cup | $0.85/each |
| Glass bottle | $1.00/each |
| Masking tape | $.01 / cm (minimum 5 cm) |
| Paper | $.10 per sheet |
| Other materials (from home, subject to approval) | Determined by teacher |

1. **ASK / ENGAGE:** What is the problem you are being asked to solve?

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1. **IMAGINE/BRAINSTORM:** What are some possible solutions to the problem that you are trying to solve? After you brainstorm, draw and label your ideas below.

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| --- | --- |
| **Idea #1** | **Idea #2** |

1. **PLAN/DESIGN:** Share your ideas with your group and collaborate to decide on a final design plan. Draw your team’s design below and make a list of the materials that you will need to complete your design.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Team Design Plan** | **Materials List** Fill in the following table as you choose materials.   |  |  |  | | --- | --- | --- | | **Material** | **Quantity** | **Cost**  **($)** | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |

1. **CREATE/TEST**: Use your Final Design Plan to create and build your solution. Test your design. Did is work well? Why or why not?

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Complete the following table as you test your design

|  |  |
| --- | --- |
| **Time (minutes)** | **Temperature (o\C)** |
| 0 - initial temperature reading |  |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |
| 7 |  |
| 8 |  |
| 9 |  |
| 10 |  |

1. **EVAULATE/IMPROVE:**  How well did your design work? Did your solution solve the problem within the given constraints?

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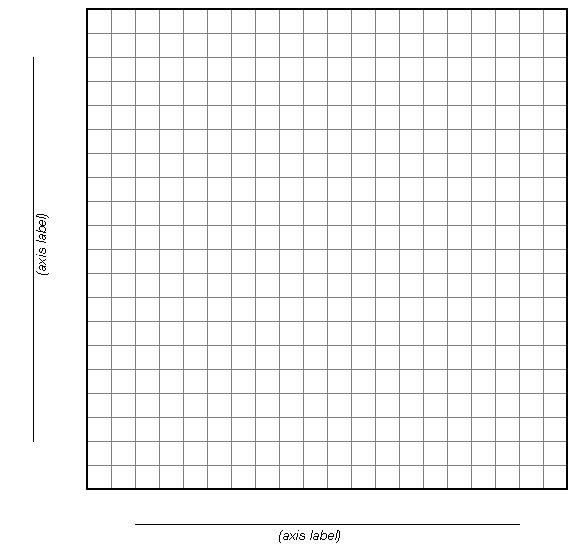
How can you improve your design? How can you make it better? Draw and label your improved design below

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Improved Team Design Plan** | **Materials List** Fill in the following table as you choose materials.   |  |  |  | | --- | --- | --- | | **Material** | **Quantity** | **Cost**  **($)** | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |

|  |  |  |  |
| --- | --- | --- | --- |
| **Time (minutes)** | **Temperature (oC)** | **Time (minutes)** | **Temperature (oC)** |
| 0 - initial temperature reading |  |  |  |
| 1 |  | 6 |  |
| 2 |  | 7 |  |
| 3 |  | 8 |  |
| 4 |  | 9 |  |
| 5 |  | 10 |  |

Complete the following table as you test your re-designed product.

:

Plot the heat loss of the group thermos final design.

6. Analysis

DESIGN COST = $

T (TEMPERATURE LOSS) = oC after 10 minutes

$/T =

**Grading Rubric:**

|  |  |  |
| --- | --- | --- |
| **Area** | **Possible Points** | **Student Score** |
| Student clearly states the problem to be solved. |  |  |
| Student brainstormed individual ideas – two drawings with labels and explanations | 10 |  |
| Team design is clearly drawn and labeled | 10 |  |
| Materials list is complete and accurate | 10 |  |
| Test results recorded | 10 |  |
| Test results examined and improved | 10 |  |
| Improved design is drawn and labeled | 10 |  |
| Materials list for re-design is accurate and complete | 10 |  |
| Test results for re-design recorded | 10 |  |
| Graph created | 10 |  |
| Analysis portion complete | 10 |  |
| **Total** | **100** |  |