Overview & Purpose: Students will be using different colored soda cans to determine which color maximizes the amount of thermal energy transferred.

Objective: Students will...
conduct an experiment to see what color transfers the most solar energy.

Background Information: Students should have already learned the different types of thermal energy transfer. The type of thermal energy transfer used here is radiation.

Performance Expectations Students who demonstrate understanding can:
MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

*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.
**Classroom Activities/Procedures & Timeline**

1. Students will be given a White can, a Black can, a Red Can, and a Yellow can.
2. The students will be asked to predict which can will heat up the most when left in the sun.
3. Students will be asked to make a prediction to the order of which the cans will transfer the most solar energy from the most energy transferred to the least.
4. The students will fill each can halfway with water.
5. The students will take their cans to an open, sunny area to test their cans.
6. The students will take the temperature of their can after 1 minute, 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes, and 30 minutes.
7. Students will bring in their materials then graph their information in the classroom.
8. They will answer the follow-up lab questions.

**Assessments:** (e.g., lab, quiz, test, oral presentation, survey, rubric, etc.)
- Classroom discussions
- Lab Sheet (attached)
- Graph

**Extensions/Homework:**
Students can write a short story utilizing the information that they learned about different colors and solar energy transfer. This will likely be about maximizing transfer during the winter and minimizing transfer during the summer by wearing different colored shirts

**References:**

**Equipment/Materials/Technology Needed:**
- 4 Empty Soda Cans per group
- White, Black, Red, and Yellow Paint
- 4 Long Thermometers per group
- Water
- Open area to conduct experiment
- Stopwatch
- Colored Pencils

**Teacher Resources:**
(e.g., readings, set-up instructions, lecture files, data files, etc.):

**Student Resources:**
(e.g., handouts, worksheets, data, etc.):
- Lab Sheet (attached)

**Accommodations & Safety Concerns:**
- Group students in groups that will work well together.
- Have the Axis and scale on the lab sheet premade for struggling students.
- You may lessen the amount of questions that struggling students have to answer.
Color and Solar Energy Transfer

1. Predict which can will transfer the most solar energy.

2. Rank each can in order of what you think will be the hottest to the coolest after being left in the sun.

<table>
<thead>
<tr>
<th>Minute</th>
<th>Temperature (Celsius)</th>
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<tbody>
<tr>
<td>1</td>
<td></td>
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<td>5</td>
<td></td>
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<td>10</td>
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<td>30</td>
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</tbody>
</table>
**Graph:**

Graph the information from your experiment using a line graph. Use the same color of crayon used for each color of can. A regular pencil can be substituted for white.

![Graph](image)

**Review and Reinforce:**

1. How did your predictions line-up to the actual results? How were they correct? How were they incorrect?

2. How can this information be used for a real-world application?

3. How might your own behavior be changed because of this information?

4. Did all of the colors rise at the same rate or did some heat up faster than others. (You can use the slope of the line to answer this question)
Overview & Purpose: Students will construct a solar oven, using their prior knowledge, to maximize the amount of thermal energy transferred inside their box and contain as much thermal energy as possible inside this box. Their goal is to reach the highest temperature inside their pizza box as possible.

This lesson is meant to be an introductory lesson to activate students’ interests in thermal energy transfer. It is not meant to teach students new terminology, but to lay the foundation for new information.

Objective: Students will...
Construct a solar oven to maximize thermal energy transfer and contain that energy, resulting in the highest temperature possible inside the box.

Background Information: Students will not have been taught any terminology or strategy to maximize the thermal energy transfer.

Performance Expectations

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

*Clariication 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.]
Lesson 1

6

Solar Ovens and Thermal Energy Transfer

Solar Oven Construction

Classroom Activities/Procedures & Timeline

1. Introduce activity to students, explaining that their goal is design a solar oven using their pizza box (with a 6” x 6” flap cut into the top) to get the temperature inside the oven to the highest temperature.
2. Show students the materials
3. Students should work in groups of approximately three students to construct their oven.
4. Instruct students that they will be testing their design in a later lesson
5. Students should construct their oven to the best of their ability, without much prompting from the teacher to assess their prior knowledge.
6. For fun, you can make the activity a competition with some sort of prize.
7. Instruct students to brainstorm and draw a “blue print” of their design (on lab sheet), (10 min)
8. Construct ovens (1-2 class periods)
9. Students will answer questions on lab sheet

Assessments: (e.g., lab, quiz, test, oral presentation, survey, rubric, etc.)
- Classroom discussions
- Lab Sheet (attached)

Extensions/Homework:
Have students research articles on inventions that use the sun as an energy source and write a response on how these inventions have a positive or negative effect on the world.

Equipment/Materials/Technology Needed:
- Pizza Boxes
- Foil
- Plastic Wrap
- Newspapers
- Tape
- Glue
- White Computer Paper
- Black Construction Paper
- Thermometers
- Marshmallows (optional)

Teacher Resources: (e.g., readings, set-up instructions, lecture files, data files, etc.):

Student Resources: (e.g., handouts, worksheets, data, etc.):
Lab Sheet (attached)

Accommodations & Safety Concerns:
- Group students in groups that will work well together.
- You can lessen the responses that students have to give on their lab sheet.
- Make sure students are using proper precautions when using items such as scissors.
Solar Oven Construction

Your goal is to build a solar oven, with the materials your teacher has supplied, that will result in the highest temperature inside your pizza box.

1 Sketch a design or “blue print” of your solar oven. Be sure to label the materials you will be using. Be as detailed as possible.

2 What materials will you need?

3 How did you come up with your design? What is the main idea behind your design?

4 What role does each material play in your design?
5 How do you think the temperature will increase over time when testing your oven? (rapidly, slowly, slowly then rapidly, rapidly then slowly) Why?

6 If you were to design your pizza box again, what changes would you make?

7 Why is this project important to you?
Solar Oven Testing and Analysis

Overview & Purpose: Students will test their solar ovens from the previous lesson, graph the data, and analyze the data. The teacher and students will discuss and analyze the different design strategies used and the effectiveness of these strategies. The students will later redesign their solar ovens for maximum effectiveness.

Objective: Students will...
Test their solar ovens, graph the time and temperature data, and analyze their design.

Background Information: Students will have already completed the Solar Oven Construction lesson.

Performance Expectations Students who demonstrate understanding can:
MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

*[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.]
Classroom Activities/Procedures & Timeline

1. Have each group show their solar oven to the class and explain how they came up with their design.
2. Have students rank the class’s ovens from highest temperature to lowest temperature.
3. Instruct students to place their thermometer inside their oven where it is visible from the outside.
4. In a sunny area, have students lay out their solar ovens. Immediately start taking data on the temperature changes inside the oven. Using the stopwatch and the lab sheet, students will find the temperature every minute. They will keep this data on their lab sheet.
5. Upon coming inside, students will make a line graph with their time and temperature data.
6. Be sure to introduce the importance of graphing in the engineering field and types of useful graphs used in the industry today.
7. Students will answer questions following their graph.
8. Collect all of the teams’ highest temperatures as a class, then make a bar graph of all of the highest temperatures.
9. Have students trade ovens and evaluate the other team’s oven. They should take notes on good things that they did and ways that they could possibly improve it.
10. Discuss the different design strategies as a class and discuss which ones worked best and which ones did not work best. Refer to their ranking predictions they did at the beginning of class. Answer the questions on the lab sheet.

Assessments: (e.g., lab, quiz, test, oral presentation, survey, rubric, etc.)

- Classroom discussions
- Lab Sheet (attached)

Extensions/Homework:

Students can come up with a solar oven improvement plan with design sketches and explanations.

Equipment/Materials/Technology Needed:

- Solar Oven from Previous Lesson
- Stopwatch
- Thermometer
- Graph Paper
- Rulers
- Colored Pencils

Teacher Resources:

(e.g., readings, set-up instructions, lecture files, data files, etc.):

Student Resources:

(e.g., handouts, worksheets, data, etc.):

Lab Sheet (attached)

Accommodations & Safety Concerns:

- Group students in groups that will work well together.
- Have the Axis and scale on the lab sheet premade for struggling students.
- You may lessen the amount of questions that struggling students have to answer.
Solar Oven Testing and Analysis

1. Rank each group's solar oven from highest temperature to lowest temperature.

2. Make a prediction of how your line graph will look. Sketch what you think it will look like here.
Data Collection:

<table>
<thead>
<tr>
<th>Time (in Minutes)</th>
<th>Temperature (in Celsius)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minute 1</td>
<td></td>
</tr>
<tr>
<td>Minute 2</td>
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<td>Minute 3</td>
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<td>Minute 6</td>
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<td>Minute 7</td>
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</tr>
</tbody>
</table>

3. Make a line graph showing your data from your data table.

4. How does your graph compare to the graph that you predicted?
5. Did your solar oven perform the way that you thought it would? Why or why not? Be sure to refer to your data.

6. Make a bar graph comparing every group’s highest temperatures.

7. How did your predictions of every group’s results compare to the actual results?

8. After seeing all of the groups’ designs and how well they performed, what type of designs performed the best? Why do you think these designs were the most effective?
After seeing different designs and their test results, what would you do differently to improve your solar oven design?