



LESSON PLAN

HEAT: TRANSFER OF THERMAL ENERGY GRADES 6-8

SUMMARY

Students collect and produce data to serve as evidence to test design solutions for the best material to keep a can of beverage (sparkling water, lemonade, beverage, etc.) cold.



MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

Science & Engineering Practices

Planning and Carrying Out Investigations
Analyzing and Interpreting Data

Connections to Classroom Activity

- Students collect, produce, and analyze data to serve as the basis for evidence to test design solutions for the best material to keep a can of beverage cold.

Disciplinary Core Ideas

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. (MS-PS3-3),(MS-PS3-4)

The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4)

Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)

Connections to Classroom Activity

- Students use their understanding of what a change in temperature indicates about thermal energy transfer when considering the type of material and the direction of energy flow.

Cross Cutting Concepts

Connections to Classroom Activity

Energy and Matter: Flows, Cycles, and Conservation

- Students track the flow of thermal energy as evidenced by the amount of temperature change of insulated cold beverage in cans removed from a refrigerator to room conditions.

DURATION

90 min.



ENGAGE

Ask students if they have ever had trouble keeping a can of beverage cold when they can't keep it refrigerated or on ice? Have students turn and talk to a partner about why the cold can of beverage gets so warm when left sitting out. Have each pair capture their ideas as well as any questions on sticky notes (one idea/question per note). Collect the sticky notes from the students and ask the class to help you determine the categories that their ideas/questions might fall under. (Note: You can also use a digital platform such as Jamboard or Padlet instead of sticky notes.) If some of the student ideas cannot be categorized as things such as energy transfer, direction of energy transfer, or good insulators, ask students questions like, "Why does the beverage warm up? How can we determine the direction of the energy flow? What things have you tried to keep a can of beverage cold? How did these things keep it cold (or not)?" Tell students that they have a great opportunity to put their understanding of the transfer of thermal energy to use designing a solution to this common design problem.

MATERIALS

Materials per group of four students:

- 6 refrigerated cans of the same beverage
- Aluminum foil
- Plastic wrap
- Cotton sock
- Wool sock
- Paper towel
- Timer or stopwatch
- Temperature probe or thermometer



EXPLORE

Tell students that they are going to conduct an investigation to produce evidence to help them design a solution for the problem of keeping a can of beverage cold after it has been removed from the refrigerator. Hand out the sets of materials to each group. Remind students that to have valid and reliable data, they need to make sure they have a sound experimental design. (See the Teaching Tips for support in leading this discussion.)

Have each group post their data on a class data chart that everyone can see or access. Ask the class what may make it easier to identify patterns in the data? (Because the data are nominal, the mean would be best to describe the effect of different materials on the melting rate of ice, and consideration should be given to scatter around the means.)

Conduct a sensemaking discussion about the data. Ask students the following questions:

- What question are you trying to answer with your investigation? (Which material keeps a can of beverage cooler the longest?)
- How might you organize all the data you have collected to look for patterns to help answer the question? (Calculate

the mean for each of the materials tested and construct a bar graph for easier comparison.)

- Was there much variability within the data? (Show students how to represent the scatter around the mean if they have not done this before. Discuss reasons for the scatter such as the accuracy of each groups' thermometers, accuracy in reading the thermometer, how each can was wrapped, and whether the open can tab was covered).

You can use a strategy like the [BSCS I²](#) to help students analyze the class data. Conclude this discussion by asking students what revisions they might make to improve the accuracy and/or precision of their data?

Wrap up day 1 by asking the class what scientific ideas or principles they think might account for their observations and conclusions and help them explain why some materials were better insulators than others. (Factors that affect the transfer of thermal energy, what temperature measures, and properties of materials will account for their observations and help explain this.)

End of Day 1



EXPLAIN



WATCH THE GENERATION GENIUS HEAT: TRANSFER OF THERMAL ENERGY VIDEO AS A GROUP

Begin class by asking a student to recap what the class figured out the day before about the engineering design problem of keeping the beverage cold when removed from the refrigerator, supported by the evidence from the class data. (The class data suggest that the type of material used to insulate the can varied in effectiveness, with the can wrapped in a wool sock showing the least amount of temperature change and the unwrapped can showing the most. Although there was not much difference in the temperature increase between the unwrapped can and the can wrapped in a cotton sock, the beverage in the wrapped can was cooler than the beverage in the unwrapped can.)

Uncover student thinking about heat as the transfer of thermal energy by asking students the Before Discussion questions. Tell students to make note of information that will help them answer their focus question: Which material will make the best insulator?

After the video, check student understanding by asking the After Discussion questions and highlighting scientific ideas from the video that students observed in their investigation. Have each student tie his or her evidence to their design recommendation using scientific ideas and principles presented in the Generation Genius video.

Ideas students should include in their justification for the best insulator include the following:

- Thermal energy was being transferred by convection from the air to the insulator to the can and then the beverage. The temperature difference from when the can was removed from the refrigerator to the last measurement indicates there was a change in thermal energy. This means that the thermal energy was greater in the air than in the can/insulator system.
- Thermal energy was transferred from the air particles to the material particles by convection, which caused the material particles to vibrate faster. The material transferred thermal energy to the can by conduction, which caused the can particles to vibrate more. The can particles transferred energy to the beverage particles in contact with the can by conduction. The particles in contact with the can moved faster and transferred energy to other beverage particles through convection.
- Different materials conduct thermal energy differently. Although there was evidence the beverage warmed with each material, it warmed more when there was no material wrapping the can, suggesting that the material has slowed the rate of energy transfer from the air. We can attribute the difference in the beverage warming to the material and not to the amount of matter in the can or beverage because the masses of the cans were very similar.
- A material is considered a good insulator if the rate of thermal energy transfer is less when compared with another material.



ELABORATE

Often in materials engineering, a combination of materials is more effective than using just one kind of material. Ask students to use their data to suggest combinations of materials to test and why they think these combinations would be more effective insulators. Give students time to test their combinations and make recommendations about the best insulator.



EVALUATE

There are multiple ways to assess your students' understanding of this topic. The exit ticket is an opportunity for students to use the science ideas they built in the lesson in a new context. Alternatively, you can use the Kahoot! quiz (which provides downloadable scores at the end of the game) and/or the paper quiz. All these resources are located right below the video in the assessment section.



EXTENSION

Challenge more advance students to graph the warming of each can of beverage and to determine the rate of warming (slope of the line). Ask if their recommendation would change based on the rate of warming compared to the temperature difference. If so, why?

