Unit Essential Question

How do we use and control thermal energy in a system?

Introduction

It is very cold outside today! What actions can you take to make yourself warmer? Why do they work? What if it is a hot day and you have a chocolate bar in your backpack? What can you do to prevent it from melting?

In this task, students will read about conductors and insulators. Students will then test different materials to see how they work as insulators and conductors. Finally, students will design their own experiment to test conduction or insulation with ice pops. They will then apply the concepts they learned from this task to the design of their device from the Culminating Project.

Objectives

Students will be able to

Content

- Explain the difference between a conductor and an insulator.

Science and Engineering Practices

- Plan and conduct an investigation.

Equity and Groupwork

- Discuss and decide on the procedures.

Language

- Write a definition of *conductor* and *insulator* in their own words.
- Use the academic vocabulary in ideas, discussions, and notes.
- Write their ideas in their science notebook and Individual Project Organizer.

Emerging →	**Expanding →**	**Bridging →**
Listen for, identify, and restate words and phrases about conductors and insulators. Ask and answer yes-no questions about the task. Respond using simple phrases.	Describe the task in sequence using words and phrases about conductors and insulators. Ask questions about the task and use complete sentences. Add information when possible.	Paraphrase and summarize the task in sequence using words and phrases about conductors and insulators. Ask questions about the task and use complete sentences. Affirm others, and build on their responses.

Assessment

1. Have students independently complete the Task 3 section of the Energy Unit Individual Project Organizer as homework or in class, depending on students' needs and/or class scheduling.
2. Collect the Individual Project Organizers and the lab reports and assess them using these criteria:
   - "Planning and Carrying Out an Investigation" row of the Science and Engineering Practices Rubric
   - "Constructing Explanations and Designing Solutions" row of the Science and Engineering Practices Rubric
3. Return the Individual Project Organizers, and give students time for revisions.

Academic Vocabulary

- conductor
- insulator
- thermal energy
- vacuum

Language of Instruction

- bold
- characteristics
- conduct (in this case means "Complete," whereas in the unit to date it has been used as a verb for heat)
- Frayer Model diagram
- ice pop (Many students would use the term Popsicle...it's a dialect difference, but can confuse)

LANGUAGE SUPPORT STRATEGIES

- Display the academic vocabulary on the board or wall.
- Use the Insulator and Conductor Resource in the Student Edition to highlight academic vocabulary. Support students' use of their own words (everyday language) to understand and explain the concepts.
- Use the Frayer Model diagrams that students create in Part I of the task to elicit ideas (in students' words) and use academic vocabulary.
- When applicable, connect students' words with academic vocabulary words during discussions by recasting or rephrasing the use of the terms.
- Acknowledge when students use the academic words. Mirror their statements back to them in complete sentences so they hear the academic term and its surrounding syntax.

Timing

This task can be completed in 5 class periods (based on 45-minute periods).

- Part I • Insulator and Conductor Reading (1 class period)
- Part II • Insulators and Conductors Experiment (1 class period)
- Part III • Design an Insulating or Conducting Experiment Using an Ice Pop (2 class periods)
- Part IV • Connect to the Culminating Project and Assessment (1 class period)

Student Materials

per group

Part II • Insulators and Conductors Experiment

- 4 containers of hot water, 500 mL each
  (Alternatively, students could use insulated take-out coffee cups with covers in order to eliminate the need to cover cups with plastic wrap. Also, students could use two containers at a time and conduct the experiment two times to get all the data.)
- Plastic wrap or tops for the containers
- Thermometer
- Timer
- Masking or Scotch tape
- A variety of materials, such as the following:
  – Aluminum foil
  – Shredded or crumpled newspaper
  – Cardboard
  – Plastic bags
  – Cloth (e.g., cotton or wool)
  – Foam

NOTE

You may want to ask students to bring items from home.

Part III • Design an Insulating or Conducting Experiment Using an Ice Pop

- Ice pops
- The same materials as in Part II: Insulators and Conductors Experiment
- Additional materials students need for their device design (ask students to bring in these items)
- Masking or Scotch tape

Teacher Materials

- Student Participant Observations form
- Stamp (to record student participation)

Background Knowledge

Thermal energy only travels from a warmer region to a colder region and never the other way around. Thermal energy is stored in molecules as vibrations. More vibration means a higher temperature. For some materials, it is easy: one high-energy molecule makes a neighboring molecule start to vibrate. That new molecule then makes its neighbors vibrate. Pretty soon, all the molecules are vibrating. Eventually, the whole object may increase in temperature. This type of material is a conductor. Metals and liquids are good conductors because the molecules are close together.

Insulators are materials that maintain molecular movement at a consistent rate. The best insulator is a vacuum, or completely empty space. If there are no molecules, there can be no vibrations. A good insulator is air. Air does not transfer heat very well because the molecules are so far apart from each other that they do not rapidly bump into other air molecules to transfer the thermal energy. The farther apart the molecules, the less influence they have on one another when they start moving. In essence, air is a good insulator because the molecules are too far apart for it to be a good conductor. A bunch of air-filled plastic bubbles arranged in a honeycomb pattern is an excellent insulator. Foam, a frothy plastic material containing gas within non-connected tiny cells, is a good insulator. Dry wood has a great deal of empty space inside it, so it is also a good insulator.

Glass is an insulator, or a poor conductor of heat. When glass separates hot regions from cooler regions, thermal energy is not transferred from the hot region to the cold region. Fiberglass is also an insulator. The insulation is a mat of fine glass strands in a suitable containing wrap. Some fiberglass insulation comes wrapped in an aluminized (reflective) material to also inhibit thermal radiation. Often, reflective surfaces are used as insulators because thermal radiation bounces off the surface rather than being absorbed. For example, in a thermos, the shiny-mirrored surface reflects the heat back toward the source, keeping the fluid hot. Cold substances in the thermos stay cool because the heat from the outside is reflected away from the contents.

Part I • Insulator and Conductor Reading

Have students independently read the Insulator and Conductor reading and fill in the Frayer Model diagrams. (Note: This step is not recommended for ELLs, unless they are proficient English readers.)

Or, have students work in small groups and rotate the reading of the Insulator and Conductor reading and the filling in of the Frayer Model diagrams. Assist ELLs with any words they need clarified in the reading.

LANGUAGE SUPPORT STRATEGIES

- Engage students' prior knowledge and their backgrounds to fill in the Frayer Model diagrams.
- Ask for students to share with the class, supporting the use of their words.
- Model how to underline definitions and circle examples using the Insulator and Conductor reading in the Student Edition.

Part II • Insulators and Conductors Experiment

1. Organize students in their project groups. Designate student roles and review the norms.
2. Optional: Distribute one Student Participation Observations form to each table. As you circulate among the groups, stamp the forms as students work on and discuss their insulators and conductors experiment.
3. Have each group select three materials to insulate containers filled with 500 mL of hot water in order to determine which materials have the best insulating or conducting properties. A variety of materials should be available to students. Encourage students to examine the different materials before deciding which materials their group would like to compare. Alternately, student groups can be (randomly) assigned materials to ensure that all material types are investigated.
4. Be sure that students understand that one container with 500 mL of hot water but no insulation will serve as the control.
5. Have a whole-class discussion so students agree on
   - What aspects they will need to control or do exactly the same in all groups
   - How much insulation or conductor to use
6. Have students run their experiment, measuring and documenting the temperatures. Option: Have groups run two experiments at a time due to material constraints.
7. Have students record their data.
8. Create a master spreadsheet to record each group's data and compare the results.
9. Have students discuss the Group Discussion questions and write out their Conclusion in a small group and then share out to the class.

Example: Which material is the best insulator?

Claim	Feathers are the best insulator.
Evidence	The temperature changed the least compared to paper and sand over 5 minutes. The water temperature only changed 2°C, while the other water temperatures changed 3°C, 4°C, and 5°C.
Reasoning	Feathers are insulators because they make it difficult for thermal energy to leave the system. There is a lot of air trapped in the spaces between the feathers, so the thermal energy has a hard time traveling from one particle to another out of the system. The thermal energy vibrations of the particles do not hit other particles, and therefore, the energy stays in the container.

LANGUAGE SUPPORT STRATEGIES

- Listen actively to students' ideas during the group discussion.
- Encourage students to discuss the experiment in their own words.
- On the board, display each group's ideas about what is the best insulator or conductor.
- Model claims, evidence, and reasoning using student examples.
- Acknowledge student use of academic vocabulary during discussions

Part III • Design an Insulating or Conducting Experiment Using an Ice Pop

1. Place students in their project groups. Designate student roles and review the norms.
2. Optional: Distribute a Student Participation Observations form to each table. As you circulate among the groups, stamp the form as students work on and discuss their experiment.
3. Have students melt or insulate an ice pop, based on their knowledge of conductors and insulators from Parts I and II.
4. Ask students to individually write a lab report in their science notebook following the format in the student instructions. Remind students to give each section a title. The titles of the sections are bold in the directions in the Student Edition.
5. Review with the class the results and the conclusions.
6. Assess students' lab reports when you assess their Individual Project Organizers.

LANGUAGE SUPPORT STRATEGIES

- Listen actively to students' ideas during the group discussion about experimental design.
- Encourage students to discuss the experiment in their own words.
- On the board, display each group's ideas about what is the best insulator or conductor.
- Acknowledge student use of academic vocabulary and connect with students' own words.
- Ensure the language of instruction is clear (e.g., reasoning and "a" control—ensure ELLs use the article "a," as many languages other than English do not contain articles).

Part IV • Connect to the Culminating Project and Assessment

1. Have students independently complete the Task 3 section of the Energy Unit Individual Project Organizer as homework or in class, depending on students' needs and/or class scheduling.

2. Collect the Individual Project Organizers and the lab reports and assess them using these criteria:
   - "Planning and Carrying Out an Investigation" row of the Science and Engineering Practices Rubric
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3. Return the Individual Project Organizers, and give students time for revisions.

LANGUAGE SUPPORT STRATEGIES

- ELLs may need extra time to complete the revisions. Consider pairing them with a more writing proficient student for peer editing.
- Provide sentence frames such as the following for group discussions and for writing:

  The _____ (material) was the best conductor. This is true because _____. For example, _____.
  Another reason is _____, as you can see when _____ occurred. Finally, _____.