3 Energy

Objectives

You will be able to

- Explain the difference between a conductor and an insulator.
- Plan and conduct an investigation.
- Discuss and decide on the procedures.
- Write a definition of *conductor* and *insulator* in your own words.

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

Evaluation and Feedback

To evaluate your work, you will

- Use the "Planning and Carrying Out an Investigation" row of the Science and Engineering Practices Rubric.
- Use the "Constructing Explanations and Designing Solutions" row of the Science and Engineering Practices Rubric.

Task 3: Insulators and Conductors

As a group:

- Read about conductors and insulators.
- Complete a Frayer Model diagram.
- Conduct an investigation about how well different materials insulate or conduct thermal energy.
- Design an experiment to melt an ice pop (or keep it frozen).
- Explain which material worked best within your design constraints.

Vocabulary

- conductor
- insulator
- thermal energy
- vacuum

Connect to the Culminating Project

Update your client in your Individual Project Organizer:

- Make a list of insulating or conducting materials to be used in your device.
- Explain why these materials would be the best for your device using evidence.
- Revise the model of your device.

Part I • Insulator and Conductor Reading

Read the following information. Then, as a group, fill in the Frayer Model diagrams.

Insulator and Conductor Reading

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?

As you now know, thermal energy can move—from the stove to the pot on top of it, from one side of a room to the other, and even from the sun to the Earth. Engineers use conductors and insulators to change how much energy is (or is not) transferred in a system.

A thermal conductor is a material that allows energy in the form of heat to be transferred within the material without any movement of the material itself. The thermal conductor helps maximize thermal energy transfer.

A thermal insulator is a material that prevents heat from being transferred. The thermal insulator helps minimize thermal energy transfer.

Watch these videos to learn more about conductors and insulators:

YouTube Video: Conduction of Heat—Elementary Science
https://www.youtube.com/watch?v=w_IbPRNZ6ho

YouTube Video: Electricity 101—Conductors and Insulators
https://www.youtube.com/watch?v=qUhxmXZwPmg

Some materials make great conductors, while others are great insulators. The difference is in how easy it is to make the particles of the material vibrate. For some materials, it is easy: one high-energy particle makes a neighboring particle start to vibrate. That particle makes its neighbors vibrate. Pretty soon, all the particles are vibrating! Conductors help thermal energy move. Metals are good at transferring thermal energy and, thus, are good conductors. Many liquids are good at transferring thermal energy and, as a result, are also good conductors.

The best insulator is a completely empty space that has no air in it, often called a vacuum. If there is nothing in a space, there are no particles to pass along vibrations. Although it is not as effective as a vacuum, air is still a good insulator. Gases like air do not transfer thermal energy very well because the particles are far apart from each other. It takes a lot of energy to make an air particle move far enough to bump into another particle. Air-filled plastic bubbles arranged in a honeycomb pattern can be an excellent insulator. Dry wood has a great deal of empty space inside it, so it is also a good insulator.

Frayer Model Diagrams for Insulator and Conductor Reading

Definition (in your own words)	Characteristics
Conductor	
Examples	Model (showing particle motion)

Definition (in your own words)	Characteristics
Insulator	
Examples	Model (showing particle motion)

Part II • Insulators and Conductors Experiment

LAB — Insulators and Conductors Experiment

Investigation Questions

- Which material is the best insulator?
- Which material is the best conductor?

Materials

- 4 containers of hot water, 500 mL each
- Plastic wrap or tops for the containers
- Thermometer
- Timer
- Masking tape or Scotch
- A variety of materials, such as the following:
  - Aluminum foil
  - Shredded or crumpled newspaper
  - Cardboard
  - Plastic bags
  - Cloth (e.g., cotton or wool)
  - Foam

Procedure

1. Pick three materials to use in your experiment.
2. Wrap the first material around the container of hot water and attach it using masking tape.
3. Using the Data Table, record the temperature of water every minute for a total of 5 minutes.
4. Repeat steps 2–3 for each of your materials.
5. Conduct a final test with no wrapping around the container. (This is the "control" container.)

Data Table

Time	Material 1:	Material 2:	Material 3:	Control (no material)
	Temperature of Water (°C)			
0 min				
1 min				
2 min				
3 min				
4 min				
5 min				
Change in Temperature				

Group Discussion

1. Which material is the best insulator?
2. Which material is the best conductor?

Conclusion

1. Out of the different materials you tested, which material is the best insulator?

Claim	
Evidence	
Reasoning	

2. Out of the different materials you tested, which material is the best conductor?

Claim	
Evidence	
Reasoning	

3. One of your containers had no material around it. This was the "control." You collected data for this container as well. What is the importance of having a "control" in your experiment?

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

LAB — Ice Pop Experiment

Choose an Option

- Option A: Test ways to insulate an ice pop so that after 15 minutes it has not melted.
- Option B: Test ways to use conductors so that an ice pop has completely melted in 15 minutes or less.

Lab Report

Write a lab report in your science notebook. Give each section a heading. Use the **bold** words in the following directions as your headings.

1. Give your experiment a **Titl**e.
2. Write the **Question** you are trying to answer.
3. Choose **Materials** you want to use as insulators or conductors on your ice pop.
4. Design a **Procedure** to keep your ice pop frozen or to completely melt it. Write the steps of your experiment.
   - ❏ Remember to include time.
   - ❏ Remember to include amounts.
5. Under your step-by-step procedure, make a labeled **Sketch** to show what your design will look like.
6. Make a **Prediction** about how the materials will insulate the ice pop (keep it frozen) or conduct heat to the ice pop (melt it quickly). You might want to use this sentence starter in your science notebook:
   - When using _____, the ice pop will _____ because _____.
7. If melting does occur for either Option A or Option B, how will you measure how much melting occurs?
8. Design a **Data Table** for your data.
9. Conduct the experiment and record your data.
10. After the experiment, write a **Scientific Explanation** including a claim, evidence, and reasoning.

Claim	Example: Which material is best at either melting the ice pop or keeping it frozen?
Evidence	Example: What data did you collect that shows how well your ice pop stayed frozen or melted?
Reasoning	Example: When your ice pop was frozen, explain what was happening in terms of thermal energy, temperature, particles, energy, and energy transfer.

Extension Challenge

Discuss the following questions in your group:

1. Based on your results from the experiment, how could you improve the design to get even better results? Describe the changes you would make.
2. What would you expect to happen after making those changes?

Part IV • Connect to the Culminating Project and Assessment

Complete the individual Project Organizer for this task.