Insulators and Conductors

Activity Description & Estimated Class Time

During three 50-minute periods, students explore how different materials behave as insulators and conductors. Part one will examine insulators and conductors of thermal energy and part two will explore insulators and conductors of electrical energy.

Correlations to NC Science Standards

PS.6.2.3 Carry out investigations to compare the transfer of thermal energy in insulated and non-insulated materials (examples could include insulated box, solar cooker, or styrofoam cup).

PS.6.2.4 Engage in argument from evidence to classify materials as conductors and insulators of energy (both thermal and electrical).

Objectives

Students will demonstrate knowledge and understanding of:

- The transfer of thermal energy in insulated and non-insulated materials
- Thermal insulators and conductors
- Electrical insulators and conductors

Brief Science Background

Materials that conduct heat or electricity are conductors. Materials that do not conduct heat or electricity are insulators. Specifically: Materials that transfer heat easily are called thermal conductors. Materials that do not transfer heat easily or limit heat transfer are called thermal insulators.

Part 1 — Thermal Energy

Materials

Materials for the whole class

- Hot pot
- Thermos
- Ability to project:
  - multimeter temperature probe picture (SD 1)
  - team challenge & definitions (SD 2)
  - cooking pot picture (SD 4)

Materials for group of 3 or 4 students

- 1 multimeter temperature probe
- 1 digital thermometer
- 1 graduated measuring cup
- 1 8 oz styrofoam cup
- 1 4 oz plastic cup
- 1 3 oz paper cup
- 1 3 oz metal cup
- 1 4 oz styrofoam cup
- 4 Thermal Energy Student Activity Sheets (SD 3)

Preparation
allow for approx. 20 min

1. Turn the multimeter temperature probes to the position shown on the multimeter temperature probe picture (SD 1) (pointer to °C). If numbers do not appear on the screen, replace the batteries (included in the kit along with a small screwdriver to remove the meter cover) When all meters show numbers on the screen, insert the red and black probes in the jacks shown on SD 1. Note: The temperature readings

Preparation cont.

will not be the same on all the meters, but they should be within about 2° C of each other. The temperature differences reflect the fact that readings vary slightly from probe to probe, so make students aware of this when comparing readings between groups

2. About 20 minutes before the activity, heat the water in the hot pot to about 55°C (131° F). It will feel hot but will not burn. Water hotter than this poses a danger of burns. Use the funnel and pot holders to transfer hot water to the thermos. Each group of students will need 1, 8oz cup of hot water.

Procedure

1. Begin a discussion of students' experiences of heat. After students give examples, ask if anyone has experienced heat moving through a material. Inform students that we are going to explore how fast heat moves through different materials. Reflect back on the Heat Transfer activity.
2. Explain to the class that we will use a temperature probe to measure temperatures at different places.
3. Hand out the multimeter temperature probes.
4. Project the picture of the multimeter temperature probe (SD 1) to show students how to plug in the probe and set the meter.
5. Have students practice using the meter. Have them determine the temperature of the air, their desk, and their skin.
6. Project only the team challenge on SD 2 and read to the students: "Your team is planning to set up a hot chocolate stand at the upcoming winter fair. Your goal is to choose the best cup to serve your hot chocolate. The best cup will keep the hot chocolate as hot as possible in the cold weather and keep the outside of the cup cool enough to hold."
7. Inform students that they will test four different cup materials: plastic, paper, metal, and styrofoam to determine which one keeps the water inside hottest, and which one stays coolest on the outside.
8. Hand out the four different cups, a measuring cup, a digital thermometer, and the Thermal Energy Student Activity Sheet (SD 3).
9. Explain to the students that each team must choose which material they want to use and provide evidence for why it is the best material to keep the hot chocolate as hot as possible and keep the outside of the cup cool enough to hold. Each team will plan how they will gather evidence that will help them make their choice. Students will document their plan on SD 3. All teams must show the teacher their plans. Accept all plans that teams come up with. Teams should document how they will keep track of the data they collect. This will allow them the opportunity to analyze, evaluate, and modify their plan.
10. Once students have a plan, provide them with a cup of hot water and let them begin.
11. Once teams are finished, ask each team to select which material they will use for their hot chocolate stand and provide evidence to support their decision.
12. Have each group present their findings to the class. Ask the class which evidence was most convincing to support the claim.

Procedure cont.

This is a great time to have a discussion on the experimental design process. In order to have a valid experiment there must only be one variable and all other items are constant. In this example the only variable would be the material of the cup. Some examples of constants are: amount of water, temperature of water, and the data collection time.

Content Connection

1. At this point, groups should have selected styrofoam as the best material. Engage in a discussion about how the heat from the water moved through the materials.
2. Project the definition for a thermal insulator (SD 2) and read out loud "Materials that do not transfer heat easily or limit heat transfer are called thermal insulators."
3. Have students determine which material was the best thermal insulator, and provide evidence.
   Styrofoam is the best insulator because it allows very little heat energy to go through it.
4. Project the definition of a thermal conductor (SD 2) and read out loud "Materials that transfer heat easily are called thermal conductors."
5. Have students determine which material was the best thermal conductor, and provide evidence.
   The metal cup is the best thermal conductor because it allows heat energy to move through it.
6. Discuss practical applications for both thermal conductors and insulators. Blankets and rubber gloves are examples of thermal insulators. An example of a good thermal conductor is a metal spoon.

Formative Assessment/ Guided Practice

1. Project the cooking pot picture (SD 4).
2. On SD 3 pg. 2 ask students to:
   a. explain how this cooking pan has both conductors and insulators.
   b. determine which material is a conductor or insulator and provide evidence for their claim.
   c. describe the function of each material.

Part 2 — Electrical Energy

Materials

Materials for the whole class

- wet wipes
- water

Materials for group of 3 or 4 students

- 1 Conductivity tester
- 1 bag of conductivity test items
- 4 Electrical Energy Student Activity Sheets (SD 5)

Preparation
allow for approx. 10 min

Test each conductivity tester to be sure the batteries are good. To test, press and HOLD the button while you touch both metal probes to a paper clip. If the indicator lights up, your tester works. Extra batteries are included if needed.

Procedure

1. Ask students to reflect on the previous lesson and explain the difference between thermal insulators and conductors.
2. Ask the class if anyone has experienced electricity moving through something. Inform the class that in this part of the activity they will explore insulators and conductors, as we did with heat, but this time we will explore electrical insulators and conductors.
3. Hand out a conductivity tester, a bag of test items, and the electrical energy student activity sheets. Have students remove the paper clip from the bag.
4. Demonstrate how to use the tester. Have students:
    a. Press and HOLD the button. Explain that each group will get a tester that lights up only when its probes touch a material that conducts electricity.
    b. Touch both metal probes with the paper clip. Ask students what they notice?
    The indicator will light up because the metal in the paper clip allows electricity to flow. Metals are usually electrical conductors. The lights light up because the electricity passed through the paper clip and completed the circuit. This is explored further in the Light the Bulb activity
    c. Explain that electricity can travel through some materials. We call those materials **electrical conductors.** Paper clips, which are made from metal, are conductors.
    d. Remove the toothpick from the bag of test items and have students touch both probes to the toothpick. Ask students what they notice?
    The indicator will not light up because wood does not allow the electricity to flow.
    e. Explain that materials that do not allow electricity to flow are called **electrical insulators**, therefore wood is an electrical insulator
    f. Collect the conductivity testers.
5. Inform the students that in a few minutes they will use the conductivity tester and determine if each item in the bag is a conductor or insulator.
6. Have students record their predictions for each item on SD 5.
7. After all the students have made predictions, hand out the testers, and have students test each item.
    Let the students know we are not concerned with any "level" or "number" associated with the tester. If any indicator lights light up, the material is a conductor.
8. Lead a discussion where students share their results. Also, ask students which items were a surprise to them and which item is an example of both?
    The pipe cleaner is an example of both. The metal wire inside is a conductor and the fuzzy material on the outside is an insulator. Have students see if they can get the pipe cleaner to conduct.
9. Tell students "Now that you have explored electrical energy in different solid materials, how do you think electrical energy interacts with liquids?"
    Allow all answers.
10. Ask students to predict if they think water will be a conductor or an insulator.

Procedure cont.

11. Fill the plastic cup with water and have students test the water with the conductivity tester.
    Water is considered a conductor.
12. Have the class suggest other liquids that they would like to test and predict if they are a conductor or an insulator.
13. The following day bring in a couple of the liquids for students to test. Make sure that vegetable oil is one of the liquids to test.
14. Distribute wet wipes and liquids to students and allow them to test the liquids. Make sure students clean the conductivity probes after use.
15. Discuss with the students that some liquids conduct electricity and some liquids do not conduct electricity.
    Water, anything that contains water, and acetone are common liquids that conduct electricity. This is because they are polar liquids. Fats, oils, and gasoline are common liquids that do not conduct electricity. This is because they are nonpolar liquids.

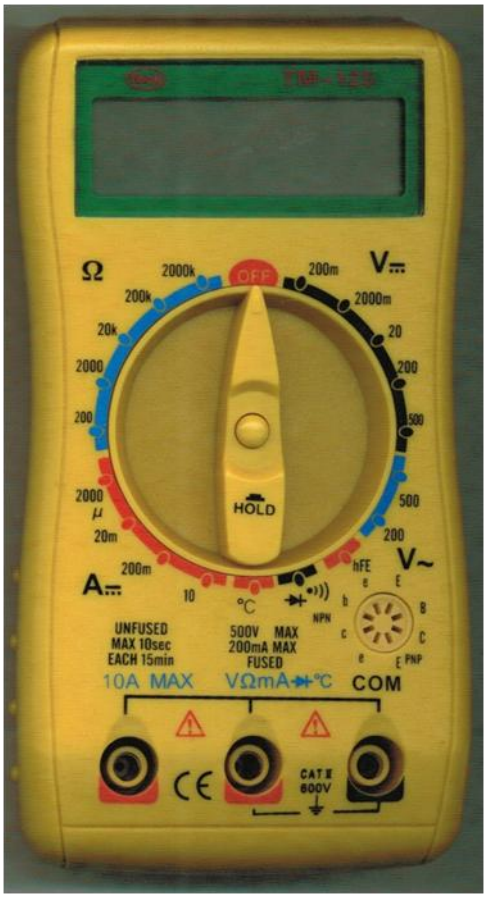
Content Connection

1. Share the following scenarios with the students and have them answer the questions:
    a. You want to go fishing on a lake. When you step outside you hear thunder and see lightning. Should you go out on the lake to fish? Explain your decision using what you know about conductors and insulators of electricity.
    b. During a storm a power line is knocked down and lands in a puddle of water. Provide an explanation why it is important not to go near the puddle.
2. Using the conductivity tester and without leaving their seat, have students identify and confirm three different conductors and insulators.
    Be sure students know not to use the tester with any electrical outlet.

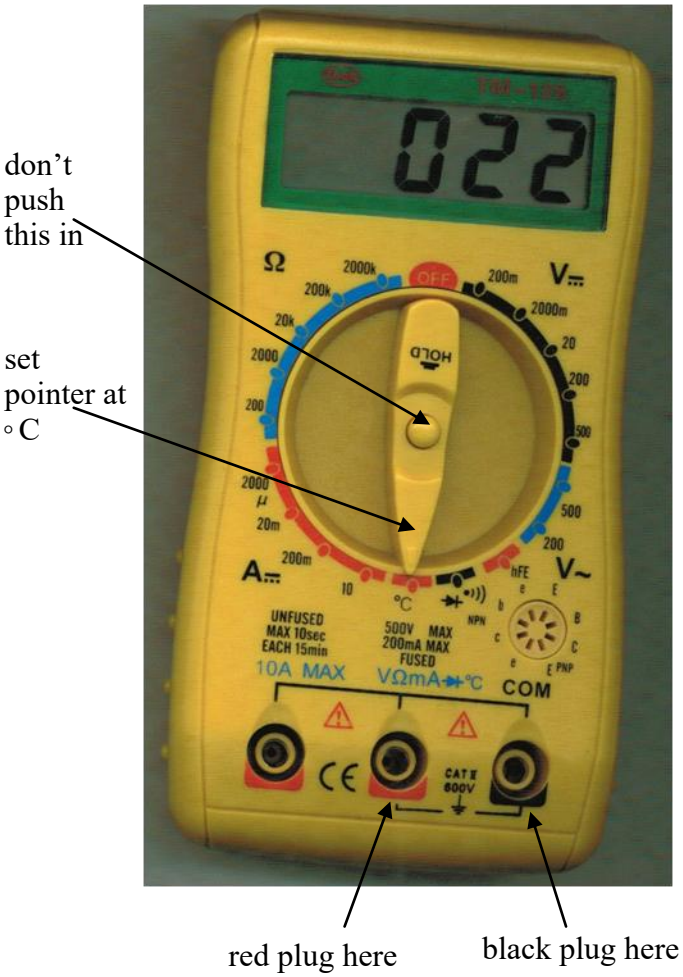
SD 1

Multimeter Temperature Probe

The meter comes out of the box with the pointer in the OFF position. **RETURN TO THE OFF POSITION WHEN FINISHED**.



To use the meter as a temperature probe, put the red and black plugs in the holes shown, and set the pointer as shown (°C). Avoid the hold button.



SD 2

Team Challenge & Definitions

"Your team is planning to set up a hot chocolate stand at the upcoming winter fair. Your goal is to choose the best cup to serve your hot chocolate. The best cup will keep the hot chocolate as hot as possible in the cold weather and keep the outside of the cup cool enough to hold."

thermal insulator: materials that do not transfer heat easily or limit heat transfer

thermal conductor: materials that transfer heat easily

SD 3 pg 1 of 2

Thermal Energy Student Activity Sheet

Name:

With your team create a plan to determine which cup material will make for the best to serve hot chocolate. Include all details including how you will collect and keep track of your data.

What material will you use to serve the hot chocolate? Provide evidence to support your decision.

Which material was the best thermal insulator? Provide evidence to support your claim.

Which material was the best thermal conductor? Provide evidence to support your claim.

SD 3 pg 2 of 2

Thermal Energy Student Activity Sheet

Name:

Look at the cooking pot.

Determine which material is a conductor or insulator and provide evidence for your claim.

Explain why this cooking pot needs both insulators and conductors.

SD 4

Cooking Pot

Plastic Handle

Metal Body

SD 5
pg. 1 of 2

Electrical Energy Student Activity Sheet

Name:
In the chart below, predict if each item is a conductor or insulator. After you have made your predictions, use the conductivity tester to test your items. Record your results.

Material	Prediction	Results
Pipe Cleaner		
Rubber Band		
Penny		
Glass Gem		
Plastic Cup		
Plastic Circle		
Brass Fastener		

In the chart below, predict if water is a conductor or an insulator. What other liquids would the class like to test? Write them under materials and predict if they will be conductors or insulators. After you have made your predictions, use the conductivity tester to test your items. Record your results.

Material	Prediction	Results
Water		

SD 5
pg. 2 of 2

Electrical Energy Student Activity Sheet

Name:

You want to go fishing on a lake. When you step outside you hear thunder and see lightning. Should you go out on the lake to fish? Explain your decision using what you know about conductors and insulators of electricity.

During a storm a power line is knocked down and lands in a puddle of water. Provide an explination why it is important to not go near the puddle.

Using the conductivity tester and without leaving their seat, have students identify and confirm three different conductors and insulators.
Do not use the tester with any electrical outlet.