Lesson Topic: Flow of Thermal Energy

Objective:
Students will be able to:

1. Determine the three different types of thermal energy
2. Describe the best and worst ways to retain thermal energy.
3. Identify ways thermal energy affects our everyday lives.

Time Required: 90 minutes

Materials Needed:

- Balloon
- 1-Liter bottle
- Bowl of hot water
- Bowl of ice water
- Teacher computer with internet access
- Projector/Smartboard
- 1 computer/laptop/iPad per student with internet access
- Flow of Thermal Energy handout (attached)
- Thermal Energy Video: https://www.youtube.com/watch?v=Atnjo7dD_bA
- 4 jars of hot water (1 set of jars per group)
- Insulation items: Aluminum foil, bubble wrap, newspaper, wool sock (1 per group)
    - Other items could be used instead if availability is an issue.
- Liquid thermometer (1 per group)

Teacher Preparation:

- Assign a Legends of Learning Instructional Quick Play playlist for the day(s) you will be teaching the lesson.
    - Instructional - Middle School - Flow of Thermal Energy
- Assign a Legends of Learning Content Review Quick Play playlist for the day(s) you will be teaching the lesson.
    - Content Review - Middle School - Flow of Thermal Energy
- Make copies of Flow of Thermal Energy Worksheet (1 per student)
- Cool a balloon and an empty 1-liter bottle in a freezer for about 5 minutes prior to class.
- Have warm water accessible.

Engage (15 minutes):

1. Bring out the bottle and the balloon.
2. Tell students “I’m going to show you a demonstration. Get out a sheet of paper to write down a few notes.
3. Tell students “Draw a line down the middle of your paper. On the right side, title it “prediction” and title the left side “observations.” We will first make our predictions about what will happen, but as I conduct this demo, I want you to write down your observations.”
4. (show the bottle and balloon). Tell students “This balloon and bottle were just in the

freezer for the past 5 minutes."

5. Put the balloon over the mouth of the bottle (there should be no air in the balloon).
6. Ask students "If I place this bottle into a bowl of hot water, what do you think will happen? Then, what If I place this bottle into a bowl of ice cold water, what do you think will happen? Write your answers down under "prediction."
7. After a moment or two, allow students to share their predictions.
8. Fill a bowl with hot (but not boiling) water.
9. Place the bottle in the hot water.
    a. The balloon should inflate.
10. Place the water in ice cold water.
    a. The balloon should deflate.

Explore (20 minutes):

1. Have your students sign in to Legends of Learning. Instruct students to complete the Instructional playlist.
2. During game play, pause the playlist if you need to address content or questions to the entire class.

Explain (20 minutes):

1. Tell students "Think back to the balloon and bottle demonstration from earlier in class. Someone remind everyone what happened."
    a. Choose a volunteer to summarize the demonstration.
2. Ask students "With a partner, briefly discuss the following question: why did the balloon inflate when the bottle was placed in the hot water?"
    a. Possible answers: When air is heated up, the molecules start to move around more quickly and move much farther apart. Placing the bottle in the hot water made the air expand and fill up the balloon.
    b. Tell students, "This is thermal energy at work."
3. Ask students, "So why then did the balloon lose all its air once it was placed in the cold water?"
    a. Possible answers: When the bottle was placed in the cold water, it cooled the air. When molecules are cold they move more slowly and stay more tightly packed together, taking up less space. This means the air moved out of the balloon and back into the bottle."
4. Pass out the Flow of Thermal Energy handout.
5. Let's write down a few definitions to some important key words (write the following on the board and have students write it down on the handout).
    a. Thermal Energy - the result of the movement of molecules; the faster the molecules, the more thermal energy it has and vice versa.
    b. Heat - the transfer of thermal energy from a hot to a cold object.
6. Tell students "When you have two objects in contact with one another, the thermal energy will flow from the hotter object to the cooler object until both temperatures are the same."
7. Tell students "I want you to turn and talk with a neighbor about the following question (write it on the board).
    a. Which set of objects would have the fastest rate of thermal energy: ice cube and hot iron OR room temperature rock and an ice cube?

i. Answer: Ice cube and hot iron, because the bigger the difference in temperature, the greater the rate of thermal energy.

8. Tell students “Let’s talk about the three different types of thermal energy. We will be watching a video clip. As we watch, write down the definitions for each type of thermal energy.”
9. Play video.
    a. Pause the video during each question and allow students to discuss briefly with a partner.
    b. Answer to the final question:
        i. Convection - the heat inside the pot is cycling, where the heat is rising and the cold is filling in the space underneath.
        ii. Conduction - the pot is getting hot from the fire and in turn the cold handle is also becoming hot.
        iii. Radiation - heat is from the fire is transferring as waves and heating the pot.
    c. Bonus! Ask students what type of thermal energy was used in the balloon activity at the beginning (convection).

Elaborate (25 minutes):

1. Tell students “Raise your hand if you have ever heard the word “insulation.” What is insulation?”
    a. Listen to student responses.
2. Tell students “Insulation is used to keep thermal energy from leaving and also keeping heat from entering an object. For example, think of a thermos of soup you may have in your lunchbox. The thermos is insulating the liquid to keep the heat in so that it is warm when you want to eat it for lunch.”
3. Tell students “In your groups, I will be giving you 4 jars of hot water. You will use a thermometer to test the temperature of the liquid. Then, use the other materials (newspaper, bubble wrap, aluminum foil, and the sock) to see which material is the best insulator. Follow the instructions on the handout.”
4. Give students time to complete the activity and fill in the handout.
5. After everyone is finished, clean up all the materials.
6. Then, bring everyone together to discuss the results.

Evaluate (10 minutes):

1. Have your students sign in to Legends of Learning. Instruct students to complete the Content Review playlist.
2. Analyze student results to determine what concepts need to be a focus for reteaching.

Additional Lesson Strategies:

- To use Legends for additional instruction, create a custom playlist with an instructional game and pre and post assessment.
- To use Legends for a quick formative assessment, create a 5-question assessment in a playlist.
- To use Legends for a student-directed experience, create a targeted freeplay playlist.

- Encourage students to play on their own at home in Legends of Learning: Awakening for a student-driven experience including avatars, battling, and quests all centered around topics they are covering in class.

Name:_____

Flow of Thermal Energy

Write down the following definitions:

Thermal Energy -

Heat -

Types of Thermal Energy

Conduction -

Convection -

Radiation -

Insulation Experiment

1. Using a thermometer, take the temperature of all 4 jars. Record your data below (Initial Temp).

	Jar 1	**Jar 2**	**Jar 3**	**Jar 4**
Initial Temp (℃)				
After Temp (℃)				

2. You will be wrapping each jar with a different insulation material (one per jar) and then re-measuring their temperature. Which material do you predict will keep the jar the warmest? Why?

   _____

   _____

   _____

3. Wrap each jar with one of the materials.
4. Let the jars sit for 10 minutes. While you wait answer the following questions:

   a. What type of thermal energy is taking place during this insulation activity? Explain.

      _____

      _____

      _____

      _____

   b. How could insulating and understanding the flow of thermal energy help you in a career? Explain.

      _____

      _____

      _____

      _____

5. Unwrap each jar, and take the temperature of each jar again. Record the data in the chart at the top of the page (After Temp).
    a. Which material insulated the best and kept the water the warmest? Why?

    _____

    _____

    _____

    b. Which material insulated the worst and let the most heat escape? Why?

    _____

    _____

    _____

    _____

    c. What do your results say about the real world?

    _____

    _____

    _____

    _____

    _____

KEY

Flow of Thermal Energy

Write down the following definitions:

Thermal Energy - the result of the movement of molecules; the faster the molecules, the more thermal energy it has and vice versa.

Heat - the transfer of thermal energy from a hot to a cold object.

Types of Thermal Energy

Conduction - transfer of heat through touching, occurs in solids, transfer of heat from the warmer part of an object to the part of the same object. It can also transfer from a hotter object to a cooler object.

Ex: cold spoon becoming hot when placed in a hot pot of water.

Convection - transfer of heat through the movement of particles, occurs in liquids and gases, warm particles rise, cool particles fill in the spaces below.

Ex: the attic or upstairs of a house are warmer than the downstairs/basement.

Radiation - transfer of energy as waves, transfer through matter or empty space.

Ex: the sun warms the Earth from its rays.

Insulation Experiment KEY

1. Using a thermometer, take the temperature of all 4 jars. Record your data below (Initial Temp).

Temperatures will vary depending on initial temperature of water.

	Jar 1	**Jar 2**	**Jar 3**	**Jar 4**
Initial Temp (℃)				
After Temp (℃)				

2. You will be wrapping each jar with ONE of the insulation materials and then re-measuring their temperature. Which material do you predict will keep the jar the warmest? Why?

   Answers will vary.

3. Wrap each jar with one of the materials.
4. Let the jars sit for 10 minutes. While you wait answer the following questions:
   a. What type of thermal energy is taking place during this insulation activity? Explain.
      i. **Conduction or Convection (depending on the explanation) - the glass jar conducts heat itself, because the hot water makes the glass jar also feel warm. By wrapping the glass jar with materials it reduces the heat transfer from hot water to cold air.**
      ii. **Using materials that are bad conductors of heat reduces the loss of heat through conduction, the insulator can also slow down the flow of cold air around the jar which is convection.**
   d. How could insulating and understanding the flow of thermal energy help you in a career? Explain.

i. **Answers will vary but may include:**
ii. **A contractor or builder who has to insulate a house, anyone who works with food prep and keeping food warm or cold, etc**.

5. Unwrap each jar, and take the temperature of each jar again. Record, the data in the chart at the top of the page (After Temp).

a. Which material insulated the best and kept the water the warmest? Why?
   i. **Answers may vary but may include:**
   ii. **The sock and the bubble wrap, because they create air pockets. Air pockets are a good thermal insulator as long as the air pockets are separated from one another.**
b. Which material insulated the worst and let the most heat escape? Why?
   i. **Newspaper and aluminum foil have no air pockets making it easier for heat to escape.**
c. What do your results say about the real world?
   i. **This is why clothes and blankets are made from fabrics that have air pockets, because it allows heat to be trapped and insulated.**