5.1 - Thermal Unit, Packet 1

Score
□ Above & Beyond
□ Meets Expectations
□ Near Expectations
□ Incomplete – *fix the following pages:*

First & Last Name: _____ Period/Hour:_____

NOTE: Packets are due after completing Part 5. Check each page to be sure all blanks are completed.

Driving Question: What is the difference between temperature & heat?

Anchoring Phenomenon: If you've ever been to the beach on a hot summer day, the sand can be burning hot while the water is often nice and cool. Why would these have a different temperature if they both are exposed to the same amount of heat? And what is the difference between temperature and heat? We'll explore what is occurring at the atomic-molecular level.

Deeper Questions

1. How does temperature relate to molecular movement?
2. What does temperature measure?
3. How is kinetic energy related to temperature?

Schedule

Part 1: Introduction
- Initial Ideas & Data Dive
- Discussion & Developing Explanations

Part 2: Core Ideas
- Core Ideas & Revisions of Part 1 Explanations

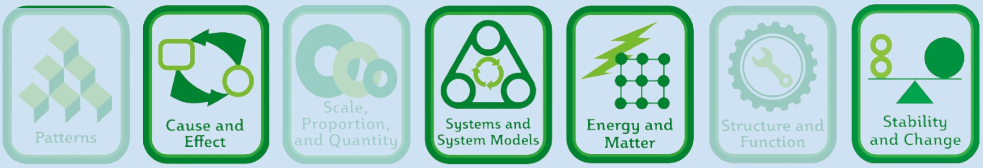
Part 3: Investigation
- Proving Temperature Difference

Part 4: Review & Assessment
- Ranking Your Readiness & Practice Problems
- Formative Assessment & Mastery Check

Part 5: Life Connections
- Life Connections - Geothermal Heat Pumps

Image Source

NGSS Standards (*PEs* & *CCCs are summarized below. SEPs are noted throughout the packet*).
HS-PS3-1 - Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-2 - Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
HS-PS3-3 - Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* HS-PS3-4 - Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).



Semester Schedule

1. Electricity
4.1: Where do charges come from?
4.2: How much force exists between charged particles?
4.3: How do voltage and resistance determine current?
4.4: How do different circuits change voltage & resistance?
4.5: Unit Assessment

2. Thermal Energy
5.1: What is the difference between temperature & heat?
5.2: What determines how quickly temperature changes?
5.3: How can thermal energy be used for work?
5.4: Unit Assessment

3. Waves, Light, Sound
6.1: How do harmonic motion & linear motion differ?
6.2: What determines the properties of waves?
6.3: What is sound, and what determines its properties?
6.4: What is light, and what determines its properties?
6.5: How is light changed by reflection & refraction?
6.6: Unit Assessment

4. Solar Cooker Project
How can we design a tool to use light & heat for work?

These materials were partly developed with assistance from artificial intelligence.

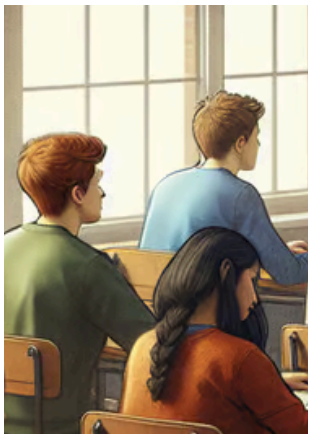
Resource Links: Class Website; Core Ideas; Quizlet;

Part 1: Introduction (5.1.1)

Overview: In this activity, you will begin by discussing your initial ideas about this packet's topics. You will then analyze data and work in teams to develop your initial explanations.

Initial Ideas - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Engaging in Argument from Evidence

Three students are staring out their open classroom window on a warm spring day. Each makes a claim about what they are observing. **Do you agree or disagree with each student's claim**? *Image Source*



- Avery: "The temperature is higher today because the air contains more heat." *Agree/Disagree*
- Bristol: "The open window lets the cool air inside the room." *Agree/Disagree*
- Daryll: "There is less heat in the shade of a tree than in the sun." *Agree/Disagree*

In groups, discuss your ideas and determine where your ideas differ. Try to reach agreement if each statement is correct & why. Prepare to share with the class.

Data Dive - *Use the data below to refine your understanding of the claims above and develop an initial explanatory model. Record your ideas separately (e.g., scratch paper, etc.).* *SEP: Engaging in Argument from Evidence*

Watch this video as an overview of this activity. Then obtain three equal sized beakers and fill them ¾ of the way with water at different temperatures: a) cold (no ice), b) room temperature, and c) warm. Add two drops of food coloring to the center of each beaker and watch what happens over the next few minutes. After completing your observations, address the questions below in groups. *Image Source*

1. **Begin by individually attempting to make sense of your observations**. What trends or patterns do you notice? How does this relate to any prior knowledge or experience that you have?
2. **Discuss your group's ideas**. Where do you agree or disagree?
3. **What are two conclusions that would be supported by your observations?** How are these claims supported by this evidence? Provide your reasoning.
4. **Based on your observations, explain how temperature relates to kinetic energy.**
5. **Are heat and temperature the same thing?** Support your claim with evidence and reasoning.
6. **Why does the food coloring behave differently in water depending on its temperature?** Support your claim with evidence and reasoning.

Discussion - *Record your ideas in the spaces below.* *SEP: Asking Questions & Defining Problems*

As a class, discuss your ideas about these topics. What are the ideas that most agreed on? Where did your ideas differ as a class? Record your ideas in the spaces below.

We generally agree that…	***We disagreed or were unsure if…***

Initial Explanations - *Record your ideas in the spaces below.* *SEP: Constructing Explanations & Designing Solutions*

What is the difference between temperature & heat? How are these concepts related to kinetic energy? Don't worry if you aren't completely sure about this. You will come back and revise this explanation as you gain more information.

Part 2: Core Ideas (5.1.2)

Overview: In this activity, you will begin with a short presentation to provide you with information that will help you improve and revise your initial ideas. Your instructor will decide on how to implement this portion. You will then work in small teams to address the questions listed below.

Driving Questions - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Developing & Using Models

1. What is temperature? How does it relate to kinetic energy?
2. Use an analogy to explain the relationship between temperature & movement.
3. Why does the liquid in a thermometer expand as the temperature rises?
4. What is thermal equilibrium?
5. How do changes to the properties of substances at different temperatures enable temperature scales to exist?
6. What is the difference between Celsius and Fahrenheit?
7. How do Celsius and Fahrenheit differ from Kelvin?
8. What is absolute zero? How do we know that an absolute zero exists?
9. What is heat? How does heat differ from temperature?
10. Why does heat flow but cold doesn't?
11. What is specific heat?
12. Why would the sand and asphalt at a beach feel so much hotter than the water?
13. How is heat measured? Is this the same unit that we would find on a food label?

Revising Explanations - *Record your ideas in the spaces below.* *SEP: Construction Explanations & Designing Solutions*

What is the difference between temperature & heat? How are these concepts related to kinetic energy? Based on this new information, how would you now respond to this question?

_____

_____

_____

Throughout this packet, you will be updating this explanation as you gain more information and more experience. When you complete this packet, compare your initial explanation to your final version. You should see clear improvement with each revision.

Part 3 Investigation: Proving Temperature Difference (5.1.3)

Pre-Investigation Questions - *Prepare verbal responses as a group for these questions. Raise your hand when you're ready to present your explanations. Your instructor will provide feedback and decide if you can proceed to the investigation.* *SEP: Developing & Using Models*

1. What is temperature? How does it relate to kinetic energy?
2. What is thermal equilibrium?
3. What is heat? How does heat differ from temperature?
4. What is specific heat?

This activity was completed _____ (*instructor signature*)

Overview: You'll begin by combining two equal amounts of water at different temperatures and predicting the resulting final temperature. Then, you'll explore how varying volumes of water at different temperatures impact the final temperature after they're combined.

Directions - *Carefully read the directions below before beginning.* *SEP: Planning & Carrying Out an Investigation*

☐ Address the following as a class: *1) Question - what are we trying to figure out? 2) Hypothesis - what do we think will happen, and why? 3) Independent Variable - what will be changed and what needs to be kept constant? 4) Dependent Variable - what data is needed for our question & hypothesis? 5) Methods - How will we collect data? How much is needed for valid & reliable results?* Reach a consensus for your protocols in this investigation.

Trial 1 - Equal Amounts - Different Temperatures. *SEP: Planning & Carrying Out an Investigation*

Combine two equal amounts of water at different temperatures. Record the final temperature. Repeat this for at least three trials. Calculate the average combined temperature. Use the space below to create a data table.

Trial 2 - Different Amounts - Different Temperatures. *SEP: Planning & Carrying Out an Investigation*

Combine two different amounts of water at different temperatures. Record the final temp. Repeat this for at least three trials. Calculate the average combined temperature. Use the space below to create a data table.

Part 4: Review & Assessment (5.1.4)

Step 1: Rank each Driving Question in Part 2 based on your comprehension (you can rank them as *1,2,3* or *green/yellow/red*, or any other method). Then work in teams to review anything that is still unclear.
Step 2: Identify any remaining areas of confusion or concern. Then review these topics with your instructor.
Step 3: Complete the Formative Assessment (*last page of the packet*). Your instructor will determine if you will work individually, in pairs, or in small groups. Then compare and evaluate your responses as a class.
Step 4: Individually complete a Mastery Check. If your performance indicates that additional support is needed, your instructor will determine how to help you move forward.

Part 5: Life Connections – Geothermal Heat Pumps (5.1.5)

Directions: For this activity, you will complete a reading and answer questions that connect the reading to this packet's core ideas.

Background: Geothermal heating and cooling systems provide an alternative to traditional furnaces and air conditioners for homes or communities. Rather than rely on energy-intensive methods, geothermal heat pumps use the earth itself for heating and cooling.

Temperatures at 30 feet below the ground's surface usually stay between 50°-59°F (10-15°C). Geothermal heat pumps use these steady underground temperatures to efficiently heat homes in winter and cool them in summer. In winter, cold air is pumped underground and warmed to at least 50° F (10° C). A traditional furnace can heat air to room temperature, requiring much less energy than if the air were heated from below-freezing temperatures. In summer, the hot air is cooled using the same method - it is cooled below ground and then is pumped back into the building.

In December 2023, the US Department of Energy found that using geothermal heat pumps on a large scale, along with making buildings more energy efficient, could cut carbon emissions and save energy in U.S. buildings. This would also significantly reduce the need for new electrical transmission wires. *(Info & Image Source).*

Questions:

1. Summarize this info. How do geothermal heat pumps reduce the energy needed to heat and cool homes?
2. How does this reading relate to each of the following? A) temperature; B) heat; C) thermal equilibrium
3. Develop a hypothesis for why temperatures below the ground are generally constant throughout the year for most of the United States. Support your claims with evidence and reasoning.
4. Heating with geothermal pumps can cost 25-50% less than that of conventional heating while reducing greenhouse gas emissions. Given these benefits, why aren't these options more widely utilized?
5. Is this something you might consider in your future home? Why or why not? Explain.
6. Imagine you are an elected official. A bill is being proposed to provide zero-interest loans for residents to cover the upfront costs of installing geothermal heating. Would you support this? Why or why not?

Thermal Packet 5.1 Formative Assessment (5.1.4)

Name: _____Hour____Date:_____Score:_____

Directions: A 3x5 notecard with *handwritten* notes can be used to guide your answers. Your instructor may allow you to work in assigned groups. If so, have a different person write each response while others assist.

1. Explain what is inaccurate about each of these claims about temperature and/or heat.

- Avery: "The temperature is higher today because the air contains more heat."

- Bristol: "An open window lets the cool air inside the room." *Agree/Disagree*

- Daryll: "There is less heat in the shade of a tree than in the sun." *Agree/Disagree*

2. **Summarize the relationship between temperature and kinetic energy. How are these ideas related?**

3. **What is the difference between temperature and heat? Are they the same thing? Explain.**

4. **In your own words, explain how a thermometer measures temperature based on a) how the transfer of heat affects the properties of objects, and b) the concept of thermal equilibrium.**

5. **Summarize how Celsius, Fahrenheit, and Kelvin are similar and how they are different.**

6. **What is absolute zero? How do we know the temperature at which it exists?**

7. **Water has greater *specific heat* than sand. What does this mean?**

