Temperature and Energy teacher's guide

Contents:

I. Background knowledge

- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1)
- Definition of kinetic energy

II. Learning Goals

- Be able to describe the relationship between energy and temperature.
- Be able to describe in words and pictures how energy is transferred between two objects at different temperatures and explain when and why this process stops.
- Be able to plan an investigation to produce data to support a model of how the system of a hot object and a cold object will change with time.

III. Begin lesson with 3-5 minutes of free play with the sim.

- Students may be prompted to write down at least 3 things they notice about the intro tab.
- Students may be challenged to find out everything you can do to the iron block.
- Students may be asked what they can measure with the sim.

IV. Energy forms and changes set up information (questions 1-5)

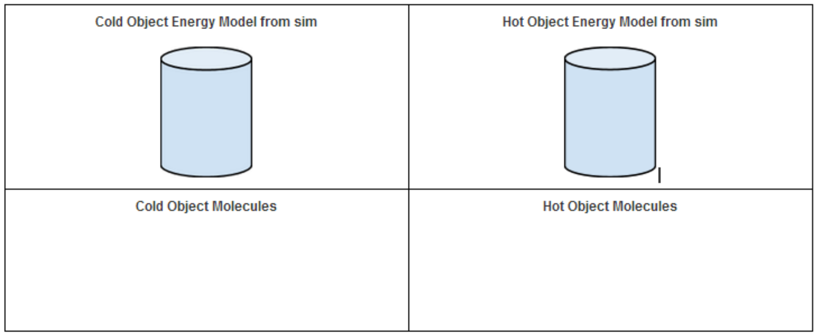
Note: Questions 1-5 should have been covered in middle school according to NGSS. This page may go quickly and be review for students, or it may take longer if the concepts are unfamiliar to students.

Note: This page is to set up an understanding of what temperature measures so that students can use temperature to gain information about energy in a student designed experiment.

Questions 1 and 2:

- Students are modeling the relationship between temperature and kinetic energy.
- Models should show molecules in the hot object moving faster than molecules in the cold object.
- Models should show the same number of molecules and depict molecules as the same size between hot and cold objects.
- Question 2 should indicate that the molecules have kinetic energy.

1) In the boxes below, draw the model given in the simulation and draw a model of the molecules in an object when the object is cold (left) and when the object is hot(right). Assume that the object in both pictures is the same object just at different temperatures.

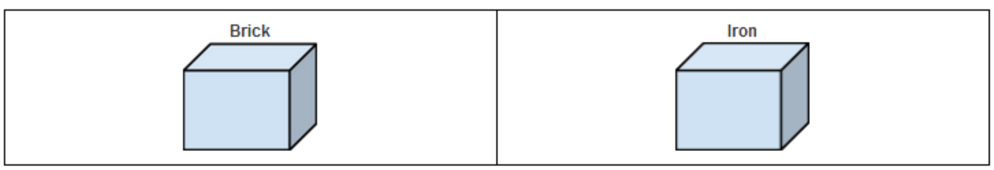


2) At the molecular level, what form of energy do the molecules have? ___________________________

Questions 3 and 4:

- Question 3 is directed at showing students that temperature does not just measure energy. There are other factors involved such as the type of substance being used.
- This question can lead to a discussion of or even calculations of specific heat capacity as an extension (note calculations of specific heat capacity are not a part of the NGSS).
- Question 4 should include the idea that temperature is proportional to energy but this proportionality is different in different types of matter.

3) Heat up the brick and the iron to the same temperature. What differences do you notice?

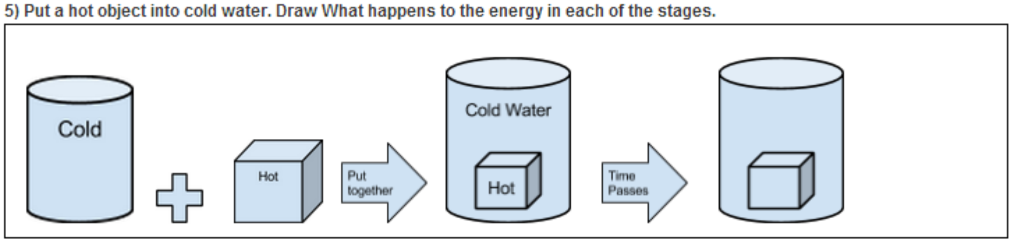


4) What does temperature measure? Support your answer with evidence from the sim.

Question 5:

- Question 5 is intended to get at the model of energy flow between hot and cold objects. The hot object gives some of it's energy to the cold object.
- The cold object should initially have few Es and the hot object should have many Es.
- After the first arrow the hot should have most of its Es but the students should indicate some flow of Es between the two objects.
- After some time the last picture should show the hot object having fewer Es and the cold object having more Es than at the beginning.
- The number of Es total should stay the same throughout the different sections unless the student specifically indicates that some got lost due to the system cooling down.

5) Put a hot object into cold water. Draw What happens to the energy in each of the stages.



V. Making and testing the model

Question 6:

- Students should identify that the process in 5 ends when the temperatures of the objects is the same, but they will need to go deeper in terms of energy to answer why the process stops.
- Technically the process stops when both objects have an an equal amount of energy per degree of freedom. This could translate to equal energy for specific heat, or simply an equal energy for the type of object.
- Students should come to the model that the flow of energy stops when there is some sort of uniform distribution of energy for that type of object

Discussion:

- Questions 5 and 6 should be discussed as a whole class.
- As a class the model to be tested is defined.
- The model is that energy flows from hot objects to cold objects until there is a uniform distribution of energy for the type of object.

Testing the model (question 7)

The following is an example of how the table could be filled out. There are many ways to fill out the table.

7) Plan an investigation in the real world to collect data to test the model from 6 and 7.

What is the claim?	Energy flows from hot objects to cold objects until there is a uniform distribution of energy for the type of object.
What evidence can be collected that will support the claim?	The temperature of both objects before contact and the temperature of both objects after they have come to the same temperature.
How will this evidence support the claim?	If the cold object ends hotter than it began, and the hot object ends colder than it began then there may have been energy transferred from the hotter object to the colder object. If the objects stay at the same temperature once they have reached the same temperature, then the process must end when the objects are at the same temperature. Temperature measures the energy for the type of object.
What will be held constant?	The size of the objects.
What is the procedure for the experiment?	1) Chill a metal object in the freezer (or cool the iron block in the sim) 2) Boil a cup of water (or heat up the water in the sim) 3) Record the initial temperatures of the object and the water 4) Keep recording the temperatures of water and object every minute 5) Keep recording the temperatures for 3 minutes after they have both come to the same temperature.

VI. NGSS alignment guide

This Activity is designed to lead towards the NGSS performance expectation 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).” The following table outlines “lesson level” performance expectations that break down HS-PS3-4 into smaller chunks. The following table shows the way that the science and engineering practices can be used to teach the disciplinary core ideas that lead to the lesson level performance objectives. The table also outlines a student friendly learning objective and some ways to assess.

Science and Engineering Practice	**Disciplinary Core Idea**	**Cross Cutting Concept**	**Lessen Level Performance Expectation**	**Learning Objective**	**Evidence/ Assessment**
Developing and using models: Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	MS-PS3.A The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.	Systems and system models	Students will use the energy model in the sim, as well as their own molecular, to illustrate the relationship between energy and temperature and to predict that the relationship also depends on the type of object (ie type of materials size of object…).	Be able to describe the relationship between energy and temperature.	Students might be given two molecular models, one with faster moving molecules. Students are asked, if the two models represent identical objects, which one has a higher temperature? Students are asked, if the two object are made of different materials, how would your answer change?
Developing and Using Models Use a model to provide mechanistic accounts of phenomena.	MS-PS3.B Energy is spontaneously transferred out of hotter regions or objects and into colder ones.	Stability and Change	Students will use their model to provide a mechanistic account of how energy is transferred out of hotter objects and into colder ones and will be able to explain when and why this process stops.	Be able to describe in words and pictures how energy is transferred between two objects at different temperature and explain when and why this process stops.	Students might be asked to draw the energy transfers that occur when a hot object is dropped into ice cold water, and explain when and why the transfers stop.

Planning and Carrying out Investigations Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible variables or effects and evaluate the confounding investigation's design to ensure variables are controlled.	HS-PS3.B Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).	Energy and Matter	Students will plan an investigation to produce data to test their model describing how the system of a hot object and a cold object will evolve to a more uniform energy distribution.	Be able to plan an investigation to produce data to support a model of how the system of a hot object and a cold object will change with time.	Assess the lab write up for this experiment.

VII. Common Core Standards Addressed

- SL.11-12.5 - Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
- HSN-Q.A.2 - Define appropriate quantities for the purpose of descriptive modeling.
- MP.2 - Reason abstractly and quantitatively.