3D Science Performance Assessment Tasks

HIGH SCHOOL

THERMAL ENERGY TRANSFER, MELTING ICE AND OCEAN CURRENTS

In Partnership with

3DSPA Assessment Tasks were developed by

A member of

In collaboration with

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Task Title	Thermal Energy Transfer, Melting Ice and Ocean Currents

Standards Bundle
PEs ● 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-PS3-4: 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).
Practices ● Planning and Carrying Out Investigations ● Developing and Using Models
Cross-Cutting Concepts ● Systems and System Models ● Matter and Energy
Core Ideas ● Definitions of Energy - ○ Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. ○ At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. ○ These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. ● Conservation of Energy and Energy Transfer ○ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. ○ 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). (HS-PS3-4) ● Energy in Chemical Processes ○ Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

CCSS ELA: ● RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS3-4) ● WHST.9-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. ● WHST.11-12.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. ● WHST.9-12.9: Draw evidence from informational texts to support analysis, reflection, and research. ● 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.
CCSS Mathematics: ● MP.2 Reason abstractly and quantitatively. ● MP.4 Model with mathematics.

Overview / Introduction of the Assessment Task This task is taken from the *National Center for Case Study Teaching in Science*. The title of the Case Study is "A Cool Glass of Water" *In this task students are presented with an initial question, "*Does an ice cube melt more quickly in salt water or in freshwater?" After making their predictions, they are asked to design an investigation to determine whether their initial predictions were correct. They will then be asked to develop a model (diagram) to explain the changes they observe in terms of particle motion and particle position.

Teacher Background
Teachers should understand the concepts of density and the modes of heat or thermal energy transfer due to a temperature difference, specifically conduction and convection.
Information for Classroom Use
Connections to Instruction: These are designed to be a series of formative tasks throughout a high school physics unit on thermal energy.
Approximate Duration for the Summative Task: 2 days
Assumptions: Students should have familiarity with molecular-level models of solids, liquids and gases (MS-PS1-4) and and how those models change as energy is added or removed from the system. Students should also have prior knowledge that the temperature of a substance is a measure of the kinetic energy of its particles, which in turn depends on the speed of those particles (MS-PS3-1, MS-PS3-4). Students should also be familiar with the property of density.
Materials Needed: Ice cubes, water, salt, food coloring, clear cups, thermometers/temperature probes, poster paper or whiteboards, markers, copies of articles

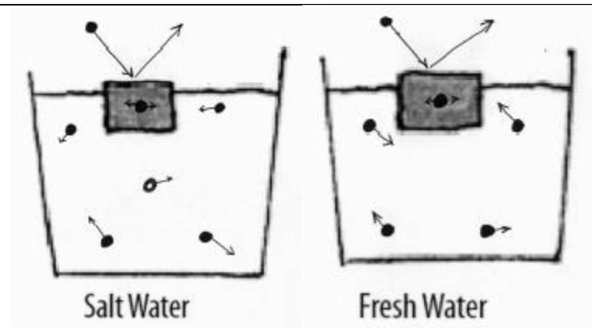
Supplementary Resources: Articles: ● Melting glaciers may affect ocean currents ● Climate change could stall the Atlantic ocean current

Learning Performances
● Students plan an investigation to produce data to support the claim that energy is a quantitative property of matter. ● Students plan an investigation to produce data to show that a system's total energy is conserved, and that systems always tend toward more uniform energy distribution. ● Students plan an investigation to demonstrate that energy is continually transferred between substances within a system. ● Students develop and use a model to demonstrate that at the microscopic scale energy is a combination of energies of motion, position and interactions of particles of matter. ● Students develop and use a model to demonstrate that energy is continually transferred between substances within a system. ● Students develop and use a model to demonstrate that energy is continually converted to less useful forms of energy. ● Students develop and use a model to demonstrate that energy is continually transferred between its various manifestations, e.g. chemical, mechanical, and thermal, by phenomena such as sound or light.

Driving Question	Anticipated Student Responses
What are the potential impacts of glaciers melting?	● everything will die ● coastlines will flood ● ocean temperature will change ● polar bears will become extinct

Performance Assessments

Student Performances		
Formative Assessment Task 1	Learning Performance: Students plan and carry out an experimental investigation to answer the research question: “Will an ice cube melt faster in a cup of fresh water or a cup of salt water?”	Expected Duration: 2 class periods
	Description: Many students predict that an ice cube will melt faster in salt water, since they’re familiar with the use of salt to melt ice on roads and sidewalks. They are surprised to learn the ice cube in fresh water melts much faster.	
	Directions: Students work in small groups to plan their investigation, and share their plan with another group or with the instructor. After getting feedback and approval, students carry out the investigation and record their observations.	
	Scoring / Teacher Look-For’s: Investigation plans should include: ● Manipulated Variable: freshwater vs. saltwater ● Measured Variable: time ● Controlled Variables: initial size and temperature of ice cubes, initial volume and temperature of fresh and saltwater samples, size of cup, surrounding air temperature, etc. ● Results: Ice cube in fresh water melts much more quickly.	
Formative Assessment Task 2	Learning Performance: Students will develop a model (i.e. diagram) to explain their observations (i.e. that the ice cube in fresh water melted much more quickly).	Expected Duration: 2 class periods
	Description: Students can be supplied with a template, or blank poster papers or white boards.	
	Directions: Students work in small groups to develop their models (diagrams). Groups share their models with other groups (or the whole class) and notice similarities and differences. This can be used to give and receive feedback, to engage in scientific argument based on alternative explanations for the phenomenon, and to revise their existing models.	
	Scoring / Teacher Look-For’s: Models should include: ● Differences in particle position - closer together, arranged regularly in solid ice, irregular arrangement in liquid water (although actually slightly more closely spaced), and much farther apart in the air above); ● Differences in particle motion - slow in solid ice, faster in liquid water, and fastest in air above; ● Presence of salt particles in one cup of water; ● Transfer of thermal energy - perhaps through collisions between ice molecules and surrounding liquid/gas molecules.	

		
Formative Assessment Task 3	Learning Performance: Students plan and carry out a second investigation to answer the question: “What happens to the water from the melted ice cube? Where does it go?”	Expected Duration: 2 class periods
	Description: During discussion, students will generally come to the conclusion that they need to color the ice cubes before submerging them in the cups.	
	Directions: Students working in small groups notice that the colored melt water from the ice cube in fresh water drops to the bottom of the cup, while the melt water in salt water accumulates at the surface of the cup, surrounding the ice cube. Some students may think of measuring the water temperature at the surface and the bottom of each container. This will provide additional data they can use in revising their models. Some students may also observe a difference in the shapes of the ice cubes melting in freshwater (tall) vs. saltwater (flat). This, too, is significant.	
	Scoring / Teacher Look-For’s: ● Manipulated Variable: freshwater vs. saltwater ● Observed Change: Meltwater accumulates at the bottom, or remains at the surface. ● Temperature differences: In fresh water, the temperature at the surface is slightly warmer than at the bottom of the cup. In salt water, the temperature at the surface is significantly colder than at the bottom of the cup. ● Ice cube shape: In fresh water, the melting ice cube tends to have a taller, narrower shape; while in salt water, the ice cube tends to have a more broad, flat shape.	

		
Formative Assessment Task 4	Learning Performance: Students will develop a revised, final model (i.e. diagram) to explain their observations from all their experimental investigations. Description: Students can be supplied with a template, or blank poster papers or white boards. Directions: Students again work in small groups to develop their models (diagrams). Groups share their models with other groups (or the whole class) and notice similarities and differences. This can be used to give and receive feedback, to engage in scientific argument based on alternative explanations for the phenomenon, and to revise their existing models. Scoring / Teacher Look-For's: In addition to all the characteristics listed in Formative Assessment #2, revised models should include: ● The role of density differences (caused by dissolved salt and temperature changes) in the process of thermal energy transfer; ● The role of convection currents, especially in the freshwater sample, in the process of thermal energy transfer, and in the shape of the melting ice cube.	Expected Duration: 2 class periods
Final Task: ***(Model, Design, Explain, Argue, Investigate)*** ***MODEL***	Learning Performance: An explanatory model of the effects of glacial melting on ocean currents that includes thermal energy transfer, particle motion and position, density, and convection currents. Phenomenon: Adding freshwater to the oceans can cause a change in ocean currents, specifically the Gulf Stream or the Atlantic ocean current . Goal: Students will develop a final model to explain how ocean currents can be impacted by the addition of fresh water. Role: Students are oceanographers.	Expected Duration: 2 class periods: -one day for research and model development -one day for presenting and feedback

Audience:	Situation:
A group of scientists attending a climate change summit	Students are oceanographers who are presenting about the effects of glacial melting on ocean currents such as the Gulf Stream.

Product / Performance

Students will develop a model to represent how glacial melting can affect ocean currents, specifically the Gulf Stream. Modes of thermal energy transfer, particle motion and position, and density need to be included in the model.

Directions

You have been invited to present at the 2018 Climate Change Summit. Your research as an oceanographer has focused on the relationship between ocean currents and climate. Recently your work has focused on how glacial melt affects ocean currents. Your task is to create a model that will be presented at the Summit to summarize your research.

Your model must:

- demonstrate that the energy in a system is a combinations of energies of particle motion and particle position.
- demonstrate that energy is continually transferred between substances within the system.
- represent the modes of energy transfer, specifically convection and conduction.
- explain how the density of the substances in the system affects the melting patterns.

Directions:

1. Students will read the article(s) Melting glaciers may affect ocean currents and/or Climate change could stall the Atlantic ocean current.
2. Students will work in small groups prepare a final model that represents how glacial melting could affect the ocean currents. The final model should include components from their previous models.
3. Groups will then present their model to a partner group. Partner groups will actively listen to the presentation and respond using Talk Moves.
4. Groups will trade roles and repeat the process in step 3.
5. Feedback and revision?

CheckBric

Student Name ____

Teacher Name ____

<table>
<tr><td colspan="5">Learning Performance:
Students develop and use a model to demonstrate that at the microscopic scale energy is a combination of energies of motion, position and interactions of particles of matter.</td><td>Comments</td></tr>
<tr><td colspan="5">Insert Evidence Statements below:</td><td rowspan="5"></td></tr>
<tr><td>models show unseen movement of energy and particles of matter and their interaction</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>The movement of energy and particles explains the phenomenon</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>The flow of energy and matter in the model supports the explanation of the phenomenon</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>LP Total:</td><td colspan="4"></td></tr>
<tr><td colspan="5">Learning Performance:
Students develop and use a model to demonstrate that energy is continually transferred between substances within a system.</td><td>Comments</td></tr>
<tr><td colspan="5">Insert Evidence Statements here:</td><td rowspan="5"></td></tr>
<tr><td>Model shows that energy moves continually between water of different temperatures</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>Continual transfer of energy between substances is clear</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>System components are labeled and it is clear how they interact</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>LP Total:</td><td colspan="4"></td></tr>
<tr><td>Checkbric Total</td><td colspan="4"></td><td></td></tr>
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4 Exemplary	Work at this level is of exceptional quality. It is both thorough and accurate. It exceeds the standard. It shows a sophisticated application of knowledge and skills.
3 Proficient	Work at this level meets the standard. It is acceptable work that demonstrates application of essential knowledge and skills. Minor errors or omissions do not detract from the overall quality.
2 Developing	Work at this level does not meet the standard. It shows basic, but inconsistent application of knowledge and skills. Minor errors or omissions detract from the overall quality. Your work needs further development.
1 Emerging	Work at this level shows a partial application of knowledge and skills. It is superficial (lacks depth), fragmented or incomplete and needs considerable development. Your work contains errors or omissions.