Phoenixville Area School District Understanding by Design (UbD) Science Template

Grade Level &/or HS Subject: Physics   Unit Name: Heat, Energy and Earth

Plain English Summary: This unit is primarily about heat. Students will learn about what temperature represents and how we can measure it, and how and when heat is transferred. They will learn how we can leverage the flow of heat energy for things like heat pumps and refrigeration, and how all those ideas can be combined in the design of a heating system, specifically solar heating of water – which ties light and waves into this unit, as well. Finally, we'll look at the role that heat plays in the behavior of our planet, from the interior behavior and the resulting measurable impacts on the surface, to the capstone project of the course. For that project, students will link energy, heat, light and possibly things like gravity and orbital motion, all together in a model and experiments meant to represent a chain of energy flows related to Earth's surface and climate.

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td rowspan="4">Overarching NGSS & PA Standards:

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 positions of particles (objects).

HS-PS3-3</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…

Ask questions and define problems
Develop and use models
Plan and carry out experiments
Analyze and interpret data using computational thinking
Obtain, evaluate, and communicate information (supported by evidence)
Construct explanations and design solutions

(Choose the appropriate content-specific transfer goals)</td></tr>
<tr><td colspan="2">Meaning-Making</td></tr>
<tr><td>Students will understand that…

A device that works within given constraints to convert one form of energy into another form of energy can be designed, built and refined.

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)

Models can be developed and used 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 positions of particles (objects).

Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.</td><td>ESSENTIAL QUESTIONS
Students will keep considering...

How is energy transferred?

How does energy within the Earth affect the movement of the Earth's crust?

How do patterns in the motion of the Earth affect climate?
How do human behaviors affect climate?</td></tr>
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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). HS-ESS2-3 Develop a model based on evidence of Earth's interior to	Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection	
	Knowledge and Skills Acquisition	
	At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. 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) Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.	*Students will be skilled at…* Design, evaluate, and/or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. Use mathematical representations of phenomena to describe explanations. Analyze data using tools, technologies, and/or models (e.g., computational,

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<td rowspan="2">describe the cycling of matter by thermal convection

HS-ESS2-4

Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

Which branch(es) of science apply:

PS ESS</td>
<td>The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles

The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space.</td>
<td rowspan="2">mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Communicate technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Develop a model based on evidence to illustrate the relationships between systems or between components of a system.</td>
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<td>KEY VOCABULARY

Heat
Temperature
Conduction
Convection
Radiation
Heat Pump
Plate Tectonics
Magnetic Field
Thermodynamics</td>
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<tr><th colspan="3">Stage 2 – Evidence</th></tr>
<tr><th>Evaluative Criteria</th><th colspan="2">Assessment Evidence</th></tr>
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<td>Good process skills (rubric);
Device meets requirements;
Device</td>
<td>PERFORMANCE TASK(S):

Solar Tank Design

Goal: To design the most efficient, powerful, and cost-effective solar water heating system for a home, business, etc.
Role: An engineer
Audience: Their parents, store owner, etc.</td>
<td>Differentiation Considerations:

Students have the choice in any modeling software, the scenario where the tanks will be used, to some extent supplies/cost.</td>
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meets/exceeds specifications. Good process skills (rubric); Demo or experiments test model; Explanation clear and understandable to audience.	Situation: Students will work in groups. They will decide on a target building or application, identify where the solar tank(s) should be placed, then design a model, set the light at an angle for sunlight, etc., to determine the effectiveness of their approach. Product: The students will produce a model of how their system will work, and then experimentally determine the effectiveness of their design. Once tested, they will make a short presentation for their target audience estimating the costs and benefits of implementing a full-scale solar heating system based on their experiments. Standards: see left **Climate Model + Demo** Goal: To develop a model of energy transfer + climate involving Earth's surface, then creating an experiment or demonstration to test the model and show how it relates to what happens on Earth. Role: Scientist/Educator Audience: The Community Situation: Students are supposed to use their work and demo(s) to illustrate how their topic affects energy and thus climate for the Earth. Any explanations should be understandable for MS students. Product: A short presentation of their model and demonstration of their experiment or demo to support their model. Standards: See Left Examples: A student decides to study the effect of volcanic ash on climate. They build a model suggesting more ash will lead to a reduction of sunlight reaching the surface of the earth, which will reduce the temperature. The student could use a container and shine a bright light into it, measure both the light (using a light sensor) and the temperature of the air or the surface. Then the student could introduce varying amounts of particles (like chalk dust or even soot/ash if they want to be very accurate) to the air, and re-check the light intensity and the temperature. For a more advance scenario, the student could apply soot in one area and watch how the air moves the soot when 'sunlight' is directly applied to that area versus areas where there isn't as much soot. Convection could be used to explain how energy is redistributed and that redistributes that soot. The student could document their experiments, put together a video showing the different results with an explanation, and that video could be played on Phantom TV, or made available in some way to the community.	Choice in inputs/outputs/storage methods, including: i. Changes in Earth's orbit and the orientation of its axis. ii. Changes in the sun's energy output. iii. Configuration of continents resulting from tectonic activity. iv. Ocean circulation. v. Atmospheric composition (including amount of water vapor and CO_2); vi. Atmospheric circulation. vii. Volcanic activity viii. Glaciation. ix. Changes in extent or type of vegetation cover; and x. Human activities. Students can also choose how many layers of interactions to examine (which will affect difficulty) and method of presentation.

	Another example could involve the surface colors that light is hitting, and the effect that has on temperature. If they actually use crushed ice to mimic snow, for instance, then they will see how as the ice melts and the surface becomes less reflective, that the temperature increases further.	

Accuracy of answers and explanations; lab/inquiry process skills	OTHER EVIDENCE:
	
	• HW – these will consist of a range of questioning goals, from basic things like vocab understanding to conceptual understanding to application
	• Labs + Assignments:
	    o Thermodynamics experiment/heat transfer for objects at different temperatures, looking at the rate of transfer by material and/or temp difference (conduction + 2nd Law of Thermodynamics)
	    o Model Earth Core based on evidence – choose a topic, from magnetic poles to plate tectonics and write a short summary of how the topic provides evidence for the properties of Earth's interior.
	• Quizzes – MC or FR where work is required; similar to HW, could be fact recall, conceptual understanding or application being assessed.
	• Test – 1 for the unit, will contain a mix of recall and application focused on the understandings and knowledge from Stage 1
	
	(What evidence will be collected to determine whether Stage 1 goals were achieved?)
		Differentiation Considerations:
		
		• Notes allowed on some assessments
		• Partial credit + test corrections