Unit 6: Thermal Energy

CONTENT AREA: General Physical & Earth Science	GRADES: 8	UNIT: 1 of 8
Pacing: Approx. 2 Months		
Planning and Carrying Out Investigations • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS3-4) **Constructing Explanations and Designing Solutions** • Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3) **Asking Questions and Defining Problems** • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1) **Developing and Using Models** • Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4) **Analyzing and Interpreting Data** • Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3) **Engaging in Argument from Evidence**	**Disciplinary Core Ideas** PS3.A: Definitions of Energy • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3- 4) PS3.B: Conservation of Energy and Energy Transfer • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MSPS3-4) • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3- 3) ETS1.A: Defining and Delimiting Engineering Problems • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) ETS1.B: Developing Possible Solutions • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1- 2), (MS-ETS1-3) • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Crosscutting Concepts** **Scale, Proportion, and Quantity** • Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-4) **Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3) **Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1) • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

• Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)	ETS1.C: Optimizing the Design Solution • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MSETS1-3)	

Performance Expectations: MS-PS3-3, MS-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, and MS-ETS1-4

Evidence Statement(s): MS-PS3-3, MS-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, and MS-ETS1-4

Essential Question: How can a standard thermometer be used to tell you how particles are behaving?

21st Century Skills: 9.2.8.B.3, 9.2.8.B.4

Career Ready Practices: CRP4, CRP6, CRP7

Technology:HS-ETS1-1 HS-ETS1-3

Technical Terms (Suggested)	Core Instructional Materials	Assessment Statement
Geologic Time Scale Rock Formations Fossils Strata Relative Dates Melting Crystallization Weathering Deformation Atomic Scale Erosion Time Motion Kinetic Energy Potential Energy Force Momentum Transfer of Energy Thermal Energy ** All terms should be taught in context rather than in isolation. These terms should be addressed after conceptual understanding.**	MS-PS3-3 - Chromebook, internet access, smartboard, notebook, pen, pencil, whiteboard. MS-PS3-4- Computer, Internet access, smartboard, notebook, pen, pencil, whiteboard. MS-ETS1-1- Computer, Internet access, smartboard, notebook, pen, pencil, whiteboard. MS-ETS1-2- Computer, Internet access, smartboard, notebook, pen, pencil, whiteboard. MS-ETS1-3- Computer, Internet access, smartboard, notebook, pen, pencil, whiteboard. MS-ETS1-4- Computer, Internet access, smartboard, notebook, pen, pencil, whiteboard.	*Students who understand the concepts can:* ● Individually and collaboratively plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles as measured by the temperature of the sample. ● As part of a planned investigation, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. ● Make logical and conceptual connections between evidence and explanations. *Students who understand the concepts can:* • Apply scientific ideas or principles to design, construct, and test a design of a device that either minimizes or maximizes thermal energy transfer. • Determine design criteria and constraints for a device that either minimizes or maximizes thermal energy transfer. • Test design solutions and modify them on the basis of the test results in order to improve them.

		• Use a systematic process for evaluating solutions with respect to how well they meet criteria and constraints.

Modifications			
English Language Learners	Special Education	At Risk	Gifted & Talented
Scaffolding Word walls Sentence/paragraph frames Bilingual dictionaries/translation Think alouds Read alouds Highlight key vocabulary Annotation guides Think-pair-share Visual aides Modeling Cognates	Word walls Visual aides Graphic organizers Multimedia Leveled readers Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Teacher tutoring Peer tutoring Study guides Graphic organizers Extended time Parent communication Modified assignments Counseling	Curriculum compacting Challenge assignments Enrichment activities Tiered activities Independent research/inquiry Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks Self-directed activities

5E Model	
Performance Expectation: MS-PS3-3, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4 MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	
Engage: Anticipatory Set	Using the following resources have students view videos, read articles and engage is discussion about thermal energy transfer. Go to MS-PS3-3 section of the page. http://www.ck12.org/ngss/middle-school-physical-sciences/energy
Exploration: Student Inquiry	Build a Solar Oven In this activity, students will design, test and construct a solar oven, providing a concrete example of thermal energy transfer. http://www.hometrainingtools.com/a/build-a-solar-oven-project Thermal Protection Systems: Day 1

	In this activity, students will apply scientific principles to design, construct and test a device that either minimizes or maximises thermal energy transfer. http://betterlesson.com/lesson/634000/thermal-protection-systems-day-1
Explanation: Concepts & Practices	In these lessons: Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS3.A: Definitions of Energy Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. PS3.B: Conservation of Energy and Energy Transfer Energy is spontaneously transferred out of hotter regions or objects and into colder ones. ETS1.A: Defining and Delimiting an Engineering Problem The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary) ETS1.B: Developing Possible Solutions A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary)
Elaboration: Extension Activity	Build a Thermos In this activity, students will desgin, construct and test a thermos strucutre to determine which model keeps the warmest temperature. http://betterlesson.com/lesson/628050/build-a-thermos
Evaluation: Assessment	

5E Model	
Performance Expectation: MS-PS3-4, MS-ETS1-1 MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	
Engage: Anticipatory Set	Using the following resources have students view videos, read articles and engage in discussion on how energy, mass and mater impact temperatures. Go to MS-PS3-4 section of the page.

	http://www.ck12.org/ngss/middle-school-physical-sciences/energy
Exploration: Student Inquiry	Heat Transfer Lab Rotation: Conduction, Convection and Radiation In this lab activities, students will identify and explain the various ways that heat transfers thorugh systems in the natural world. http://betterlesson.com/lesson/634878/heat-transfer-lab-rotation-conduction-convection-and-radiation Thermal Protection Systems: Day 2 and Day 3 In these activities, students use their knowledge of radiation, conduction, and convection to design thermal protection systems for NASA that will protect a spacecraft from burning up in the atmosphere! http://betterlesson.com/lesson/635048/thermal-protection-systems-day-2-and-day-3
Explanation: Concepts & Practices	In these lessons: Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS3.A: Definitions of Energy Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. PS3.B: Conservation of Energy and Energy Transfer The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environ
Elaboration: Extension Activity	Related Activities http://participatoryscience.org/standard/ms-ps3-4
Evaluation: Assessment	

How can a standard thermometer be used to tell you how particles are behaving?

In this unit, students *ask questions*, *plan and carry out investigations*, *engage in argument from evidence*, *analyze and interpret data, construct explanations*, *define problems and design solutions* as they make sense of the difference between energy and temperature. They use the practices to make sense of how the total change of energy in any system is always equal to the total energy transferred into or out of the system. The crosscutting concepts of *energy and matter, scale, proportion, and quantity*, and *influence of science, engineering, and technology on society and the natural world* are the organizing concepts for these disciplinary core ideas. Students ask *questions*, *plan and carry out investigations*, *engage in argument from evidence*, *analyze and interpret data*, *construct explanations*, *define problems and design solutions.* Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on MS-PS3-3, MS-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, and MS-ETS1-4.

#	STUDENT LEARNING OBJECTIVES	CORRESPONDING PEs and DCIs
1	**Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.** *[Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]* **(MS-PS3-3)**	MS-PS3-3
2	**Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.** *[Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]* **(MS-PS3-4)**	MS-PS3-4
3	**Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)**	MS-ETS1-1
4	**Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)**	MS-ETS1-2
5	**Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)**	MS-ETS1-3
6	**Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MS-ETS1-4)**	MS-ETS1-4

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence	**PS3.A: Definitions of Energy** **Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.**	**Crosscutting Concepts** **Energy and Matter** The transfer of energy can be tracked as energy flows through a designed or natural system.

consistent with scientific ideas, principles, and theories. Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** **Science knowledge is based upon logical and conceptual connections between evidence and explanations**	**PS3.B: Conservation of Energy and Energy Transfer** **Energy is spontaneously transferred out of hotter regions or objects and into colder ones.** **ETS1.A: Defining and Delimiting an Engineering Problem** **The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary)** **ETS1.B: Developing Possible Solutions** **A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary)** **PS3.A: Definitions of Energy** **Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.** **PS3.B: Conservation of Energy and Energy Transfer**	**Scale, Proportion, and Quantity** Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

	The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.	

Connections to other DCIs in this grade-band: MS.PS1.B ; MS.ESS2.A ; MS.ESS2.C ; MS.ESS2.D ; MS.PS1.A ; MS.PS2.A ; MS.ESS2.C ; MS.ESS2.D ; MS.ESS3.D
Articulation of DCIs across grade-bands: 4.PS3.B ; HS.PS3.B ; 4.PS3.C ; HS.PS1.B ; HS.PS3.A ; HS.PS3.B
Common Core State Standards Connections: **ELA: RST.6-8.3, WHST.6-8.7 ; RST.6-8.3, WHST.6-8.7** **Math: N/A**