

## Unit 1: Structures and Properties of Matter

Instructional Days: 30

## Unit Summary

***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

**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](#))

**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](#))

**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](#))

**Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and**

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constraints of the problem. ([MS-ETS1-2](#))

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](#))

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](#))

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MS-PS3-3	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer
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
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
ETS1.A	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
ETS1.B	There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem

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4](#)[Future Learning p. 7](#)[Appendix A: NGSS and Foundations  
p. 10](#)[Modifications p. 5](#)**Enduring Understandings**

- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.
- 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.
- Energy is spontaneously transferred out of hotter regions or objects and into colder

**Essential Questions**

- What is energy?
- How is energy conserved and transferred?
- What is the relationship between energy and forces?

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Unit Sequence	
<b>Part A:</b> <i>How can a standard thermometer be used to tell you how particles are behaving?</i>	
Concepts	Formative Assessments
<ul style="list-style-type: none"> <li>• There are 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.</li> <li>• Temperature is a measure of the average kinetic energy of particles of matter.</li> <li>• The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.</li> <li>• 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.</li> <li>• Proportional relationships among the amount of energy transferred, the mass, and the change in the average kinetic energy of particles as measured by temperature of the sample provide information about the magnitude of properties and processes.</li> </ul>	<p><i>Students who understand the concepts can:</i></p> <ul style="list-style-type: none"> <li>• 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.</li> <li>• 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.</li> <li>• Make logical and conceptual connections between evidence and explanations.</li> </ul>

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## Unit Sequence

**Part B:** You are an engineer working for NASA. In preparation for a manned space mission to the Moon, you are tasked with designing, constructing, and testing a device that will keep a hot beverage hot for the longest period of time. It costs approximately \$10,000 per pound to take payload into orbit so the device must be lightweight and compact. The lack of atmosphere on the Moon produces temperature extremes that range from -157 degrees C in the dark to +121 degrees C in the light. Your device must operate on either side of the Moon (<https://spaceflight systems.grc.nasa.gov/education/rocket/moon.html>).

## Concepts

- 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.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
- The transfer of energy can be tracked as energy flows through a designed or natural system.
- 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.
- 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.

## Formative Assessments

*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.

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**What It Looks Like in the Classroom**

In Unit 5, students learned about the interactions between kinetic and potential energy. In this unit, they will be introduced to the idea of thermal energy and will explore how it relates to the interactions from Unit 5. Prior to planning an investigation, students will need to understand that temperature is actually a measure of the average kinetic energy of the particles in a sample of matter.

Students will begin this unit by individually and collaboratively planning an investigation to determine energy transfer 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. Students could start with an individual, small-group, or whole-class brainstorm to determine what might happen if they changed the temperature in a sample of matter. This brainstorm could take the form of a sketch, graphic organizer, or written response, and it could include everyday activities like taking a can of soda out of the refrigerator and setting it on a table or putting an ice cube into a warm beverage.

After brainstorming, students may need some guidance to determine what variables they would like to test in their experiment. Students could examine how the mass of ice cubes added to the beverage affects the temperature change. They could also investigate how the mass of the can of soda affects the temperature change as it sits on the table after being removed from the refrigerator. Examples of experiments could include a comparison of final temperatures after different masses of ice have melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials as they cool or heat in the environment, or the same material with different masses when a specific amount of thermal energy is added. Another example could include placing heated steel washers into water to investigate temperature changes. Each of these examples helps to show the proportional relationship between different masses of the same substance and the change in average kinetic energy when thermal energy is added to or removed from the system. In planning, students will identify independent and dependent variables and controls, decide what tools and materials are needed, how measurements will be recorded, and how many data are needed to support their claim. Once experiments have been planned and performed, students will move into the engineering process to solve a problem using this content.

In Unit 4, students used the design and engineering process to maximize a solution to a problem. In this unit of study, students will combine the concepts of thermal energy and engineering processes to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. Examples of devices could include an insulated box, a solar cooker, or a Styrofoam cup. Calculation of the total amount of thermal energy is not to be assessed at this time.

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Based on their brainstorm and investigations, students will identify a device to control the transfer of thermal energy into or out of the system they studied. Once students have identified the type of device they will construct, they can begin to define the criteria and constraints of the design problem that will help to minimize or maximize the transfer of thermal energy. Using informational texts to support this process is important. Students will draw evidence from these texts in order to support their analysis, reflection, and research.

When students consider constraints, they should conduct short research projects to examine factors such as societal and individual needs, cost effectiveness, available materials and natural resources, current scientific knowledge, and current advancements in science and technology. They should also consider limitations (design constraints) due to the properties of the materials of their design (i.e., Styrofoam vs. glass). While conducting their research, students will need to gather their information from multiple print and digital sources and assess the credibility of each source. When they quote or paraphrase the data and conclusions found in their resources, they will need to avoid plagiarism and provide basic bibliographic information for each source. After comparing the information gained from their research, experiments, simulations, video, or other multimedia sources, they will be able to determine precise design criteria and constraints that lead to a successful solution.

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**Connecting with English Language Arts/Literacy and Mathematics***English Language Arts/Literacy*

- Follow precisely a multistep procedure for an investigation that has been planned individually and collaboratively 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.
- Conduct short research projects 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, drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
- Follow precisely a multistep process for the design, construction, and testing of a device that either minimizes or maximizes thermal energy transfer.
- Conduct short research projects to apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer, drawing on several sources and generating additional related, focused questions that allow for multiple avenue of exploration.
- Gather relevant information to inform the design, construction, and testing of a device that either minimizes or maximizes thermal energy transfer using multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.
- Draw evidence from informational texts to support analysis, reflection, and research that informs the design, construction, and testing of a device that either minimizes or maximizes thermal energy transfer.
- Cite specific textual evidence to support analysis of science and technical texts that provide information about the application of scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
- Compare and contrast the information gained from experiments, simulations, or multimedia sources with that gained from reading text about devices that either minimize or maximize energy transfer.

*Mathematics*

- Reason abstractly and quantitatively while collecting and analyzing numerical and symbolic data as part of an investigation

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that has been planned individually and collaboratively.

- Summarize numerical data sets in relation to the amount of energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles in the sample as measured by the temperature of the sample.
- Reason abstractly and quantitatively while collecting and analyzing numerical and symbolic data as part of a systematic process for evaluating solutions with respect to how well they meet criteria and constraints of a problem involving the design of a device that either minimizes or maximizes thermal energy transfer.

**Modifications**

*(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: [All Standards, All Students/Case Studies](#) for vignettes and explanations of the modifications.)*

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals ([http://www.cast.org/our-work/about-udl.html#.VXmoXcfD\\_UA](http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA))

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**Research on Student Learning**

Students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy-change focus only on forms which have perceivable effects. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen.

The idea of energy conservation seems counterintuitive to middle-school students who hold on to the everyday use of the term energy. Even after instruction, however, students do not seem to appreciate that energy conservation is a useful way to explain phenomena. A key difficulty students have in understanding conservation appears to derive from not considering the appropriate system and environment. In addition, middle students tend to use their conceptualizations of energy to interpret energy conservation ideas. For example, some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form. Or, students may believe that no energy remains at the end of a process, but may say that "energy is not lost" because an effect was caused during the process (for example, a weight was lifted) ([NSDL, 2015](#))

**Prior Learning**

*By the end of Grade 5, students understand that:*

- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- Light transfers energy from place to place.
- Energy can be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light.
- Transforming the energy of motion into electrical energy may have produced the currents to begin with.
- When objects collide, the contact forces transfer energy so as to change the objects' motions.

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**Future Learning***Physical science*

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
- 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 means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

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- The availability of energy limits what can occur in any system.
- 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).
- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
- 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.
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical and in making a persuasive presentation to a client about how a given design will meet his or her needs.
- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

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**Connections to Other Units****Grade 6, Unit 4: Forces and Motion**

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

**Grade 6, Unit 7: Weather and Climate**

- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.
- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
- Global movements of water and its changes in form are propelled by sunlight and gravity.
- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.
- Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.
- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- Because these patterns are so complex, weather can only be predicted probabilistically.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

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**Grade 7, Unit 1: Structure and Properties of Matter**

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

**Grade 7, Unit 2: Interactions of Matter**

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

**Grade 7, Unit 3: Chemical Reactions**

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

**Grade 7, Unit 8: Earth Systems**

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

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**Grade 8, Unit 3: Stability and Change on Earth**

- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

**Sample of Open Education Resources**

[Energy Forms and Changes](#): Explore how heating and cooling iron, brick, and water adds or removes energy. See how energy is transferred between objects. Build your own system, with energy sources, changers, and users. Track and visualize how energy flows and changes through your system.

[States of Matter](#): Watch different types of molecules form a solid, liquid, or gas. Add or remove heat and watch the phase change. Change the temperature or volume of a container and see a pressure-temperature diagram respond in real time. Relate the interaction potential to the forces between molecules.

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## Appendix A: NGSS and Foundations for the Unit

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](#))

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](#))

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](#))

Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. ([MS-ETS1-2](#))

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](#))

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](#))

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The performance expectations above were developed using the following elements from the NRC document [A Framework for K-12 Science Education](#):

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><b>Planning and Carrying Out Investigations</b></p> <ul style="list-style-type: none"> <li>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)</li> </ul> <p><b>Constructing Explanations and Designing Solutions</b></p> <ul style="list-style-type: none"> <li>Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3)</li> </ul> <p><b>Asking Questions and Defining Problems</b></p> <ul style="list-style-type: none"> <li>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</li> </ul>	<p><b>PS3.A: Definitions of Energy</b></p> <ul style="list-style-type: none"> <li>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)</li> </ul> <p><b>PS3.B: Conservation of Energy and Energy Transfer</b></p> <ul style="list-style-type: none"> <li>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. (MS-PS3-4)</li> <li>Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)</li> </ul> <p><b>ETS1.A: Defining and Delimiting Engineering Problems</b></p> <ul style="list-style-type: none"> <li>The more precisely a design task's criteria and constraints can be defined, the more likely it is that the</li> </ul>	<p><b>Scale, Proportion, and Quantity</b></p> <ul style="list-style-type: none"> <li>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)</li> </ul> <p><b>Energy and Matter</b></p> <ul style="list-style-type: none"> <li>The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)</li> </ul> <p><b>Influence of Science, Engineering, and Technology on Society and the Natural World</b></p> <ul style="list-style-type: none"> <li>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)</li> <li>The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of</li> </ul>

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<p>solutions. (MS-ETS1-1)</p> <p><b>Developing and Using Models</b></p> <ul style="list-style-type: none"> <li>Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4)</li> </ul> <p><b>Analyzing and Interpreting Data</b></p> <ul style="list-style-type: none"> <li>Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)</li> </ul> <p><b>Engaging in Argument from Evidence</b></p> <ul style="list-style-type: none"> <li>Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)</li> </ul>	<p>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)</p> <p><b>ETS1.B: Developing Possible Solutions</b></p> <ul style="list-style-type: none"> <li>A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)</li> <li>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)</li> <li>Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)</li> <li>Models of all kinds are important for testing solutions. (MS-ETS1-4)</li> </ul> <p><b>ETS1.C: Optimizing the Design Solution</b></p> <ul style="list-style-type: none"> <li>Although one design may not perform the best across all tests, identifying the characteristics of the design that</li> </ul>	<p>scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)</p>
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	<p>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. (MS-ETS1-3)</p> <ul style="list-style-type: none"><li>• The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)</li></ul>	
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English Language Arts	Mathematics
<p>Cite specific textual evidence to support analysis of science and technical texts. (MS-PS3-5),(MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3) <b>RST.6-8.1</b></p> <p>Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS3-3),(MS-PS3-4) <b>RST.6-8.3</b></p> <p>Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS3-3),(MS-PS3-4),(MS-ETS1-3) <b>RST.6-8.7</b></p> <p>Compare and contrast the information gained from experiments, simulations, videos, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2),(MS-ETS1-3) <b>RST.6-8.9</b></p> <p>Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2) <b>WHST.6-8.7</b></p> <p>Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1) <b>WHST.6-8.8</b></p> <p>Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2) <b>WHST.6-8.9</b></p> <p>Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ETS1-4) <b>SL.8.5</b></p>	<p>Reason abstractly and quantitatively. (MS-PS3-4),(MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4) <b>MP.2</b></p> <p>Summarize numerical data sets in relation to their context. (MS-PS3-4) <b>6.SP.B.5</b></p> <p>Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3) <b>7.EE.3</b></p> <p>Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy. (MS-ETS1-4) <b>7.SP</b></p>

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Common Vocabulary	
Orientation	Mass to energy conversion
Albert Einstein	Special theory of relativity
Bernoulli's principle	Speed of light
Buoyancy	Torque
Elasticity	Conversion
Electric field	Particle
Inertial frame of reference	Store
Magnetic field	Transfer