Matter and Its Interactions

Grade 6: Unit 1: Matter and Its Interactions  (MS-PS1) (MS-PS3-3) (MS-PS3-4) (MS-PS3-5)

Students will develop an understanding of matter and its interaction involving energy. Substances can take on different forms of matter and can react physically or chemically based on various types of reactants given the atomic structure of those reactants. Potential and kinetic energy may be used to express the exchange of energy amongst objects. There is a difference, yet a connection, between thermal energy and temperature. Heat is energy transferred, while 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. Students will apply their understanding of matter and its interactions using real-world situations.

Recommended Pacing: 8 Weeks

Core Standards Addressed
Next Generation Science Standards: MS-PS1-1, MS-PS1-2, MS-PS1-3, MS-PS1-4, MS-PS1-5, MS-PS1-6, MS-PS3-3, MS-PS3-4, MS-PS3-5, ETS1-1, ETS1-2, ETS1-3

| RST.6-8.1 | Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-PS1-2) (MS-PS1-3) (MS-PS3-1) (MS-PS3-5) |
| RST.6-8.3 | Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6), (MS-PS1-1), (MS-PS3-4) |
| RST.6-8.7 | 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-PS1-1),(MS-PS1-2),(MS-PS1-4),(MS-PS1-5), (MS-PS3-1) |
| WHST.6-8.7 | 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-PS1-6), (MS-PS3-3), (MS-PS3-4) |
| WHST.6-8.8 | 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-PS1-3) |
### Essential Questions

- What do you know about matter and mass?
- What are atoms?
- What are atomic structures and how may they be altered?
- What is potential and kinetic energy?
- How can energy be transferred from one object to another?

### Enduring Understandings

- Molecules vary in complexity.
- Properties of substances interact.
- Natural resources undergo a chemical process to form synthetic materials.
- Substances are made from different types of atoms that combine in various ways.
- Qualitative molecular-level models of solids, liquids, and gases show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs.
- Natural resources can undergo a chemical process to form synthetic materials.

### 21st Century Life & Career Skills Standards

#### 21st Century Standards

- **9.1.8.F.2** Examine the implications of legal and ethical behaviors when making financial decisions.
- **9.2.8.B.1** Research careers within the 16 Career Clusters® and determine attributes of career success.
- **9.2.4.A.3** Investigate both traditional and nontraditional careers and relate information to personal likes and dislikes.
- **9.2.4.A.4** Explain why knowledge and skills acquired in the elementary grades lay the foundation for future academic and career success.

#### 21st Century Practices

- CRP1. Act as a responsible and contributing citizen and employee.
- CRP2. Apply appropriate academic and technical skills.
- CRP3. Attend to personal health and financial well-being.
- CRP4. Communicate clearly and effectively and with reason.
- CRP5. Consider the environmental, social and economic impacts of decisions.
- CRP6. Demonstrate creativity and innovation.
- CRP7. Employ valid and reliable research strategies.
- CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
- CRP9. Model integrity, ethical leadership and effective management.
- CRP10. Plan education and career paths aligned to personal goals.
- CRP11. Use technology to enhance productivity.
- CRP12. Work productively in teams while using cultural global competence.

### Science and Engineering Practices

### Disciplinary Core Ideas

### Crosscutting Concepts
### Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to predict and/or describe phenomena. (MS-PS1-1), (MS-PS1-4)
- Develop a model to describe unobservable mechanisms. (MS-PS1-5)

### 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. (MS-PS3-4)

### Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and

### PS1.A: Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2), (MS-PS1-3)
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4)
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4)
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1)
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)

### PS1.B: Chemical Reactions

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-6)

### Patterns

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)

### Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

### Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)
- 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

- Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5)
- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-5)
- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6) (MS-PS3-3)
### CHESTERFIELD SIXTH GRADE SCIENCE CURRICULUM

**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 consistent with scientific knowledge, principles, and theories.

- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. (MS-PS1-6)
- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3)

**Engaging in Argument from Evidence**

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds.

- Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5)

**Obtaining, Evaluating, and Communicating Information**

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses

**Structure and Function**

- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS1-3)

**Connections to Engineering, Technology, and Applications of Science**

- Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-PS1-3)

**Interdependence of Science, Engineering, and Technology**

- The uses of technologies and any limitation 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. Thus technology use varies from region to region and over time. (MS-PS1-3)

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**PS3.A: Definitions of Energy**

- The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. *(secondary to MS-PS1-4)*
- 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. *(secondary to MS-PS1-4)*
- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and

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**Examples of Differences in Findings:**

- The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5)
- Some chemical reactions release energy, others store energy. (MS-PS1-6)
to evaluating the merit and validity of ideas and methods.

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-PS1-3)

**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. (MS-PS1-2) (MS-PS3-4) (MS-PS3-5)

**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**

- Laws are regularities or mathematical descriptions of natural phenomena. (MS-PS1-5)

**PS3.B: Conservation of Energy and Energy Transfer**

- Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)
- 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)
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)

**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) (MS-PS3-3)

**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. (secondary to MS-PS1-6)
- 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) (MS-PS1-6)
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 the characteristics may be incorporated into the new design. *(secondary to MS-PS1-6)*
- 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. *(secondary to MS-PS1-6)*

### Performance Expectation

**MS-PS1-1** Develop models to describe the atomic composition of simple molecules and extended structures. *Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms. (Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.)*

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<td><strong>PS1.A: Structure and Properties of Matter</strong>&lt;br&gt;  - Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.&lt;br&gt;  - Solids may be formed from molecules, or they may be extended structures with</td>
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**CHESTERFIELD SIXTH GRADE SCIENCE CURRICULUM**

| repeating subunits (e.g., crystals). |

**Learning Objective**

- SWBAT identify how specific terms relate back to matter and mass, i.e. elements, atoms, minerals, molecules, and elements.
- SWBAT explain that diamond and graphite both consist of Carbon, yet have different properties, making them two completely different minerals.

**Performance Expectation**

**MS-PS1-2** Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride. [Assessment boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]

**Practice**

- **Analyzing and Interpreting Data**
  Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
  - Analyze and interpret data to determine similarities and differences in findings.

**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.

**DCIs**

- **PS1.A: Structure and Properties of Matter**
  - Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- **PS1.B: Chemical Reactions**
  - Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

**Crosscutting Concepts**

- **Patterns**
  - Macroscopic patterns are related to the nature of microscopic and atomic-level structure.

**Learning Objective**

- SWBAT determine properties of different substances.
**Performance Expectation**

**MS-PS1-3** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.  
Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.  
*Assessment Boundary: Assessment is limited to qualitative information.*

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  • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or now supported by evidence. | **PS1.A: Structure and Properties of Matter**<br>  
  • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.<br>  
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  • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. | **Structure and Function**<br>  
  • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.  
  **Connections to Engineering, Technology, and Applications of Science**<br>  
  **Interdependence of Science, Engineering, and Technology**<br>  
  • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.  
  **Influence of Science, Engineering and Technology on Society and the Natural World**<br>  
  • The uses of technologies and any limitation 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. Thus technology use varies from region to region and over time.

### Learning Objective

- SWBAT classify different resources based on whether they are natural, synthetic, or GMO.
- SWBAT determine that natural resources undergo a chemical process to form synthetic materials and identify how they are used in society.

### Performance Expectation

**MS-PS1-4 Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.** Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.

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The uses of technologies and any limitation 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. Thus technology use varies from region to region and over time.

Learning Objective
- SWBAT define kinetic and potential energy.
- SWBAT determine and illustrate how heat affects particle motion.
- SWBAT apply their understanding of changes in particle motion and temperature when thermal energy is added or removed to explain a visual that represents the bending of metals when heat is applied, i.e. train tracks.

Performance Expectation
MS-PS1-5 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.

[Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]

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### CHESTERFIELD SIXTH GRADE SCIENCE CURRICULUM

- Laws are regularities or mathematical descriptions of natural phenomena.

#### Learning Objective
- Covered in MS-PS1-1/1-2

#### Performance Expectation

**MS-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.**

Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride. [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.]

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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 consistent with scientific knowledge, principles, and theories.  
- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. | **PS1.B: Chemical Reactions**  
- Some chemical reactions release energy, others store energy.  
**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. *secondary*  
**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 the characteristics may be incorporated into the new design. *secondary*  
- 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 | **Energy and Matter**  
- The transfer of energy can be tracked as energy flows through a designed or natural system. |
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that is likely to limit possible solutions. 
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**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)

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### Learning Objective

- SWBAT define solar energy and its uses.
- SWBAT design, construct, and test a solar cooker.
- SWBAT explain their knowledge of solar energy and how their device traps and holds heat.

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### Performance Expectation

**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. 

**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.

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### Practice

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- 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 | **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. |
**CHESTERFIELD SIXTH GRADE SCIENCE CURRICULUM**

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**Learning Objective**

- SWBAT interpret data provided by box plots and dot plots.
- SWBAT investigate and analyze energy transfer and graph the results.

**Performance Expectation**

**MS-PS3-5** Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object. [Assessment Boundary: Assessment does not include calculations of energy.]

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Learning Objective

- SWBAT discuss and interpret data related to potential and kinetic energy.
- SWBAT apply their understanding of kinetic and potential energy to create a catapult that will launch a projectile the farthest distance.
- SWBAT justify energy transfer from one object to another with data collected from the catapult experiment.

Possible Anchor Chart

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- Reference Chart Chemical Reaction
- MS-PS1-2 Example of Chemical Reaction

Resources/Websites:

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- Video: Chemical Reactions: MS-PS1-2, MS-PS1-5, MS-PS1-6
- MS-PS1-4 Visual Image
- Video: How Does Heat Affect Particle Motion?
- Video: Hot vs. Cold Particle Motion
- MS-PS1-4 Heat and Temperature