MS-PS1-2 Matter and its Interactions

Students who demonstrate understanding can:

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.]*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.	**PS1.A: Structure and Properties of Matter** 8. 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** 4. 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.	**Patterns** • Macroscopic patterns are related to the nature of microscopic and atomic-level structure.

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

4.2 Ability to analyze data to identify relationships

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

4.2.1 Ability to use observational and/or empirical data to describe patterns and relationships

Disciplinary Core Idea Assessment Targets

PS1.A.8a Identify characteristic physical properties of pure substances (e.g. color, smell, boiling point, melting point, and density)

PS1.A.8b Identify characteristic chemical properties of pure substances (e.g. flammability)

PS1.B.4a Describe that during a chemical reaction the atoms that make up the original substances (reactants) are rearranged to form new substances (products)

PS1.B.4b Describe that the properties of the reactants are different than the properties of the products

PS1.B.4c Determine whether a chemical reaction has occurred based on the properties of the reactants and the products

Crosscutting Concept Assessment Target(s)

CCC1 Identify macroscopic patterns that are related to the nature of microscopic and atomic-level structure

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides data on physical and chemical properties of a pure substance:

- Determines which element is represented (4.2.1, PS1.A.8, and CCC1)

Task provides a pure substance:

- Identifies characteristic chemical properties of the substance (4.2.1, PS1.A.8, and CCC1)

Task provides a scenario involving a chemical reaction or set of reactions:

- Interprets the observations and data and describes how the observations and data indicate that a chemical change has occurred (4.2.1, PS1.B.4, and CCC1)
- Describes how the properties of the reactants and products are different (4.2.1, PS1.B.4, and CCC1)

Task provides a set of reactants and a set of products:

- Determined whether a chemical reaction occurred based on observations and/or empirical data of physical and chemical properties (4.2.1, PS1.B.4, and CCC1)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Combustion reactions
  - Combustion of natural gas in furnaces or boilers, combustion of butane in lighters, etc.
- Replacement (displacement) reactions that produce a gas, precipitate, or color change
  - Baking soda/acid reaction as leavening agent in baking
  - Analysis of chlorine in pools or water/wastewater using the oxidation of DPD
- Synthesis and decomposition reactions
  - Decomposition of H_2O_2 (foaming on skin cuts vs stable in 3% solution; experiment adding H_2O_2 to freshly cut potato pieces (data-based items))
  - Dissolving sugar/salt/other substances in water using amounts greater than their solubility (how this is NOT an indication of a chemical change)
  - UV-induced decomposition of AgCl and application to photochromic lenses or black-and-white photography (reaction based on “color” changes)

Common Misconceptions

Note that the list in this section is not exhaustive.

- All physical changes are reversible/all chemical changes are irreversible.
- Changes of state are chemical changes.
- Chemical changes always occur when substances are mixed/dissolved.
- An increase or decrease in the temperature of a chemical system always indicates a chemical change.

Additional Assessment Boundaries

None listed at this time.

Additional References

MS-PS1-2 Evidence Statement (PDF)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

> *Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12 (PDF)*

MS-PS1-5 Matter and its Interactions

Students who demonstrate understanding can:

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.]*

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 describe unobservable mechanisms. --- ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Laws are regularities or mathematical descriptions of natural phenomena.	**PS1.B: Chemical Reactions** 4. 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. 5. The total number of each type of atom is conserved, and thus the mass does not change.	**Energy and Matter** • Matter is conserved because atoms are conserved in physical and chemical processes.

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

2.1 Ability to develop a model

2.2 Ability to use models

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

2.1.1 Ability to determine the components as well as relationships among multiple components, to include or omit, of a scientific event, system, or design solution

2.2.2 Ability to use the model to generate explanations and predictions about the behavior of a scientific phenomenon

Disciplinary Core Idea Assessment Targets

PS1.B.5a Describe that during a chemical reaction the atoms that make up the reactants are rearranged to form new products

PS1.B.5b Identify and describe the number and types of atoms in a molecule of a substance based on a chemical formula and/or molecular model

PS1.B.5c Describe that each type of atom has a specific mass, which is the same for all atoms of that type

PS1.B.5d Describe that the number and types of atoms in the reactants are equal to the number and types of atoms in the products

PS1.B.5e Describe that atoms and thus mass are conserved during chemical reactions

PS1.B.5f Recognize the components, relationships, and predictive power of a balanced chemical equation

Crosscutting Concept Assessment Target(s)

CCC5 Identify that matter is conserved because atoms are conserved in physical and chemical processes

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides description of a chemical reaction and a list of relevant and irrelevant components:

- Selects the appropriate components to develop the model to illustrate the conservation of atoms/mass (2.1.1, PS1.B.5, and CCC5)

Task provides an incomplete model of a chemical reaction and a list of relevant and irrelevant components:

- Selects the appropriate components to complete the model to illustrate the conservation of atoms/mass (2.1.1, PS1.B.5, and CCC5)

Task provides a model of a chemical reaction that illustrates the conservation of atoms/mass:

- Identifies the explanation that the model is trying to convey (2.2.2, PS1.B.5, and CCC5)
- Identifies the predictive meaning of the model (2.2.2, PS1.B.5, and CCC5)
- Uses the model to make a correct prediction (2.2.2, PS1.B.5, and CCC5)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Simple, one-directional reactions representing combustion, synthesis, decomposition, and replacement
    - Simple reaction type that use particle diagrams
    - Ability to explain whether or not a model is correct/incorrect based on conservation of mass (for reactions that use stoichiometric amounts only)
    - Ratio/proportion in which substances react
    - Potential “everyday” reactions: neutralization of stomach acid with milk of magnesia, decomposition of sodium azide in airbags, using a base (soap) to

neutralize formic acid (sting from ant or bee), acid rain dissolving marble or limestone (statues, monuments, etc.)

- Reaction involving a limiting reagent

Common Misconceptions

Note that the list in this section is not exhaustive.

- Atoms and molecules are the same thing.
- The number of molecules before and after a reaction should be equal.
- Mass is lost or gained in certain reactions out of nowhere.
- Mass of an atom changes during a chemical reaction.
- Chemical reactions cause changes to atoms, not molecules.

Additional Assessment Boundaries

None listed at this time.

Additional References

MS-PS1-5 Evidence Statement (PDF)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12 (PDF)

MS-PS2-2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

> **Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.**
>
> [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] *[Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.]*

Continue to the next page for the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.	**PS2.A: Forces and Motion** 6. 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. 7. 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.	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

3.1 Ability to clarify the goal of the investigation and identify the evidence needed to address the purpose of the investigation

3.2 Ability to develop, evaluate and refine a plan for the investigation

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

3.1.2 Ability to identify relevant independent and dependent variables and to consider possible confounding variables or effects

3.1.3 Ability to describe what and how much data need to be collected to provide sufficient evidence to the purpose of the investigation

3.2.1 Ability to decide how to measure and observe relevant variables, including considering the level of accuracy and precision required, and the kinds of instrumentation and techniques best suited to making such measurements to reduce both random and systematic error

3.2.2 Ability to describe detailed experimental procedure, including how the data will be collected, the number of trials, the experimental set up, and the equipment and tools required

Disciplinary Core Idea Assessment Targets

PS2.A.6a Identify the objects interacting within a system (object or group of objects under investigation) as well as the forces acting upon them (which may be external to the system)

PS2.A.6b Describe the relative magnitude and direction of the forces exerted onto a system and whether they balance each other or not

PS2.A.6c	Describe the relationship between the mass of an object (or system of objects), the sum of the forces acting on that object, and the acceleration that the object experiences
PS2.A.6d	Describe the balance of the forces exerted on an object (or system of objects) based on the measurement of the object's motion
PS2.A.7a	Describe how the choice of a reference frame is an arbitrary selection based on ease of analysis
PS2.A.7b	Choose a reference frame for the investigation that best facilitates measurement of mass, motion, and/or force
PS2.A.7c	Choose the appropriate units for measuring mass, force, and motion in light of the relationship among the three and the effect of a reference frame choice

Crosscutting Concept Assessment Target(s)

CCC7	Construct explanations of stability and change in natural or designed systems by examining the changes over time and forces at different scales

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a simulation that allows students to manipulate a system objects' mass and the magnitude of forces exerted on various components of the system:

- Identifies the system and all the external objects interacting with the system, affecting its motion (3.1.2, PS2.A.6, and CCC7)
- Identifies that if the external forces exerted by objects in a specific direction balance each other, then the system's motion in that direction remains unchanged (3.1.2, PS2.A.6, and CCC7)
- Identifies that if the external forces exerted by objects in a specific direction do not balance each other, then the system's velocity in that direction changes (3.1.2, PS2.A.6, and CCC7)

Task provides a scenario where two groups, using alternative methods, investigate how the sum of forces exerted on a system correlate to its types of motion:

- Compares and evaluates the methods used to determine which group, if any, correctly addresses the goal of the investigation (3.1.3, PS2.A.6, and CCC7)

Task provides a list of materials/measuring tools (e.g., metersticks, stopwatches, electric balances, force probes/spring scales, slow motion video camera) to carry out an investigation regarding forces and motion:

- Selects and determines which instruments will provide accurate and precise data and identifies any gaps in data (3.2.1, PS2.A.7, and CCC7)

Task provides a scenario where four different students describe the detailed experimental procedures they used to investigate how the sum of forces exerted on an object determines its type of motion:

- Selects the most appropriate experimental procedure that targeted the investigation based on an appropriate choice of instruments and an appropriate choice of a reference frame for analysis (3.2.2, PS2.A.7, and CCC7)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Comparing and contrasting different motion graphs (position vs. time or velocity vs. time) of specific physical situations
- Acceleration vs. unbalanced force graph
- Unbalanced force vs. mass graph
- Cart launched into motion by a force (e.g. spring-loaded plunger)
- Cart-pulley-mass system on a ramp
- Block sliding across surface as it is pulled by a force applied to a spring scale

Common Misconceptions

Note that the list in this section is not exhaustive.

- Different types of motion—rest, constant velocity, and constant acceleration—are the same.
- If speed increases, then acceleration must be increasing as well.
- Contact/field forces and net forces are the same.
- Forces must be exerted on a system in order for the system to maintain motion.
- If the sum of all forces adds to zero, then the object must be at rest.

- If the sum of all forces adds to zero, then the object cannot move.
- Any force on an object must be in the direction of movement.
- Individual forces, not their sum, determine the motion of an object.
- If an object is moving, the sum of all forces cannot equal zero.
- Constant speed, not constant acceleration, results from constant force.
- An object can have a force within it that keeps it moving.

Additional Assessment Boundaries

None listed at this time.

Additional References

MS-PS2-2 Evidence Statement (PDF)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

> *Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12 (PDF)*

MS-PS2-3 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

[Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] *[Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.]*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	**PS2.B: Types of Interactions** 5. Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

1.3 Ability to ask and evaluate investigable questions

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

1.3.1 Ability to ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory

1.3.2 Ability to evaluate a question to determine if it is empirically testable and relevant

Disciplinary Core Idea Assessment Targets

PS2.B.5a Describe how the magnitude of magnetic strength, distance between, and relative orientation of two objects affect their magnetic interactions

PS2.B.5b Identify the relationship between the circuit features (such as magnitude of an electric current or the number of turns of wire in a coil) and the resulting magnetic forces that arise (simplified version of Faraday's Law)

PS2.B.5c Identify the effect of distance between two electric charges, their magnitude and sign, or nearby magnetic forces on the resulting electric forces acting upon those charges (Coulomb's law or basic versions of Maxwell's equations)

PS2.B.5d Describe patterns in data that correspond to proportionate relationships between the various factors (stated in bullet points above) on the magnitude and direction of electromagnetic forces experienced by two interacting objects

PS2.B.5e Distinguish between instances in which observed interactions match predictions and instances in which observations are unexpected

PS2.B.5f Distinguish between investigations which are and are not possible within a particular scope (e.g., in the classroom, in informal learning settings, in museums, or in a laboratory)

Crosscutting Concept Assessment Target(s)

CCC2 Use cause and effect relationships to predict phenomena in natural or designed systems

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task describes a classroom investigating the interaction of two magnets and a model for that interaction (can be a mathematical equation, a force diagram, or a picture of the results of putting iron filings around a magnet):

- Identifies a question that can be used to expand the model in light of the investigation (1.3.1, PS2.B.5, and CCC2)

Task provides a model showing the distribution of iron filings around a coil of wire experiencing a fixed current:

- Identifies which, in a set of questions, would provide the evidence a student needs to include information about poles in the model (1.3.1, PS2.B.5, and CCC2)

Task provides an interactive investigation into how the strength of an electromagnet may be controlled:

- Selects a hypotheses that would include a factor known to affect the strength of an electromagnet (1.3.1, PS2.B.5, and CCC2)

Task provides a picture of the electric field generated from a charged point-source that incudes arrows tracking the paths of various test particles of different charges (positive or negative) of varying magnitudes:

- Generates/identifies questions about the results of an experiment that would clarify the relationship between charge magnitude and resulting force (linear), distance and resulting force (inversely quadratic), and the sign of the interacting charges and the resulting forces (directional) (1.3.1, PS2.B.5, and CCC2)

Task provides a model for the interaction between two electric charges that indicates that two like charges repel with a magnitude that increases in an inversely quadratic relationship with the distance between them:

- Selects between two students' questions regarding a potential investigation on the basis of which question is empirically testable with the materials available in a classroom (1.3.2, PS2.B.5, and CCC2)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Two electrically charged objects of various charge intensities at various distances
- Two electrically charged objects of similar or different polarities at various distances
- Two identical magnets at various distances and relative orientations
- Two magnets of different strength, size, shape, or material
- A magnet and another object that may or may not be ferromagnetic
- A magnet and items of unknown composition
- Magnets and other materials that serve a specific purpose, such as latching a door or keeping a hook attached to a wall

Common Misconceptions

Note that the list in this section is not exhaustive.

- Magnetic forces only act between objects when they are in contact.
- The separation of a magnet into two halves creates two monopoles; one north and one south.

Additional Assessment Boundaries

None listed at this time.

Additional References

MS-PS2-3 Evidence Statement (PDF)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

> *Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12* (PDF)

MS-PS3-1 Energy

Students who demonstrate understanding can:

> **Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.**
>
> [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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. • Construct and interpret graphical displays of data to identify linear and nonlinear relationships.	**PS3.A: Definitions of Energy** 6. Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.	**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.

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

4.1 Ability to record and organize data

4.2 Ability to analyze data to identify relationships

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

4.1.3 Ability to organize data in a way that facilitates analysis and interpretation

4.2.1 Ability to use observational and/or empirical data to describe patterns and relationships

4.2.2 Ability to identify patterns (qualitative or quantitative) among variables represented in data

Disciplinary Core Idea Assessment Targets

PS3.A.6a Demonstrate through graphical displays that when the mass and/or the speed of an object increases, the kinetic energy increases

PS3.A.6b Demonstrate through graphical displays that when the mass and/or the speed of an object decreases, the kinetic energy decreases

PS3.A.6c Demonstrate through graphical displays that kinetic energy and mass have a linear proportional relationship

PS3.A.6d Demonstrate through graphical displays that kinetic energy and speed have a proportional relationship that is nonlinear

PS3.A.6e Draw comparisons between the rate of change between mass and kinetic energy, and speed and kinetic energy (i.e., the kinetic energy doubles as the mass of the object doubles, yet the kinetic energy quadruples as the speed of the object doubles)

Crosscutting Concept Assessment Target(s)

CCC3 Identify proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities that provide information about the magnitude of properties and processes

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides data showing indentations made when objects of different masses hit a barrier:

- States that the different masses make different indentations along barrier upon impact (4.1.3, PS3.A.6, and CCC3)
- Graphs the relationship between mass/speed and the depth of the indentation (4.1.3, PS3.A.6, and CCC3)
- Uses their generated graph to correctly identify a pattern between the masses or velocities of the object and the indentation along the barrier (4.1.3, PS3.A.6, and CCC3)

Task provides a graph of an increase in mass versus kinetic energy and/or a graph of an increase in velocity versus kinetic energy:

- Describe the relationship shown by the graph as linear or non-linear (4.2.1, PS3.A.6, and CCC3)

Task provides an interactive model where the mass and velocity of an object in motion can be varied and the object's kinetic energy is displayed:

- States that increasing the object's mass results in a directly proportional increase of the object's kinetic energy (4.2.2, PS3.A.6, and CCC3)
- States that increasing the object's speed results in an increase of the object's kinetic energy proportional to the square of its speed (4.2.2, PS3.A.6, and CCC3)

Common Misconceptions

Note that the list in this section is not exhaustive.

- The material make-up of an object affects its kinetic energy.
- Inanimate objects do not have energy associated with them.
- Kinetic energy depends on its direction of travel.
- Kinetic energy only depends on mass or speed.
- Kinetic energy equally depends on mass and speed.

Additional Assessment Boundaries

None listed at this time.

Additional References

MS-PS3-1 Evidence Statement (PDF)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

> *Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12 (PDF)*

MS-PS3-4 Energy

Students who demonstrate understanding can:

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.]*

Continue to the next page for the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.A: Definitions of Energy** 3. 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** 6. 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.	**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.

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

3.2 Ability to develop, evaluate, and refine a plan for the investigation

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

3.2.1 Ability to decide how to measure and observe relevant variables, including considering the level of accuracy and precision required, and the kinds of instrumentation and techniques best suited to making such measurements to reduce both random and systematic error

3.2.2 Ability to describe detailed experimental procedure, including how the data will be collected, the number of trials, the experimental set up, and the equipment and tools required

Disciplinary Core Idea Assessment Targets

PS3.A.3a Identify the variables needed to determine the total amount of energy in the system

PS3.A.3b Explain how to measure the total amount of energy in a system based on these variables

PS3.A.3c Define the dependent and independent variables that will be measured

PS3.A.3d Explain the relationship between temperature and average kinetic energy of particles in matter

PS3.B.6a Identify how certain variables (mass, container, etc.) will affect the amount of energy transfer

PS3.B.6b Determine the best starting temperatures to allow an optimal amount of data points to be taken

PS3.B.6c Decide how many data points need to be taken to get meaningful data

Crosscutting Concept Assessment Target(s)

CCC3 Identify proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities that provide information about the magnitude of properties and processes

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a list of materials one would use to conduct an experiment involving temperature and thermal energy:

- Identifies the role of each item on the list and its appropriateness for the investigation (3.2.1, PS3.A .3, and CCC3)
- Explains, using this list, how the total energy of the system can be measured (3.2.1, PS3.A .3, & CCC3)
- Identifies the appropriate variables to measure that would reveal a pattern describing the phenomenon of thermal energy (3.2.1, PS3.A .3, and CCC3)
- Uses the results of the experiment to correctly explain the relationship between temperature and average kinetic energy of particles in the matter (3.2.1, PS3.A .3, and CCC3)

Task provides a desired outcome of an experiment (e.g., measure the change in temperature or determine which substance will gain/lose more energy to heat):

- Selects the suitable equipment with which to achieve the desired results with minimal error or uncertainty (3.2.1, PS3.B.6, and CCC3)
- Identifies procedures that would result in better data (e.g., choosing a proper starting temperature) (3.2.1, PS3.B.6, and CCC3)
- Determines if the correct amount of meaningful data was collected verifying the desired outcome (3.2.1, PS3.B.6, and CCC3)

Environmental Principles and Concepts

- EP4: The exchange of matter between natural systems and human societies affects the long-term functioning of both.

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- An experiment to measure the temperature change of samples of different materials with the same mass as they cool or heat in the environment
- An experiment to measure the temperature change of the same material with different masses when a specific amount of energy is added
- An investigation of a two-object system at different temperatures
- An investigation involving a liquid in containers of different material with the same volume

Common Misconceptions

Note that the list in this section is not exhaustive.

- Heat and temperature are the same.
- Heat is a substance that flows in and out of matter, not a transfer of energy.

Additional Assessment Boundaries

None listed at this time.

Additional References

MS-PS3-4 Evidence Statement (PDF)

Environmental Principles and Concepts

California Education and the Environment Initiative

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12 (PDF)

Appendix 2: Connections to Environmental Principles and Concepts (PDF)

MS-PS3-5 Energy

Students who demonstrate understanding can:

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.]*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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. --- ***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** 5. When the motion energy of an object changes, there is inevitably some other change in energy at the same time.	**Energy and Matter** • Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

7.1 Ability to construct scientific arguments

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

7.1.1 Ability to develop scientific arguments that are supported by evidence/data

7.1.2 Ability to identify evidence/data that supports a claim

7.1.3 Ability to use reasoning to explain how relevant evidence/data supports or refute the claim; the reasoning should reflect application of scientific concepts, principles, ideas

Disciplinary Core Idea Assessment Targets

PS3.B.5a Describe that when the kinetic energy of an object changes, energy is transferred to or from that object

PS3.B.5b Identify and describe evidence that supports the change in observable features (e.g., motion, temperature, sound) of an object before and after the interaction that changes the kinetic energy of the object

PS3.B.5c Identify and describe evidence that supports the change in observable features of other objects or the surroundings in a defined system

PS3.B.5d Evaluate evidence to support claims about the kinetic energy of an object and energy transferred to or from that object

PS3.B.5e Use reasoning to connect evidence and construct an argument based on changes in the observable features of the object (e.g., motion, temperature) to explain that the kinetic energy of the object changed

PS3.B.5f Use reasoning to connect evidence and construct an argument describing that when the kinetic energy of an object increases or decreases, the energy of other objects or the surroundings within the system increases or decreases, indicating that energy was transferred to or from the object

Crosscutting Concept Assessment Target(s)

CCC5 Identify that energy may take different forms

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a video/simulation/animation of a phenomena where there is an energy input (e.g., a hand cranking a hand-crank flashlight) and an energy output (e.g., the light turning on and glowing):

- Constructs an argument correctly claiming that energy was transferred within the system, supported with evidence of changes in energy from the video/simulation/animation (7.1.1, PS3.B.5, and CCC5)

- Explains the energy changes from the beginning to the end of the video/simulation/animation (7.1.3, PS3.B.5, and CCC5)

Task provides a claim about a phenomena that includes unexplained evidence:

- Selects analysis statements that connect the evidence to the claim (7.1.1, PS3.B.5, and CCC5)

Task provides a claim that adding energy results in an increase in kinetic energy:

- Selects evidence statements that support the claim (7.1.2, PS3.B.5, and CCC5)

Task provides multiple arguments explaining how energy is transferred to or from an object based on a change in kinetic energy:

- Selects the strongest argument based on the evidence provided (7.1.2, PS3.B.5, and CCC5)

Task provides a claim about how energy is transferred to or from an object based on a change in kinetic energy:

- Selects the best evidence from a group of options and selects the appropriate crosscutting concept that best applies the evidence to the claim (7.1.3, PS3.B.5, and CCC5)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Generating sound through physical movement
- Changing the velocity of an object with a physical force
- Changing the temperature of a substance
- An object at rest at some height is lowered changing the object's kinetic energy
- An object moving in contact with a surface abruptly comes to rest
- Two colliding objects

Common Misconceptions

Note that the list in this section is not exhaustive.

- Objects at zero temperature (Celsius or Fahrenheit) have zero energy.
- Particles in solids or in freezing temperatures are not in motion.

Additional Assessment Boundaries

None listed at this time.

Additional References

MS-PS3-5 Evidence Statement (PDF)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

> *Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12* (PDF)

MS-PS4-1 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

[Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] *[Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use mathematical representations to describe and/or support scientific conclusions and design solutions. --- ***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.	**PS4.A: Wave Properties** 4. A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	**Patterns** • Graphs and charts can be used to identify patterns in data.

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

5.2 Ability to conduct mathematical and/or computational analyses

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

5.2.1 Ability to use the results of computational models (e.g., graphical representation in a simulation) to identify the mathematical and/or computational representations to support a scientific explanation or a design solution

5.2.2 Ability to use computational models (e.g., simulations) to make predictions of a scientific phenomenon

Disciplinary Core Idea Assessment Targets

PS4.A.4a Identify the properties of a simple mathematical wave model of a phenomenon

PS4.A.4b Mathematically represent the properties of a simple wave e.g., wavelength, frequency, amplitude)

PS4.A.4c Relate the properties of a mathematical model of a wave to their corresponding properties in physical phenomena

PS4.A.4d Relate the properties of a wave to the energy of the wave

PS4.A.4e Use a mathematical model to predict how a change in one property of a wave will change the amount of energy present or transmitted

Crosscutting Concept Assessment Target(s)

CCC1 Use graphs and charts to identify patterns in data

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides data about a repeating physical phenomenon that can be represented as a wave:

- Identifies the mathematical relationship between amplitude and energy (energy is proportional to the square of the amplitude) (5.2.1, PS4.A.4, and CCC1)
- Identifies the relationships between frequency, wavelength, wave speed, and energy transmitted in a given time (5.2.1, PS4.A.4, and CCC1)
- Identifies the properties of the mathematical wave model that correspond to the properties of the physical phenomenon (5.2.1, PS4.A.4, and CCC1)

Task provides a mathematical model or a description about a repeating physical phenomenon that can be represented as a wave:

- Uses the model to identify how the energy of the wave changes based on a change in another property (5.2.2, PS4.A.4 and CCC1)
- Uses the model to make predictions about the physical phenomenon (5.2.2, PS4.A.4 and CCC1)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Sound waves (e.g., frequency corresponds to sound pitch; amplitude corresponds to sound volume)
- Water waves (e.g., if the height of a water wave is doubled, each wave will have four times the energy)
- Seismic waves

Common Misconceptions

Note that the list in this section is not exhaustive.

- Period, frequency, and wavelength are interchangeable.
- Amplitude affects wavelength and/or frequency.

Additional Assessment Boundaries

None listed at this time.

Additional References

MS-PS4-1 Evidence Statement (PDF)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12 (PDF)