Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

Grade Level Expectation:

1. The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter and phases changes.

Evidence Outcomes

Students Can:

a. Develop models to describe the atomic composition of simple molecules and extended structures. (MS PS1-1) *(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, 3-D ball and stick structures, or computer representations showing different molecules with different types of atoms.) (Boundary Statement: 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.)*

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

c. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. (MS-PS1-3) *(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.) (Boundary Statement: Limited to qualitative information.)*

d. 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. (MS-PS1-4) *(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.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Develop a model to predict and/or describe phenomena. (Developing and using models) (Personal: Initiative/Self-direction)
2. Analyze and interpret data to determine similarities and differences in findings. (Analyzing and interpreting data) (Entrepreneurial: Inquiry/Analysis)
3. 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 support or not supported by evidence (Obtaining, Evaluating, and Communication Information) (Professional: Information literacy)
4. Connection to Nature of Science: Science knowledge is based upon logical and conceptual connections between evidence and explanations.

Elaboration on the GLE:

1. Students can answer the question: How do particles combine to form the variety of matter one observes?
2. 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. Solids may be formed from molecules, or they may be extended structures with repeating sub-units (e.g., crystals). Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. 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. The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. 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. The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

Cross Cutting Concepts:

1. Scale, Proportion and Quantity: Time, space and energy phenomena can be observed at various scales using models to study systems that are too small or too large.
2. Patterns: Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
3. 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.
4. Cause and Effect: Cause - and - effect relationships may be used to predict phenomena in natural or designed systems.
5. Interdependence of Science, Engineering and Technology: 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 engineering systems.
6. Influence of Science, Engineering, and Technology on Society and the Natural World: The uses of technology and any limitation on their use are driven by individual and 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.

Prepared Graduates:

1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.

Grade Level Expectation:

2. Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy.

Evidence Outcomes

Students Can:

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

b. 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. (MS PS 1-5) *(Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms that represent atoms.) (Boundary Statement: Does not include the use of atomic masses, balancing symbolic equations or intermolecular forces.)*

c. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. (MS PS1-6) *(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.) (Boundary Statement: Limited to the criteria of amount, time and temperature of substance in testing the device.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Develop a model to describe unobservable mechanisms. (Developing and Using Models) (Entrepreneurial: Creativity/Innovation)
2. Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. (Constructing Explanation and Designing Solutions) (Entrepreneurial: Creativity/Innovation)
3. Connections to Nature of Science: Laws are regularities or mathematical descriptions of natural phenomena.

Elaboration on the GLE:

1. Students can answer the questions: How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?
2. 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. The total number of each type of atom is conserved, and thus the mass does not change. Some chemical reactions release energy, others store energy.

Cross Cutting Concepts:

1. Energy and Matter: Matter is conserved because atoms are conserved in physical and chemical processes. The transfer of energy can be tracked as energy flows through a designed or natural system.

Prepared Graduates:

2. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding interactions between objects and within systems of objects.

Grade Level Expectation:

3. Motion is described relative to a reference frame that must be shared with others and is determined by the sum of the forces acting on it. The greater the mass of the object, the greater the force needed to achieve the same change in motion.

Evidence Outcomes

Students Can:

a. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. (MS-PS-2-1) *(Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.) (Boundary Statement: Limited to vertical or horizontal interactions in one dimension.)*

b. Plan an investigation to provide evidence that the change in an objects motion depends on the sum of the forces on the object and the mass of the object. (MS-PS-2-2) *(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.) (Boundary Statement: 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.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Apply scientific ideas or principles to design an object, tool, process, or system. (Constructing Explanation and Designing Solutions) (Personal: Personal responsibility)
2. 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. (Planning and Carrying Out Investigations) (Personal: Initiative/Self-direction)
3. Connections to Nature of Science: Science is knowledge based upon logical and conceptual connections between evidence and explanations.

Elaboration on the GLE:

1. Students can answer the question: How can one predict an object's continued motion, changes in motion or stability?
2. PS2:A 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.

Cross Cutting Concepts:

1. Systems and System Models: Models can be used to represent systems and their interactions - such as inputs, processes and outputs - and energy and matter flows within systems.
2. 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.
3. Connections to Engineering, Technology and Applications of Science: The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources and economic conditions.

Prepared Graduates:

2. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding interactions between objects and within systems of objects.

Grade Level Expectation:

4. Forces that act a distance (gravitational, electric, and magnetic) can be explained by force fields that extend through space and can be mapped by their effect on a test object.

Evidence Outcomes

Students Can:

a. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. (MS-PS2-3) *(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.) (Boundary Statement: Limited to questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.)*
b. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. (MS-PS2-4) *(Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.) (Boundary Statement: Does not include Newton's Law of Gravitation or Kepler's Laws.)*
c. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. (MS-PS2-5) *(Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically charged strips of tape, and electrically-charged pith balls. Examples of investigations could include firsthand experiences or simulations.) (Boundary Statement: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. 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. (Asking Questions and Defining Problems) (Entrepreneurial: Inquiry/Analysis)
2. Construct 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 or a solution to a problem. (Engage in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)
3. Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. (Planning and Carrying Out Investigations) (Personal: initiative/Self-direction)
4. Connections to Nature of Science: Science knowledge is based upon logical and conceptual connections between evidence and explanations.

Elaboration on the GLE:

1. Students can answer the question: What underlying forces explain the variety of interactions observed?
2. PS2:B Types of Interactions: 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. Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass — e.g., Earth and the sun. Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).

Cross Cutting Concepts:

1. Cause and Effect: Cause - and - effect relationships may be used to predict phenomena in natural or designed systems.
2. Systems and Systems Models: Models can be used to represent systems and their interactions–such as inputs, processes and outputs – and energy and matter flows within systems.

Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

Grade Level Expectation:

5. Kinetic energy can be distinguished from the various forms of potential energy.

Evidence Outcomes

Students Can:

a. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and the speed of an object. (MS-PS3-1) *(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.)*

b. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. (MS-PS-3-2) *(Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster car at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.) (Boundary Statement: Limited to two objects and electric, magnetic, and gravitational interactions.)*

c. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (MS-PS3-3) *(Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.) (Boundary Statement: Does not include calculating the total amount of thermal energy transferred.)*

d. 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-PS3-4) *(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.) (Boundary Statement: Does not include calculating the total amount of thermal energy transferred.)*

e. 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. (MS-PS3–5) *(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.) (Boundary Statement: Does not include calculations of energy.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
2. 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. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)
3. Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Inquiry/Analysis)
4. 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. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)
5. 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.

Elaboration on the GLE:

1. Students can answer the question: What is energy?
2. PS3:A Definitions of Energy: 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. A system of objects may also contain stored (potential) energy, depending on their relative positions. Temperature is a measure of the average kinetic energy of particles of matter. The relationships between the temperature and total energy of a system depends on the types, states, and amounts of matter present.

Cross Cutting Concepts:

1. Scale, proportion and quantity: Proportional relationships (e.g., speed as the relation of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
2. Energy and Matter: Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.

Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

Grade Level Expectation:

6. Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states and amounts of matter.

Evidence Outcomes

Students Can:

a. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (MS PS3-3) *(Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.) (Boundary Statement: Does not include calculating the total amount of thermal energy transferred.)*
b. 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-PS3-4) *(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.) (Boundary Statement: Does not include calculating the total amount of thermal energy transferred.)*
c. Construct, use, and present arguments to support the claim that when kinetic energy of an object changes, energy is transferred to or from the object. (MS-PS3-5) *(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.) (Boundary Statement: Does not include calculations of energy.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system. (Construct Explanations and Designing Solutions) (Civic/Interpersonal: Civic-Engagement)
2. 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. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)
3. 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. (Engaging in Argument from Evidence) (Entrepreneurial: Inquiry/Analysis)
4. Connections to Nature of Science: Scientific knowledge is based upon logical and conceptual connections between evidence and explanations.

Elaboration on the GLE:

1. Students can answer the questions: What is meant by conservation of energy? How is energy transferred between objects or systems?
2. PS3:B Conservation of Energy and Energy Transfer: 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 ones.

Cross Cutting Concepts:

1. Energy and Matter: The transfer of energy can be tracked as energy flows through a designed or natural system. Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).
2. 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.

Prepared Graduates:

3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.

Grade Level Expectation:

7. When two objects interact, each one exerts a force on the other that can cause energy to be transferred to and from the object.

Evidence Outcomes

Students Can:

a. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. (MS-PS3-2) *(Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster car at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.) (Boundary Statement: Limited to two objects and electric, magnetic, and gravitational interactions.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (Developing and Using Models) (Personal: Initiative/Self-direction)

Elaboration on the GLE:

1. Students can answer the question: How are forces related to energy?
2. PS3:C Relationship Between Energy and Forces: When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. For example, when energy is transferred to an Earth-object system as an object is raised, the gravitational field energy of the system increases. This energy is released as the object falls; the mechanism of this release is the gravitational force. Likewise, two magnetic and electrically charged objects interacting at a distance exert forces on each other that can transfer energy between the interacting objects.

Cross Cutting Concepts:

1. Systems and System Models: Models can be used to represent systems and their interactions - such as inputs, processes, and outputs - and energy and matter flows within systems.

Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

Grade Level Expectation:

8. A simple wave model has a repeating pattern with specific wavelength, frequency, and amplitude and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena which include light and sound.

Evidence Outcomes

Students Can:

a. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in the wave. (MS PS4-1) *(Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.) (Boundary Statement: Does not include electromagnetic waves and is limited to standard repeating waves.)*
b. Develop and use a model to describe that waves are reflected, absorbed or transmitted through various materials. (MS-PS4-2) *(Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.) (Boundary Statement: Limited to qualitative applications pertaining to light and mechanical waves.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Use mathematical representations to describe and/or support scientific conclusions and design solutions. (Use Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)
2. Connections to Nature of Science: Science knowledge is based upon logical and conceptual connections between evidence and explanations.

Elaboration on the GLE:

1. Students can answer the question: What are the characteristic properties and behaviors of waves?
2. PS4:A Wave Properties: A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. A sound wave needs a medium through which it is transmitted. Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet.

Cross Cutting Concepts:

1. Patterns: Graphs and charts can be used to identify patterns in data.

Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

Grade Level Expectation:

9. A wave model of light is useful to explain how light interacts with objects through a variety of properties.

Evidence Outcomes

Students Can:

a. Develop and use a model to describe that waves are reflected, absorbed or transmitted through various materials. (MS-PS4-2) *(Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.) (Boundary Statement: Limited to qualitative applications pertaining to light and mechanical waves.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Develop and use a model to describe phenomena (Developing and Using Models) (Personal: Personal responsibility)

Elaboration on the GLE:

1. Students can answer the question: How can one explain the varied effects that involve light?
2. PS4:B Electromagnetic Radiation: When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. Lenses and prisms are applications of this effect. A wave model of light is useful for explaining brightness, color and the frequency dependent bending of light at a surface between media (prisms). However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Cross Cutting Concepts:

1. 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.

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Prepared Graduates:

4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.

Grade Level Expectation:

10. Designed technologies can transmit digital information as wave pulses.

Evidence Outcomes

Students Can:

a. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. (MS-PS4-3) *(Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in Wi-Fi devices, and conversion of stored binary patterns to make sound or text on a computer screen.) (Boundary Statement: Does not include binary counting or the specific mechanism of any given device.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings. (Obtaining, Evaluating, and Communicating Information) (Professional: Communication)

Elaboration on the GLE:

1. Students can answer the question: How are instruments that transmit and detect waves used to extend human senses?
2. PS4:C Information Technologies and Instrumentation: Appropriately designed technologies (e.g., radio, television, cell-phones, wired and wireless computer networks) make it possible to detect and interpret many types of signals that cannot be sensed directly. Designers of such devices must understand both the signal and its interactions with matter. Many modern communication devices use digitized signals (sent as wave pulses) as a more reliable way to encode and transmit information.

Cross Cutting Concepts:

1. Structure and Function: Structures can be designed to serve particular functions.
2. Connections to Engineering, Technology, and Applications of Science: Technologies extend the measurement, exploration, modeling and computational capacity of scientific investigations.
3. Connections to Nature of Science: Advances in technology influence the progress of science and science has influenced advances in technology.