ENVISION 21
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SCIENCE

Academic Standards
Three Dimensions of Science Learning
Learning Goals

June 2020

PHYSICAL SCIENCE

HIGH SCHOOL
PHYSICAL SCIENCE

CATALINA FOOTHILLS SCHOOL DISTRICT
HIGH SCHOOL PHYSICAL SCIENCE OVERVIEW

High School Physical Science is a laboratory course that includes the fundamental principles of chemistry and physics with a focus on the conceptual understanding of the structure of matter and energy. Course topics encompasses physical and chemical sub-processes that occur within systems. Students gain an understanding of these processes at both the micro and macro levels through the study of matter, energy, and forces. Students are expected to apply these concepts to real-world phenomena to gain a deeper understanding of causes, effects, and solutions for physical processes in the real world. Physical Science includes all of the "essential" standards for Chemistry and Physics. The essential standards are those that every high school student is expected to know and understand.

The list of high school Physical Science topics below does not indicate the instructional sequence or how the standards will be organized for instruction. Educators will make decisions about instructional sequence and how standards will be grouped by units for classroom instruction and assessment to best meet student needs.

High School Physical Science Topics:

- Structures and Properties of Matter
- Chemical Reactions
- Nuclear Processes and Applications of Chemistry
- Motion & Stability – Forces & Interactions
- Energy and Waves

High school students continue the pattern from previous years by engaging in the science and engineering practices to apply their knowledge of core ideas to understand how scientists continue to build an understanding of phenomena and see how people are impacted by natural phenomena or to construct solutions. The crosscutting concepts support their understanding of patterns, cause and effect relationships, and systems thinking as students make sense of phenomena in the natural and designed worlds.

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Navigating the Science Standards: Abbreviated Version

The standards serve as the basis for the design of instruction and assessment of the district's science curriculum.

- **Standards** are what a student needs to know, understand, and be able to do by the end of each grade or course. They build across grade levels in a progression of increasing understanding and through a range of cognitive demand levels.
- **Curriculum** refers to the resources used for teaching and learning the standards (units, lessons, texts, materials, tech apps, assessments, etc.).
- **Instruction** refers to the methods or methodologies used by teachers to teach their students. Instructional techniques are employed by individual teachers in response to the needs of students in their classes to help them progress through the curriculum to achieve the standards.

Grade Level or Course and **Topic Area** for standard.

Standard – What is Assessed
Describes what students should be able to do at the end of instruction to show what they have learned. Combines Science and Engineering Practices, Core Ideas, and Crosscutting Concepts.

Life Science
Description of what students will learn for the area of science under study (K-8 only).

Learning Goals
Indicators or evidence of learning at the end of a lesson or unit as aligned to the standard.

KINDERGARTEN

LIFE SCIENCE: LIVING AND NON-LIVING THINGS

Students develop an understanding that the world is comprised of living and non-living things. They investigate the relationship between structure and function in living things; plants and animals use specialized parts to help them meet their needs and survive.

Science Standard: K.L2U1.8 **Observe, ask questions, and explain the differences between the characteristics of living and non-living things.**

Learning Goals

I can:

- Based on prior experiences, ask questions about living and non-living things.
- Make direct or indirect observations about living and non-living things:
  - Identify traits of living and non-living things.
  - Record observations (*e.g., through pictures and/or words*).
  - Make inferences about the characteristics of living and non-living things.
- List the characteristics of living things (*i.e., move, reproduce, react to stimuli*).
- Use evidence to explain how the characteristics of living things differ from the characteristics of non-living things.

Core Ideas for Knowing and Using Science
"Understandings" or big ideas for physical, earth and space, and life sciences that build in complexity across grade levels and students develop over time.
Background Information (Content) is provided under each Core Idea.

Core Ideas

Knowing Science

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.

- There is a wide variety of living things (organisms), including plants and animals. They are distinguished from non-living things by their ability to move, reproduce, and react to certain stimuli.

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students ask questions to frame their exploration of living and non-living things.
- Students make observations about living and non-living things.
- Students use the evidence from their observations to make inferences about the characteristics of living and non-living things.

Three Dimensions (3-D) of Science:
The Practices, Core Ideas, and Crosscutting Concepts that were used to create the standards.

Science and Engineering Practices
Skills and knowledge that scientists and engineers engage in to either understand the world or solve a problem.

Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions based on observations of the natural and/or designed world. **Constructing Explanations and Designing Solutions** • Use information from direct or indirect observations to construct explanations. • Distinguish between opinions and evidence in one's own explanations.	**Patterns** • Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. **Structure and Function** • The shape and stability of structures of natural and designed objects are related to their function(s). **Systems and System Models** • Objects and organisms can be described in terms of their parts.

Crosscutting Concepts
Concepts that cut across all disciplines and help students deepen their understanding of core ideas.

STRUCTURES AND PROPERTIES OF MATTER

HIGH SCHOOL PHYSICAL SCIENCE
PHYSICAL SCIENCE
STRUCTURES AND PROPERTIES OF MATTER

Science Standard: Essential HS.P1U1.1 Develop and use models to explain the relationship of the structure of atoms to patterns and properties observed within the Periodic Table and describe how these models are revised with new evidence.

Learning Goals

I can:

- Develop models (*e.g., in the form of diagrams, drawings, physical replicas, mathematical representations, analogies, and/or computer simulations*) to represent the relationships of the structure of atoms and patterns and properties observed within the Periodic Table:
    - Use design criteria to create models to represent the relationships of the structure of atoms and patterns and properties observed within the periodic table.
    - Use multiple types of models to represent the relationships of the structure of atoms and patterns and properties observed within the periodic table.
    - Develop models based on evidence to illustrate the relationships between the structure of an atom and the way that an atom behaves.
    - Use multiple types of models to represent the relationships of the structure of atoms and patterns and properties observed within the periodic table.
    - Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
- Use models to explain the relationship of the structure of atoms to patterns and properties observed within the periodic table:
    - Use multiple types of models to support explanations of why various atoms on the periodic table interact.
    - Use models to describe patterns and properties observed in the periodic table.
    - Use models to identify and predict patterns in properties that determine how the periodic table is organized based on subatomic particles and element properties.
- Describe how models are revised with new evidence:
    - Evaluate limitations of multiple models on predicting relationships between atoms on the periodic table.
    - Describe how the periodic table was created using patterns and how the patterns determine how to add new elements.
    - Describe how and why the atomic model has been changed/revised over time.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Atomic structures are too small to be studied directly; therefore, students use models to better understand the relationships between patterns, structures, and properties. They also explore how models are adjusted over time in response to new evidence.

Science and Engineering Practices	Crosscutting Concepts
Developing and Using Models • Develop, revise, and use models to predict and support explanations of relationships	**Patterns** • Mathematical representations are needed to identify some patterns.

between systems or between components of a system. • Use models (including mathematical and computational) to generate data to support explanations and predict phenomena, analyze systems, and solve problems.	• Empirical evidence is needed to identify patterns. **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

CHEMICAL REACTIONS

HIGH SCHOOL PHYSICAL SCIENCE
PHYSICAL SCIENCE

CHEMICAL REACTIONS

Science Standard: Essential HS.P1U1.2 Develop and use models for the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes.

Learning Goals

I can:

- Develop models (*e.g., in the form of diagrams, drawings, physical replicas, mathematical representations, analogies, and/or computer simulations*) to represent the transfer or sharing of electrons:
  - Use design criteria to create models to represent the transfer or sharing of electrons.
  - Use multiple types of models to represent the transfer or sharing of electrons.
  - Develop models to show the movement of electrons from one atom to another based on electronegativity changes.
  - Develop models to show the differences between ionic and covalent bonding using the sharing/transfer of electrons between molecules.
  - Evaluate a model against criteria in order to determine its validity and effectiveness.
- Use models to predict the formation of ions, molecules, and compounds in both natural and synthetic processes:
  - Use models to describe the differences between natural and synthetic processes of ion formation.
  - Use models to predict and explain which atoms will form which types of ions.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. Stable forms of matter are those in which the electric and magnetic field energy is minimized.
- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, that are matched by changes in kinetic energy.

Using Science:

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Because subatomic and molecular structures are too small to be observed directly, students use models to better understand and predict formation of ions, molecules, and compounds.

Science and Engineering Practices	Crosscutting Concepts
Developing and Using Models • Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations. • Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Empirical evidence is needed to identify patterns. **Systems and System Models**

	• Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

HIGH SCHOOL PHYSICAL SCIENCE
PHYSICAL SCIENCE

CHEMICAL REACTIONS

Science Standard: Essential HS.P1U1.3 Ask questions, plan, and carry out investigations to explore the cause and effect relationship between reaction rate factors.

Learning Goals

I can:

- Ask questions to explore the cause and effect relationship between reaction rate factors
  - Ask questions that arise from careful observation of reaction rate phenomena.
  - Ask questions that require relevant empirical evidence to answer.
  - Ask and evaluate questions to identify the factors that affect the speed at which a reaction proceeds.
- Plan investigations individually and/or collaboratively to explore the cause and effect relationship between reaction rate factors:
  - Ask testable questions regarding relationships between independent and dependent variables.
  - Select appropriate variables to illustrate the importance of temperature, surface area, volume, concentration, and/or catalysts on the rates of reactions.
  - Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
  - Determine the data (*e.g., types, amount, and accuracy*) needed to produce reliable measurements of the relationship between reaction rate factors.
  - Select appropriate tools to collect, record, analyze, and evaluate data about reaction rate factors.
  - Consider limitations on the precision of the data (*e.g., number of trials, cost, risk, time*), and refine the design accordingly.
- Conduct investigations individually and collaboratively to explore the cause and effect relationship between reaction rate factors:
  - Conduct investigations in a safe and ethical manner including considerations of environmental, social, and personal impacts.
  - Use data from the investigation to identify and analyze cause and effect relationships between reaction rate factors.
  - Use evidence from the investigation to describe the significance of reaction rates in chemical processes.
  - Make quantitative and qualitative claims regarding the relationship between reaction rate factors.
    Explain how reaction mechanisms affect the rate of a reaction.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

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

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students explore cause and effect relationships through scientific investigations. The design of the investigations and the ways in which the procedures are carried out will have a significant impact on the quality of the evidence produced.

Science and Engineering Practices	Crosscutting Concepts

Asking Questions and Defining Problems • Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. • Ask questions that require relevant empirical evidence to answer. **Planning and Carrying Out Investigations** • Design and conduct an investigation individually and collaboratively, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Select appropriate tools to collect, record, analyze, and evaluate data.	**Cause and Effect: Mechanism and Prediction** • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. **Energy and Matter: Flows, Cycles, and Conservation** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy drives the cycling of matter within and between systems. **Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

NUCLEAR PROCESSES AND APPLICATIONS OF CHEMISTRY

HIGH SCHOOL PHYSICAL SCIENCE	
PHYSICAL SCIENCE	
NUCLEAR PROCESSES AND APPLICATIONS OF CHEMISTRY	
Science Standard: Essential HS.P1U3.4 Obtain, evaluate, and communicate information about how the use of chemistry related technologies have had positive and negative ethical, social, economic, and/or political implications. Learning Goals I can: • Obtain information about the positive and negative implications (*i.e., ethical, social, economic, and/or political*) of the use of chemistry related technologies: ○ Ask questions to frame the collection of information. ○ Gather information from a variety of sources (*e.g., texts, investigations, media, data sets, models, etc.*) in response to the investigative questions. ○ Determine the central ideas or conclusions of a complex scientific text. ○ Summarize and paraphrase complex concepts, processes, or information about the implications of the use of chemistry-related technologies. • Evaluate information about the positive and negative implications (*i.e., ethical, social, economic, and/or political*) of the use of chemistry related technologies: ○ Verify data across texts. ○ Use scientific reasoning to evaluate the validity and reliability of information regarding positive and negative implications of the use of chemistry related technologies. • Communicate information about the positive and negative implications (*i.e., ethical, social, economic, and/or political*) of the use of chemistry related technologies: ○ Produce scientific/technical writing and/or oral presentations (*e.g., blog post, newspaper column, position paper, poster, Socratic Seminar*) that communicate the cause and effect relationships between chemistry related technologies and their ethical, social, economic, and/or political implications. Compare, integrate, and evaluate multiple sources of information presented in different media or formats (*e.g., visually, quantitatively*) in order to describe the positive and negative implications of the use of chemistry related technologies.	
Core Ideas	
Knowing Science P1: All matter in the Universe is made of very small particles. • Scientific understanding can help to identify implications of certain applications but decisions about whether certain actions should be taken will require ethical and moral judgements which are not provided by knowledge of science. • There is an important difference between the understanding that science provides about, for example, the need to preserve biodiversity, the factors leading to climate change and the adverse effects of harmful substances and lifestyles, and the actions that may or may not be taken in relation to these issues. Opinions may vary about what action to take but arguments based on scientific evidence should not be a matter of opinion. **Using Science** U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications. • Students explore the positive and negative ethical, social, economic, and political implications of chemistry related technologies. Applications of chemical technology can be controversial, so it is important to evaluate claims and evidence to determine their scientific validity.	
Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems	**Cause and Effect: Mechanism and Prediction**

• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. **Obtaining, Evaluating, and Communicating Information** • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. • Produce scientific and/or technical writing and/or oral presentations that communicate scientific ideas and/or the process of development and the design and performance of a proposed process or system. • Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem.	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Changes in systems may have various causes that may not have equal effects.

MOTION & STABILITY – FORCES & INTERACTIONS

HIGH SCHOOL PHYSICAL SCIENCE
PHYSICAL SCIENCE
MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: Essential HS.P2U1.5 Construct an explanation for a field's strength and influence on an object (electric, gravitational, magnetic).

Learning Goals

I can:

- Construct an explanation based on evidence to explain observations of electric, gravitational, and magnetic field phenomena:
  - Explain the structure of fields and how they allow forces to act at a distance.
  - Quantitatively determine the strength of various fields (gravitational, electric, or magnetic) based on the relationships between variables *(i.e., distance, mass, charge, etc.)*.
  - Apply scientific knowledge to predict how objects *(e.g., orbiting bodies, electrons, and magnets)* are influenced by an external field.
- Revise explanations based on evidence obtained from a variety of sources and peer review.

Core Ideas

Knowing Science

P2: Objects can affect other objects at a distance.

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
- Forces at a distance are explained by fields (gravitational, electric, magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.
- When two objects interacting through a field change relative position, the energy stored in the field is changed.

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models, and theories can be revised.

- Students examine evidence from a variety of sources and then select appropriate scientific evidence to explain the influence of electric, gravitational, and magnetic fields.

Science and Engineering Practices

Constructing Explanations and Designing Solutions

- Make quantitative and qualitative claims regarding the relationship between dependent and independent and variables.
- Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.
- Using Mathematics and Computational Thinking
- Use mathematical or algorithmic representations of phenomena or design solutions to describe and support claims and explanations, and create computational models or simulations.

Crosscutting Concepts

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

Cause and Effect: Mechanism and Prediction

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms with the system.

HIGH SCHOOL PHYSICAL SCIENCE	
PHYSICAL SCIENCE	
MOTION & STABILITY – FORCES & INTERACTIONS	

Science Standard: Essential HS.P3U1.6 Collect, analyze, and interpret data regarding the change in motion of an object or system in one dimension, to construct an explanation using Newton's Laws.
 	
Learning Goals
I can:
• Collect data (*e.g., from investigations, demonstrations, scientific texts, data sets, simulations, etc.*) regarding the change in motion of an object or system in one dimension:
  ○ Ask questions to frame data collection, analysis, and interpretation.
  ○ Decide on types, how much, and accuracy of data needed to construct an explanation using Newton's Laws.
  ○ Select appropriate tools to collect and record data.
• Use tools, technologies, and models to analyze and interpret data measuring changes to an object's motion in relation to mass and forces:
  ○ Identify and describe patterns in data.
  ○ Compare and contrast various types of data sets to (*e.g., self-generated, archival*) to examine observations about the change in motion of an object or system in one dimension.
  ○ Interpret data, applying concepts of statistics and probability, to describe how forces can change the motion of objects, as predicted by Newton's Laws of Motion.
• Construct an explanation using Newton's Laws:
  ○ Construct or adapt an explanation of changes to an object's motion using momentum and the Law of Conservation of Momentum.
  ○ Use data to make claims regarding the motion of objects in terms of kinematic variables such as position, velocity, and acceleration.	

Core Ideas	
Knowing Science P3: Changing the movement of an object requires a net force to be acting on it. • Newton's second law accurately predicts changes in the motion of macroscopic objects, but it requires revision for subatomic scales or for speeds close to the speed of light. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. **Using Science** U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. • Students interpret data to explore change in motion of objects to build an understanding of Newton's Laws. Tools and procedures for data collection and analysis must be carefully selected in order to ensure that the data are valid. Students apply their analysis and interpretations of data as well as their understanding of Newton's Laws to explain changes in motion of objects or systems.	
Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. • Ask questions that require relevant empirical evidence to answer.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Systems and Systems Models**

• Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. **Constructing Explanations and Designing Solutions** • Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review. **Analyzing and Interpreting Data** • Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution. • Consider limitations (e.g., measurement error, sample selection) when analyzing and interpreting data. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.	• Systems can be designed to do specific tasks. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

HIGH SCHOOL PHYSICAL SCIENCE

PHYSICAL SCIENCE

MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: Essential HS.P3U2.7 Construct an explanation to demonstrate how Newton's laws are used in engineering and technologies to create products to serve human ends.

Learning Goals

I can:

- Construct explanations based on evidence *(e.g., scientific principles, models, theories, simulations*) to describe how Newton's laws are used in engineering and technologies to create products and solutions that meet human needs:
  - Apply scientific knowledge and evidence to explain how Newton's laws have provided engineers with physical, mathematical, and computer models to use in the construction of products.
  - Evaluate designs and models based on their environmental and societal impacts.
  - Revise explanations based on evidence obtained from a variety of sources and peer review.

Core Ideas

Knowing Science

P3: Changing the movement of an object requires a net force to be acting on it.

- The application of science in making new materials is an example of how scientific knowledge has led advances in technology and provided engineers with a wider choice in designing constructions.
- At the same time technological advances have helped scientific developments by improving instruments for observation and measuring, automating processes that might otherwise be too dangerous or time consuming to undertake, and particularly through the provision of computers. Thus, technology aids scientific advances which in turn can be used in designing and making things for people to use.

Using Science

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

- Students examine how technology aids scientific advances, which in turn, can be used in designing and making things for people to use.

Science and Engineering Practices	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific knowledge and evidence to explain phenomena and solve design problems, taking into account possible unanticipated effects. • Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.	**Systems and Systems Models** • Systems can be designed to do specific tasks. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions - including energy, matter, and information flows - within and between systems at different scales. **Cause and Effect: Mechanism and Prediction** • Systems can be designed to cause a desired effect.

ENERGY AND WAVES

HIGH SCHOOL PHYSICAL SCIENCE

PHYSICAL SCIENCE

ENERGY & WAVES

Science Standard: Essential HS.P4U1.8 Engage in argument from evidence that the net change of energy in a system is always equal to the total energy exchanged between the system and the surroundings.

Learning Goals

I can:

- Construct, use, and present oral and written arguments regarding the law of conservation of energy:
  - Make and defend a claim about the law of conservation of energy.
  - Use quantitative and qualitative scientific evidence to develop and support the claim.
  - Describe the transfer of energy between different parts of a system, including its surroundings.

Core Ideas

Knowing Science

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students evaluate, develop, and defend arguments using scientific evidence from texts, observations, and investigations. As they weigh evidence regarding the conservation of energy, students will refine their understanding of the role of energy within a system.

Science and Engineering Practices

Engaging in Argument from Evidence

- Critique and evaluate competing arguments, models, and/or design solutions in light of new evidence, limitations (e.g., trade-offs), constraints, and ethical issues
- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Crosscutting Concepts

Energy and Matter: Flows, Cycles, and Conservation

- The total amount of energy and matter in closed systems is conserved.
- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.
- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

HIGH SCHOOL PHYSICAL SCIENCE
PHYSICAL SCIENCE
ENERGY & WAVES

Science Standard: ESSENTIAL HS.P4U3.9 Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer.

Learning Goals

I can:

- Evaluate arguments regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer:
  - Evaluate the claims, evidence, and reasoning of oral and/or written arguments to determine merits of arguments and elicit elaboration from peers.
  - Evaluate ethical, social, economic, and/or political perspectives of energy use and transfer.
  - Critique and evaluate competing arguments about the benefits and liabilities of energy usage and transfer.
  - Evaluate the evidence and reasoning behind currently accepted methods of energy usage and transfer.
- Construct, use, and present oral and written arguments regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer:
  - Make and defend a claim about the benefits and liabilities of energy usage and transfer.
  - Develop and support a claim with analysis of the positive and negative economic, social, and/or political implications of the demand for energy usage.
  - Construct a counter-argument that is based on data and evidence that challenges another proposed argument.
  - Use scientific evidence to develop and support the claim.
  - Describe the transfer of energy between different parts of a system, including its surroundings.

Core Ideas

Knowing Science

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

- The availability of energy limits what can occur in any system.
- Across the world, the demand for energy increases as human populations grow and because modern lifestyles require more energy, particularly in the convenient form of electrical energy.
- Fossil fuels, frequently used in power stations and generators, are a limited resource and their combustion contributes to global warming and climate change. Therefore, other ways of generating electricity have to be sought, whilst reducing demand and improving the efficiency of the processes in which we use it.

Using Science

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

- There are limits to the amount of available energy; therefore, there are multiple ethical, social, economic, and political perspectives when it comes to energy use. Students examine and evaluate these perspectives when weighing the benefits and liabilities for energy usage and transfer.

Science and Engineering Practices	Crosscutting Concepts
Engaging in Argument from Evidence • Critique and evaluate competing arguments, models, and/or design solutions in light of new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**Stability and Change** • Systems can be designed for greater or lesser stability. **Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity

• Construct a counter-argument that is based on data and evidence that challenges another proposed argument. • Make and defend a claim about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.	at which it occurs. **Energy and Matter: Cycles, Flows, and Conservation** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. • Energy drives the cycling of matter within and between systems.

HIGH SCHOOL PHYSICAL SCIENCE
PHYSICAL SCIENCE
ENERGY & WAVES

Science Standard: Essential HS.P4U1.10 Construct an explanation about the relationships among the frequency, wavelength, and speed of waves traveling in various media, and their applications to modern technology.

Learning Goals

I can:

- Construct explanations based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations):*
  - Apply scientific reasoning, theory, and models to compare the processes by which waves *(i.e., light, sound, vibration, etc.)* propagate through various media.
  - Draw connections between observed properties and associated quantities of a wave. (*e.g., how color is associated by the wavelength of a light wave or pitch is associated with the frequency of a sound wave*).
  - Explain how changes in a wave's medium and/or speed will affect its properties or direction. (*e.g., refraction, reflection, the Doppler effect, redshifts, talking through helium or sulfur hexafluoride*)
  - Apply scientific knowledge and evidence to explain how waves are used in applications of modern technology to meet human needs.
  - Revise explanations based on evidence obtained from a variety of sources and peer review.

Core Ideas

Knowing Science

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. The reflection, refraction, and transmission of waves at an interface between two media can be modeled on the basis of these properties.
- Combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.
- All electromagnetic radiation travels through a vacuum at the same speed, called the speed of light. Its speed in any other given medium depends on its wavelength and the properties of that medium.
- Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. Knowledge of quantum physics enabled the development of semiconductors, computer chips, and lasers, all of which are now essential components of modern imaging, communications, and information technologies.

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students examine a variety of evidence to better understand the role of waves in media and modern technology. They then select evidence to support a scientific explanation of the relationships among frequency, wavelength, and speed of waves.

Science and Engineering Practices	Crosscutting Concepts
Constructing Explanations and Designing Solutions	**Cause and Effect: Mechanism and Prediction**

• Make quantitative and qualitative claims regarding the relationship between dependent and independent variables. • Apply scientific reasoning, theory, and models to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Systems can be designed to cause a desired effect. **Energy and Matter: Cycles, Flows, and Conservation** • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.