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SCIENCE

Academic Standards
Three Dimensions of Science Learning
Learning Goals

June 2020

FIELD SCIENCE

HIGH SCHOOL

FIELD SCIENCE

CATALINA FOOTHILLS SCHOOL DISTRICT

HIGH SCHOOL FIELD SCIENCE OVERVIEW

High School Field Science is a laboratory and inquiry-centered outdoor course that studies local environments through the physics topics of motion and stability, wave phenomena, energy and matter interactions, electricity, and magnetism. Students gain an understanding of physical and chemical sub-processes that occur within systems at both the micro and macro levels.

Students plan and conduct field investigations using field sampling and analysis methods and other science and engineering practices to build scientific understanding about phenomena in the environment. They grapple with the challenges of working in a natural system while at the same time developing an understanding of its complexities and subsystems. Other topics/sub-topics of study include physical geology, ecosystems, and identification of local plants and animals. The course also encompasses processes that occur on Earth while also addressing Earth's place within our solar system and galaxy. The crosscutting concepts of *patterns*, *cause and effect relationships*, and *systems thinking* support understanding as students make sense of phenomena in the natural and designed worlds.

Field Science is a third-year science course and students will have been taught the full set of "essential" standards upon completion of the course. The "essential" standards are those that every high school student is expected to know and understand by the end of the third year. Because students have some flexibility in the pathway they select to meet the graduation requirements for science, specific "essential" standards were integrated into some of the high school science courses to meet this Arizona State Board of Education requirement.

The standards for high school Field Science are categorized according to the topics listed below. The list does not imply 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 Field Science Topics:

- Life Science: Interdependence of Organisms (Ecosystems), Biogeography, Phenomena in Natural Systems
- Physical Science: Motion & Stability – Forces & Interactions, Energy & Waves
- Earth Science: Cartography, Earth's Systems, Role of Water in Earth's Surface Processes, Weather and Climate
- Space Science: Earth and the Solar System, The Universe and its Stars

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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.

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

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.

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

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.

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

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

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

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

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.

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.

LIFE SCIENCE

HIGH SCHOOL FIELD SCIENCE

LIFE SCIENCE

INTERDEPENDENCE OF ORGANISMS

Science Standard: HS.FS.L2U1.1 Develop and use models to show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment. (Aligns to PLUS HS+B.L2U1.1 & ESSENTIAL HS L2U1.19 - Ecosystems)

Learning Goals

I can:

- Develop models that represent how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment (*i.e., Arizona plant and animal species*):
  - Use design criteria to develop a diagram, drawing, physical replica, mathematical representation, analogy, and/or computer simulation that represents the system of interactions between and among biotic and abiotic elements within an ecosystem.
  - Use multiple types of models to represent abiotic and biotic elements in an ecosystem, and some of the interactions that occur in the model ecosystem.
  - Evaluate the merits and limitations of model types *(e.g., food chain vs. food web*) in order to select or revise a model that best fits the evidence or design criteria.
  - Design a test of a model to ascertain its reliability.
  - Revise models based on results of tests and design criteria to more appropriately represent connections between energy transfer within an ecosystem and its combination of biotic and abiotic factors.
- Use models to show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment (*i.e., Arizona plant and animal species*):
  - Use models to show how organisms are influenced by a particular combination of biotic and abiotic factors in an environment.
  - Use models to show the system of interactions between and among biotic and abiotic elements within an ecosystem.
  - Use models to analyze the conservation of matter and energy transfer in an ecosystem.
  - Use models to show how matter and energy are conserved at each link in an ecosystem (*i.e., some matter reacts to release energy for life functions, some is stored in newly made structures, and much is discarded*).
  - Use models to analyze patterns of energy/matter transfer within ecosystems *(e.g., food webs)* and effects of changes in components of that ecosystem *(e.g., removal of a predator*).
  - Use models to show the relationships among organisms within populations, communities, ecosystems, and biomes.

Core Ideas

Knowing Science

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

- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil and are combined and recombined in different ways.
- At each link in an ecosystem, matter and energy are conserved; some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. Competition among species is ultimately competition for the matter and energy needed for life.
- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

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 engage with models to better understand relationships among parts of an ecosystem. Models are developed through an iterative process of comparing what they predict and what is found in the real world.

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. • Evaluate merits and limitations of two different models of the same proposed tool, process, or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability.	**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. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. **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.

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HIGH SCHOOL FIELD SCIENCE

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BIOGEOGRAPHY

Science Standard: HS.FS.L2U1.2 Obtain, evaluate, and communicate information about the distribution of organisms around the world based on evidence from Earth's past (geological and biological) and present day. (Aligns to PLUS HS+B.L4U1.2 & ESSENTIAL HS.L2U3.18 - Ecosystems) (past and present)

Learning Goals

I can:

- Obtain information about past and present distribution of organisms around the world:
  - Ask questions about ecological succession and the distribution of organisms around the world 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 in simpler, but still accurate terms.
- Evaluate information about succession and past and present distribution of organisms around the world:
  - Evaluate the validity and reliability of evidence supporting claims about the past and present distribution of organisms around the world.
  - Verify data across texts.
- Communicate scientific ideas about succession and past and present distribution of organisms around the world:
  - Describe the various stages in a biogeographic sequence (*e.g., colonization, isolation, extinction, and others*).
  - Produce scientific/technical writing and/or oral presentations (*e.g., blog post, newspaper column, position paper, Socratic Seminar*) that present qualitative evidence about past and present distribution of organisms around the world.
  - Compare and integrate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively*) in order to describe past and present distribution of organisms around the world.
  - Explain the process of ecological succession in natural environments (*e.g., natural school environments, various ecosystems, land management practices*).
  - Describe natural restoration techniques in ecological restoration, including local desert ecosystems.
  - Revise explanations based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations)* and peer review.

Core Ideas

Knowing Science

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

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. Moreover, anthropogenic changes (induced by human activity) in the environment —including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change —can disrupt an ecosystem and threaten the survival of some species.
- Changes in the physical environment, whether naturally occurring or human induced, have contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth.

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 use data from a variety of sources to make sense of the cause and effect relationships between succession and the distribution of organisms in natural environments.	
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. **Obtaining, Evaluating, and Communicating Information** • Synthesize, communicate, and evaluate the validity and reliability of claims, methods, and designs that appear in scientific and technical texts or media reports, verifying the data when possible. • 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.	**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. **Cause and Effect: Mechanism and Prediction** • Changes in systems may have various causes that may not have equal effects. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

HIGH SCHOOL FIELD SCIENCE

LIFE SCIENCE

PHENOMENA IN NATURAL SYSTEMS

Science Standard: **HS.FS.L2U1.3 Plan and conduct field investigations about biological phenomena in natural systems.** (Aligns to ESSENTIAL HS.L2U1.19 and Plus HS+B.L2U1.3 - Ecosystems)

Learning Goals

I can:

- Plan field investigations individually and collaboratively to explore biological phenomena in natural systems (*i.e., wild birds, vegetation, and microhabitats*):
    - Ask investigative questions regarding relationships between independent and dependent variables.
    - Determine the data (*e.g., types, amount, and accuracy*) needed to produce reliable qualitative and/or quantitative observations and/or measurements of wild bird behaviors, vegetation, and/or microhabitats.
    - Consider limitations on the precision of the data (*e.g., number of trials, cost, risk, time*), and refine the design accordingly.
    - Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
    - Select appropriate tools to collect, record, analyze, and evaluate data (*e.g., how, when, and/or where observations/measurements will be taken; how samples or measurements will be repeated; how sampling/measurement method is consistent or systematic*).
- Conduct investigations individually and collaboratively to explore biological phenomena in natural systems (*i.e., wild birds, vegetation, and microhabitats*):
    - Conduct investigations in a safe and ethical manner including considerations of environmental, social, and personal impacts.
    - Collect data from the investigation about wild bird behavior, vegetation, and/or microhabitats in a natural environment *(e.g., observations/measurements recorded systematically; location, date, time of day and description of study site, including weather).*
    - Analyze and interpret data about wild bird behavior, vegetation, and/or microhabitats in a natural environment to identify relationships and/or patterns and trends and how they provide evidence to support a conclusion/explanation or claim.
    - Consider limitations *(e.g., measurement error, sample selection)* when analyzing and interpreting data.
    - Compare and contrast various types of data sets *(e.g., self-generated, class aggregated, and archival).*
    - Use evidence from the investigation to support an explanation or to make a qualitative or quantitative claim that responds to the research question related to natural processes associated with wild bird behavior(s), vegetation, and/or microhabitats.

Core Ideas

Knowing Science

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

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.
- Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Biological extinction, being irreversible, is a critical factor in reducing the planet's natural capital. Humans depend on the living world for the resources and other benefits provided by biodiversity.

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 plan and carry out field investigations to study natural phenomena and better understand relationships among parts of an ecosystem. Observations and data collected are used to test existing theories and explanations or to revise and develop new ones.	
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. **Planning and Carrying Out Investigations** • Design an investigation individually and collaboratively as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • 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. • Use investigations to gather evidence to support explanations or concepts.	**Patterns** • Mathematical representations are needed to identify some patterns. **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. **Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

EARTH AND SPACE SCIENCES

HIGH SCHOOL FIELD SCIENCE

EARTH AND SPACE SCIENCES

CARTOGRAPHY

Science Standard: HS.FS.E1U1.4 Analyze and interpret topographic and geospatial mapping data in the context of field research to study natural phenomena on Earth's surface.

Learning Goals

I can:

- Use cartographic tools, technologies, and/or models *(e.g., computational, mathematical)* to analyze and interpret mapping data:
    - Ask questions to frame data analysis and interpretation.
    - Navigate to specific locations using cartographic measurements, topographical data, and/or mathematical techniques and representations.
    - Use Geographic Information Systems (GIS) and Global Positioning Systems (GPS) technologies to analyze and represent geospatial mapping data.
    - Compare and contrast various types of data sets (e.g., topographic maps, satellite photographs) to examine consistency of measurements and observations.
    - Evaluate limitations (*e.g., measurement error, sample selection*) when analyzing and interpreting data.

Core Ideas

Knowing Science

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

- Topographical maps are detailed, accurate graphic representations of features that appear on Earth's surface. These maps give the user the ability to view a three-dimensional landscape on a two-dimensional map, such as the elevation and location of valleys, peaks, ridges, and other land features.
- Geospatial mapping technologies and tools contribute to the geographic mapping and analysis of the Earth and human societies. This technology enables us to acquire data that is referenced to the Earth and use it for analysis, modeling, simulations, and visualization. Then informed decisions can be made based on the importance and priority of resources most of which are limited in nature.
- GIS is a mapping tool for capturing, storing, checking, and displaying data related to positions on Earth's surface. GIS can show many different kinds of data on one map, such as streets, buildings, and vegetation. GIS can be used to study geologic features, analyze soils and strata, assess seismic information, analyze rock information characteristics, and/or create three-dimensional displays of geographic features.
- Global Positioning Systems (GPS) are used to find the exact location of things. GPS is perhaps the most well-known geospatial technology. It defines the tools, systems, and data that are used to study and understand features, such as geography, weather patterns, sociopolitical movements, geology, and the impact of natural disasters. Modern geospatial technology includes a vast range of tools, software applications, and systems used for analyzing spatial information.

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 use various types of data to make sense of phenomena on Earth's surface. They compare and combine data to identify and interpret patterns.

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. **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. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. **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.	**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. **Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.

HIGH SCHOOL FIELD SCIENCE

EARTH AND SPACE SCIENCES

EARTH'S SYSTEMS

Science Standard: HS.FS.E1U1.5 Evaluate and communicate explanations and theories about the role of energy and matter in geologic changes over time. (Aligns to HS.E1U1.13)

Learning Goals

I can:

- Evaluate information about the role of energy and matter in geologic changes over time:
    - Evaluate the validity and reliability of evidence supporting claims about how geologic processes have changed Earth's surface at varying times and scales.
    - Verify data across texts.
- Communicate scientific explanations and theories about the role of energy and matter in geologic changes over time:
    - Describe the mechanisms of heat transfer (*required: convection, conduction, radiation*) within the Earth's core and mantle and explain the significance of heat transfer to the layers of the Earth.
    - Produce scientific/technical writing and/or oral presentations (*e.g., blog post, newspaper column, position paper, Socratic Seminar*) that present evidence that geologic events of the ancient past can be explained by the same processes that happen today *(e.g., tectonics, volcanism, erosion*).
    - Compare, integrate, and evaluate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively*) in order to describe relationships among earthquakes, volcanoes, mountain ranges, mid-oceanic ridges, deep-sea trenches, and tectonic plates.
    - Explain the relationship between the Earth's internal convective heat flow and plate tectonics.
    - Describe natural restoration techniques in ecological restoration, including local desert ecosystems.
    - Revise explanations based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations)* and peer review.

Core Ideas

Knowing Science

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and the gravitational movement of denser materials toward the interior.
- Active geological processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock records on Earth. Radioactive decay lifetimes and isotopic content in rocks provide a way of dating rock formations and thereby fixing the scale of geological time.

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 pertaining to geologic change over time. Not all explanations are equally valid, so students must compare and evaluate the claims, methods, theories, and conclusions presented in order to better understand the role of energy and matter in geologic changes over time.

Science and Engineering Practices	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Synthesize, communicate, and evaluate the validity and reliability of claims, methods, and designs that appear in scientific and technical texts or media reports, verifying the data when possible. • 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.	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. **Energy and Matter: Flows, Cycles, and Conservation** • Energy drives the cycling of matter within and between systems.

HIGH SCHOOL FIELD SCIENCE
EARTH AND SPACE SCIENCES

ROLE OF WATER IN EARTH'S SURFACE PROCESSES

Science Standard: HS.FS.E1U1.6 Develop and use models to demonstrate and predict the effects of water on Earth's materials, surface processes, and groundwater systems.

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 effect of water on Earth's materials, surface processes, and groundwater systems:
    - Use design criteria to create models to represent the relationships between properties of water and its effects on Earth's materials, surface processes, and groundwater systems.
    - Use multiple types of models to represent the components and interactions within the desert wash system.
    - Develop models based on evidence to illustrate the relationships between the properties of water and its effects on Earth's materials, surface processes, and groundwater systems.
    - Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
    - Design a test of a model to ascertain its reliability (*e.g., using criteria or simulations*).
    - Revise models based on results of tests and design criteria to more appropriately represent the effect of water on Earth's materials, surface processes, and groundwater systems.
- Use models to demonstrate and predict the effect of water on Earth's materials, surface processes, and groundwater systems:
    - Use multiple types of models to demonstrate how the unique properties of water can interact with Earth materials to shape Earth's surface.
    - Use models to describe patterns and relationships within the desert wash system.
    - Use models to demonstrate the connection between hydrological structures *(e.g., meanders, headcuts, terraces, and alluvial fans)* and processes in a desert wash and the broader world with the quality of building sites near or on hydrological structures (e.g., building a house near a river meander).
    - Use models to infer the effect of water on Earth's surface processes (*e.g., stream transportation and deposition using a stream table - the role of flowing water to pick up, move, and deposit sediment, erosion*).
    - Use models *(e.g., SkyClub desert wash*) to predict the mechanical effects of water on Earth materials.

Core Ideas

Knowing Science

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks.

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 information from various sources and use evidence to make sense of the effect of water on Earth's materials, surface processes, and groundwater systems.

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. • Design a test of a model to ascertain its reliability. • Evaluate merits and limitations of two different models of the same proposed tool, process, or system in order to select or revise a model that best fits the evidence or design criteria.	**Cause and Effect: Mechanism and Prediction** • Changes in systems may have various causes that may not have equal effects. **Structure and Function** • 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. **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.

HIGH SCHOOL FIELD SCIENCE
EARTH AND SPACE SCIENCES

WEATHER AND CLIMATE

Science Standard: HS.FS.E1U1.7 Analyze and interpret data to determine how energy from the Sun affects weather patterns and climate. (Aligned to ESSENTIAL HS.E1U1.11)

Learning Goals

I can:

- Use tools, technologies, and/or models to analyze and interpret data (including graphs, data sets, and others) to determine how energy from the Sun affects weather patterns and climate:
    - Ask questions to frame data analysis and interpretation.
    - Generate and analyze data from models of Earth's weather as a system.
    - Use data to make valid and reliable claims about how energy transfers, moves, and changes within weather systems.
    - Interpret data and scientific evidence to explain the origin, life cycle, and behavior of weather systems.
    - Interpret data and scientific evidence to explain the factors that determine climate and weather.
    - Interpret data and scientific evidence to explain the causes and/or effects of climate changes over long periods of time.

Core Ideas

Knowing Science

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

- Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. Climate is longer term and location sensitive; it is the range of a region's weather over 1 year or many years, and, because it depends on latitude and geography, it varies from place to place.
- The foundation for Earth's global climate system is the electromagnetic radiation from the sun as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems and this energy's reradiation into space.
- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

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 use data from various sources to make sense of the cause and effect relationships between the Sun's energy and weather patterns and climate.

Science and Engineering Practices	Crosscutting Concepts
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. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.	**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. **Energy and Matter: Flows, Cycles, and Conservation** • Changes of energy and matter in a system can be described in terms of energy

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.	and matter flows into, out of, and within that system. • Energy drives the cycling of matter within and between systems. **Cause and Effect: Mechanism and Prediction** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Changes in systems may have various causes that may not have equal effects.

HIGH SCHOOL FIELD SCIENCE
EARTH AND SPACE SCIENCES

EARTH AND THE SOLAR SYSTEM

Science Standard: **HS.FS.E2U1.8 Construct an explanation of how gravitational forces impact the evolution of planetary motion, structure, surfaces, atmospheres, moons, and rings.** (Aligned to ESSENTIAL HS.E2.Ua.16)

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 to explain how Kepler's Laws show the formation and evolution of planetary motion.
    - Apply scientific reasoning to explain how Newton's Law of Universal Gravity predicts the formation of planetary structure, moons, and rings.
    - Apply scientific reasoning to explain how Newton's Law of Universal Gravity predicts the evolution of planetary surfaces and atmospheres.
    - Apply scientific reasoning, theory, and models to explain how gravitational forces and the moon influence biological systems on the Earth.
    - Apply scientific reasoning, theories, and models to explain the formation of planetary motion, structure, surfaces, atmospheres, moons, and rings based on gravitational forces between bodies.
    - Revise explanations based on evidence obtained from a variety of sources and peer review.

Core Ideas

Knowing Science

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.

- Earth and the moon, sun, and planets have predictable patterns of movement. These patterns, which are explainable by gravitational forces and conservation laws, in turn explain many large-scale phenomena observed on Earth.
- Planetary motions around the sun can be predicted using Kepler's three empirical laws, which can be explained based on Newton's theory of gravity. Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. (Note: application of the laws should be emphasized rather than memorization).

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.

- Where factors cannot be experimentally manipulated, as in the case of the movement of planets in the solar system, a phenomenon can be investigated by observing systematically over a period of time.

Science and Engineering Practices	Crosscutting Concepts
Constructing Explanations and Designing Solutions • 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.	**Structure and Function** • 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. **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.

HIGH SCHOOL FIELD SCIENCE

EARTH AND SPACE SCIENCES

THE UNIVERSE AND ITS STARS

Science Standard: HS.FS.E2U1.9 Construct an explanation of the origin, expansion, and scale of the universe based on astronomical evidence. (Aligns to ESSENTIAL HS.E2U1.17)

Learning Goals

I can:

- Construct explanations based on astronomical evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations):*
  - Apply scientific reasoning to explain the origin and expansion of the universe.
  - Apply scientific reasoning to explain distances between planets, stars, moons, and other bodies in the universe (*i.e., next nearest star, furthest planet of Neptune*) using different scales (*i.e., light years*).
  - Use valid and reliable empirical evidence to quantify and estimate the scale and size of the universe.
  - Assess the extent to which the reasoning and evidence about the origin and expansion of the universe support the explanations.
  - Revise explanations based on evidence obtained from a variety of sources and peer review.

Core Ideas

Knowing Science

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.

- There are billions of galaxies in the universe, almost unimaginably vast distances apart and perceived as moving rapidly away from each other. This apparent movement of galaxies indicates that the universe is expanding from an event called a 'big bang', about 13.7 billion years ago.
- The next nearest star [from the Sun] is much further away than the distance of the furthest planet, Neptune. The distances between and within galaxies are so great that they are measured in 'light years', the distance that light can travel in a year.

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 use evidence from a variety of sources to develop their understanding of the universe.

Science and Engineering Practices

Constructing Explanations and Designing Solutions

- 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.

Crosscutting Concepts

Scale, Proportion, and Quantity

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.

Energy and Matter: Flows, Cycles, and Conservation

- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

PHYSICAL SCIENCE

HIGH SCHOOL FIELD SCIENCE

PHYSICAL SCIENCE

MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: HS.FS.P2U1.10 Construct an explanation for a field's strength and influence on an object (electric, gravitational, magnetic). (Aligns to ESSENTIAL HS.P2U1.5)

Learning Goals

I can:

- Construct explanations based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations; i.e., Newton's Law of Universal Gravitation, Coulomb's Law):*
    - 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 (for example: 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	Crosscutting Concepts
Constructing Explanations and Designing Solutions • 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.	**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 FIELD SCIENCE

PHYSICAL SCIENCE

MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: HS.FS.P3U1.11 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. (Aligns to ESSENTIAL HS.P3U1.6)

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/or models to generate and analyze data in order to make claims about changes to an object's motion in relation to mass and forces:
  - Identify and describe patterns in data.
  - Evaluate limitations (*e.g., measurement error, sample selection*) when analyzing and interpreting data.
- Apply scientific reasoning, theory, and models to construct or revise an explanation that describes how forces can change the motion of objects, as predicted by Newton's Laws of Motion:
  - Explain how Newton's Laws apply to general wind circulation on Earth.
  - Explain the effect of the Earth's rotation on the movement of atmospheric water and air.
  - Explain how Newton's Laws apply to animal movement and flight.

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.

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. • Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.	**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 • Systems can be designed to do specific tasks. **Stability and Change**

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

HIGH SCHOOL FIELD SCIENCE

PHYSICAL SCIENCE

MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: HS.FS.P3U2.12 Construct an explanation to demonstrate how Newton's laws are used in engineering and technologies to create products to serve human ends. (Aligns to ESSENTIAL HS.P3U2.7)

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.
  - Apply techniques of algebra *(e.g., hydrologic discharge formulas, sixth power law of river competence)* to represent how engineers have used Newton's laws to find solutions to problems *(e.g., design structures that control erosion - gabions/rock dams).*
  - 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. **Using Mathematics and Computational Thinking** • Apply techniques of algebra and functions to represent and solve scientific and engineering problems.	**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.

HIGH SCHOOL FIELD SCIENCE	
PHYSICAL SCIENCE	
ENERGY & WAVES	

Science Standard: **HS.FS.P4U1.13 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.** (Aligns to ESSENTIAL HS.P4U1.8)
 	
Learning Goals
I can:
• Evaluate arguments regarding the law of conservation of energy:
    o Evaluate the claims, evidence, and reasoning of oral and/or written arguments to determine merits of arguments and elicit elaboration from peers.
    o Critique and evaluate competing arguments about conservation of energy in light of evidence, limitations (trade-offs), constraints and ethical issues.
• Construct and present oral and written arguments regarding the law of conservation of energy:
    o Use systems computer models to generate and analyze data about animal heat loss and retention in a variety of settings.
    o Use reasoning and data from computer models as evidence to make and defend a claim about the relationship between the law of conservation of energy and animal heat loss and retention.
    o 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 use evidence to construct an argument about the law of conservation of energy.	
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. • Make and defend a claim about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.	**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. **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.

HIGH SCHOOL FIELD SCIENCE
PHYSICAL SCIENCE
ENERGY & WAVES

Science Standard: **HS.FS.P4U3.14 Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer.** (Aligns to ESSENTIAL HS.P4U3.9)

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 (*i.e., Glen Canyon power generation conflicts).*
  - 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:
  - Use systems computer models to generate and analyze data about the generation of power at Glen Canyon Dam, and the effect of that power generation on the Grand Canyon.
  - Make and defend a claim about the benefits and liabilities of energy usage and transfer.
  - Use scientific evidence to develop and support the claim.
  - Describe the transfer of energy between different parts of a system, including its surroundings.
  - 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.

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	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate

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. • 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.	systems and interactions—including energy, matter, and information flows—within and between systems at different scales. **Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a 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.

HIGH SCHOOL FIELD SCIENCE
PHYSICAL SCIENCE

ENERGY & WAVES

Science Standard: HS.FS.P4U1.15 Construct an explanation about the relationship among the frequency, wavelength, and speed of waves traveling in various media, and their applications to modern technology. (Aligns to ESSENTIAL HS.P4U1.10)

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.
    - Use models to generate data about the mathematical relationships between frequency, wavelength, and the speed of seismic (earthquake) waves.
    - Use models to compare seismic waves traveling through various media (rock, sand, water, and others).
    - Use algorithmic representations and earthquake strength and duration to describe how earthquake resistant buildings are designed in different areas with different land types *(e.g., rock, sand, water, and others).*
    - Predict and explain mathematically, the relative change in the wavelength of a wave when it moves from one medium to another in terms of cause (different media) and effect (different wavelengths but same frequency.)
    - Explain from evidence that all electromagnetic radiation travels through a vacuum at the speed of light.
    - 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 • 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. **Use Mathematical 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.	**Cause and Effect: Mechanism and Prediction** • 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. **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.