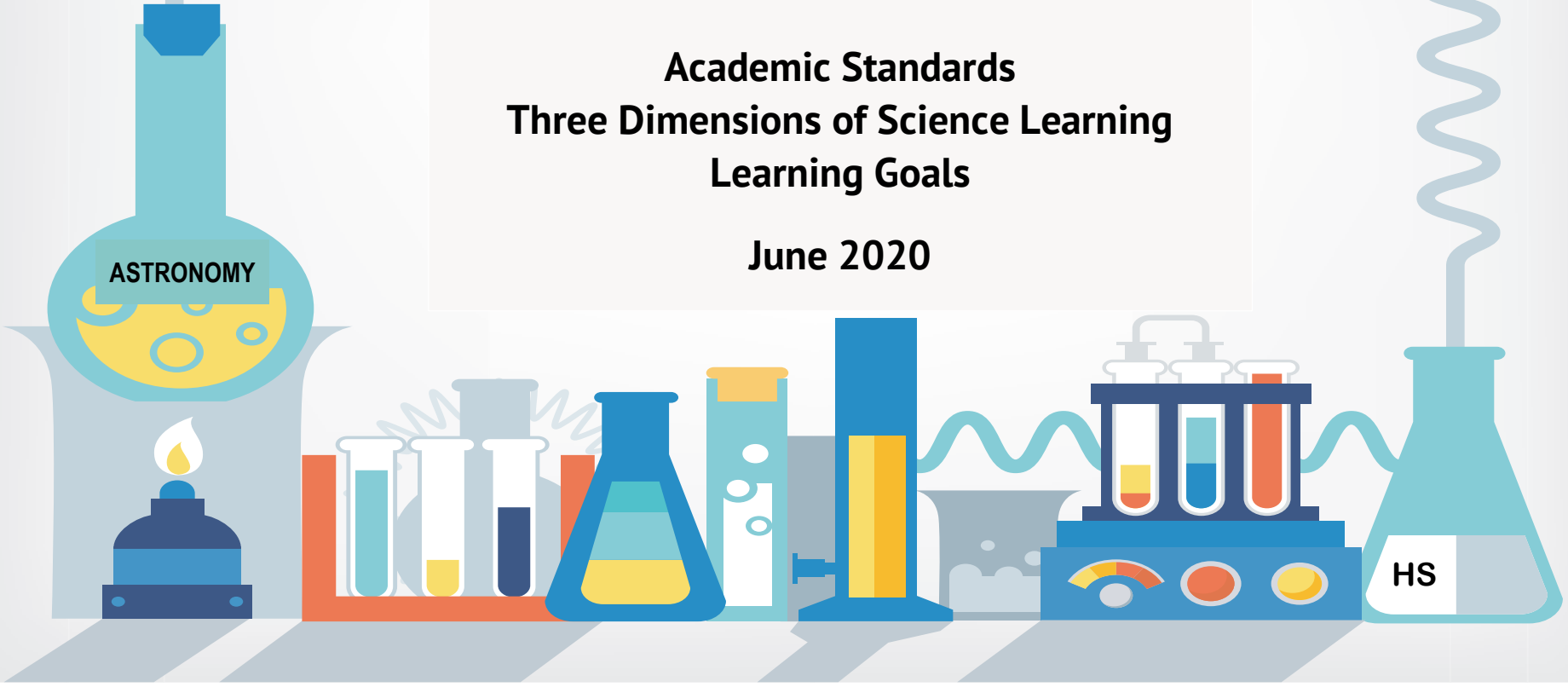
ENVISION 21

DEEP LEARNING • CFSD

SCIENCE

Academic Standards
Three Dimensions of Science Learning
Learning Goals

June 2020



HIGH SCHOOL
ASTRONOMY

HIGH SCHOOL ASTRONOMY OVERVIEW

The high school Astronomy course encompasses processes that occur on Earth while also addressing Earth's place within our solar system and galaxy. Students gain an understanding of these processes through a wide scale: unimaginably large to invisibly small. Earth and Space Sciences, more than any other discipline , are rooted in other scientific disciplines. Students, through the close study of Earth and space, will find clear applications for their knowledge of gravitation, energy, magnetics, cycles, and biological processes. The course also includes the study of physical and chemical sub-processes that occur within systems. Students gain will study these processes at both the micro and macro levels through the intensive 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. The essential standards are those that every high school student is expected to know and understand. Plus standards in Astronomy are designed to extend the concepts learned in the essential standards to prepare students for entry level college courses.

Astronomy 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 "essential" and "plus" standards for High School Astronomy are grouped by topics based on areas of science. One additional topic from the standards in the Earth and Space Sciences, have been integrated into the course. This is to ensure that students have been taught the full set of "essential" science standards by their third year of high school (see "coding standards" below).

The list of high school Astronomy 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 Astronomy Topics:

- Space Science: Earth's Place in the Universe, Earth and the Solar System, The Universe and its Stars
- Earth Science: Weather and Climate
- Physical Science: Motion and Stability – Forces and 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.

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.

KINDERGARTEN

LIFE SCIENCE: LIVING AND NON-LIVING THINGS

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

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

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.

Crosscutting Concepts

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.

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.

EARTH'S PLACE IN THE UNIVERSE

HIGH SCHOOL ASTRONOMY

EARTH & SPACE SCIENCES

EARTH'S PLACE IN THE UNIVERSE

Science Standard: PLUS HS+E.E2U1.12 Obtain, evaluate, and communicate scientific information about the way stars, throughout their stellar stages, produce elements and energy.

Learning Goals

I can:

- Obtain information about the way stars, throughout their stellar stages, produce elements and energy:
  - Ask questions to frame the search for 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.
- Evaluate information from scientific texts about the way stars, throughout their stellar stages, produce elements and energy:
  - 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.
- Communicate scientific ideas about the stellar stages of stars and how they produce elements and energy:
  - Communicate in writing and/or oral presentations information about how observations of distant stars provide insight on various stages of development.
  - Compare, integrate, and evaluate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively*) to explain the process of stellar evolution from star birth to star death.
  - Use evidence to connect stellar evolution to stellar nucleosynthesis (element production).
  - Use evidence to describe how stars evolve along the main sequence including changes in size, temperature, luminosity, spectral type, and color (Hertzsprung-Russell diagram).

Core Ideas

Knowing Science

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

- Our Sun is one of many stars that make up the Universe, essentially made of hydrogen. The source of energy that the Sun and all stars radiate comes from nuclear reactions in their central cores.
- Nearly all observable matter in the universe is hydrogen or helium, which formed in the first minutes after the Big Bang. Elements other than these remnants of the Big Bang continue to form within the cores of stars.
- Nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases the energy seen as starlight. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.

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.

- A scientific theory is a well-substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and so become well-established.

Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems	**Structure and Function**

• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. • Ask questions that require relevant empirical evidence to answer. • Ask and evaluate questions that challenge the premise of an argument, the interpretation of a data set, or the suitability of a design. **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. • 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.	• 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. **Energy and Matter: Flows, Cycles, and Conservation** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

EARTH AND THE SOLAR SYSTEM

HIGH SCHOOL ASTRONOMY

EARTH & SPACE SCIENCES

EARTH AND THE SOLAR SYSTEM

Science Standard: ESSENTIAL HS.E2U1.16 Construct an explanation of how gravitational forces impact the evolution of planetary motion, structure, surfaces, atmospheres, moons, and rings.

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 support how Kepler's Laws explain 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.
  - 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

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.
- Base causal explanations on valid and reliable empirical evidence from multiple sources and the assumption that natural laws operate today as they did in the past and will continue to do so in the future.

Crosscutting Concepts

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 ASTRONOMY

EARTH & SPACE SCIENCES

EARTH AND THE SOLAR SYSTEM

Science Standard: PLUS HS+E.E2U1.13 Construct an explanation of how gravitational forces are influenced by mass and the distance between objects.

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 gravitational forces are influenced by mass and the distance between objects.
  - Use Newton's Law of Universal Gravity to explain relationships between gravitational forces, mass, and distance.
  - Use calculations to support explanations of relationships between gravitational forces, mass, and distance.
  - 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.

- The solar system consists of the sun and a collection of objects of varying sizes and conditions—including planets and their moons—that are held in orbit around the sun by its gravitational pull on them. This system appears to have formed from a disk of dust and gas, drawn together by gravity.

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 explain relationships between gravitational force, mass, and distance.

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.
- Base causal explanations on valid and reliable empirical evidence from multiple sources and the assumption that natural laws operate today as they did in the past and will continue to do so in the future.

Crosscutting Concepts

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.
- Changes in systems may have various causes that may not have equal effects.

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 ASTRONOMY

EARTH & SPACE SCIENCES

EARTH AND THE SOLAR SYSTEM

Science Standard: PLUS HS+E.E2U1.14 Use mathematics and computational thinking to explain the movement of planets and objects in the solar system.

Learning Goals

I can:

- Use algebraic representations of Kepler's three Laws of Motion to predict and explain the movement of planets and objects in the solar system.
- Use Newton's Law of Gravitation and Law of Motion to predict how the acceleration of a planet towards the Sun varies with its distance from the Sun, and explain how this relates to the observed orbits.
- Show quantitative patterns that provide evidence of elliptical orbital motion including planets, moons, or human-made spacecraft.
- Create mathematical models for the paths of objects in the solar system, such as orbiting bodies, comets, asteroids, meteoroids, meteors, and meteorites.

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.
- Gravity holds Earth in orbit around the sun, and it holds the moon in orbit around Earth. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.
- 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.

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.

- Planets and other objects in the solar systems are so large and so far away that mathematics and computational thinking are necessary to make sense of their movement and position.

Science and Engineering Practices

Using Mathematics and Computational Thinking

- Use mathematical or algorithmic representations of phenomena to describe and support claims and explanations, and create computational models or simulations.

Crosscutting Concepts

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.
- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

THE UNIVERSE AND ITS STARS

HIGH SCHOOL ASTRONOMY

EARTH & SPACE SCIENCES

THE UNIVERSE AND ITS STARS

Science Standard: ESSENTIAL HS.E2U1.17 Construct an explanation of the origin, expansion, and scale of the universe based on astronomical evidence.

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 over time.
  - Apply scientific reasoning to explain distances between planets, stars, moons, and other bodies in the universe (*e.g., next nearest star, furthest planet of Neptune*) using different scales (*e.g., 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.

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.

Crosscutting Concepts

Scale, Proportion, and Quantity

- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- Patterns observable at one scale may not be observable or exist at other scales.

Energy and Matter: Flows, Cycles, and Conservation

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

HIGH SCHOOL ASTRONOMY

EARTH & SPACE SCIENCES

THE UNIVERSE AND ITS STARS

Science Standard: PLUS HS+E.E2U1.15 Obtain, evaluate, and communicate information on how the nebular theory explains solar system formation with distinct regions characterized by different types of planetary and other bodies.

Learning Goals

I can:

- Obtain information about the nebular theory of solar system formation:
  - Ask questions to frame the search for 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.
- Evaluate information from scientific texts on the nebular theory of solar system formation:
  - 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.
- Communicate scientific ideas about the stellar stages of stars and how they produce elements and energy:
  - Communicate in writing and/or oral presentations how the nebular theory supports solar system formation, including the orderly patterns of motion in our solar system, two major types of planetary bodies, and the existence of smaller bodies.
  - Compare, integrate, and evaluate multiple sources of information presented in different media or formats (*e.g., visually, quantitatively*) to explain the nebular theory's explanation of solar system formation.
  - Identify and explain the evident properties within the solar system that support the nebular theory.
  - Describe the processes that lead to the patterns (*i.e., motion - orbit in same direction and plane, size and location - two types of planets*) that we see in our solar system's structure.
  - Explain how the nebular theory supports the formation and location of rocky planets, gaseous planets, and other bodies, such as the Asteroid Belt.

Core Ideas

Knowing Science

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

- The solar system consists of the sun and a collection of objects of varying sizes and conditions—including planets and their moons—that are held in orbit around the sun by its gravitational pull on them.
- This system appears to have formed from a disk of dust and gas, drawn together by gravity.

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.

- Theories help students make sense of phenomena. Students explore solar system formation through the lens of nebular theory.

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.	**Cause and Effect: Mechanism and Prediction** • Changes in systems may have various causes that may not have equal effects. **Patterns**

• Ask questions that require relevant empirical evidence to answer. • Ask and evaluate questions that challenge the premise of an argument, the interpretation of a data set, or the suitability of a design. **Obtaining, Evaluating, and Communicating Information** • 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. • 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.	• Empirical evidence is needed to identify patterns.

HIGH SCHOOL ASTRONOMY

EARTH & SPACE SCIENCES

THE UNIVERSE AND ITS STARS

Science Standard: PLUS H+E.E2U1.16 Obtain, evaluate, and communicate information about patterns of size and scale of our solar system, galaxy, and the universe.

Learning Goals

I can:

- Obtain information about the size and scale of astronomical structures (*i.e., our solar system, galaxy, and the universe*):
  - Ask questions to frame the search for 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.
- Evaluate information from scientific texts regarding the size and scale of astronomical structures (*i.e., our solar system, galaxy, and the universe*):
  - 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.
- Communicate information about patterns of size and scale of our solar system, galaxy, and universe:
  - Communicate in writing and/or oral presentations how, due to gravitational forces, patterns appear in astronomical structures at different scales in the universe, despite vast size differences.
  - Compare, integrate and evaluate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively*) regarding the size and scale of our solar system, galaxy, and universe.
  - Explain patterns of evidence (*i.e., composition of stars, existence of cosmic background radiation, redshift, hydrogen-helium ratio of stars and interstellar gases*) about the size and scale of the universe.
  - Explain the current theory for the origin of the universe and how astronomical evidence from numerous sources is used collectively to support that the universe is expanding.

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 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 develop an understanding of the size and scale of our solar system, galaxy, and universe through examination of evidence and analysis of 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. • 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. **Scale, Proportion, and Quantity**

• Ask and evaluate questions that challenge the premise of an argument, the interpretation of a data set, or the suitability of a design. **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.	• Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. • Patterns observable at one scale may not be observable or exist at other scales.

HIGH SCHOOL ASTRONOMY

EARTH & SPACE SCIENCES

THE UNIVERSE AND ITS STARS

Science Standard: PLUS H+E.E2U2.17 Obtain, evaluate, and communicate the impact of technology on human understanding of the formation, scale, and composition of the universe.

Learning Goals

I can:

- Obtain information about the impact of technology on human understanding of the formation, scale, and composition of the universe:
  - Ask questions to frame the search for 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.
- Evaluate information from scientific texts about the progression and impact of technology and tools used to understand astronomical concepts such as formation, scale, and composition:
  - 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.
- Communicate information about the impact of technology on human understanding of the universe:
  - Communicate in writing and/or oral presentations the development and function of various tools scientists have developed to further study the expansion and scale of the universe.
  - Compare, integrate and evaluate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively)* regarding how scientists have developed tools and methods to progressively overcome challenges in observational astronomy.

Core Ideas

Knowing Science

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

- 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. 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.

Using Science

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

- Students explore how technology has helped us develop an understanding of that which is too large to be studied directly.

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 and evaluate questions that challenge the premise of an argument, the interpretation of a data set, or the suitability of a design. **Obtaining, Evaluating, and Communicating Information**	**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. **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination

• 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.	of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

WEATHER AND CLIMATE

HIGH SCHOOL ASTRONOMY

EARTH & SPACE SCIENCES

WEATHER AND CLIMATE

Science Standard: ESSENTIAL HS.E1U1.11 Develop and use models to explain how energy from the Sun affects weather patterns and climate.

Learning Goals

I can:

- Develop a model to explain how energy from the Sun affects weather patterns and climate:
  - Use design criteria to create representations of weather patterns and climate based on energy from the Sun.
  - 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.
- Revise models based on results of tests and design criteria to more appropriately represent weather patterns and climate based on energy from the Sun.

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.
- Climate change can occur when certain parts of Earth's systems are altered. Geological evidence indicates that past climate changes were either sudden changes caused by alterations in the atmosphere; longer term changes (e.g., ice ages) due to variations in solar output, Earth's orbit, or the orientation of its axis; or even more gradual atmospheric changes due to plants and other organisms that captured carbon dioxide and released oxygen. The time scales of these changes varied from a few to millions of years.

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 models to explore interactions among weather, climate, and the Sun's energy.

Science and Engineering Practices

Developing and Using Models

- Develop, revise, and use models to predict and support explanations of relationships 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.

Crosscutting Concepts

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.

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.

	Systems and Systems 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.

MOTION AND STABILITY – FORCES & INTERACTIONS

HIGH SCHOOL ASTRONOMY

PHYSICAL SCIENCE

MOTION AND 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 use 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 ASTRONOMY

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:
  - 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. • 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**

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

HIGH SCHOOL ASTRONOMY

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

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.

Crosscutting Concepts

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 & WAVES

HIGH SCHOOL ASTRONOMY

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.
- 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.

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 ASTRONOMY

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 ASTRONOMY

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.

- By exploring relationships among frequency, wavelength, and speed of waves, students come to understand these abstract concepts in real-life contexts.

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. • Changes in systems may have various causes that may not have equal effect. **Energy and Matter: Flows, Cycles, and Conservation** • The total amount of energy and matter in closed systems is conserved. • 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.