SCIENCE

Academic Standards
Three Dimensions of Science Learning
Learning Goals

June 2020

PHYSICS

HS

ENVISION 21
DEEP LEARNING • CFSD

HIGH SCHOOL
PHYSICS & HONORS PHYSICS

CATALINA FOOTHILLS SCHOOL DISTRICT

HIGH SCHOOL PHYSICS & HONORS PHYSICS OVERVIEW

High School Physics and Honor Physics encompass physical and chemical sub-processes that occur within systems. At the high school level, students gain an understanding of 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 chemistry are designed to extend the concepts learned in the essential standards to prepare students for entry level college courses.

The "essential" and "plus" standards for High School Physics and Honors Physics are grouped into two main topics. In addition, three topics from 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). 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 science courses to meet this Arizona State Board of Education requirement.

The list of high school Physics and Honors Physics 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 Physics and Honors Physics Topics:

- Motion & Stability – Forces & Interactions
- Energy and Waves
- Weather and Climate
- Earth and the Solar System
- The Universe and its Stars

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.

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.

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.

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.

MOTION & STABILITY – FORCES & INTERACTIONS

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

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

Learning Goals

I can:

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

Core Ideas

Knowing Science

P2: Objects can affect other objects at a distance.

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

Using Science

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

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

Science and Engineering Practices	Crosscutting Concepts
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.	**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 PHYSICS & HONORS PHYSICS

PHYSICAL SCIENCE

MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: Plus HS+Phy.P2U1.1 Plan and carry out investigations to demonstrate that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Learning Goals

I can:

- Plan investigations individually and collaboratively to identify and analyze relationships between electric currents and magnetic fields:
  - Ask investigative questions regarding relationships between independent and dependent variables.
  - Determine the data (*e.g., types, amount, and accuracy*) needed to produce reliable measurements of electric currents and/or magnetic fields.
  - 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.
- Conduct investigations individually and collaboratively to identify and analyze relationships between electric currents and magnetic fields:
  - Conduct investigations in a safe and ethical manner including considerations of environmental, social, and personal impacts.
  - Use data from the investigation to identify and analyze relationships between electric currents and magnetic fields.
  - Make quantitative and qualitative claims regarding the relationship between dependent and independent variables.

Core Ideas

Knowing Science

P2: Objects can affect other objects at a distance.

- Some cases of action at a distance are not explained in terms of radiation from a source to a receiver. A magnet, for example, can attract or repel another magnet and both play equal parts. Similarly, the attraction and repulsion between electric charges is reciprocal.
- The idea of a field is useful for thinking about such situations. A field is the region of the object's influence around it, the strength of the field decreasing with distance from the object. Another object entering this field experiences an effect – attraction or repulsion. Gravity, electric and magnetic interactions can be described in terms of fields.

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 obtained from their investigations to explore relationships between electric currents and magnetic fields. The design of the investigations and the ways in which the procedures are carried out will have a significant impact on the quality of the evidence produced.

Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. • Ask questions that require relevant empirical evidence to answer. • Ask questions to determine relationships, including quantitative relationships, between	**Cause and Effect: Mechanism and Prediction** • 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.

independent and dependent variables. **Planning and Carrying out Investigations** • Design an investigation individually and collaboratively and test designs 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. • Select appropriate tools to collect, record, analyze, and evaluate data. **Constructing Explanations and Designing Solutions** • Make quantitative and qualitative claims regarding the relationship between dependent and independent variables.	• Energy drives the cycling of matter within and between systems. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

HIGH SCHOOL PHYSICS & HONORS PHYSICS
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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.

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

HIGH SCHOOL PHYSICS & HONORS PHYSICS

PHYSICAL SCIENCE

MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: Plus HS+Phy.P3U1.2 Develop and use mathematical models of Newton's law of gravitation and Coulomb's law to describe and predict the gravitational and electrostatic forces between objects.

Learning Goals

I can:

- Develop mathematical models of Newton's law of gravitation and Coulomb's law:
  - Use design criteria to create mathematical representations of Newton's law of gravitation and Coulomb's law.
  - Use multiple types of mathematical models to represent Newton's law of gravitation and Coulomb's law.
  - 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 Newton's law of gravitation and Coulomb's law.
- Use mathematical models of Newton's law of gravitation and Coulomb's law to describe and predict the gravitational and electrostatic forces between objects:
  - Use evidence from models to explain how massive objects interact gravitationally and charged objects interact electrically at a distance.
  - Use algebraic representations of Newton's Law of Gravitation and Coulomb's Law to quantitatively predict the forces between relevant objects.

Core Ideas

Knowing Science

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

- 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 permeating space that can transfer energy through space. Gravity, electric, and magnetic interactions can be described in terms of fields.
- Magnets or changing electric fields cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

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.

- Mathematical models help students better understand, describe, and predict forces between objects. Students combine quantitative and qualitative thinking to make sense of the law of gravitation and Coulomb's law.

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. • Use models (including mathematical and computational) to generate data to support explanations and predict phenomena, analyze systems, and solve problems.	**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**

• 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 of design criteria.	• 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 PHYSICS & HONORS PHYSICS

PHYSICAL SCIENCE

MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: Plus HS+Phy.P3U1.3 Develop a mathematical model, using Newton's laws, to predict the motion of an object or system in two dimensions (projectile and circular motion).

Learning Goals

I can:

- Develop mathematical models of motion in two dimensions, using Newton's laws of motion:
    - Use design criteria to create mathematical representations of Newton's laws.
    - Use multiple types of mathematical models to represent Newton's laws.
    - 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 Newton's laws.
- Use mathematical models, using Newton's laws, to predict the motion of an object or system in two dimensions (projectile and circular motion):
    - Use mathematical representations of motion to predict the motion of projectiles.
    - Use mathematical representations of motion to predict the motion of objects in circular paths.

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.

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.

- Mathematical models help students better understand and more accurately predict motion of objects and systems. Students refine models using tests, feedback, and criteria in order to more effectively represent the system.

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. • Use models (including mathematical and computational) to generate data to support explanations and predict phenomena, analyze systems, and solve problems. • 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 of design criteria. **Using Mathematics and Computational Thinking**	**Systems and Systems Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using 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.

• Use mathematical or algorithmic representations of phenomena or design solutions to describe and support claims and explanations, and create computational models or simulations. • Create a simple computational model or simulation of a designed device, process, or system.	• Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. **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 can be designed for greater or lesser stability.

HIGH SCHOOL PHYSICS & HONORS PHYSICS

PHYSICAL SCIENCE

MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: Plus HS+Phy.P3U1.4 Engage in argument from evidence regarding the claim that the total momentum of a system is conserved when there is no net force on the system.

Learning Goals

I can:

- Construct, use, and present oral and written arguments regarding the law of conservation of linear momentum:
  - Make and defend a claim that the momentum of a system is the same before and after an interaction between the objects in a system, so that the momentum of the system is constant.
  - Use quantitative and qualitative and scientific evidence to develop and support the claim.
  - Describe the transfer of momentum between different parts of a system.

Core Ideas

Knowing Science

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

- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

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 multiple sources to evaluate and develop arguments regarding the Law of Conservation of Momentum. They select appropriate evidence and use scientific reasoning to develop and support claims.

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.
- 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

Systems and Systems Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Energy and Matter: Cycles, Flows, 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.

HIGH SCHOOL PHYSICS & HONORS PHYSICS

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.

HIGH SCHOOL PHYSICS & HONORS PHYSICS
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MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: **Plus HS+Phy.P3U2.5 Design, evaluate, and refine a device that minimizes or maximizes the force on a macroscopic object during a collision.**

Learning Goals

I can:

- Design a device that minimizes or maximizes the force on a macroscopic object during a collision:
  - Define the design problem, identifying the complexity of the system, criteria for success, and constraints that may include social, technical and/or environmental considerations.
  - Use criteria *(e.g., cost, mass, the maximum force applied to the object, requirements set by society for widely-used collision-mitigation devices)* to design a device that minimizes or maximizes the force on a macroscopic object during a collision *(e.g., seatbelts, football helmets).*
  - Apply scientific reasoning and models to design a device that either minimizes or maximizes the force during a collision, including the scientific rationale for choice of materials and the structure of the device.
  - Communicate designs through sketches, drawings, or physical models.
- Evaluate and refine a device that minimizes or maximizes the force on a macroscopic object during a collision:
  - Ask and evaluate questions that challenge the suitability of a design.
  - Test and compare multiple designs (*e.g., using simulations or criteria*).
  - Evaluate designs based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoffs that would optimize the device to better minimize or maximize the force impact.
  - Use performance data and/or peer review to refine the performance of a device *(e.g., extending impact time, reducing the device mass, and/or considering cost-benefit analysis)* that either minimizes or maximizes the force during a collision.

Core Ideas

Knowing Science

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

- If a system interacts with objects outside itself, the total momentum of the system can change; however any such change is balanced by changes in the momentum of objects outside the system.
- 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.

Using Science

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

- Students design a product to solve a real-world problem pertaining to forces and collision.

Science and Engineering Practices	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.	**Cause and Effect: Mechanism and Prediction** • Systems can be designed to cause a desired effect. **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination

• Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

ENERGY AND WAVES

HIGH SCHOOL PHYSICS & HONORS PHYSICS

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 PHYSICS & HONORS PHYSICS

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 PHYSICS & HONORS PHYSICS

PHYSICAL SCIENCE

ENERGY & WAVES

Science Standard: Plus HS+Phy.P4U1.6 Analyze and interpret data to quantitatively describe changes in energy within a system and/or energy flows in and out of a system.

Learning Goals

I can:

- Use tools, technologies, and models to analyze and interpret data (*e.g., from investigations, demonstrations, texts, data sets, simulations, etc.*) to quantitatively describe changes in energy within a system and/or energy flows in and out of a system:
  - Ask questions to frame data analysis and interpretation.
  - Evaluate statistical limitations (*e.g. sample size or selection*) and systematic effects (*e.g. measurement errors*) when analyzing and interpreting data.
  - Compare and contrast various types of data sets to (*e.g. self-generated, archival*) to examine changes in energy within a system and/or energy flows in and out of a system.
  - Interpret data to track the changes in the energy and energy forms within a system.
  - Calculate the change of energy between different forms and between the system and its surroundings.
  - Use data to quantitatively describe changes in energy within a system and/or energy flows in and out of a system.

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.

- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. The availability of energy limits what can occur in any system.

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 quantitative data to better understand energy changes and flows in and out of a system.

Science and Engineering Practices

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.
- Ask and evaluate questions that challenge the premise of an argument, the interpretation of a data set, or the suitability of a design.

Analyzing and Interpreting Data

Crosscutting Concepts

Stability and Change

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

Scale, Proportion, and Quantity

- The significance of a phenomenon is dependent on the scale, proportion, and quantity 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.

• 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. • 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.	• 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 PHYSICS & HONORS PHYSICS

PHYSICAL SCIENCE

ENERGY & WAVES

Science Standard: Plus HS+Phy.P4U2.7 Design, evaluate, and refine a device that works within given constraints to transfer energy within a system.

Learning Goals

I can:

- Design a device that works within given constraints to transfer energy within a system:
  - Define the design problem, identifying the complexity of the system, criteria for success, and constraints that may include social, technical and/or environmental considerations:
    - Specify the initial and final form of energy *(e.g., gravitational, kinetic, electrical energy, etc.)*
    - Predict how conservation of energy will affect system behavior.
    - Identify the device by which the energy will be transformed *(e.g., light bulb to convert electrical energy to light energy, motor to convert electrical energy into kinetic energy)*
  - Use criteria and constraints to design a device that transfers energy from one form to another within a system, including:
    - The initial and final forms of energy
    - A description of how the device functions to transfer energy from one form to the another
    - The materials available for construction of the device
    - Safety considerations
  - Communicate designs through sketches, drawings, or physical models.
- Evaluate and refine a device that works within given constraints to transfer energy within a system:
  - Ask and evaluate questions that challenge the suitability of a design.
  - Test and compare multiple designs (*e.g., using experimentation, simulations, or criteria*).
  - Evaluate designs based on scientific knowledge, student-generated sources of evidence, prioritized criteria, constraints, and trade-off considerations. Use performance data and/or peer review to refine the performance of a device that transfers energy from one form to another within a system to improve its functioning.

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

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

- Students use their understanding of energy transfer to design a device that will transfer energy within a system.

Science and Engineering Practices	Crosscutting Concepts
Constructing Explanations and Designing Solutions	**Systems and System Models**

• Make quantitative and qualitative claims regarding the relationship between dependent and independent variables. • Apply scientific knowledge and evidence to explain phenomena and solve design problems, taking into account possible unanticipated effects. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	• Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. **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. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

HIGH SCHOOL PHYSICS & HONORS PHYSICS
PHYSICAL SCIENCE

ENERGY & WAVES

Science Standard: Plus HS+Phy.P4U1.8 Use mathematics and computational thinking to explain the relationships between power, current, voltage, and resistance.

Learning Goals

I can:

- Apply techniques of algebra and functions to represent the physical relationships between current, voltage, and resistance for elements in a simple circuit (series and parallel resistor circuits).
- Use a simple computational model or simulation of a device to determine how resistance affects current flow in simple circuits.
- Use algorithmic representations to support physical observations or measurements of electrical power.

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.

- Electrical energy may mean energy stored in a battery or energy transmitted by electric currents.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in a system.

Using Science

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

- Students explore electrical energy and use mathematical thinking to make sense of and explain the relationships between power, current, voltage, and resistance.

Science and Engineering Practices	Crosscutting Concepts
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. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Create a simple computational model or simulation of a designed device, process, or system.	**Cause and Effect: Mechanism and Prediction** • Systems can be designed to cause a desired effect. • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **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 PHYSICS & HONORS PHYSICS

PHYSICAL SCIENCE

ENERGY & WAVES

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

Learning Goals

I can:

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

Core Ideas

Knowing Science

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

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

Using Science

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

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

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

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

EARTH AND SPACE SCIENCES

WEATHER AND CLIMATE

EARTH AND THE SOLAR SYSTEM

THE UNIVERSE AND ITS STARS

HIGH SCHOOL PHYSICS & HONORS PHYSICS

EARTH & SPACES 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

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: 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 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 PHYSICS & HONORS PHYSICS
EARTH & SPACES 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.

- Students examine multiple sources of evidence to better understand gravitational forces in space. They use evidence and Kepler's laws to construct scientific explanations.

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. • 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.	**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.

ENVISION 21 DEEP LEARNING • CFSD

HIGH SCHOOL PHYSICS & HONORS PHYSICS

EARTH & SPACES 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., lightyears*).
  - 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 examine evidence from a variety of sources to develop their understanding of the universe. They then use astronomical evidence to support scientific explanations of the origin, expansion, and scale of the universe.

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. • Make quantitative and qualitative claims regarding the relationship between dependent and independent variables. • 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. • Apply scientific knowledge and evidence to explain phenomena and solve design problems, taking into account possible unanticipated effects.	**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: 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.