UTAH 9–12
SCIENCE
WITH ENGINEERING EDUCATION (SEEd) STANDARDS
(BIOLOGY, CHEMISTRY, EARTH AND SPACE SCIENCE, AND PHYSICS)

Adopted June 2019
by the
Utah State Board of Education
250 East 500 South
P.O. Box 144200
Salt Lake City, UT 84114-4200

Sydnee Dickson, Ed.D.
State Superintendent of Public Instruction

https://www.schools.utah.gov

Articulation of SEPs, CCCs, and DCIs

Science and Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
Asking questions or defining problems: Students engage in asking testable questions and defining problems to pursue understandings of phenomena. **Developing and using models:** Students develop physical, conceptual, and other models to represent relationships, explain mechanisms, and predict outcomes. **Planning and carrying out investigations:** Students plan and conduct scientific investigations in order to test, revise, or develop explanations. **Analyzing and interpreting data:** Students analyze various types of data in order to create valid interpretations or to assess claims/conclusions. **Using mathematics and computational thinking:** Students use fundamental tools in science to compute relationships and interpret results. **Constructing explanations and designing solutions:** Students construct explanations about the world and design solutions to problems using observations that are consistent with current evidence and scientific principles. **Engaging in argument from evidence:** Students support their best explanations with lines of reasoning using evidence to defend their claims. **Obtaining, evaluating, and communicating information:** Students obtain, evaluate, and derive meaning from scientific information or presented evidence using appropriate scientific language. They communicate their findings clearly and persuasively in a variety of ways including written text, graphs, diagrams, charts, tables, or orally.	Patterns: Students observe patterns to organize and classify factors that influence relationships Cause and effect: Students investigate and explain causal relationships in order to make tests and predictions. Scale, proportion, and quantity: Students compare the scale, proportions, and quantities of measurements within and between various systems. Systems and system models: Students use models to explain the parameters and relationships that describe complex systems. Energy and matter: Students describe cycling of matter and flow of energy through systems, including transfer, transformation, and conservation of energy and matter. Structure and function: Students relate the shape and structure of an object or living thing to its properties and functions. Stability and change: Students evaluate how and why a natural or constructed system can change or remain stable over time.	Physical Sciences: (PS1) Matter and Its Interactions (PS2) Motion and Stability: Forces and Interactions (PS3) Energy (PS4) Waves Life Sciences: (LS1) Molecules to Organisms (LS2) Ecosystems (LS3) Heredity (LS4) Biological Evolution Earth and Space Sciences: (ESS1) Earth's Place in the Universe (ESS2) Earth's Systems (ESS3) Earth and Human Activity Engineering Design: (ETS1.A) Defining and Delimiting an Engineering Problem (ETS1.B) Developing Possible Solutions (ETS1.C) Optimizing the Design Solution

PHYSICS

INTRODUCTION

The physics SEEd standards explore the foundational principles of physics including forces, energy, fields, and waves. Students analyze and interpret data to determine the cause and effect relationship between the net force of an object and its change in motion. Students develop and use models to illustrate that energy at all levels can be accounted for as a combination of energies associated with motion and relative positions of objects. Students use mathematics and computational thinking to support the claim that the total momentum of a system is conserved when there is no net force acting on a system. Students plan and conduct investigations to provide evidence that an electric current causes a magnetic field and that a changing magnetic field causes an electric current. Students also engage in argument to support the assertion that electromagnetic radiation can be described either by a wave or a particle model. Additionally, students design and evaluate solutions to problems that exist in these areas.

Strand PHYS.1: FORCES AND INTERACTIONS

Uniform motion of an object is natural. Changes in motion are caused by a nonzero sum of forces. A "net force" causes an acceleration as predicted by Newton's 2nd Law. Qualitative and quantitative analysis of position, velocity, and acceleration provide evidence of the effects of forces. Momentum is defined for a particular frame of reference; it is the product of the mass and 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. The time over which these paired forces are exerted determines the impact force.

- **Standard PHYS.1.1** **Analyze and interpret data** to determine the cause and effect relationship between the net force on an object and its change in motion as summarized by Newton's Second Law of Motion. Emphasize one-dimensional motion and macroscopic objects moving at non-relativistic speeds. Examples could include objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force. (PS2.A)

- **Standard PHYS.1.2** **Use mathematics and computational thinking** to support the claim that the total momentum of a system is conserved when there is no net force acting on the system. Emphasize the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. Examples could include one-dimensional elastic or inelastic collisions between objects within the system. (PS2.A)

- **Standard PHYS.1.3** **Design a solution** that has the function of minimizing the impact force on an object during a collision. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution*. Emphasize problems that require application of Newton's Second Law of Motion or conservation of momentum. (PS2.A, ETS1.A, ETS1.B, ETS1.C)

Strand PHYS.2: ENERGY

Energy describes the motion and interactions of matter and radiation within a system. Energy is a quantifiable property that is conserved in isolated systems and in the universe as a whole. At the macroscopic scale, energy manifests itself in multiple ways such as in motion, sound, light, and thermal energy. Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution. Examining the world through an energy lens allows us to model and predict complex interactions of multiple objects within a system and address societal needs.

- **Standard PHYS.2.1** **Analyze and interpret data** to track and calculate the transfer of energy within a system. Emphasize the identification of the components of the system, along with their initial and final energies, and mathematical descriptions to depict energy transfer in the system. Examples of energy transfer could include the transfer of energy during a collision or heat transfer. (PS3.A, PS3.B)

- **Standard PHYS.2.2** **Plan and conduct an investigation** to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system. Emphasize that uniform distribution of energy is a natural tendency. Examples could include the measurement of the reduction of temperature of a hot object or the increase in temperature of a cold object. (PS3.B)

- **Standard PHYS.2.3** **Develop and use models** on the macroscopic scale to illustrate that energy can be accounted for as a combination of energies associated with the motion of objects and energy associated with the relative positions of objects. Emphasize relationships between components of the model to show that energy is conserved. Examples could include mechanical systems where kinetic energy is transformed to potential energy or vice versa. (PS3.A)

- **Standard PHYS.2.4** **Design a solution** by constructing a device that converts one form of energy into another form of energy to solve a complex real-life problem. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution*. Examples of energy transformation could include electrical energy to mechanical energy, mechanical energy to electrical energy, or electromagnetic radiation to thermal energy. (PS3.A, PS3.B, ETS1.A, ETS1.B, ETS1.C)

(Continued)

■ **Standard PHYS 2.5** **Design a solution** to a major global problem that accounts for societal energy needs and wants. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution*. Emphasize problems that require the application of conservation of energy principles through energy transfers and transformations. Examples of devices could include one that uses renewable energy resources to perform functions currently performed by nonrenewable fuels or ones that are more energy efficient to conserve energy. (PS3.A, PS3.B, PS3.D, ETS1.A, ETS1.B, ETS1.C)

Strand PHYS.3: FIELDS

Fields describe how forces act through space and how potential energy is stored in systems. These take on different forms of electric, magnetic, or gravitational fields, but similarly provide a mechanism for how matter interacts. When two objects interacting through a field change relative position, the energy stored in the field is changed. These fields are important at a wide variety of scales, ranging from the subatomic to the astronomic.

- **Standard PHYS.3.1** **Use mathematics and computational thinking** to compare the scale and proportion of gravitational and electric fields using Newton's Law of Gravitation and Coulomb's Law. Emphasize the comparative strength of these two field forces, the effect of distance between interacting objects on the magnitudes of these forces, and the use of models to understand field forces. (PS2.B)

- **Standard PHYS.3.2** **Plan and conduct an investigation** to provide evidence that an electric current causes a magnetic field and that a changing magnetic field causes an electric current. Emphasize the qualitative relationship between electricity and magnetism without necessarily conducting quantitative analysis. Examples could include electromagnets or generators. (PS2.C)

- **Standard PHYS.3.3** **Analyze and interpret data** to compare the effect of changes in position of interacting objects on electric and gravitational forces and energy. Emphasize the similarities and differences between charged particles in electric fields and masses in gravitational fields. Examples could include models, simulations, or experiments that produce data or illustrate field lines between objects. (PS3.C)

- **Standard PHYS.3.4** **Develop and use a model** to evaluate the effects on a field as characteristics of its source and surrounding space are varied. Emphasize how a field changes with distance from its source. Examples of electric fields could include those resulting from point charges. Examples of magnetic fields could include those resulting from dipole magnets or current-bearing wires. (PS3.C)

Strand PHYS.4: WAVES

Waves transfer energy through oscillations of fields or matter. 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 passes. Waves produce interference as they overlap but they emerge unaffected by each other. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. Electromagnetic radiation can be modeled as a wave of changing electric and magnetic fields or as particles called photons. When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy. Because waves depend upon the properties of fields and the predictable transformation of energy, they can be used to interpret the nature of matter and its energy. Waves are utilized to transmit information both in analog and digital forms.

- **Standard PHYS.4.1** **Analyze and interpret data** to derive both qualitative and quantitative relationships based on patterns observed in frequency, wavelength, and speed of waves traveling in various media. Emphasize mathematical relationships and qualitative descriptions. Examples of data could include electromagnetic radiation traveling in a vacuum or glass, sound waves traveling through air or water, or seismic waves traveling through Earth. (PS4.A)

- **Standard PHYS.4.2** **Engage in argument based on evidence** that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model better explains interactions within a system than the other. Emphasize how the experimental evidence supports the claim and how models and explanations are modified in light of new evidence. Examples could include resonance, interference, diffraction, or the photoelectric effect. (PS4.A, PS4.B)

- **Standard PHYS.4.3** **Evaluate information** about the effects that different frequencies of electromagnetic radiation have when absorbed by biological materials. Emphasize that the energy of electromagnetic radiation is directly proportional to frequency and that the potential damage to living tissue from electromagnetic radiation depends on the energy of the radiation. (PS4.B)

- **Standard PHYS.4.4** **Ask questions** and **construct an explanation** about the stability of digital transmission and storage of information and their impacts on society. Emphasize the stability of digital signals and the discrete nature of information transmission. Examples of stability and instability could include that digital information can be stored in computer memory, is transferred easily, copied and shared rapidly can be easily deleted, has limited fidelity based on sampling rates, or is vulnerable to security breaches and theft. (PS4.A)

■ **Standard PHYS.4.5** **Obtain, evaluate, and communicate information** about how devices use the principles of electromagnetic radiation and their interactions with matter to transmit and capture information and energy. Emphasize the ways in which devices leverage the wave-particle duality of electromagnetic radiation. Examples could include solar cells, medical imaging devices, or communication technologies. (PS4.A, PS4.B, PS4.C)