PHYSICAL SCIENCE

Physical Science, **a one-credit course,** provides opportunities for students to develop and communicate a basic understanding of physics and chemistry through lab-based activities, integrated STEM activities, inquiry, suitable mathematical expressions, and concept exploration. The Physical Science course will prepare students for the transition to other science courses and to become informed citizens of a modern world that is constantly changing. To be successful in Physical Science, it is recommended that students have completed Algebra I (Integrated Math I) or be enrolled in this math course.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to utilize the science and engineering practices to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. It is recommended that students should actively engage in inquiry activities, laboratory experiences, and scientific research (projects) for a minimum of 30% of class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Physical Science

PHS.1 Nature of Matter

Conceptual Understanding: To actively develop scientific investigation, reasoning, and logic skills, this standard develops basic ideas about the characteristics and structure of matter. Matter is anything that has mass and occupies space. All matter is made up of small particles called atoms. Matter can exist as a solid, liquid, gas, or plasma.

PHS.1 Students will demonstrate an understanding of the nature of matter.

PHS.1.1 *Use contextual evidence to describe particle theory of matter. Examine the particle properties of solids, liquids, and gases.*

PHS.1.2 *Use scientific research to generate models to compare physical and chemical properties of elements, compounds, and mixtures.*

PHS.1.3 *Conduct an investigation to determine the identity of unknown substances by comparing properties to known substances.*

PHS.1.4 *Design and conduct investigations to explore techniques in measurements of mass, volume, length, and temperature.*

PHS.1.5 *Design and conduct an investigation using graphical analysis (e.g., line graph) to determine the density of liquids and/or solids.*

PHS.1.6 *Use mathematical and computational analysis to solve density problems. Manipulate the density formula to determine density, volume, or mass or use dimensional analysis to solve problems.*

Physical Science

PHS.2 Atomic Theory

Conceptual Understanding: Many scientists have contributed to our understanding of atomic structure. The atom is the basic building block of matter and consists of subatomic particles (proton, neutron, electron, and quark) that differ in their location, charge, and relative mass.

PHS.2 Students will demonstrate an understanding of both modern and historical theories of atomic structure.

PHS.2.1 *Research and develop models (e.g., 3-D models, online simulations, or ball and stick) to investigate both modern and historical theories of atomic structure. Compare models and contributions of Dalton, Thomson, Rutherford, Bohr, and of modern atomic theory.*

Physical Science

PHS.3 Periodic Table

Conceptual Understanding: The organization of the periodic table allows scientists to obtain information and develop an understanding of concepts of atomic interactions. Developing scientific investigations increases logical reasoning and deduction skills to present the nature of science in the context of key scientific concepts.

PHS.3 Students will analyze the organization of the periodic table of elements to predict atomic interactions.

PHS.3.1 *Use contextual evidence to determine the organization of the periodic table, including metals, metalloids, and nonmetals; symbols; atomic number; atomic mass; chemical families/groups; and periods/series.*

PHS.3.2 *Using the periodic table and scientific methods, investigate the formation of compounds through ionic and covalent bonding.*

PHS.3.3 *Using naming conventions for binary compounds, write the compound name from the formula, and write balanced formulas from the name (e.g., carbon dioxide - CO_2, sodium chloride - NaCl, iron III oxide- Fe2O3, and calcium bromide - $CaBr_2$).*

PHS.3.4 *Use naming conventions to name common acids and common compounds used in classroom labs (e.g., sodium bicarbonate (baking soda), $NaHCO_3$; hydrochloric acid, HCl; sulfuric acid, H_2SO_4 ; acetic acid (vinegar), $HC_2H_3O_2$; and nitric acid, HNO_3).*

PHS.3.5 *Use mathematical and computational analysis to determine the atomic mass of binary compounds.*

Physical Science

PHS.4 The Law of Conservation of Matter and Energy

Conceptual Understanding: The law of conservation of matter and energy states that matter and energy can be transformed in different ways, but the total amount of mass and energy will be conserved. These concepts should be investigated and further developed in the classroom.

PHS.4 Students will analyze changes in matter and the relationship of these changes to the law of conservation of matter and energy.

PHS.4.1 *Design and conduct experiments to investigate physical and chemical changes of various household products (e.g., rusting, sour milk, crushing, grinding, tearing, boiling, and freezing) and reactions of common chemicals that produce color changes or gases.*

PHS.4.2 *Design and conduct investigations to produce evidence that mass is conserved in chemical reactions (e.g., vinegar and baking soda in a Ziploc© bag).*

PHS.4.3 *Apply the concept of conservation of matter to balancing simple chemical equations.*

PHS.4.4 *Use mathematical and computational analysis to examine evidence that mass is conserved in chemical reactions using simple stoichiometry problems (1:1 mole ratio) or atomic masses to demonstrate the conservation of mass with a balanced equation.*

PHS.4.5 *Research nuclear reactions and their uses in the modern world, exploring concepts such as fusion, fission, stars as reactors, nuclear energy, and chain reactions.*

PHS.4.6 *Analyze and debate the advantages and disadvantages of nuclear reactions as energy sources.*

Physical Science

PHS.5 Newton's Laws of Motion

Conceptual Understanding: Kinematics (contact forces) describe the motion of objects using words, diagrams, numbers, graphs, and equations. The goal of any study of kinematics is to develop scientific models to describe and explain the motion of real-world objects. Newton's laws of motion are an example of a tool that can aid in the explanation of motion.

PHS.5 Students will analyze the scientific principles of motion, force, and work.

PHS.5.1 *Research the scientific contributions of Newton, and use models to communicate Newton's principles.*

PHS.5.2 *Design and conduct an investigation to study the motion of an object using properties such as displacement, time of motion, velocity, and acceleration.*

PHS.5.3 *Collect, organize, and interpret graphical data using correct metric units to determine the average speed of an object.*

PHS.5.4 *Use mathematical and computational analyses to show the relationships among force, mass, and acceleration (i.e., Newton's second law).*

PHS.5.5 *Design and construct an investigation using probe systems and/or online simulations to observe relationships between force, mass, and acceleration (F=ma).*

PHS.5.6 *Use an engineering design process and mathematical analysis to design and construct models to demonstrate the law of conservation of momentum (e.g., roller coasters, bicycle helmets, bumper systems).*

PHS.5.7 *Use mathematical and computational representations to create graphs and formulas that describe the relationships between force, work, and energy (i.e., W=Fd, KE=½ mv^2, PE=mgh, W=KE).*

PHS.5.8 *Research the efficiency of everyday machines, and debate ways to improve their economic impact on society (e.g., electrical appliances, transportation vehicles).*

Physical Science

PHS.6 Waves

Conceptual Understanding: Waves are everywhere in nature. Understanding of the physical world is not complete until we understand the nature, properties, and behaviors of waves. Students have experienced transverse and horizontal waves in their everyday lives. The exploration of waves in greater depth will allow students to conceptualize these waves. The goal is to develop various models of waves and apply those models to understanding wave interactions.

PHS.6 Students will explore the characteristics of waves.

PHS.6.1 *Use models to analyze and describe examples of mechanical waves' properties (e.g., wavelength, frequency, speed, amplitude, rarefaction, and compression).*

PHS.6.2 *Analyze examples and evidence of transverse and longitudinal waves found in nature (e.g., earthquakes, ocean waves, and sound waves).*

PHS.6.3 *Generate wave models to explore energy transference.*

PHS.6.4 ***Enrichment:*** *Use an engineering design process to design and build a musical instrument to demonstrate the influence of resonance on music.**

PHS.6.5 *Design and conduct experiments to investigate technological applications of sound (e.g., medical uses, music, acoustics, Doppler effects, and influences of mathematical theory on music).*

PHS.6.6 *Research real-world applications to create models or visible representations of the electromagnetic spectrum, including visible light, infrared radiation, and ultraviolet radiation.*

PHS.6.7 ***Enrichment:*** *Use an engineering design process to design and construct an apparatus that forms images to project on a screen or magnify images using lenses and/or mirrors.**

PHS.6.8 ***Enrichment:*** *Debate the particle/wave behavior of light.*

Physical Science

PHS.7 Energy

Conceptual Understanding: Concepts about different energy forms and energy transformations continue to be expanded and explored in greater depth, leading to the development of more mathematical applications. Focus should be on students actively developing scientific investigations, reasoning, and logic skills.

PHS.7 Students will examine different forms of energy and energy transformations.

PHS.7.1 *Using digital resources, explore forms of energy (e.g., potential and kinetic energy, mechanical, chemical, electrical, thermal, radiant, and nuclear energy).*

PHS.7.2 *Use scientific investigations to explore the transformation of energy from one type to another (e.g., potential to kinetic energy, and mechanical, chemical, electrical, thermal, radiant, and nuclear energy interactions).*

PHS.7.3 *Using mathematical and computational analysis, calculate potential and kinetic energy based on given data. Use equations such as PE=mgh and KE=½ mv^2.*

PHS.7.4 *Conduct investigations to provide evidence of the conservation of energy as energy is converted from one form of energy to another (e.g., wind to electric, chemical to thermal, mechanical to thermal, and potential to kinetic).*

Physical Science

PHS.8 Thermal Energy

Conceptual Understanding: Thermal energy is transferred in the form of heat. Heat is always transferred from an area of high heat to low heat. More complex concepts and terminology related to phase changes are developed, including the distinction between heat and temperature.

PHS.8 Students will demonstrate an understanding of temperature scales, heat, and thermal energy transfer.

PHS.8.1 *Compare and contrast temperature scales by converting between Celsius, Fahrenheit, and Kelvin.*

PHS.8.2 *Apply particle theory to phase change and analyze freezing point, melting point, boiling point, vaporization, and condensation of different substances.*

PHS.8.3 *Relate thermal energy transfer to real world applications of conduction (e.g., quenching metals), convection (e.g., movement of air masses/weather/plate tectonics), and radiation (e.g., electromagnetic).*

PHS.8.4 ***Enrichment:*** *Use an engineering design process to construct a simulation of heat energy transfer between systems. Calculate the calories/joules of energy generated by burning food products. Communicate conclusions based on evidence from the simulation.**

Physical Science

PHS.9 Electricity

Conceptual Understanding: Electrical energy (both battery and circuit energy) is transformed into other forms of energy. Charged particles and magnetic fields are similar because they both store energy. Magnetic fields exert forces on moving charged particles. Students investigate practical uses of these concepts and develop a working understanding of the basic concepts of magnetism and electricity.

PHS.9 Students will explore basic principles of magnetism and electricity (e.g., static electricity, current electricity, and circuits).

PHS.9.1 *Use digital resources and online simulations to investigate the basic principles of electricity, including static electricity, current electricity, and circuits. Use digital resources (e.g., online simulations) to build a model showing the relationship between magnetic fields and electric currents.*

PHS.9.2 *Distinguish between magnets, motors, and generators, and evaluate modern industrial uses of each.*

PHS.9.3 ***Enrichment:*** *Use an engineering design process to construct a working electric motor to perform a task. Communicate the design process and comparisons of task performance efficiencies.**

PHS.9.4 *Use an engineering design process to construct and test conductors, semiconductors, and insulators using various materials to optimize efficiency.**

Overarching (start to finish) SEPs for Inquiry Extension of Labs

Ask questions to generate hypotheses for scientific investigations based on empirical evidence and observations and/or ask questions to **clarify or refine** models, explanations, or designs.

Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.