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Content Area: Physical Science
Grade Span: 10
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COURSE OVERVIEW

Description

This Physical Science course is the beginning of a multi-year course sequence emphasizing the conceptual flow of the physical science performance expectations in high school, to prepare struggling students for successful completion of a full year of one or both of the succeeding physical sciences courses (chemistry and/or physics), potentially at a more rigorous level. This physical science curriculum helps students learn the foundations of physics and chemistry through practicing it. It is fully consistent with the Next Generation Science Standards as the units of the course are logically connected and allow students to build their conceptual understanding of physical science concepts, develop relevant mathematical reasoning and simultaneously learn how to think like scientists. The units seek to lay a foundation for understanding the complexities of the physical science domains by deeply understanding the driving principles - through a focus on the science and engineering practices and the crosscutting concepts - that allow matter to exist and function as it does in the universe.

Goals

Students will be able to take future science courses with success, as this course: ● aids students in the area of analyzing data so they will be able to propose meaningful conclusions ● gives students the opportunity to experiment and improve existing lab techniques and learn additional ones ● involves students in the inquiry process of science ● develop those processes of inquiry by which scientific problems are explained, predicted, and/or controlled ● provide a spiraling curriculum of core concepts to teach students how to move from simple, concrete concepts to more difficult and abstract ideas.

Scope and Sequence

Unit	Topic	Length
Unit 1	Skill Development of Science and Engineering Practices	10 blocks
Unit 2	Describing Motion as Interacting Forces	35 blocks
Unit 3	Structure and Properties of Matter & Its Interactions	25 blocks
Unit 4	Energy and Bonds In Chemical Reactions	20 blocks

UNIT 1: SKILL DEVELOPMENT OF SCIENCE AND ENGINEERING PRACTICES

Summary and Rationale

In this introductory unit, all students continue their efforts from previous science courses in the development of the following Science and Engineering Practices. They are highlighted in this unit and then are present throughout each unit of the course.

Recommended Pacing

10 blocks

Instructional Focus

The following overview outlines the Science and Engineering Practices:

Practice: Asking questions
Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Practice: Developing and using models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Practice: Planning and Carrying Out Investigations
Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Practice: Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Practice: Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9- 12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data.

Practice: Constructing Explanations (Science) and Designing Solutions (Engineering)
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Practice: Engaging in argument from evidence
Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s).

Practice: Obtaining, evaluating, and communicating information
Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

UNIT 2: DESCRIBING MOTION AS INTERACTING FORCES

Summary and Rationale	
Students will be able to begin to apply Newton's Laws to relate forces to explain the motion of objects. Students also apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials move in the way that they do. Students answer the question, "How can one describe motion and physical interactions between objects and within systems of objects?" The performance expectations in this unit focus on helping students understand ideas related to why some objects will keep moving, why objects fall to the ground, and why some materials are attracted to each other while others are not. Students will continue to apply Newton's Laws to relate forces to explain the motion of objects. It is important to note that the performance expectations described are intended as end-of-instructional unit expectations and additional practices should be used throughout instruction.	
Recommended Pacing	
35 blocks	
State Standards (Performance Expectations)	
HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.	
Clarification Statement	Examples of data could include tables or graphs of position or velocity as a function of time for 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.
Assessment Boundary	Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.
HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.	
Clarification Statement	Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.
Clarification Statement	Assessment is limited to systems of two macroscopic bodies moving in one dimension.
HS-PS2-3. Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.	
Clarification Statement	Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.
Assessment Boundary	Assessment is limited to qualitative evaluations and/or algebraic manipulations.
HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.	
Clarification Statement	Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields
Assessment Boundary	Assessment is limited to systems with two objects.
HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.	

Clarification Statement	Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.
Assessment Boundary	Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.
HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.	
Clarification Statement	Emphasis is on explaining the meaning of mathematical expressions used in the model.
Assessment Boundary	Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.
HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).	
Clarification Statement	Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.

Instructional Focus

Unit Enduring Understandings (Cross Cutting Concepts)

- Patterns (HS-PS2-4)
- Cause and Effect (HS-PS2-1),(HS-PS2-3)
- Systems and System Models (HS-PS2-2), (HSPS3-1)
- Energy and Matter (HS-PS3-2)
- Structure and Function (HS-PS2-6)
- ***Connections to Nature of Science*:** Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Essential Questions

- How can one describe motion and physical interactions between objects and within systems of objects?
- How can we predict the motion of an object?

Objectives

Students will know (DCIs):

- **Structure and Properties of Matter** The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
- **Forces and Motion** Newton's second law accurately predicts changes in the motion of macroscopic objects.
- **Types of Interactions** 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.
- **Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system.
- **Conservation of Energy and Energy Transfer** 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.
- **Relationship Between Energy and Forces** When two objects interacting through a field change relative position, the energy stored in the field is changed.
- **Defining and Delimiting an Engineering Problem** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

- **Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Students will be able to (SEPs):

- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Obtaining, Evaluating, and Communicating Information

UNIT 3: STRUCTURE AND PROPERTIES OF MATTER

Summary and Rationale
The performance expectations in this unit help students to formulate an answer to the questions: “How can particles combine to produce a substance with different properties? How does thermal energy affect particles?” by building understanding of what occurs at the atomic and molecular scale. Students will be able to apply understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They will be able to provide molecular level accounts to explain states of matters and changes between states. It is important to note that the performance expectations described are intended as end-of-instructional unit expectations and additional practices should be used throughout instruction.
Recommended Pacing
25 blocks

State Standards (Performance Expectations)	
HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.	
Clarification Statement	Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen
Assessment Boundary	Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.
HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.	
Clarification Statement	Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.
Assessment Boundary	Assessment does not include Raoult’s law calculations of vapor pressure.
HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.	
Clarification Statement	Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.
Assessment Boundary	Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays
HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.	
Clarification Statement	Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.
Assessment Boundary	Assessment is limited to provided molecular structures of specific designed materials.
HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*	
Clarification Statement	Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.

Assessment Boundary	Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.
HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.	
Clarification Statement	Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.
Assessment Boundary	Assessment does not include using quantum theory.
HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.	
Clarification Statement	Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.
HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	
HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	

Instructional Focus

Unit Enduring Understandings (Cross Cutting Concepts)

- Patterns (HS-PS1-1),(HS-PS1-3)
- Energy and Matter (HS-PS1-8)
- Structure and Function (HS-PS2- 6)
- ***Connections to Engineering, Technology, and Applications of Science:*** Influence of Science, Engineering, and Technology on Society and the Natural World (HS-PS3-3)
- ***Connections to Nature of Science:*** Scientific Knowledge Assumes an Order and Consistency in Natural Systems

Unit Essential Questions

- How can particles combine to produce a substance with different properties?
- How does thermal energy affect particles?

Objectives

Students will know (DCIs):

- **Energy in Chemical Processes** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
- **Structure and Properties of Matter:** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
- **Nuclear Processes:** Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy.
- **Types of Interactions:** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
- **Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

Students will be able to (SEPs):

- Developing and Using Models
- Planning and Carrying Out Investigations
- Obtaining, Evaluating, and Communicating Information
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions

UNIT 4: ENERGY AND BONDS IN CHEMICAL REACTIONS

Summary and Rationale

The performance expectations in this unit help students to build understanding of what occurs at the atomic and molecular scale during chemical reactions. Students will be able to provide molecular level accounts to explain that chemical reactions involve regrouping of atoms to form new substances, and that atoms rearrange during chemical reactions. Students are also able to apply an understanding of the design and the process of optimization in engineering to chemical reaction systems.
It is important to note that the performance expectations described are intended as end-of-instructional unit expectations and additional practices should be used throughout instruction.

Recommended Pacing

20 blocks

State Standards (Performance Expectations)

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	
Clarification Statement	Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.
Clarification Statement	Assessment is limited to chemical reactions involving main group elements and combustion reactions.
HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	
Clarification Statement	Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.
Assessment Boundary	Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.
HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.	
Clarification Statement	Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.
Assessment Boundary	Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.
HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*	
Clarification Statement	Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.
Assessment Boundary	Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.
HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.	
Clarification Statement	Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.

Assessment Boundary	Assessment does not include complex chemical reactions.

Instructional Focus

Unit Enduring Understandings (Cross Cutting Concepts)

- Patterns (HS-PS1-2),(HS-PS1-5)
- Energy and Matter (HS-PS1-7), (HS-PS1-4)
- Stability and Change (HS-PS1-6)
- ***Connections to Nature of Science:*** Scientific Knowledge Assumes an Order and Consistency in Natural Systems

Unit Essential Questions

- What happens when new materials are formed? What stays the same and what changes?

Objectives

Students will know (DCIs):

- **Structure and Properties of Matter:** The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.
- **Chemical Reactions:** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.
- **Optimizing the Design Solution:** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others.

Students will be able to (SEPs):

- Developing and Using Models
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions