High School Physical Sciences

Students in high school continue to develop their understanding of the four core ideas in the physical sciences. These ideas include the most fundamental concepts from chemistry and physics, but are intended to leave room for expanded study in upper-level high school courses. The high school performance expectations in Physical Science build on the middle school ideas and skills and allow high school students to explain more in-depth phenomena central not only to the physical sciences, but to life and earth and space sciences as well. These performance expectations blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain ideas across the science disciplines. In the physical science performance expectations at the high school level, there is a focus on several scientific practices. These include developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations; and to use these practices to demonstrate understanding of the core ideas. Students are also expected to demonstrate understanding of several engineering practices, including design and evaluation.

The performance expectations in the topic **Structure and Properties of Matter** help students formulate an answer to the question, "How can one explain the structure and properties of matter?" Two sub-ideas from the *NRC Framework* are addressed in these performance expectations: the structure and properties of matter, and nuclear processes. Students are expected to develop understanding of the substructure of atoms and provide more mechanistic explanations of the properties of substances. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Phenomena involving nuclei are also important to understand, as they explain the formation and abundance of the elements, radioactivity, the release of energy from the sun and other stars, and the generation of nuclear power. The crosscutting concepts of patterns, energy and matter, and structure and function are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and conducting investigations, and communicating scientific and technical information; and to use these practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Chemical Reactions** help students formulate an answer to the questions: "How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?" Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Using this expanded knowledge of chemical reactions, students are able to explain important biological and geophysical phenomena. Students are also able to apply an understanding of the process of optimization in engineering design to chemical reaction systems. The crosscutting concepts of patterns, energy and matter, and stability and change are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, using mathematical thinking, constructing explanations, and designing solutions; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Forces and Interactions** supports students' understanding of 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 should be able to answer the question, "How can one explain and predict interactions between objects and within systems of objects?" The disciplinary core idea expressed in the *Framework* for PS2 is broken down into the sub ideas of Forces and Motion and Types of Interactions. The performance expectations in PS2 focus on students building understanding of forces and interactions and Newton's Second Law. Students also develop understanding that the total momentum of a system of objects is conserved when there is no net force on the system. Students are able to use Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. Students are able to apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. The crosscutting concepts of patterns, cause and effect, and systems and system models are called out as organizing concepts for these disciplinary core ideas. In the PS2 performance expectations, students are expected to demonstrate proficiency in planning and conducting investigations, analyzing data and using math to support claims, and applying scientific ideas to solve design problems; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Energy** help students formulate an answer to the question, "How is energy transferred and conserved?" The disciplinary core idea expressed in the *Framework* for PS3 is broken down into four sub-core ideas: Definitions of Energy, Conservation of Energy and Energy Transfer, the Relationship between Energy and Forces, and Energy in Chemical Process and Everyday Life. Energy is understood as quantitative property of a system that depends on the motion and interactions of matter and radiation within that system, and the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy at both the macroscopic and the atomic scale can be accounted for as either motions of particles or energy associated with the configuration (relative positions) of particles. In some cases, the energy associated with the configuration of particles can be thought of as stored in fields. Students also demonstrate their understanding of engineering principles when they design, build, and refine devices associated with the conversion of energy. The crosscutting concepts of cause and effect; systems and system models; energy and matter; and the influence of science, engineering, and technology on society and the natural world are further developed in the performance expectations associated with PS3. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and carry out investigations, using computational thinking, and designing solutions; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Waves and Electromagnetic Radiation** are critical to understand how many new technologies work. As such, this disciplinary core idea helps students answer the question, "How are waves used to transfer energy and send and store information?" The disciplinary core idea in PS4 is broken down into Wave Properties, Electromagnetic Radiation, and Information Technologies and Instrumentation. Students are able to apply understanding of how wave properties and the interactions of electromagnetic radiation with matter can transfer information across long distances, store information, and investigate nature on many scales. Models of electromagnetic radiation as either a wave of changing electric and magnetic fields or as particles are developed and used. Students understand that combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Students also demonstrate

their understanding of engineering ideas by presenting information about how technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. The crosscutting concepts of cause and effect; systems and system models; stability and change; interdependence of science, engineering, and technology; and the influence of engineering, technology, and science on society and the natural world are highlighted as organizing concepts for these disciplinary core ideas. In the PS3 performance expectations, students are expected to demonstrate proficiency in asking questions, using mathematical thinking, engaging in argument from evidence, and obtaining, evaluating and communicating information; and to use these practices to demonstrate understanding of the core ideas.