Howard County Public School System
Curriculum for High School Science

Grades 10, 11, 12: Advanced Physical Science

Overview:

High school Advanced Physical Science will equip students to address the following essential questions as identified within the Next Generation Science Standards:

1. How can one explain the structure, properties, and interactions of matter?
2. How can one explain and predict interactions between objects and within systems of objects?
3. How is energy transferred and conserved?
4. How are waves used to transfer energy and send and store information?

The high school Performance Expectations (PEs) in the physical sciences address essential questions about chemistry and physics and build on middle school ideas and experiences. They blend Disciplinary Core Ideas (DCI) with Scientific and Engineering Practices (SEP) and Crosscutting Concepts (CCC) to support students in developing usable knowledge to explain real-world phenomena. In Advanced Physical Science, students regularly engage in asking scientific questions that drive their investigations and lead to increasingly sophisticated evaluation of data and their presentation. Students also have opportunities to learn and apply engineering-specific practices such as designing solutions to identified problems. Read the full NGSS storyline for Physical Sciences.

The learning sequence in Advanced Physical Science is organized around a series of driving questions that provide the context and motivation for learning. While exploring each driving question, students engage in unique learning experiences that are carefully designed to immerse them in the SEPs as they construct their understanding of important concepts. These experiences are carefully sequenced so that students encounter ideas that are developmentally and cognitively appropriate. By the end of the learning experiences, students will be able to meet the NGSS performance expectations and address the driving questions.

Performance Expectations:

The Next Generation Science Standards (NGSS), adopted as the Maryland Science Standards (MSS), are very different than previous standards documents. NGSS purposely combines the three dimensions of science learning into single, target statements for student learning known as Performance Expectations (PE). The three dimensions of science learning are: Science and Engineering Practices (SEP), Crosscutting Concepts (CCC), and Disciplinary Core Ideas (DCI). Earlier science standards treated the three dimensions as separate and distinct. This treatment led to assessment and instruction that emphasized one dimension preferentially over the others. The combination of SEP, CCC, and DCI in each PE is not intended to limit instruction.

Instead, the PEs are designed to guide assessment of student learning. The performance expectations for High School Advanced Physical Science support student learning in four main areas: *Matter and its interactions, Motion and Stability: Forces and Interactions, Energy, and Waves* and *their Applications in Technology for Information Transfer.* The performance expectations for high school Advanced Physical Science are listed below:

HS-PS1: Matter and Its Interactions
Students who demonstrate understanding can:

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.**
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.**
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.**
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.**
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.**
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.**
HS-PS1-7.	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.**
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.**

HS-PS2: Motion and Stability: Forces and Interactions
Students who demonstrate understanding can:

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.**
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.**
HS-PS2-3.	**Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.**

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.**
HS-PS2-5.	**Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.**
HS-PS2-6.	**Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.**

HS-PS3: Energy

Students who demonstrate understanding can:

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.**
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).**
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.**
HS-PS3-4.	**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 (second law of thermodynamics).**
HS-PS3-5.	**Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.**

HS-PS-4: Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

HS-PS4-1	**Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**
HS-PS4-2	**Evaluate questions about the advantages of using a digital transmission and storage of information.**
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.**
HS-PS4-4	**Evaluate the validity and reliability of claims in published materials of the**

	effects that different frequencies of electromagnetic radiation have when absorbed by matter.
HS-PS4-5	**Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.**

HCPSS Learning Sequence:

Students will continue to develop their understanding of the disciplinary core ideas in the physical sciences throughout the school year. The high school performance expectations in physical science allow high school students to explain more in-depth phenomena central to this discipline as well as to the life and Earth sciences. 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. While the performance expectations shown in high school Advanced Physical Science couple particular practices with specific disciplinary core ideas, instruction will include the use of many science and engineering practices that lead to the performance expectations.

The Advanced Physical Science course is organized into five units:

Unit 1:	Unit 2:	Unit 3:	Unit 4:	Unit 5:
Interactions between Particles	**Interactions between Objects**	**Forces, Energy, and Matter**	**Energy and Bonds**	**Electric and Electromagnetic Energy**

Students develop understanding of a wide range of topics in physical science by using the science and engineering practices and crosscutting concepts. In Unit 1: *Interactions between Particles*, students will explore the atomic-level structure of matter and interactions between particles. Students will utilize the periodic table to predict relative properties of elements.

In Unit 2: *Interactions between objects*, students will use science and engineering practices to determine the relationship between force, mass and acceleration. Students will be able to use mathematical formulas to predict the gravitational forces between objects and the electrostatic forces between charged objects.

In Unit 3: *Forces, Energy, and Matter*, students will use the science and engineering practices to investigate the conservation of momentum of two particles during a collision. Students will explore the conservation of energy of a system, and investigate the changes of energy from one form to another.

In Unit 4: *Energy and Bonds*, students will develop a mathematical model to describe the changes in energy from a chemical reaction system and investigate factors that affect rate of reactions. Students will be able to provide a mathematical evidence to support the Law of Conservation of Mass.

In Unit 5: *Electric and Electromagnetic Energy*, students will investigate electromagnetic waves including the relationship between changing electric fields and magnetic fields. Students will explore properties of waves and communicate technical information of their practical uses.