ILLINOIS STATE BOARD OF EDUCATION

SCIENCE HIGH SCHOOL PHYSICAL SCIENCES

Theory of Action: Academic standards represent a collective commitment around what students should learn each year. The state assessment asks students to demonstrate their knowledge, skills, and understanding related to these standards using a common measure. The resulting data allows us to see patterns in performance that should guide school and district improvement, helping identify areas of strength and opportunity.

Role of Performance Level Descriptors in Defining Proficiency: Performance level descriptors bridge the state assessment to classroom instruction and the systems of formative assessments that guide local instruction and choices about individual students. ***Academic proficiency represents a range of observable student performance characteristics***. There are multiple pathways to proficiency, and students rely upon their strengths differently within that range of performance.

Proficiency and Difficulty: A student's ability to demonstrate proficiency is influenced by the complexity of the texts or stimuli presented, tasks they're asked to complete, and the contexts in which they are engaged. As student performance improves, students are typically able to handle more challenging texts/stimuli, tasks, and contexts, and are able to demonstrate their skills and knowledge more accurately and consistently.

Physical Sciences *Student performance indicates the ability to…*

HS-PS1-1	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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. **SEPs**: Developing and using models **DCIs**: Structure and properties of matter **CCCs**: Patterns; Structure and function **ACT Integrations**: Interpretation of Data, Scientific Investigation	Identify basic features of the periodic table, such as groups and periods, and recognize that elements differ in properties. However, models are not yet used and there is not a description of how **electron structure** relates to those properties. Crosscutting ideas such as **patterns** or **structure-function** may not be evident in responses.	Recognize and describe **basic patterns** on the periodic table and begin to relate these to element behavior. Acknowledge that group 1 elements tend to be reactive or that metals are on the left side of the table but struggle to fully connect these patterns to **electron configurations**. Use of models and structure-based explanations is emerging but not yet consistently accurate.	Use the **periodic table as a model** to explain relationships between **electron arrangement and element properties**, such as size or reactivity. Describe patterns across groups and periods (e.g., reactivity decreases across a period) and use this to justify why elements in the same group exhibit similar behaviors. Understanding of the **disciplinary core idea of atomic structure** is supported by correct application of **crosscutting concepts** like **patterns** and **structure-function relationships**.	Apply **models of atomic structure** to make precise predictions about unfamiliar elements. Independently use the periodic table to identify patterns in **outer electron configurations** and apply them to support reasoning about **chemical reactivity or bonding** in real-world contexts. *For example, a student might explain the high reactivity of alkali metals due to their single valence electron and relate this to group trends in ionization energy.* Extend these ideas across systems, showing **pattern recognition** and **structure-function reasoning** beyond the examples provided.

HS-PS1-2	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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 patterns of chemical properties. **SEPs**: Constructing explanations and designing solutions **DCIs**: Chemical reactions; Structure and properties of matter **CCCs**: Cause and effect; Stability and change **ACT Integrations**: Scientific Investigation, Evaluation of Models/Claims	Identify basic reactants and products but may not connect these to **electron structure** or **periodic trends**. Explanations may be general and lack **scientific reasoning**. Crosscutting ideas such as **cause and effect** or **stability** are not evident, and there may not be an evidence of the use or modeling or feedback to revise thinking.	Begin to relate **reactivity** to **atomic structure** and periodic position, offering partial explanations of reaction outcomes. May describe that “elements in the same group react similarly” or mention that “some elements lose electrons,” but without full explanation. Use of the **science and engineering practice** of constructing explanations is emerging, and reasoning with **cause and effect** or **patterns** is developing.	Use evidence from the **periodic table and atomic structure** to construct explanations of chemical reactions, connecting **valence electron arrangements** to reactivity and compound formation. *For example, they may explain why halogens readily form compounds with alkali metals.* Responses show clear understanding of the **core idea** of **chemical change** and apply **cross-cutting concepts** like **cause and effect** and **conservation of matter** to explain why certain reactions occur.	Construct and refine explanations for chemical reactions using **periodic trends, electron behavior**, and **crosscutting concepts** such as **cause and effect** and **system stability**. Revise explanations using new data or feedback, connecting **molecular-level reasoning** to observed reaction outcomes. *For instance, they might explain why magnesium reacts more vigorously than calcium using a combination of electron shell reasoning and periodic trends and propose changes to reaction conditions based on **scientific practices** and understanding of **bonding energy**.*

HS-PS1-3	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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. **SEPs**: Planning and carrying out investigations **DCIs**: Structure and properties of matter; Forces and interactions **CCCs**: Scale, proportion, and quantity; Systems and system models **ACT Integration**: Scientific Investigation, Interpretation of Data	Observe and describe general properties (e.g., "this one melted faster"), but may not yet connect those observations to **atomic or molecular structure**. Investigations may be limited to basic comparisons without control of variables or reference to **forces between particles**. Use of **disciplinary core ideas**, **scientific practices**, or **crosscutting concepts** may not yet be evident.	Describe observable differences between materials and make initial attempts to investigate structure-based explanations, though designs may lack rigor or consistent measurement. *For example, may reference "strong bonds" or "closer particles" when describing solids versus liquids but struggle to connect these to specific **forces** or **particle arrangements***. **Scale and system reasoning** are beginning to appear in thinking.	Plan and carry out **structured investigations** comparing the physical properties of different substances, such as melting point or solubility, to make inferences about **intermolecular forces**. Connect observations to particle structure using **cause-and-effect reasoning**, and their conclusions reflect a clear understanding of the **disciplinary core ideas** of **structure and bonding**. Apply appropriate tools and techniques to gather and analyze data.	Design and refine **investigations** that examine the relationship between **macroscopic properties** (e.g., hardness, conductivity) and **microscopic particle interactions**. Use **quantitative measurements** to infer the strength of electrical forces, such as ionic or covalent bonds, and apply **system models** to explain these relationships. *For example, a student might measure boiling points across a set of substances and explain how molecular structure and bond types contribute to the differences.* Demonstrate strong integration of **scale** and **systems thinking**.

HS-PS1-4	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends on the changes in total bond energy. **SEPs**: Developing and using models **DCI**: Chemical reactions; Energy in chemical processes **CCCs**: Energy and matter; Systems and system models **ACT Integrations**: Evaluation of Models/Claims, Interpretation of Data	Recognize that some chemical reactions involve energy changes, such as feeling heat or observing light. However, it does not yet describe these changes in terms of **bond energy** or use models to represent reactions. Reasoning does not yet show understanding of **conservation of energy** or systems concepts.	Build **basic models** of chemical reactions, recognizing that energy is involved when bonds are broken or formed. *For example, may describe that "energy is released" in one reaction and "absorbed" in another but struggle to link this to **bond energy changes**.* Application of **system thinking** or energy conservation is emerging but not consistently accurate.	Develop **accurate models** that represent how **energy is absorbed or released** based on **changes in bond energy**. Identify reactants and products and explain how the total energy of bonds broken and formed accounts for energy transfer. Explanations reflect an understanding of **energy conservation** and system inputs/outputs, and they apply these principles to reactions like neutralization or combustion.	Create and refine **detailed models** that show how **bond energy changes** relate to the release or absorption of energy in chemical reactions. *For example, they may build a model comparing combustion and photosynthesis, clearly identifying which bonds break and form and how this accounts for the energy transfer observed*. Apply **conservation of energy**, analyze **system boundaries**, and communicate how different molecular interactions lead to different outcomes. Models demonstrate high-level reasoning across **multiple systems**.

HS-PS1-5	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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. **SEPs**: Constructing explanations and designing solutions **DCIs**: Chemical reactions; Kinetics **CCCs**: Cause and effect; Energy and matter **ACT Integrations**: Interpretation of Data, Scientific Investigation	Recognize that reaction speed can change but offer limited or inaccurate explanations. *For example, they may say, "hot things react faster" without connecting this to molecular behavior.* Explanations may not yet reflect understanding of **scientific principles**, and **cross-cutting concepts** such as energy or system interactions are not evident.	Describe trends, such as "increasing temperature makes the reaction faster," but may not explain why this happens at the particle level. Reference **concentration** or **temperature** but may not accurately apply **collision theory** or reasoning about energy input. Crosscutting concepts such as **energy** and **cause-effect** are beginning to appear but are inconsistently applied.	Explain how **temperature and concentration changes** affect **reaction rates** by referencing **particle collisions** and energy distribution. Use evidence to support claims and apply **scientific principles** like **collision theory** or **activation energy** to justify why a reaction speeds up or slows down. Reasoning reflects solid understanding of **chemical kinetics** and **energy flow**.	Provide **well-supported explanations** for how **temperature and concentration** influence **reaction rate**, referencing data, scientific principles, and molecular behavior. *For instance, they might explain how increasing temperature increases kinetic energy, leading to more frequent and effective collisions, supported by particle motion diagrams or energy distribution graphs.* Use **cause-and-effect reasoning**, apply **kinetic molecular theory**, and predict outcomes across varied conditions and systems.

HS-PS1-6	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. **SEPs**: Designing solutions; Constructing explanations **DCIs**: Chemical reactions; Equilibrium **CCCs**: Stability and change; Systems and system models; Cause and effect **ACT Integrations**: Scientific Investigation, Evaluation of Models/Claims	Recognize that reactions can reach a balance but do not yet describe how to influence the **position of equilibrium**. May suggest changes to a system without accurate predictions or reasoning. **Scientific practices**, such as evaluating models or using feedback, are not evident, and **crosscutting concepts** like **stability and change** are not yet applied.	Suggest basic changes to chemical systems (e.g., adding more reactant) and may begin referencing **equilibrium shifts**, but predictions are not always accurate or well supported. Show early understanding of **system dynamics** and **stability** but may not apply these concepts consistently in explanation or design refinement.	Specify changes in **reaction conditions, s**uch as increasing reactant concentration or decreasing temperature, and correctly predict how these affect **product yield at equilibrium**. Use **scientific reasoning** and **chemical principles** to explain these outcomes and apply **cause-and-effect reasoning** within defined system boundaries to justify their design choices.	**Refine and justify** chemical system designs by applying **equilibrium principles**, such as **Le Chatelier's Principle**, to optimize product formation. *For example, they might explain how decreasing temperature shifts equilibrium in an exothermic reaction, using **system models** and **stability/change reasoning** to support predictions.* Consider **multiple variables** (e.g., concentration, pressure) and integrate feedback, data trends, and **cross-system thinking** to propose high-impact changes across varied contexts.

HS-PS1-7	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. **SEPs**: Using mathematics and computational thinking **DCIs**: Chemical reactions; Conservation of matter **CCCs**: Systems and system models; Energy and matter **ACT Integrations**: Interpretation of Data, Data Representation	Recognize that substances change during reactions but may not understand that **atoms are conserved**. Attempts to use math or count atoms may be incorrect or incomplete. Application of the idea of **systems** or conservation principles may not be evident in their reasoning.	Begin to use math to balance equations but may miss steps or make small errors. Understand that mass should be conserved and may make general statements like "you can't lose atoms," but may not connect the math to the **principle of conservation** in a system. Use of **system thinking** and **mathematical modeling** is developing.	Balance chemical equations and apply **mathematics** to support the idea that **mass is conserved** during chemical reactions. *For example, they show how the number of atoms on each side of the equation is the same, supporting the idea that matter cannot be created or destroyed.* Use **system models** to define the reaction space and apply the **disciplinary core idea** with consistency.	Use **mathematical representations**, such as balanced chemical equations and system models, to **demonstrate conservation of mass** across complex or multi-step reactions. Accurately calculate and explain how atom counts remain consistent and interpret results within **system boundaries**, using principles of **matter conservation** and **quantitative reasoning** to support claims about chemical processes across different reaction types.

HS-PS2-1	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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. **SEPs**: Analyzing and interpreting data **DCIs**: Forces and motion **CCCs**: Cause and effect; Scale, proportion, and quantity **ACT Integrations**: Interpretation of Data, Scientific Investigation	Recognize that force affects motion but may not understand how **mass and acceleration** are involved. May describe motion changes without analyzing data or applying **mathematical relationships**, and their explanations. May not yet demonstrate clear understanding of **scientific principles** or **crosscutting concepts**.	Describe how force and motion are connected using simple data (e.g., "more force makes it move faster"), but may not consistently apply the **F=ma** relationship or interpret trends accurately. Begin to reason about **cause and effect** but may not yet support claims using full **quantitative reasoning**.	Use data from **investigations** or models to explain how **force, mass, and acceleration** are mathematically related. *For example, they might describe how doubling the net force on a cart doubles its acceleration if mass stays the same.* Consistently apply **Newton's Second Law**, demonstrating understanding of **proportional relationships** and **causal mechanisms** in motion.	Analyze and interpret **data from multiple sources** (e.g., motion graphs, force sensors) to demonstrate how **Newton's Second Law** (F=ma) predicts object motion. Model how changing one variable affects the others and apply the law in new contexts, such as analyzing friction or inclined planes. Explanations demonstrate **cause-effect reasoning** and **quantitative thinking** across scales, integrating multiple data types to support a scientific claim.

HS-PS2-2	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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. **SEPs**: Using mathematics and computational thinking **DCIs**: Forces and interactions; Conservation of momentum **CCCs**: Systems and system models; Stability and change **ACT Integrations**: Data Representation, Interpretation of Data	May recognize that objects can transfer motion but do not yet understand or apply the concept of **momentum conservation**. May not define a **system** or use equations to support their ideas, and reasoning may lack **scientific or crosscutting coherence**.	Begin calculating momentum or describe momentum conservation in simple systems (e.g., two carts colliding), but may not define the system accurately or apply formulas consistently. Reference ideas like "total momentum stays the same" but lack clear justification or mathematical accuracy.	Calculate momentum before and after interactions to show that **total momentum is conserved** in a system where no external force acts. Clearly define system components and apply the formula p=mv appropriately, using **mathematical thinking** and **system reasoning** to support claims about conservation.	Use **mathematical models** to analyze and compare momentum across different types of collisions (elastic and inelastic), explaining how momentum is conserved even when energy is transformed. Define **system boundaries**, justify conservation using **quantitative reasoning**, and apply the concept of **system stability** to novel or real-world problems, such as vehicle safety or sports physics.

HS-PS2-3	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. **SEPs**: Constructing explanations and designing solutions **DCIs**: Forces and interactions; Engineering design **CCCs**: Cause and effect; Systems and system models **ACT Integrations**: Scientific Investigation, Evaluation of Models/Claims	Suggest ways to reduce damage in collisions (e.g., "use cushions") but may not yet explain how these changes relate to **scientific principles** like force or time of impact. May not apply **engineering practices** and **systems-based reasoning**.	Propose designs with the goal of reducing force in a collision and may reference simple ideas such as padding or slowing down impact. Begin to apply **engineering ideas** but may not fully explain how their design uses **force or motion concepts**. Reasoning includes elements of **cause-effect** but lacks depth or coherence.	Apply scientific principles of **momentum and force** to create or evaluate devices that **minimize impact force**. Use **engineering design practices**, including identifying constraints, testing prototypes, and using data to support decisions. Explanations reflect understanding of **cause and effect** and show how the device changes the motion or force acting on an object during a collision.	Design and refine **collision-reducing devices** by applying principles from **force and momentum change**, conducting **iterative testing**, and optimizing based on performance data. *For example, they may explain how increasing the time of impact in a crumple zone reduces the force on a passenger and model this interaction using diagrams or data.* Apply **system thinking** and integrate **cause-and-effect reasoning** to explain how each design component contributes to overall safety.

HS-PS2-4	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. **SEPs**: Using mathematics and computational thinking **DCIs**: Forces and interactions **CCCs**: Scale, proportion, and quantity; Patterns **ACT Integrations**: Data Representation, Interpretation of Data	May identify that gravity or charge can create attraction or repulsion but cannot yet describe or calculate these forces using **mathematical representations**. Understanding of **scaling laws** or patterns in force interactions is not demonstrated.	Begin to use formulas for gravitational or electrostatic forces but may not apply them accurately or interpret the results correctly. Recognize that mass and charge affect force but may not describe **proportional relationships** fully. Use of **mathematical models** and **crosscutting concepts** like scale is developing.	Use mathematical equations to **describe gravitational or electrostatic forces** between objects and correctly identify relationships such as "force increases as distance decreases." Interpret and use **quantitative relationships** to support claims and apply formulas like $F = G(m_1m_2)/r^2$ and $F = k(q_1q_2)/r^2$, demonstrating understanding of **patterns** and **scale** in physical systems.	Apply **Newton's Law of Gravitation** and **Coulomb's Law** in **mathematical models** to analyze and predict **force magnitudes** across varying distances and charges. Explain how changes in mass, charge, or distance affect the resulting force, and extend these models to novel contexts (e.g., satellites or charged particles). Use the **inverse-square law** concept and understand how **proportional relationships** affect interactions across scales.

HS-PS2-5	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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. **SEPs**: Planning and carrying out investigations **DCIs**: Electromagnetic interactions **CCCs**: Cause and effect; Energy and matter; Systems and system models **ACT Integrations**: Scientific Investigation, Interpretation of Data	Make general observations about electricity and magnetism but may not yet conduct effective investigations or connect evidence to the idea of **electromagnetic interactions**. Explanations may be vague (e.g., "the magnet made it move") and lack use of **crosscutting concepts** or **disciplinary reasoning**.	Conduct basic investigations that show effects like "a wire gets a magnetic field" or "a magnet can cause current" but may not control variables or explain the **mechanism of induction** clearly. Reasoning shows the initial use of **scientific practices**, and concepts such as **energy flow** or **system models** begin to emerge.	Plan and conduct investigations that provide evidence for the reciprocal relationship between **electric currents and magnetic fields**. *For example, they may demonstrate that a wire carrying current deflects a compass needle, or that moving a magnet through a coil generates current.* Work reflects understanding of **cause and effect**, and they control variables to isolate effects in the system.	Design and carry out investigations showing **electromagnetic induction**, using clear **variable control**, data collection, and evidence-based conclusions. Explain how changing a magnetic field induces current in a wire coil, or how running current through a conductor produces a magnetic field, using both **observational evidence** and conceptual models. Apply **energy transfer reasoning** and systems thinking to predict and explain phenomena across contexts, such as power generation or magnetic storage.

HS-PS3-1	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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 the energy flows in and out of the system are known. **SEPs**: Using mathematics and computational thinking; Developing and using models **DCIs**: Definitions of energy; Conservation of energy and energy transfer **CCCs**: Energy and matter; Systems and system models **ACT Integrations**: Data Representation, Scientific Investigation	May describe energy changes (e.g., "energy goes to light and heat") but may not yet use **computational models** or calculations. Understanding of **energy conservation** is limited, and may not apply **systems reasoning** to track energy flows between components.	Attempt to model energy changes using basic formulas or diagrams but may miscalculate or omit key components. Recognize that energy transfers affect systems but may not define the **system boundaries** clearly or apply the **conservation principle** consistently. Models show early awareness of **energy and matter** and **system interactions**.	Create **computational models** that show how changes in one part of a system affect energy levels in another. *For example, they may calculate how energy lost as heat in a motor affects the usable energy output.* Models reflect an understanding of **energy conservation**, and they consistently apply **system boundaries** and **inputs/outputs** in their analysis.	Develop and apply **computational models** to track **energy flow** through complex systems, such as ecosystems or mechanical systems, adjusting for multiple variables and energy transfers. Accurately calculate how energy changes in one component affect others, using **quantitative analysis** and applying the **principle of conservation of energy**. Reasoning incorporates **systems thinking** and may include real-world applications like power grid efficiency or thermal system design.

HS-PS3-2	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields. **SEPs**: Developing and using models **DCIs**: Definitions of energy; Conservation of energy and energy transfer **CCCs**: Energy and matter; Scale, proportion, and quantity **ACT Integrations**: Evaluation of Models/Claims, Interpretation of Data	Recognize that energy exists in systems but cannot yet distinguish clearly between **motion-based** and **field-based** energy. May describe surface features (e.g., “the ball moves”) without showing understanding of **energy transfer**, particle motion, or system interactions.	Describe different forms of energy and attempt to link **macroscopic observations** (e.g., movement, heat) to **microscopic causes** (e.g., particle motion), but models may be oversimplified or lack explanation of field-based energy. Application of **scale** and **energy transformation** is emerging but inconsistent.	Develop and use **models** to show that **energy at larger scales** (like motion, heat, or electricity) can be explained by the movement of particles or by energy stored in fields. *For example, they might explain that thermal energy results from particle motion or that lifting an object stores energy in a gravitational field.* Models reflect understanding of **energy conservation** and **system-level thinking**.	Construct **refined models** that accurately distinguish **kinetic and potential energy** and connect **macroscopic behavior** (like the motion of a pendulum or a rollercoaster) to **molecular motion** or **field interactions** (like gravitational or magnetic fields). Explain how energy shifts between forms in a system and apply their models across different scales and contexts using **energy tracking** and **quantitative reasoning**.

HS-PS3-3	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. **SEPs**: Designing solutions; Constructing explanations **DCIs**: Definitions of energy; Conservation of energy and energy transfer; Engineering design **CCCs**: Systems and system models; Energy and matter; Cause and effect **ACT Integrations**: Scientific Investigation, Engineering Practices	Describe examples of energy conversion but may not demonstrate an ability to design or build a device that meets a specific **constraint**. May not explain **how or why** the energy changes form, and do not yet apply **scientific or engineering reasoning** in their approach.	Build **simple devices** that perform basic energy conversions, such as lighting a bulb with a battery. May describe the form of energy being used but do not fully explain **how the conversion occurs** or how to improve efficiency. Use of **cause and effect** and **system reasoning** is emerging but limited.	Design and build **functioning devices** (e.g., wind turbines, electric circuits) that convert one type of energy into another. Explain the conversion process (e.g., mechanical to electrical), evaluate performance against **constraints**, and use evidence to support revisions. Designs reflect understanding of **energy conservation**, system boundaries, and **engineering design** practices.	Design, build, and improve **energy-conversion devices** using **scientific reasoning** and **engineering design principles**, refining their systems based on test results and **efficiency data**. *For instance, they might create a solar-powered water heater and explain how design choices affect energy capture and conversion.* Work demonstrates **crosscutting concept integration** such as energy flow, system optimization, and feedback loops.

HS-PS3-4	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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 (second law of thermodynamics). **SEPs**: Planning and carrying out investigations **DCIs**: Conservation of energy and energy transfer; Second law of thermodynamics **CCCs**: Energy and matter; Stability and change; Systems and system models **ACT Integrations**: Scientific Investigation, Interpretation of Data	May observe that objects become warmer or cooler but cannot yet explain or investigate how **thermal energy** moves or why **temperature equalizes**. May not demonstrate understanding of **system constraints**, energy distribution, or the **second law of thermodynamics**.	Investigate **temperature changes** during energy transfer but may not fully connect their findings to **system boundaries** or to the concept of **energy equilibrium**. Make general statements like "heat moves from hot to cold" but may not apply this to **evidence-based reasoning** or broader scientific principles.	Plan and conduct investigations that show **thermal energy moves** from warmer to cooler substances and reaches **equilibrium** in a **closed system**. Use **data collection tools** and analyze evidence to describe how energy distribution becomes more uniform. Conclusions reflect understanding of **energy conservation** and **system stability** as described in the **second law of thermodynamics**.	Design and carry out **controlled investigations** to gather evidence showing how **thermal energy transfers** between substances until equilibrium is reached. Precisely measure temperature change over time, consider **heat capacity**, and use **data** to explain how energy is distributed in closed systems. Conclusions connect to the **second law of thermodynamics**, using **systems reasoning** and recognizing **energy flow** patterns across different materials and situations.

HS-PS3-5	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Develop and use a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. **SEPs**: Developing and using models **DCIs**: Conservation of energy and energy transfer; Forces and interactions **CCCs**: Energy and matter; Systems and system models; Cause and effect **ACT Integrations**: Evaluation of Models/Claims, Interpretation of Data	Recognize that some objects can store energy (e.g., "a spring pops back"), but may not yet describe **how object arrangement affects energy storage**. Models may not distinguish between **kinetic and potential energy**, and there may not be evidence of application of concepts like **systems** or **field interactions**.	Describe that potential energy changes when object positions change but may oversimplify or misrepresent how the energy is stored in a **field**. Models may be visual or verbal but lack accurate explanation of how **interactions at a distance** relate to **energy**.	Use models to show that when the **position of interacting objects** changes, the **potential energy** in the system also changes. Accurately describe examples such as "a stretched spring stores more energy" or "lifting a weight stores energy in the gravitational field," applying **cause-and-effect reasoning** and understanding of **system energy storage**.	Create and apply **dynamic models** to describe how **potential energy** changes with **object arrangement** in systems involving **gravitational, electric, or magnetic fields**. *For example, they may model how lifting an object, charging a capacitor, or moving magnets apart increases stored energy.* Explain reasoning using **system boundaries**, **field interactions**, and **energy conservation**, and extend models across **multiple physical systems**.

HS-PS4-1	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. **SEPs**: Using mathematics and computational thinking **DCIs**: Wave properties **CCCs**: Patterns; Energy and matter; Scale, proportion, and quantity **ACT Integrations**: Data Representation, Interpretation of Data	Recognize that waves can have height or strength but do not yet connect this to **energy** or use **math models** to describe wave behavior. May describe wave properties in basic terms but cannot explain their relationship using scientific principles.	Describe or graph basic wave features such as amplitude or frequency and may make general statements like "taller waves have more energy," but may not consistently apply **mathematical representations** or relate these to **energy principles**. Understanding of **scale** or **patterns** is beginning to emerge.	Apply **math formulas or graphs** to describe the relationship between **wave amplitude and energy**. Explain that greater amplitude means more energy and demonstrate this using wave diagrams or data tables. Understanding reflects the **core idea of wave properties**, and they accurately use **crosscutting concepts** such as **scale** and **energy transfer** to explain the interaction.	Use **mathematical models** to describe the relationship between **amplitude and energy** across multiple types of waves (e.g., sound, light, seismic), making comparisons across **scales** and applying their understanding to real-world examples such as sound systems or earthquake energy. Recognize and analyze **patterns** in data, explain how wave energy increases with amplitude, and justify reasoning using **proportional reasoning** and **energy transfer concepts**.

HS-PS4-2	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Evaluate questions about the advantages of using digital transmission and storage of information. **SEPs**: Asking questions and defining problems; Evaluating information **DCIs**: Information technologies and instrumentation **CCCs**: Systems and system models; Stability and change; Structure and function **ACT Integrations**: Evaluation of Models/Claims, Scientific Investigation	Identify that information can be sent or stored but may not distinguish clearly between **digital and analog systems** or evaluate their advantages. Responses do not demonstrate **crosscutting concepts** or connections to **technological design**.	Recognize differences between **digital and analog** signals and may describe surface-level advantages (e.g., "digital is clearer"), but evaluations are limited to basic reasoning or examples. Application of **system thinking** and **structure-function** is developing but not yet well integrated.	Analyze and evaluate questions about **digital systems**, identifying **advantages** like clarity, reliability, or the ability to store and transmit information without loss. Compare digital systems to analog ones and apply **scientific reasoning** and **crosscutting concepts** like **system design** and **stability** to support conclusions.	**Critically evaluate** a wide range of **questions and claims** related to **digital transmission**, including how digital signals improve **reliability, error correction, and efficiency**. Explain how system design affects data storage or communication and compare digital and analog systems using concepts like **signal fidelity**, **noise**, and **compression**. Reasoning integrates **system modeling** and **structure-function thinking** across technological applications.

HS-PS4-3	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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. **SEPs**: Engaging in argument from evidence; Evaluating models **DCIs**: Electromagnetic radiation **CCCs**: Systems and system models; Scale, proportion, and quantity; Structure and function **ACT Integrations**: Evaluation of Models/Claims	May recall that light has wave or particle properties but may not explain or evaluate the usefulness of either model. **Evidence or context** may not connect to model selection and may not demonstrate understanding of **scientific modeling** or **evidence-based argumentation**.	Recognize that light can behave like both a **wave and a particle** but may struggle to explain **why or when** each model applies. Refer to evidence but may not evaluate it effectively or apply reasoning consistently. Understanding of model use is emerging.	Compare the **wave and particle models** of light and evaluate which one better explains a given situation. *For instance, they might explain that light behaves like a wave in diffraction experiments but like a particle in the photoelectric effect.* Reasoning includes appropriate use of **scientific evidence** and **crosscutting concepts** like **systems and models**.	Evaluate competing models of **electromagnetic radiation**, using **evidence** from contexts like the photoelectric effect or interference patterns to justify which model (wave or particle) is more useful. Recognize the **limitations and strengths** of each model and explain how scientific reasoning depends on **scale** and **phenomenon type**. Evaluation incorporates **structure-function reasoning** and critiques both the data and the underlying scientific claims.

HS-PS4-4	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. **SEPs**: Engaging in argument from evidence; Evaluating information **DCIs**: Electromagnetic radiation; Effects of radiation **CCCs**: Cause and effect; Scale, proportion, and quantity; Structure and function **ACT Integrations**: Interpretation of Data, Evaluation of Claims	Describe some interactions between radiation and matter but may not evaluate claims or distinguish between **types of radiation**. May not yet consider **energy levels**, **wavelength**, or the **validity of sources**, and their reasoning lacks connection to **scientific principles**.	Identify basic effects of EM radiation (e.g., "microwaves heat food") and may recognize that **higher-frequency waves carry more energy**, but evaluations of published claims are surface-level or unsupported. Use of **scientific evidence** or attention to **scale and reliability** is emerging but inconsistent.	Assess claims about how **electromagnetic radiation** interacts with matter by comparing **frequency and energy** levels. Provide evidence (e.g., "UV light can damage DNA, while radio waves do not") and explain why some types of radiation have greater effects. Reasoning reflects understanding of **structure-function relationships**, and they apply **cause-and-effect logic** to determine which claims are scientifically valid.	**Critically evaluate** scientific and media-based claims about how **different frequencies of EM radiation** affect materials, referencing **specific evidence**, including absorption rates, health impacts, or energy transfer. Assess **reliability of sources**, compare **frequencies and effects** (e.g., UV vs. visible light), and explain how **wavelength and energy** interact with matter. Evaluations demonstrate a strong grasp of **cause-effect relationships** and **scaling laws**, supported by **quantitative and qualitative analysis**.

HS-PS4-5	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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. **SEPs**: Obtaining, evaluating, and communicating information **DCIs**: Wave properties; Information technologies **CCCs**: Structure and function; Systems and system models; Energy and matter **ACT Integrations**: Scientific Investigation, Evaluation of Models/Claims	Mention that devices use waves but may not explain how or why. May confuse types of waves or misrepresent how **information is transmitted** and may not yet use **scientific reasoning** or **technical vocabulary** in their communication.	Describe general wave behaviors (e.g., "waves bounce or travel") and mention that devices use these, but explanations lack clarity or precision. *For example, they may state "a cell phone sends waves" without specifying how.* Communication includes **relevant ideas** but may lack **detail**, and understanding of **energy transfer** or **device systems** is partial.	Accurately explain how specific technologies (e.g., radios, ultrasound, or satellite dishes) rely on **wave properties** to function. Describe how **wave interactions** support the transmission and reception of information or energy, using correct **scientific vocabulary** and clear reasoning. Communication reflects understanding of **structure-function relationships** and how devices operate within **systems**.	Communicate **clear, precise technical explanations** of how devices (e.g., fiber optics, sonar, wireless routers) use **wave interactions**—like **reflection, refraction, absorption, or interference**—to transmit signals or capture energy. Include diagrams, signal processing steps, or comparative designs to explain how these technologies function within a **system**. Communication demonstrates a strong understanding of **energy flow**, **wave behavior**, and **design constraints** across technologies.