Kentucky Alternate Assessment

Kentucky Department of
EDUCATION

Kentucky Academic Standards
Alternate Assessment Targets

Science Grade 11

INTRODUCTION

Background on the Kentucky Academic Standards for Science

In a world that is becoming increasingly complex, it is important that students have the knowledge and understanding to engage in public discussions around issues infused in science. The *Framework for K-12 Science Education* outlines three dimensions that, when used together, support students' deep understanding of the sciences, how science knowledge is acquired and understood and how the sciences are all connected through concepts that have a common application across the disciplines.

Promoting scientific literacy in an equitable and quality manner for *all* students is an ideal worthy of focused attention and continued effort. Equitable access to high-quality educational standards provides common expectations for all students and equips students with the strong science-based skills, including critical thinking and inquiry-based problem-solving, to be scientifically literate and succeed in college, careers and citizenship.

Engineering is taking science and applying it to create solutions that benefit society and the environment. The *Kentucky Academic Standards for Science* represents a commitment to integrate engineering thinking through engineering design practices into the structure of science education from kindergarten through grade 12 by raising engineering design thinking to the same level as scientific inquiry when teaching science disciplines. Providing all students with a foundation in engineering design allows them to better engage in and aspire to solve major societal and environmental challenges they will face in the decades ahead and to engage in public discussions on science-related issues related to their everyday lives.

Kentucky's Vision for Students

Knowledge about science and the ability to be critically educated consumers of scientific information related to their everyday lives directly aligns with the vision of the Kentucky Board of Education (KBE). The board's vision is that each and every student is empowered and equipped to pursue a successful future. To equip and empower students, the following capacity and goal statements frame instructional programs in Kentucky schools. These statements were established by the Kentucky Education Reform Act (KERA) of 1990, as found in Kentucky Revised Statute (KRS) 158.645 and KRS 158.6451, stating that all students shall have the opportunity to acquire the following capacities and learning goals:

- Communication skills necessary to function in a complex and changing civilization;
- Knowledge to make economic, social and political choices;
- Core values and qualities of good character to make moral and ethical decisions throughout life;
- Understanding of governmental processes as they affect the community, the state and the nation;
- Sufficient self-knowledge and knowledge of their mental health and physical wellness;
- Sufficient grounding in the arts to enable each student to appreciate their cultural and historical heritage;
- Sufficient preparation to choose and pursue their life's work intelligently; and
- Skills to enable students to compete favorably with students in other states

Furthermore, schools shall:

- Expect a high level of achievement from all students.
- Develop their students' ability to:
  - Use basic communication and mathematics skills for purposes and situations they will encounter throughout their lives;
  - Apply core concepts and principles from mathematics, the sciences, the arts, the humanities, social studies and practical living studies to situations they will encounter throughout their lives;
  - Become self-sufficient individuals of good character exhibiting the qualities of altruism, citizenship, courtesy, hard work, honesty, human worth, justice, knowledge, patriotism, respect, responsibility and self-discipline;
  - Become responsible members of a family, work group or community, including demonstrating effectiveness in community service;
  - Think and solve problems in school situations and a variety of other situations they will encounter in life;
  - Connect and integrate experiences and new knowledge from all subject matter fields with what students have previously learned and build on past learning experiences to acquire new information through various media sources; and
  - Express their creative talents and interests in visual arts, music, dance and dramatic arts.
- Increase student attendance rates.
- Increase students' graduation rates and reduce dropout and retention rates.
- Reduce physical and mental health barriers to learning.
- Be measured on the proportion of students who make a successful transition to work, postsecondary education and the military.

To ensure legal requirements of science classes are met, the Kentucky Department of Education (KDE) encourages schools to use the *Model Curriculum Framework* to ensure curricular coherence in the development of curricula that meet the grade-level expectations set forth by standards. The Model Curriculum Framework describes curricular coherence as the "local alignment of the standards, curriculum, instructional resources, assessment and instructional practices within and across grade-levels in a school or district to help students meet grade-level expectations."

Legal Basis

The following KRS and Kentucky Administrative Regulations (KAR) provide a legal basis for this publication:

> **KRS 156.160 Promulgation of administrative regulations by the Kentucky Board of Education**
> With the advice of the Local Superintendents Advisory Council (LSAC), the KBE shall promulgate administrative regulations establishing standards that public school districts shall meet in student, program, service and operational performance. These regulations shall comply with the expected outcomes for students and schools set forth in KRS 158:6451.

KRS 158.6453 Review of academic standards and assessments

Beginning in fiscal year 2017-2018, and every six (6) years thereafter, the Kentucky Department of Education shall implement a process for reviewing Kentucky's academic standards and the alignment of corresponding assessments for possible revision or replacement to ensure alignment with post-secondary readiness standards necessary for global competitiveness and with state career and technical education standards. The revisions to the content standards shall:

1. Focus on critical knowledge, skills, and capacities needed for success in the global economy;
2. Result in fewer but more in-depth standards to facilitate mastery learning;
3. Communicate expectations more clearly and concisely to teachers, parents, students and citizens;
4. Be based on evidence-based research;
5. Consider international benchmarks; and
6. Ensure that the standards are aligned from elementary to high school to post-secondary education so that students can be successful at each education level.

704 KAR 3:305 Minimum high school graduation requirements

This administrative regulation establishes the minimum high school graduation requirements necessary for entitlement to a public high school diploma.

704 KAR 008:120 Kentucky Academic Standards for Science

This administrative regulation adopts into law the *Kentucky Academic Standards for Science*.

Standards Creation Process

Per KRS 158.6453, the *Kentucky Academic Standards for Science* were entirely conceived and written by teams of Kentucky educators. Kentucky teachers understand that elementary and secondary academic standards must align with postsecondary readiness standards and state career and technical education standards. This focus helps ensure that students are prepared for the jobs of the future and can compete with students from other states and nations.

The Science Advisory Panel (AP) was composed of 28 teachers, three public post-secondary professors from institutes of higher education and three community members. The function of the AP was to review public comments on the existing standards and make recommendations for changes to a Review Committee (RC). The Science RC was composed of six science teachers, two public post-secondary professors from institutes of higher education and three community members. The function of the Science RC was to review the work and findings from the AP and make recommendation to revise or replace existing standards.

The team was selected based on their expertise in the field of science and their role as practicing science teachers. When choosing writers, the selection committee considered state-wide representation for public elementary, middle and high school teachers as well as higher education instructors and community members.

Writers' Vision Statement

The writing team was guided by a vision for equitable science education in Kentucky that begins in kindergarten and progresses yearly through grade 12 to ensure that all students possess sufficient understanding of the science and engineering practices, crosscutting concepts and core ideas of science to engage in public discussions on science-related issues and are critically educated consumers of scientific information related to their everyday lives. To achieve this, *all* students at *all* grade levels must experience multiple sustained and authentic learning opportunities to investigate phenomena, engage in collaborative conversations and reflect the diversity encountered within the classroom in the local community and across the globe.

To meet this vision, the writers recognize that students need sustained opportunities to work with and develop the ideas that underly science and engineering practices and to appreciate how those ideas are interconnected over a period of years rather than weeks or months. Students should be provided multiple, ongoing opportunities to engage with the interconnectedness of the three dimensions of science as they work to make sense of the natural world. To assist teachers in this endeavor, the writers recommend that teachers at all grade levels have ongoing access to high-quality professional learning and resources about science.

The KDE provided the following foundational documents to inform the writing team's work:

- Bell, P. (2019). Infrastructuring Teacher Learning about Equitable Science Instruction. *Journal of Science Teacher Education*, *30*(7), 681–690. https://doi.org/10.1080/1046560X.2019.1668218
- Bell, P. & Bang, M. (2015). *STEM Teaching Tool #15 Overview: How can we promote equity in science education?* http://stemteachingtools.org/brief/15
- Michaels, S., Shouse, A., & Schweingruber, H. (2008). Ready, Set, SCIENCE!: Putting Research to Work in K-8 Science Classrooms. The National Academies Press. https://www.nap.edu/catalog/11882/ready-set-science-putting-research-to-work-in-k-8
- Morrison, D. & Bell, P. (2018). *STEM Teaching Tool #54 How to build an equitable learning community in your science classroom.* http://stemteachingtools.org/brief/54
- National Research Council. (2012). *A Framework for K-12 Science Education Practices, Crosscutting Concepts, and Core Ideas.* https://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts
- NGSS Lead States. (2013). *The Next Generation Science Standards: For States, By States.* Appendix D: All Standards, All Students. https://www.nextgenscience.org/sites/default/files/Appendix%20D%20Diversity%20and%20Equity%206-14-13.pdf
- NGSS Lead States. (2013). *The Next Generation Science Standards: For States, By States.* Appendix E: DCI Progressions in the NGSS. https://www.nextgenscience.org/sites/default/files/resource/files/AppendixE-ProgressionswithinNGSS-061617.pdf
- NGSS Lead States. (2013). *The Next Generation Science Standards: For States, By States.* Appendix F: Science and Engineering Practices. https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf

- NGSS Lead States. (2013). *The Next Generation Science Standards: For States, By States.* Appendix G: Crosscutting Concepts. https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
- Review of state academic documents and frameworks (Alaska, Arizona, Massachusetts, New York, Oklahoma, South Dakota, Tennessee, Utah).
- Duncan, R., Krajcik, J., & Rivet, A. (Eds.). (2017). *Disciplinary Core Ideas Reshaping Teaching and Learning*. NSTA Press.
- Schwarz, C., Passmore, C., & Reiser, B. (Eds.). (2017). *Helping Students Make Sense of the World Using Next Generation Science and Engineering Practices.* NSTA Press.

Additionally, participants brought their own knowledge to the process. The writers also thoughtfully considered feedback from the public and science community.

Design Considerations

Design considerations were informed by research, public comment and review of science standards from other states. A recurring theme reported from the first round of public comment was the desire to have more clarity about what specific performance expectations required. Upon examination, it was determined that examples and further information were provided but that the information was not readily accessible. This resulted in a redesign of the layout to address this concern.

Three-Dimensional Science

Understanding science and how it works goes beyond knowing discrete pieces of information. To meet the vision of scientifically literate students, the integration of the three dimensions of science, as outlined in the *Framework for K-12 Science Education*, must be maintained. These dimensions are:

- Science and Engineering Practices – describe the methods and way that:
  - Scientists investigate and develop models about the natural world and
  - Engineers design and build systems;
- Crosscutting Concepts – intellectual tools that students can draw from as they begin to investigate the natural/designed world;
- Disciplinary Core Ideas – ideas that have broad importance across multiple sciences or a key principle in a discipline

For students to develop a deep understanding of the core ideas, they must engage in exploring the natural and designed world. This is accomplished through the use of the practices and the crosscutting concepts. While only a subset of science and engineering practices and crosscutting concepts are explicitly identified as the mechanism for how students demonstrate mastery of a performance expectation at the end of instruction, students should still use all of the science and engineering practices and crosscutting concepts as they develop their understanding of each disciplinary core idea.

Engineering, Technology and Application of Science

The linkage between learning science and learning engineering is demonstrated within the *Kentucky Academic Standards for Science*.

> *Just as new science enables or sometimes demands new technologies, new technologies enable new scientific investigations, allowing scientists to probe realms and handle quantities of data previously inaccessible to them. It is impossible to do engineering today without applying science in the process, and, in many areas of science, designing and building new experiments requires scientists to engage in some engineering practices. This interplay of science and engineering makes it appropriate to [include] engineering and technology.* (National Research Council, 2012)

Engineering design in the earliest grades introduces students to "problems" as situations that people want to change. They can use tools and materials to solve simple problems, use different representations to convey solutions, and compare different solutions to a problem and determine which is best. Students in all grade levels are not expected to come up with original solutions, although original solutions are always welcome. Emphasis is on thinking through the needs or goals that need to be met, and which solutions best meet those needs and goals.

For those engineering design standards with no crosscutting concepts identified, the crosscutting concept will be identified by the nature of the problem chosen.

Clarification Statements and Assessment Boundaries

A recurring theme reported from the first round of public comment was the desire to have more clarity about what specific performance expectations required. Most of the performance expectations defined in the *Kentucky Academic Standards for Science* include clarification statements and assessment boundaries. Clarification statements are one or two sentences that provide examples or particular emphasis that can assist in further understanding of the intent and in developing instructional experiences. Assessment boundaries define the limits of large-scale assessment. This, however, does not limit assessment practices within the classroom.

Science for All

The vision set forth by the writers emphasizes that "*all* students will possess sufficient understanding … to engage in public discussion … and be critically educated consumers of scientific information." The *Kentucky Academic Standards for Science*, written as performance expectations, imply that students will be active participants in the scientific and engineering process. The inclusion of the science and engineering practices "offer rich opportunities and demands for language learning while they support science learning for all students" (Appendix D, p. 5).

The crosscutting concepts demonstrate the interrelatedness of scientific concepts, which is often seen as implied background knowledge – knowledge that derives from experiences that not all students have access to. As noted in Appendix D of the Next Generation Science Standards (NGSS), "Explicit teaching of the crosscutting concepts enables less privileged students … to make connections among big ideas that cut across science disciplines" (Appendix D, p. 6). As such, the multidimensionality demonstrated in the *Kentucky Academic Standards for Science* levels the playing field for all students to actively engage in scientific sensemaking and engineering design.

Standards Use and Development

The Kentucky Academic Standards Are Standards, Not Curriculum

The *Kentucky Academic Standards for Science* outlines the minimum standards Kentucky students should learn in each grade level kindergarten through eighth grade or high school grade-span. The standards address a foundational framework of what is to be learned, but do not address how learning experiences are to be designed or what resources should be used.
A standard represents a goal or outcome of an educational program; standards are vertically aligned expected outcomes for all students. The standards do not dictate the design of a lesson plan or how units should be organized. The standards establish a statewide baseline of what students should know and be able to do at the conclusion of a grade or grade-span. The instructional program should emphasize the development of students' abilities to acquire and apply the standards. The curriculum must ensure that appropriate accommodations are made for diverse populations of students found within Kentucky schools.

These standards are not a set of instructional or assessment tasks, but rather statements of what students should be able to master after instruction. Decisions on how best to help students meet these program goals are left to local school districts and teachers. Curriculum includes the vast array of instructional materials, readings, learning experiences and local mechanisms of assessment, including the full body of content knowledge to be covered, all of which are to be selected at the local level according to Kentucky law.

Translating the Standards into Curriculum

The Kentucky Department of Education does not require specific curricula or strategies to be used to engage students in the *Kentucky Academic Standards*. Local schools and districts choose to meet the minimum required standards using a locally adopted curriculum according to KRS 160.345, which outlines the method by which the curriculum is to be determined. As educators implement academic standards, they, along with community members, must guarantee postsecondary readiness that will ensure all learners are transition ready. To achieve this, Kentucky students need a curriculum designed and structured for a rigorous, relevant and personalized learning experience, including a wide variety of learning opportunities. The Kentucky *Model Curriculum Framework* is a resource to support districts and schools in the continuous process of designing and reviewing local curriculum.

Organization of the Standards

The *Kentucky Academic Standards for Science* are organized by grade level for kindergarten through grade 8, with high school standards being grade banded. Within each grade level/band, the performance expectations are organized around the disciplinary core ideas, resulting in a coherence of understanding as students move through their academic career. This, in turn, provides for greater flexibility for arranging the performance expectations in a grade level in a way that best represents the needs of schools and districts without sacrificing coherence.

The National Research Council, the functional staffing of the National Academies of Science, released the *Framework for K-12 Science Education* in 2011, which is the research base that was used in the development of the science standards. The framework provides that a quality science education for K-12 students integrates the three dimensions of science: science and engineering practices, disciplinary core ideas and the crosscutting concepts.

This results in the *Kentucky Academic Standards for Science* being written at the intersection of these three dimensions and being described as performance expectations students are required to demonstrate to show mastery. These dimensions describe the processes of doing science, the structure that helps organize and connect understanding and the deep knowledge that provides predictive power. Taken together, these represent how we use science to make sense of the natural/designed world and are most meaningful when learned in concert with one another.

Science and Engineering Practices: Practices refer to the way in which scientists and engineers engage in their work. They engage in wonder, design, modeling, argumentation, communication, and engineering thinking. While a specific practice may be identified in each performance expectation, students should engage in all practices because this helps them understand how scientific knowledge develops and the links between science and engineering.

Disciplinary Core Ideas: Core ideas found in the *Kentucky Academic Standards for Science* are foundational understandings so that students may later acquire additional information on their own. The core ideas are organized within physical, life and earth/space science, which are traditionally associated with science knowledge. Also found here are the ideas used in the engineering design process, identified as ETS (engineering, technology, and application of science).

Crosscutting Concepts: Crosscutting concepts are conceptual tools that are used as lenses for understanding the natural/designed world. They provide ways of thinking and reasoning about phenomena across disciplines, uniting core ideas throughout the fields of science and engineering. While specific crosscutting concepts may be identified in each performance expectation, explicit instruction and engagement in all of the crosscutting concepts is expected. This will help deepen students' sensemaking across a range of disciplinary contexts.

The table below provides a summary of each science dimension mentioned above.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking questions or defining problems: Students engage in asking testable questions and defining problems to pursue understanding of phenomena. **Developing and using models:** Students develop physical, conceptual and other models to represent relationships, explain mechanisms, communicate ideas and predict outcomes. **Planning and carrying out investigations:** Students plan and conduct scientific investigations to test, revise or develop explanations.	**Physical Sciences:** (PS1) Matter and Its Interactions (PS2) Motion and Stability: Forces and Interactions (PS3) Energy (PS4) Waves **Life Sciences:** (LS1) Molecules to Organisms (LS2) Ecosystems (LS3) Heredity (LS4) Biological Evolution	**Patterns:** Students observe patterns to organize and classify factors that influence relationships. **Cause and effect mechanisms and explanation**: Students investigate and explain causal relationships and their mechanisms to make tests and predictions. **Scale, proportion and quantity:** Students recognize the relevancy of and changes in scale, proportions and quantities of measurement within and between various systems.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and interpreting data: Students analyze various types of data to identify features or patterns for interpretation and further use. **Using mathematics and computational thinking:** Students use fundamental tools in science to compute relationships and interpret results. **Constructing explanations and designing solutions:** Students construct explanations about the world and design solutions to problems using observations that are consistent with current evidence and scientific principles. **Engaging in argument from evidence:** Students support their best conclusions and solutions with lines of reasoning using evidence to defend their claims. **Obtaining, evaluating and communicating information:** Students obtain, evaluate and derive meaning from scientific information or presented evidence using appropriate scientific language. They communicate their findings clearly and persuasively in a variety of ways including written text, graphs, diagrams, charts, tables or orally.	**Earth and Space Sciences:** (ESS1) Earth's Place in the Universe (ESS2) Earth's Systems (ESS3) Earth and Human Activity **Engineering Design:** (ETS1.A) Defining and Delimiting an Engineering Problem (ETS1.B) Developing Possible Solutions (ETS1.B) Optimizing the Design Solution	**Systems and system models:** Students use models to explain the boundaries and relationships that describe complex systems. **Energy and matter flows, cycles and conservation:** Students describe cycling of matter and flow of energy through systems, including transfer, transformation and conservation of energy and matter. **Structure and function:** Students relate the shape and structure of an object or living thing to its properties and functions. **Stability and change:** Students explain how and why a natural or built system can change or remain stable over time.

How to Read the Standards

Performance Expectation (PE): The performance students demonstrate to show mastery

Foundation Boxes: Provides further information about each dimension that was combined to develop the PE.

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, swings on a playground, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.

Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concepts
Planning and Carrying Out Investigations With guidance, plan and conduct an investigation in collaboration with peers.	**PS2.A: Forces and Motion** Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. **PS2.B: Types of Interactions** When objects touch or collide, they push on one another and can change motion. **PS3.C: Relationship Between Energy and Forces** A bigger push or pull makes things speed up or slow down more quickly.	**Cause and Effect** Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Clarification Statement: Provide examples or additional information

Assessment Boundary: States the limit of assessment for large-scale assessment

Meaning of Each Component

Performance Expectation: The performance students demonstrate to show mastery. It states how a student will demonstrate their understanding of a core idea on a large-scale assessment. Some performance expectations include an asterisk, which signifies the inclusion of engineering design.

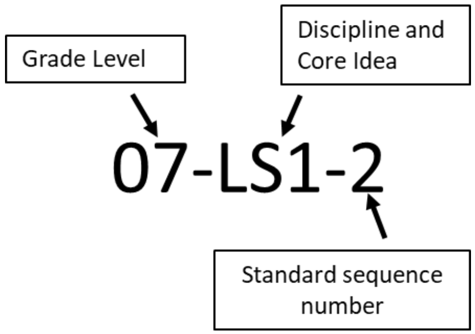
Clarification Statement: These provide examples or additional information about the performance expectation. Not all performance expectations include a clarification statement. In instances in which the committee felt clarification was not necessary, the notation "none provided" is present.

Assessment Boundary: This states the limit of assessment for a large-scale assessment. It does not, however, limit the assessment that could occur in the classroom. The notation "none provided" indicates that the committee did not believe a boundary needed to be identified.

Foundation Boxes: These boxes represent the foundational components of three dimensions that encompass the performance expectation, which are:

- Science and Engineering Practices: This box describes the element of the practice associated with the performance expectation.
- Disciplinary Core Idea: This box includes conceptual information related to the overall core idea of the performance expectation. The coding found in this box is consistent with the coding and component ideas described in the framework.
- Crosscutting Concepts: This box describes the element of the concept associated with the performance expectation.

How to Read the Coding



Discipline Codes	
PS	Physical Science
LS	Life Science
ESS	Earth and Space Science
ETS	Engineering, Technology and Applications of Science

Supplementary Materials to the Standards

Appendix A: Writing and Review Teams

This appendix includes information on the writing teams who developed the Kentucky Academic Standards for Science.

Alternate Assessment Targets: (not a standard)

An Alternate Assessment Target represents limits to a selected Kentucky Academic Standard. An Alternate Assessment Target may reduce parts of the standard with specific guidance to what an assessment item could represent. Not all Kentucky Academic Standards selected for assessments will have an Alternate Assessment Target and may display the language: *"No limitations. All parts of the Kentucky Academic Standard are eligible to be included as an assessment item."* This would mean that the entire standard in its original form is reduced in depth and breadth and is eligible in its entirety to be used in the development of assessment items.

Grade 11 Science Kentucky Academic Standards Assessed by Window

Window	Standard
1	HS-LS4-4
1	HS-LS4-5
1	HS-ESS1-5
1	HS-ESS2-5

Window	Standard
2	HS-PS2-3
2	HS-PS3-3
2	HS-PS3-4
2	HS-LS1-2
2	HS-LS2-8
2	HS-ETS1-1

High School Overview

High School Physical Sciences

There are four HS Physical Science core ideas: Matter and its Interactions (PS1); Motion and Stability: Forces and Interactions (PS2); Energy (PS3); Waves and Their Applications in Technologies for Information Transfer (PS4). These four core ideas are divided into 12 topics: Structure and Properties of Matter, Chemical Reactions, Nuclear Processes, Forces and Motion and Types of Interactions, Definitions of Energy, Conservation of Energy and Energy Transfer, the Relationship between Energy and Forces, Energy in Chemical Processes and Everyday Life, Wave Properties, Electromagnetic Radiation, and Information Technologies and Instrumentation. To meet the Physical Science performance expectations, students are expected to demonstrate proficiency in asking questions, developing and using models, analyzing data and using math to support claims, planning and carrying out investigations, using mathematical thinking, and constructing explanations and designing solutions, communicating scientific and technical information, engaging in argument from evidence and obtaining, evaluating and communicating information; and to use these practices to demonstrate their understanding of the core ideas. Performance expectations for PS1 include substructure of atoms, chemical reactions, energy changes, periodic properties, and radioactivity. Performance expectations for PS2 include forces and interactions, momentum, gravitational and electrostatic forces. Performance expectations for PS3 include system energy, energy flow, energy transfer, energy fields, and energy conversions. Performance expectations for PS4 include wave properties, wave interactions, electromagnetic radiation, and encoding and transmitting information. The crosscutting concepts of patterns that include energy and matter; stability and change; cause and effect; systems and system models; structure and function; and the influence of science, engineering and technology on society and the natural world are highlighted as organizing concepts for these disciplinary core ideas.

High School Life Sciences

There are four HS Life Sciences core ideas: From Molecules to Organisms: Structures and Processes (LS1); Ecosystems: Interactions, Energy, and Dynamics (LS2); Heredity: Inheritance and Variation of Traits (LS3); and Biological Evolution: Unity and Diversity (LS4). These four core ideas are divided into eight topics: Structure and Function, Matter and Energy, Inheritance and Variation of Traits, Matter and Energy in Organisms, Matter and Energy in Ecosystems, Interdependent Relationships in Ecosystems, Inheritance of and Variation of Traits, and Natural Selection and Evolution. To meet these performance expectations, students are expected to demonstrate proficiency in analyzing and interpreting data, constructing explanations and designing solutions, developing and using models, planning and carrying out investigations, using mathematical and computational thinking, engaging in argument, and obtaining, evaluating and communicating information; and to use these practices to demonstrate their understanding of the core ideas. Performance expectations for LS1 include the role of DNA in the essential functions of life through specialized cells; organization and function of interacting systems; role of feedback mechanisms in homeostasis, photosynthesis, carbon-based molecules, cellular respiration, and mitosis. Performance expectations for LS2 include carrying capacity, biodiversity and populations, cycling of matter and energy flow, roles of photosynthesis and cellular respiration, ecosystem stability, impacts of human activities on environment, and group behavior. The LS3 performance expectations include DNA/chromosomes, inheritable genetic variations and variation and distribution of expressed traits. The LS4 performance expectations include evidence of common ancestry, factors of evolution, heredity of advantageous traits, effect of environmental conditions on species and mitigate impacts of human activity on biodiversity. The crosscutting concepts of matter and energy, structure and function, and systems and system models, cause and effect, scale, proportion and quantity, and stability and change play an important role in students' understanding and are highlighted as organizing concepts for these core ideas.

High School Earth and Space Sciences

There are three HS Earth and Space Sciences core ideas: Earth's Place in the Universe (ESS1), Earth's Systems (ESS2), and Earth and Human Activity (ESS3). These three core ideas are divided into five topics: Space Systems, History of Earth, Earth's Systems, Weather and Climate, and Human Impacts. To meet these performance expectations, students are expected to demonstrate grade-appropriate proficiency in developing and using models; using mathematical and computational thinking; constructing explanations and designing solutions; and obtaining, evaluating, and communicating information. Performance expectations for ESS1 include life span of the sun, Big Bang theory, element production by stars, motion of orbiting objects, plate tectonics, and Earth's formation and early history. Performance expectations for ESS2 include Earth's internal and surface processes, Earth systems, thermal convection within the Earth, properties of water and its effects on Earth's materials, carbon cycling, coevolution of life and Earth's systems, energy flow, and climate. Performance expectations for ESS3 include future impacts of global climate change, impact of natural resources/hazards on human activities, evaluating competing designs for management of mineral and energy resources, natural resource management and sustainability, reducing human impact on natural systems, and how human activity modifies relationships among Earth systems. The crosscutting concepts of cause and effect; systems and system models; patterns; scale, proportion and quantity; structure and function; energy and matter; and stability and change are highlighted as organizing concepts for these disciplinary core ideas.

High School Engineering Design

There is one HS Engineering Design core idea: Engineering Design (ETS1). This core idea is divided into three topics: defining and delimiting engineering problems, developing solutions and optimizing design solutions. To meet these performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions and defining problems, using mathematical and computational thinking, and constructing explanations and designing solutions. Performance expectations for ETS 1 include analyzing global challenges, designing solutions to real-world problems, evaluating solutions, and modeling the impacts of proposed solutions. The crosscutting concept of systems and system models is used as an organizing concept for these disciplinary core ideas.

Note While only a subset of science and engineering practices and crosscutting concepts are explicitly identified as the mechanism for how students demonstrate mastery at the end of instruction, students should still utilize all of the science and engineering practices and crosscutting concepts as they develop their understanding. See front matter for more information.

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.*

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.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concepts
Constructing Explanations and Designing Solutions Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.	**PS2.A: Forces and Motion** If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. **ETS1.A: 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. **ETS1.C: 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.	**Cause and Effect** Systems can be designed to cause a desired effect.

Alternate Assessment Target: Limit full standard to qualitative evaluation.

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.		
Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**PS3.A: Definitions of Energy** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **PS3.D: 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. **ETS1.A: 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.	**Energy and Matter** Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Alternate Assessment Target: No limitations. All parts of the Kentucky Academic Standard are eligible to be included as an assessment item.

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).**	
Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water. **Assessment Boundary:** Assessment is limited to investigations based on materials and tools provided to students.		
Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS3.B: Conservation of Energy and Energy Transfer** Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). **PS3.D: 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.	**Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Alternate Assessment Target: Limit full standard to qualitative observations (e.g., no calculations of specific heat).

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.		
Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, organism movement and behavioral response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system. **Assessment Boundary:** Assessment does not include interactions and functions at the molecular or chemical reaction level.		
Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concepts**
Developing and Using Models Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.A: Structure and Function** Multicellular organisms have a hierarchical structural organization in which any one system is made up of numerous parts and is itself a component of the next level. **LS1.D: Information Processing** In a more complex organism, the systems become more complex to provide more input to allow for decision making regarding events around the organism. The organism begins to develop memories that motivate it to seek rewards and avoid punishments. The integration of the systems is important for the successful interpretation of inputs and generation of behaviors in response to them.	**Systems and System Models** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales.

Alternate Assessment Target: Limit the full standard to human body systems as a whole (e.g., digestive system, respiratory system, etc.). Excludes interactions and functions at the molecular level.

HS-LS2-8. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.		
Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming. **Assessment Boundary:** None provided.		
Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concepts**
Engaging in Argument from Evidence Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**LS2.D: Social Interactions and Group Behavior** Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Alternate Assessment Target: No limitations. All parts of the Kentucky Academic Standard are eligible to be included as an assessment item.

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.		
Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations. **Assessment Boundary:** None provided.		
Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS4.C: Adaptation** Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Alternate Assessment Target: No limitations. All parts of the Kentucky Academic Standard are eligible to be included as an assessment item.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Clarification Statement: Emphasis is on determining cause-and-effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.

Assessment Boundary: None provided.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concepts
Engaging in Argument from Evidence Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**LS4.C: Adaptation** Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Alternate Assessment Target: No limitations. All parts of the Kentucky Academic Standard are eligible to be included as an assessment item.

HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.		
Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate (a result of past plate interactions). **Assessment Boundary:** None provided.		
Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concepts**
Engaging in Argument from Evidence Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**ESS1.C: The History of Planet Earth** Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. **PS1.C: Nuclear Processes** Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.	**Patterns** Empirical evidence is needed to identify patterns.

	storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	

Alternate Assessment Target: Limit full standard to qualitative comparisons of rock over time (excludes radioactive dating).

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).

Assessment Boundary: None provided.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concepts
Planning and Carrying Out Investigations Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**ESS2.C: The Roles of Water in Earth's Surface Processes** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	**Structure and Function** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Alternate Assessment Target: No limitations. All parts of the Kentucky Academic Standard are eligible to be included as an assessment item.

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. *		
Clarification Statement: None provided. **Assessment Boundary:** None provided.		
Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concepts**
Asking Questions and Defining Problems Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**ETS1.A: 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. Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	

Alternate Assessment Target: No limitations. All parts of the Kentucky Academic Standard are eligible to be included as an assessment item.