Attachment B

(A comparison of the Next Generation Science Standards and Kentucky's current science standards)

Kentucky's current Core Academic Standards (KCAS) for science consists of the 2006 Revision of the Program of Studies and the Science Core Content for Assessment, version 4.1, which is the assessable subset of that content. The KCAS is subdivided into seven "Big Ideas" which are present at all grade levels K-12. Those Big Ideas are then clustered into the four content subdomains of life science, earth/space science, physical science, and unifying concepts. Each of the seven Big Ideas is represented by a set of Understandings, and these Understandings are supported by a related set of Skills and Concepts. The smaller set of concepts that are eligible for testing (the Core Content for Assessment) are then derived from these Understandings and Skills and Concepts.

Our current standards are configured into an End of Primary (K-2) grade band plus individual grade-leveled standards for grades 3,4,5,6,7,8 and grade banded again for high school (9-12). The example below is a segment of a single Big Idea from grade 4 that was taken from the Combined Curriculum Document. This Combined Curriculum Document was developed by the Kentucky Department of Education (KDE) staff to illustrate the relationship between the Program of Studies and Core Content for Assessment for each Big Idea and grade level.

<table>
<tr><td colspan="3">Big Idea: Motion and Forces (Physical Science) Grade: End of Primary
Whether observing airplanes, baseballs, planets, or people, the motion of all bodies is governed by the same basic rules. In the elementary years of conceptual development, students need multiple opportunities to experience, observe, and describe (in words and pictures) motion, including factors (e.g., pushing, pulling) that affect motion.

Academic Expectations
2.1 Students understand scientific ways of thinking and working and use those methods to solve real-life problems.
2.2 Students identify, analyze, and use patterns such as cycles and trends to understand past and present events and predict possible future events.
2.3 Students identify and analyze systems and the ways their components work together or affect each other.</td></tr>
<tr><td>Program of Studies: Understandings</td><td>Program of Studies: Skills and Concepts</td><td>Related Core Content for Assessment</td></tr>
<tr><td>SC-P-MF-U-1
Students will understand that things move in many different ways (e.g., fast and slow, back and forth, straight, zig zag, etc.).

SC-P-MF-U-3
Students will understand that the position of an object can be described by locating it relative to another object or the background.

SC-P-MF-U-2
Students will understand that</td><td>SC-P-MF-S-1
Students will identify points of reference/reference objects in order to describe the position of objects.

SC-P-MF-S-2
Students will observe and describe (e.g., using words, pictures, graphs) the change in position over time (motion) of an object.

SC-P-MF-S-3
Students will make qualitative (e.g., hard, soft, fast, slow) descriptions of</td><td>SC-EP-1.2.2
Students will describe the change in position over time (motion) of an object.

An object's motion can be observed, described, compared and graphed by measuring its change in position over time.

DOK 2

SC-EP-1.2.3
Students will describe the</td></tr>
</table>

forces (pushes or pulls) can cause objects to start moving, go faster, slow down, or change the direction they are going.	pushes/pulls and motion. SC-P-MF-S-4 Students will use tools (e.g., timer, meter stick, balance) to collect data about the position and motion of objects in order to predict changes resulting from pushes and pulls. SC-P-MF-S-8 Students will ask questions about motion, magnetism and sound and use a variety of print and non-print sources to gather and synthesize information.	**position and motion of objects and predict changes in position and motion as related to the strength of pushes and pulls.** **The position and motion of objects can be changed by pushing or pulling, and can be explored in a variety of ways (such as rolling different objects down different ramps). The amount of change in position and motion is related to the strength of the push or pull (force). The force with which a ball is hit illustrates this principle. By examining cause and effect relationships related to forces and motions, consequences of change can be predicted.** **DOK 2** *SC-EP-1.2.4* *Students will understand that the position of an object can be described by locating it relative to another object or the background. The position can be described using phrases such as to the right, to the left, 50 cm from the other object.*

The structure of the Next Generation Science Standards is different than our current standards in a number of ways. For an exhaustive description of the architecture of the NGSS, see the publication from Achieve, Inc. entitled "How to Read the Next Generation Science Standards (**Attachment C**).

Copied below is a single topic from the January public draft of the NGSS to compare to the current example above.

3.Forces and Interactions

Students who demonstrate understanding can:

3-PS2-b. Investigate the motion of objects to determine when a consistent pattern can be observed and used to predict future motions in the system. [Clarification Statement: An example of motion with a predictable pattern is a child swinging in a swing. In this example, the student could observe the swing moving at different relative rates depending on where it is in the arc of the swing.]

3-PS2-a. Carry out investigations of the motion of objects to predict the effect of forces on an object in terms of balanced forces that do not change motion and unbalanced forces that change motion. [Clarification Statement: An example is pushing on one side of a box can make it start sliding and pushing on a box from both sides, with equal forces, will not produce any motion at all.] [Assessment Boundary: Limit testing to one variable at a time: number, size, or direction of forces. The size and direction of forces should be qualitative. Gravity is only to be addressed as a force that pulls objects down.]

3-PS2-c. Investigate the effect of electric and magnetic forces between objects not in contact with each other and use the observations to describe their relationships. [Clarification Statement: An example of an electric force could be the force on hair from an electrically charged balloon; an example of a magnetic force could be the force between two magnets. Cause and effect relationships include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.] [Assessment Boundary: Limited to forces produced by objects that can be manipulated by students.]

3-PS2-d. Apply scientific knowledge to design and refine solutions to a problem by using the properties of magnets and the forces between them.* [Clarification Statement: Example problems include constructing a latch to keep a door shut, or creating a device to keep two moving objects from touching each other. Students should understand that the results of investigations about non-contact forces inform design solutions.]

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in grades 3–5 builds from grades K–2 experiences and progresses to specifying qualitative relationships.
- Formulate questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (3-PS2-b),(3-PS2-a),(3-PS2-c)

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.
- Design and conduct investigations collaboratively, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-a)
- Make observations and/or measurements, collect appropriate data, and identify patterns that provide evidence for an explanation of a phenomenon or test a design solution. (3-PS2-b),(3-PS2-a),(3-PS2-c)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 3–5 builds on prior experiences in K–2 and progresses to the use of evidence in constructing multiple explanations and designing multiple solutions.
- Apply scientific knowledge to solve design problems. (3-PS2-d)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods
- Science investigations use a variety of tools and techniques. (3-PS2-b),(3-PS2-a),(3-PS2-c)
- There is not one scientific method. (3-PS2-b),(3-PS2-a),(3-PS2-c)

Disciplinary Core Ideas

PS2.A: Forces and Motion
- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-a)
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-b)

PS2.B: Types of Interactions
- Objects in contact exert forces on each other (friction, elastic pushes and pulls). (3-PS2-b)
- Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact—for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2-c),(3-PS2-d)

PS2.C: Stability and Instability in Physical Systems
- A system can change as it moves in one direction (e.g., a ball rolling down a hill), shift back and forth (e.g., a swinging pendulum), or go through cyclical patterns (e.g., day and night). (3-PS2-b)
- Examining how the forces on and within the system change as it moves can help explain a system's patterns of change. (3-PS2-a)
- A system can appear to be unchanging when processes within the system are going on at opposite but equal rates. (3-PS2-a)

Crosscutting Concepts

Cause and Effect
- Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-a),(3-PS2-c)

Stability and Change
- Change is measured in terms of differences over time and may occur at different rates. (3-PS2-b)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
- Tools and instruments (e.g., rulers, balances, thermometers, graduated cylinders, telescopes, microscopes) are used in scientific exploration to gather data and help answer questions about the natural world. Engineering design can develop and improve such technologies. (3-PS2-d)
- Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (3-PS2-d)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science assumes consistent patterns in natural systems. (3-PS2-b)

Notable differences in the *structure* of the two documents are:

- The assessable components of the NGSS are written as student performance expectations.

- Each student performance expectation is a blend of the three dimensions of the framework: Science & Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.
- Many performance expectations include Assessment Boundary statements that provide information on how deeply that expectation is to be assessed.
- Each topic includes correlations to the Common Core State Standards for mathematics and English/language arts as appropriate.
- The reasoning behind each performance expectation is made explicit by supporting statements in the color coded Foundation Boxes included below them.
- An interactive version of the NGSS on the web will allow readers to activate color coding of the text so that every word of each performance expectation can be explicitly linked to the foundational statement from which it was derived.

Notable differences in the *content* of the two documents are:

- Engineering, Technology & Applications of Science is included in the NGSS as a separate and equal content domain alongside the traditional content domains of life, earth and physical science. The engineering content is integrated across those three domains, but still exists as a discrete set of performance expectations. Those performance expectations that integrate engineering are noted with an asterisk. Engineering concepts are incorporated in all grades from K-12.
- The nature of science and scientific thought is given more prominence in the NGSS.
- There have been shifts of specific concepts to new grade levels. Some examples include:
    - Waves as a mechanism for energy transfer appears for the first time in elementary rather than in middle or high.
    - Light and sound has moved downward to first grade.
    - Earth's surface processes are introduced two years earlier than before.
    - The specific details of the particulate nature of matter have moved to higher grades than before.
    - Biological change (commonly known as evolution) does not appear in the NGSS until middle school. It is addressed as one of the seven Big Ideas as early as Primary in the current (KCAS) standards.
    - Earth/space science at the middle and high school level makes more explicit reference to human activity and impacts.

There has been very little negative feedback from either the field or Kentucky's lead state team regarding these shifts in concepts. More feedback has focused on the non-continuous nature of some concepts as compared to the KCAS. For example, in the current standards the Big Idea of Unity and Diversity is addressed every year in all grade levels, but the analogous idea of Structures and Processes appears in the NGSS at grades K, 1 and 3, but not in grades 2 or 5.