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 forces (pushes or pulls) can cause objects to start moving, go faster, slow down, or change the direction they are going.</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 pushes/pulls and motion.

SC-P-MF-S-4
Students will use tools (e.g., timer,</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 position and motion of objects and predict changes in position and motion as related to the strength of pushes and pulls.</td></tr>
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	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.	**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."

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

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Students who demonstrate understanding can:

3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.]

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. [Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.] [Assessment Boundary: Assessment does not include technical terms such as period and frequency.]

3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could 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: Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.]

3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.* [Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.
- Ask questions that can be investigated based on patterns such as cause and effect relationships. (3-PS2-3)
- Define a simple problem that can be solved through the development of a new or improved object or tool. (3-PS2-4)

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.
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-1)
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (3-PS2-2)

Connections to Nature of Science

Science Knowledge is Based on Empirical Evidence
- Science findings are based on recognizing patterns. (3-PS2-2)

Scientific Investigations Use a Variety of Methods
- Science investigations use a variety of methods, tools, and techniques. (3-PS2-1)

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-PS2-1)
- 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-PS2-2)

PS2.B: Types of Interactions
- Objects in contact exert forces on each other. (3-PS2-1)
- Electric and magnetic forces between a pair of objects do not require that the objects be in contact. 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-PS2-3),(3-PS2-4)

Crosscutting Concepts

Patterns
- Patterns of change can be used to make predictions. (3-PS2-2)

Cause and Effect
- Cause and effect relationships are routinely identified. (3-PS2-1)
- Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-3)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
- Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (3-PS2-4)

Connections to other DCIs in third grade: N/A

Articulation of DCIs across grade-levels: **K.PS2.A** (3-PS2-1); **K.PS2.B** (3-PS2-1); **K.PS3.C** (3-PS2-1); **K.ETS1.A** (3-PS2-4); **1.ESS1.A** (3-PS2-2); **4.PS4.A** (3-PS2-2); **4.ETS1.A** (3-PS2-4); **5.PS2.B** (3-PS2-1); **MS.PS2.A** (3-PS2-1),(3-PS2-2); **MS.PS2.B** (3-PS2-3),(3-PS2-4); **MS.ESS1.B** (3-PS2-1),(3-PS2-2); **MS.ESS2.C** (3-PS2-1)

Common Core State Standards Connections:
ELA/Literacy –

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. *(3-PS2-1)*,(3-PS2-3)
RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-PS2-3)
RI.3.8 Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence). *(3-PS2-3)*
W.3.7 Conduct short research projects that build knowledge about a topic. (3-PS2-1),(3-PS2-2)
W.3.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-PS2-1),*(3-PS2-2)*
SL.3.3 Ask and answer questions about information from a speaker, offering appropriate elaboration and detail. *(3-PS2-3)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(3-PS2-1)*
MP.5 Use appropriate tools strategically. *(3-PS2-1)*
3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. *(3-PS2-1)*

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. Engineering Design is listed as a separate set of performance expectations by grade band.
- 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.
    - The middle school standards model used (Achieve's revised conceptual progression model) distributes all of the standards for earth science between sixth or eighth grade.
    - 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.
    - Individual topics are not 'spiraled' so they are revisited in every grade. As an example, concepts of Forces and Interactions are introduced in Kindergarten and not again until third grade at a higher level of rigor.
    - 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. There is a single performance expectation in third grade that is foundational to the ideas of evolution because it establishes fossils as evidence for a old Earth, but it does not explicitly make a connection to evolution.
    - Earth/space science at the middle and high school level makes more explicit reference to human activity and impacts.
- The overall number of standards has been reduced, but the three dimensional nature of the new standards means the individual performance expectations are generally more rigorous that the ones they replace.