South Carolina Academic Standards and Performance Indicators for Science 2014

Instructional Unit Resource

Physics

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As support for implementing the *South Carolina Academic Standards and Performance Indicators for Science 2014*, the standards for Physics have been grouped into possible units. In the Overview of Units below, the titles for those possible units are listed in columns. Refer to the Overview document to note these unit titles and how Standards, Conceptual Understandings, Performance Indicators, Science and Engineering Practices, and Crosscutting Concepts align. Following the Overview of Units, an Instructional Unit document is provided that delivers guidance and possible resources in teaching our new *South Carolina Academic Standards and Performance Indicators for Science 2014*. The purpose of this document is to provide guidance as to how all the standards in this grade may be grouped into units and how those units might look. Since this document is merely guidance, districts should implement the standards in a manner that addresses the district curriculum and the needs of students. This document is a living document and instructional leaders from around the state will continuously update and expand these resource documents. These documents will be released throughout the 2016-2017 school year with the intentionality of staying ahead of instruction. Teachers should also note that links to the Standards document, A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, the SEP Support Document, and the Support Document 2.0 are embedded throughout the Instructional Unit format for reference.

Acknowledgments

Jean Baptiste Massieu, famous deaf educator, made a statement that is now considered a French proverb. "Gratitude is the memory of the heart. Indeed, appreciation comes when you feel grateful from the depths of your heart. The head keeps an account of all the benefits you received and gave. But the heart records the feelings of appreciation, humility, and generosity that one feels when someone showers you with kindness." It is with sincere appreciation that we humbly acknowledge the dedication, hard work and generosity of time provided by teachers and instructional leaders across the state that have made and are continuing to make the Instructional Unit Resources possible.

Physics Overview of Units

Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7
FORCES AND MOTION	WORK, ENERGY, AND MOMENTUM	ELECTRICITY AND MAGNETISM	WAVES	LIGHT AND OPTICS	THERMODYNAMICS	NUCLEAR AND MODERN PHYSICS
Standard	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**
H.P.1 H.P.2	H.P.1 H.P.2 H.P.3	H.P.1 H.P.2 H.P.3	H.P.1 H.P.3	H.P.1 H.P.3	H.P.1 H.P.3	H.P.1 H.P.3
Conceptual Understanding	**Conceptual Understanding**	**Conceptual Understanding**	**Conceptual Understanding**	**Conceptual Understanding**	**Conceptual Understanding**	**Conceptual Understanding**
H.P.2A H.P.2B H.P.2C	H.P.2B H.P.3A H.P.3B	H.P.2D H.P.3E	H.P.3D	H.P.3F	H.P.3C	H.P.3G
Performance Indicators	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**
H.P2A.1 H.P.2A.2 H.P.2A.3 H.P.2A.4 H.P.2A.5 H.P.2A.6 H.P.2B.1 H.P.2B.2 H.P.2B.3 H.P.2B.8 H.P.2B.9 H.P.2B.10 H.P.2C.1 H.P.2C.2 H.P.2C.3 H.P.2C.4 H.P.2C.5	H.P.2B.4 H.P.2B.5 H.P.2B.6 H.P.2B.7 H.P.3A.1 H.P.3A.2 H.P.3A.3 H.P.3A.4 H.P.3A.5 H.P.3B.1 H.P.3B.2 H.P.3B.3	H.P.2D.1 H.P.2D.4 H.P.2D.5 H.P.2D.7 H.P.3E.1 H.P.3E.2 H.P.3E.3 H.P.3E.4 H.P.3E.5 H.P.3E.6 H.P.3E.7	H.P.3D.1 H.P.3D.2 H.P.3D.3 H.P.3D.4	H.P.3F.1 H.P.3F.2 H.P.3F.3 H.P.3F.4 H.P.3F.5 H.P.3F.6	H.P.3C.1 H.P.3C.2 H.P.3C.3	H.P.3G.1 H.P.3G.2 H.P.3G.3 H.P.3G.4 H.P.3G.5
***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**
S.1A.2 S.1A.5 S.1A.3 S.1A.6 S.1A.4 S.1A.8	S.1A.2 S.1A.7 S.1A.3 S.1A.8 S.1A.5	S.1A.2 S.1A.6 S.1A.3 S.1A.8 S.1A.5 S.1B.1	S.1A.2 S.1A.5 S.1A.3 S.1A.6	S.1A.1 S.1A.5 S.1A.2 S.1A.6 S.1A.3 S.1A.8	S.1A.1 S.1A.4 S.1A.2 S.1A.3	S.1A.2 S.1A.8 S.1A.5 S.1A.6
***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**
1, 2, 3, 4, 5, 6, 7	1, 2, 3, 4, 5,	2, 3, 5, 6, 7	1, 2, 3, 5, 6, 7	1, 2, 3, 5, 6, 7	1,2,3,5,6,7	1,2,3,5,6,7

**Teachers have the discretion to enhance the selected SEP's and CCCs.*

Unit Title
Nuclear and Modern Physics
Standard http://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf
H.P.3 The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.

Conceptual Understanding

H.P.3G. Conceptual Understanding: Nuclear energy is energy stored in an atom's nucleus; this energy holds the atom together and is called binding energy. Binding energy is a reflection of the equivalence of mass and energy; the mass of any nucleus is always less than the sum of the masses of the individual constituent nucleons that comprise it. Binding energy is also a measure of the strong nuclear force that exists in the nucleus and is responsible for overcoming the repulsive forces among protons. The strong and weak nuclear forces, gravity, and the electromagnetic force are the fundamental forces in nature. Strong and weak nuclear forces determine nuclear sizes, stability, and rates of radioactive decay. At the subatomic scale, the conservation of energy becomes the conservation of mass-energy.

New Academic Vocabulary

Some students may need extra support with the following academic vocabulary in order to understand what they are being asked to understand and do. Teaching these terms in an instructional context is recommended rather than teaching the words in isolation. A great time to deliver explicit instruction for the terms would be during the modeling process. Ultimately, the student should be able to use the academic vocabulary in conversation with peers and teachers. These terms are pulled from the essential knowledge portion of the Support Doc 2.0 (http://ed.sc.gov/instruction/standards-learning/science/support-documents-and-resources/) and further inquiry into the terms can be found there.

Alpha particle	Beta Particle	Gamma ray	Neutron emission	Fission	Fusion
Critical mass	Ionization	Radioactive tracer	Half life	Isotopes	Binding energy
Transmutation					

Performance Indicators

Text highlighted below in *orange* and *italicized/underlined* shows connections to SEP's.

H.P.3G.1 *Develop and use models* to represent the basic structure of an atom (including protons, neutrons, electrons, and the nucleus).
H.P.3G.2 *Develop and use models* (such as drawings, diagrams, computer simulations, and demonstrations) to communicate the similarities and differences between fusion and fission. Give examples of fusion and fission reactions and include the concept of conservation of mass-energy.
H.P.3G.3 *Construct scientific arguments* to support claims for or against the viability of fusion and fission as sources of usable energy.
H.P.3G.4 *Use mathematical and computational thinking* to predict the products of radioactive decay (including alpha, beta, and gamma decay).
H.P.3G.5 *Obtain information to communicate* how radioactive decay processes have practical applications (such as food preservation, cancer treatments, fossil and rock dating, and as radioisotopic medical tracers).

*Science and Engineering Practices

Support for the guidance, overviews of grade level progressions, and explicit details of each SEP can found in the Science and Engineering Support Doc (http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf). It is important that teachers realize that the nine science and engineering practices are not intended to be used in isolation. Even if a performance indicator for a given standard only lists one of the practices as a performance expectation, scientists and engineers do not use these practices in isolation, but rather as part of an overall sequence of practice. When educators design the learning for their students, it is important that they see how a given performance expectation fits into the broader context of the other science and engineering practices. This will allow teachers to provide comprehensive, authentic learning experiences through which students will develop and demonstrate a deep understanding of scientific concepts.

H.P.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships; (2) test devices or solutions; or (3) communicate ideas to others.
H.P.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data.
H.P.1A.6: Construct explanations of phenomena using (1) primary or secondary scientific evidence and models; (2) conclusions from scientific investigations; (3) predictions based on observations and measurements; or (4) data communicated in graphs, tables, or diagrams.
H.P.1A.8: Obtain and evaluate scientific information to (1) answer questions; (2) explain or describe phenomena; (3) develop models; (4) evaluate hypotheses, explanations, claims, or designs; or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate, primary or secondary scientific literature or (2) reporting the results of student experimental investigations.

*Cross Cutting Concepts (http://www.nap.edu/read/13165/chapter/8)

The link above provides support from the Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012). The text in blue and *italicized/underlined* below provides a brief explanation of how the specific content ties to the CCC's.

1. Patterns: The National Research Council states, "observed patterns of forms and events guide organization and classification, and they prompt

questions about relationships and the factors that influence them" (p. 84). How do simple patterns arise in complex nuclei?

2. Cause and effect: Mechanism and explanation: The National Research Council (2012) states that "events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts" (p. 84). What is the effect of a leak in a nuclear reactor?

3. Scale, proportion, and quantity: The National Research Council (2012) states that "in considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance" (p. 84). Use models to communicate the similarities and differences between fusion and fission.

5. Energy and matter: The National Research Council states, "Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations" (p. 84). Diagram how energy flows in fusion and fission.

6. Structure and function: The National Research Council (2012) states that "the way in which an object or living thing is shaped and its substructure determine many of its properties and functions " (p. 84). The chemical properties of an atom are determined by the arrangement of its electrons.

7. Stability and change: The National Research Council (2012) states that "For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study" (p. 84). Nuclei of unstable isotopes will undergo radioactive decay in order to become a more stable element.

**Teachers have the discretion to enhance the selected SEP's and CCC's.*

Prior Knowledge
• 7.P.2 Atomic Models, Subatomic Particles, Periodic Table • H.C.2 Atomic Models, Bohr Model, Subatomic Particles, Nuclear Processes
Subsequent Knowledge
• N/A

Possible Instructional Strategies/Lessons
Strategies and lessons that will enable students to master the standard and/or indicator.

- H.P.3G.1
  - Model of the Atom Timeline: Students construct a timeline that displays the development of the model of the atom focusing on how these models led to the current understanding of the structure of the atom. Each student, or group of students, can focus on one development which can be combined with those of other students, or groups, to create a timeline. This can be done in poster format or digitally. There are a variety of guidelines and rubrics for projects like this that can be found by an internet search.
  - Build an Atom: Interactive simulation in which students build atoms using the number of protons, neutrons, and electrons. They predict the charge on an ion when electrons are added to or removed from an atom as well as generating an isotope symbol for an atom based on the number of subatomic particles. This simulation can be found at https://phet.colorado.edu/en/simulation/build-an-atom.
- H.P.3G.2
  - Fission Demonstration: This lesson has students model fission using twisting balloons. It includes instructions for a traditional method and a guided inquiry method as well as follow up questions and assessment ideas. This lesson can be found at http://www.nuclearconnect.org/in-the-classroom/for-teachers/what-is-fission.
  - Energy Flow Diagrams: Students can draw energy diagrams of the flow of energy through fusion and fission.
- H.P.3G.3
  - Fission vs. Fusion: This lesson has students construct scientific arguments for and against the use of nuclear energy by writing a mini-position paper. The lesson plan contains resources, implementation options, and assessment ideas. This lesson can be found at http://teachnuclear.ca/resources-db/files/Fission-vs-Fusion-Lesson-Plan.pdf.
- H.P.3G.4
  - Modeling Nuclear Equations: This activity has students model radioactive decay and use manipulatives to help students use mathematical and computational thinking to predict the products of radioactive decay. This activity can be found at http://www.ocr.org.uk/Images/177372-modelling-nuclear-equations-activity-teacher-instructions.pdf.

- Alpha-Decay: Students predict what happens to an element when it undergoes alpha decay. This resource can be found at https://phet.colorado.edu/en/simulation/alpha-decay.

- Balancing Nuclear Equations: This interactive activity in which students use mathematical and computational thinking to predict the products of radioactive decay. This activity can be found at http://www.sciencegeek.net/Chemistry/taters/Unit1NuclearEquations.htm.

- Nuclear Fission: Students control energy production in a nuclear reaction. This resource can be found at https://phet.colorado.edu/en/simulation/legacy/nuclear-fission.

- H.P.3G.5
  - Applications of Radioactive Decay: Students research to obtain information to communicate how radioactive decay processes can be used in practical applications. Assign or have students choose a practical application to research and present to the class. Presentations can be in the form of posters, infographics, brochures, student created videos, etc.

Resources

- Introduction to Atomic Physics: This website contains information about atomic physics including the structure of the atom, the history of the atomic model, as well as examples of nuclear equations. This resource can be found at http://www.atomicarchive.com/Physics/Physics1.shtml.

- Half Life Lab: Students can visualize and model what is meant by half-life of a reaction. This website has student data collection sheets. This resource can be found at http://www.nuclearconnect.org/in-the-classroom/for-teachers/half-life-of-paper-mms-pennies-or-puzzle-pieces.

- Energy Flow Diagrams for Teaching Physics: http://www.need.org/files/curriculum/guides/Energy%20Flows.pdf

- Atomic and Nuclear Physics Webquest: This resource can be found at http://physicsquest.homestead.com/nuclear.html.

- Nuclear Science Week: This website has several nuclear lessons: http://www.nuclearscienceweek.org/get-involved/lessons_and_resources/.

- Half-Life: There are two labs available to teach the half-life concept. Students will create a graph representing the half-life of an element. This lesson can be found at http://extension.uga.edu/k12/science-behind-our-food/lesson-plans/CalculatingHalflife.pdf.

- Fusion Animation: This resource can be found at http://www.need.org/content.asp?contentid=160.

Sample Formative Assessment Tasks/Questions

Additional sample formative assessment tasks/questions for grade bands are located at the end of each of the SEP Support Doc.
(http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf)

- Whiteboard problems: Subatomic particles and isotope notation

- Fission & Fusion Analogies: Students can create an analogy to illustrate the concepts of fission and fusion.

- Discussion Paper: Students can compare alpha, beta, and gamma radiation in terms of mass, charge, penetrating power, and the release of these particles from the nucleus.

- Create a graphic organizer for alpha, beta, and gamma radiation in terms of mass, charge, and penetrating power.

- Create a Venn diagram comparing and contrasting fission and fusion.

- Nuclear Energy Position Paper: Students can discuss safety, security, and health issues associated with radiation and nuclear power production and half-life.

- Infographic: Students create an infographic (a visual representation of information) regarding the pros and cons of nuclear energy or comparing/contrasting fission and fusion. Students can use free infographic creation websites to create their infographics.

- Energy Flow: Students can draw energy diagrams of the flow of energy through fusion and fission.

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