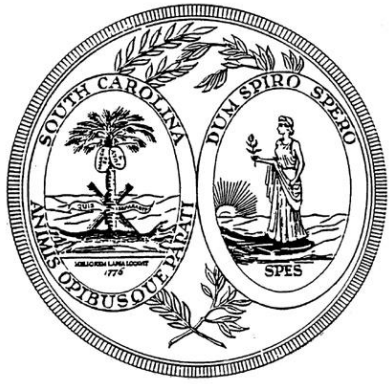
South Carolina Academic Standards and Performance Indicators for Science 2014



Instructional Unit Resource

Physics

South Carolina Academic Standards and Performance Indicators for Science 2014 Physics Instructional Unit Resource

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.2B.8 H.P.2A.2 H.P.2B.9 H.P.2A.3 H.P.2B.10 H.P.2A.4 H.P.2C.1 H.P.2A.5 H.P.2C.2 H.P.2A.6 H.P.2C.3 H.P.2B.1 H.P.2C.4 H.P.2B.2 H.P.2C.5 H.P.2B.3	H.P.2B.4 H.P.3A.3 H.P.2B.5 H.P.3A.4 H.P.2B.6 H.P.3A.5 H.P.2B.7 H.P.3B.1 H.P.3A.1 H.P.3B.2 H.P.3A.2 H.P.3B.3	H.P.2D.1 H.P.3E.5 H.P.2D.4 H.P.3E.6 H.P.2D.5 H.P.3E.7 H.P.2D.7 H.P.3E.1 H.P.3E.2 H.P.3E.3 H.P.3E.4	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
Light and Optics
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.3F. During radiant energy interactions, energy can be transferred over long distances without a medium. Radiation can be modeled as an electromagnetic wave or as a stream of discrete packets of energy (photons); all radiation travels at the same speed in a vacuum (speed of light). This electromagnetic radiation is a major source of energy for life on Earth.
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.**
Electromagnetic Spectrum, Reflection, Refraction, Transmission, Interference, Diffraction Snell's Law, Angle of Incident, Angle of Refraction, Index of Refraction, Ray Diagrams Frequency
Performance Indicators **Text highlighted below in *orange* and *italicized/underlined* shows connections to SEP's.**
H.P.3F.1 *Construct scientific arguments* that support the wave model of light and the particle model of light. H.P.3F.2 *Plan and conduct controlled scientific investigations* to determine the interaction between the visible light portion of the electromagnetic spectrum and various objects (including mirrors, lenses, barriers with two slits, and diffraction gratings) and to construct explanations of the behavior of light (reflection, refraction, transmission, interference) in these instances using models (including ray diagrams).

H.P.3F.3 *Use drawings to exemplify* the behavior of light passing from one transparent medium to another and construct explanations for this behavior.
H.P.3F.4 *Use mathematical and computational thinking* to analyze problems that relate the frequency, period, amplitude, wavelength, velocity, and energy of light.
H.P.3F.5 *Obtain information to communicate* the similarities and differences among the different bands of the electromagnetic spectrum (including radio waves, microwaves, infrared, visible light, ultraviolet, and gamma rays) and give examples of devices or phenomena from each band.
H.P.3F.6 *Obtain information to construct explanations* on how waves are used to produce, transmit, and capture signals and store and interpret information (including ultrasound imaging, telescopes, cell phones, and bar code scanners).

***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.1 Ask questions to (1) generate hypotheses for scientific investigations; (2) refine models, explanations, or designs; or (3) extend the results of investigations or challenge scientific arguments or claims.
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.3 Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information; (2) identify materials, procedures, and variables; (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data; and (4) record and represent data in an appropriate form. Use appropriate safety procedures.
H.P.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate English and metric units, (2) express relationships between variables for models and investigations, or (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). *The higher the frequency means more waves pass a point.*

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). *When light passes from one medium to another, the velocity of the wave changes.*

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). *Different frequencies of light have different energies and therefore different properties.*

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). *Radiant energy is the ultimate energy source on Earth. Organisms obtain their energy from radiant energy.*

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). *Light has properties of both waves and particles. Light can experience the Doppler Effect just like sound waves and can also behave like any other object that has mass and takes up space.*

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). *The nature of the medium will determine how the velocity of the wave changes.*

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

Prior Knowledge
• 1.P.2 Visible Light • 4.P.4 Light and Energy • 8.P.3 Light Waves, Electromagnetic Waves, Reflection, Refraction and Diffraction
Subsequent Knowledge
• N/A

Possible Instructional Strategies/Lessons

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

- H.P.3F.1
    - Light on Trial-Wave or Particle?: In this activity, students construct models, make predictions based on observations and measurements, or data communicated in graphs, tables, or diagrams to determine whether light is a wave or a particle or a combination of both. Students will present evidence and conclusions in a mock trial format. This lesson can be found at http://www.beaconlearningcenter.com/lessons/lesson.asp?ID=496.
- H.P.3F.2
    - PhET: Geometric Optics: How does a lens form an image? Students can adjust the focal length of the lens, move the object, move the lens, or move the screen to observe how light rays are refracted by a lens. This simulation can be found at https://phet.colorado.edu/en/simulation/legacy/geometric-optics.
    - PhET-Wave Interference: Using this simulation, students can plan and conduct investigations to determine the interaction between light and barriers. This simulation can be found at https://phet.colorado.edu/en/simulation/legacy/wave-interference.
- H.P.3F.3
    - PhET-Bending Light: Students will bend light between two media with different indices of refraction. Students can observe how changing from air to water to glass changes the bending angle. Students use prisms of different shapes to make rainbows. After completing this activity, students can use drawing to exemplify the behavior of light passing from one transparent medium to another and construct explanations for this behavior. This simulation can be found at

https://phet.colorado.edu/en/simulation/bending-light.

- H.P.3F.4
    - PhET-Wave on a String: Students can observe a string vibrate in slow motion. Students can manipulate the end of the string to model waves, or adjust the frequency and amplitude of an oscillator. This simulation can be found at https://phet.colorado.edu/en/simulation/wave-on-a-string.
    - Make waves using springs, ropes, or rubber bands and paper clips/washers. Have students physically make longitudinal and compressional waves. Vary the wavelength, frequency, and energy. Students must write down how they changed each variable and the effect on the other variables. Students can also measure amplitude, wavelength, and period; and then they use this data to calculate the velocity and energy of the wave.
- H.P.3F.5
    - PhET-Radio Waves and Electromagnetic Fields: Broadcast radio waves from KPhET by manipulating the transmitter electron manually or allowing it to oscillate automatically. Students may display the field as a curve or vectors and the strip chart will show the electron positions at the transmitter as well as at the receiver. This simulation can be found at https://phet.colorado.edu/en/simulation/legacy/radio-waves.
    - Making Waves with the Electromagnetic Spectrum: This lesson has students explore the electromagnetic spectrum through videos and discussion. It culminates with students making a model of the spectrum along the wall of the classroom including examples of uses and phenomena for each band of the spectrum. This lesson can be found at http://scetv.pbslearningmedia.org/resource/phy03.sci.phys.energy.lp_emspect/making-waves-with-the-electromagnetic-spectrum/.
- H.P.3F.6
    - PhET-Simplified Magnetic Resonance Imaging (MRI): This lesson shows students that the head is comprised of small radio transmitters (the nuclear spins of the hydrogen nuclei of water molecules). Students can discuss the limitations of models after the simulation. This simulation can be found at https://phet.colorado.edu/en/simulation/legacy/mri.

Resources

- Physics4Kids.com!: This tutorial introduces light and optics in physics. Other sections include motion, heat, electricity, magnetism, and modern physics. This site can be found at www.physics4kids.com/files/light_intro.html.

- Wave Behaviors - Mission: Science: This site contains information and images of different wave behaviors of light, including reflection, refraction and diffraction. This site can be found at http://missionscience.nasa.gov/ems/03_behaviors.html.

- Optics for kids: There are easy, medium, hard hands-on activities. Covers topics like reflection, interference, and diffraction. These activities can be downloaded at http://www.optics4kids.org/home/content/classroom-activities.

- Waves, Sound and Light-Light Waves: This set of problems target students' ability to determine wave quantities (frequency, wavelength, and speed) from verbal descriptions and diagrams of situations relating to wave propagation and interference. This site can be found at http://www.physicsclassroom.com/calcpad/light.

- Light Waves and Color: This source contains lessons, illustrations, animations, and questions about the behavior of light (reflection, refraction, interference, etc.). This resource can be found at http://www.physicsclassroom.com/class/light/Lesson-1/Wavelike-Behaviors-of-Light.

- Reflection and the Ray Model of Light: This resource contains information, illustrations, animations, and examples of reflection. This resource can be found at http://www.physicsclassroom.com/class/refln.

- Teaching Waves and Sound Ideas: This blog has ideas and videos for teaching waves. This resource can be found at http://neilatkin.com/2013/08/20/teaching-waves-and-sound/.

- Wave-Particle Duality of Light: This video can be used to help students construct scientific arguments as to how light can be treated like both a particle and a wave. This video can be found at https://www.youtube.com/watch?v=h1tflE-L2Dc .

- The Physics Classroom » Physics Tutorial » Refraction and the Ray Model of Light: This resource can be found at http://www.physicsclassroom.com/class/refrn.

- Cow Eye Dissection: Teachers could possibly piggyback with an anatomy class for this activity. This resource can be found at http://scetv.pbslearningmedia.org/resource/lsps07.sci.life.stru.coweye/cows-eye-dissection/.

- Hands-on Lab Activities: This resource contains hands-on lab activities about wave characteristics and the electromagnetic spectrum. This resource can be found at https://www.myips.org/cms/lib8/IN01906626/Centricity/Domain/8123/electromagnetic%20wave%20activities.doc.

- The Electromagnetic Spectrum: This site contains information on the different bands of the electromagnetic spectrum including uses and dangers. This resource can be found at http://www.darvill.clara.net/emag/index.htm.

- etv: PBS Learning: This site has multiple resources including support materials. This resource can be found at http://scetv.pbslearningmedia.org/.

- Electromagnetic Waves and Electromagnetic Spectrum: This resource has a variety of activities covering visible light, electromagnetic waves and speed of light. It can be downloaded at http://ebookinga.com/pdf/electromagnetic-waves-and-electromagnetic-spectrum.

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)

- Energy of Light Problems: book questions, PhET printouts

- Use drawings to exemplify the behavior of light passing from one transparent medium to another and construct explanations for this behavior using Snell's Law.

- Give students different scenarios, such as light passing through a two-slit barrier, and using white boards have them draw a diagram of the scenario.

- Students can make infographics on one or more of the concepts learned in class. Assign different concepts to each student.

- Exit slips: Describe how to increase the amplitude, wavelength, frequency or velocity of a wave (either transverse or longitudinal).

- Compare and contrast reflection and refraction.
- Create an analogy to model the behavior of light when it passes from one medium to another. Examples of this can be found at http://www.physicsclassroom.com/class/refrn/Lesson-1/The-Direction-of-Bending.
- Obtain information of how barcode scanners, cell phones, or telescopes work. Students can use drawings to communicate the information they obtained.
- Students are to make qualitative observations of the different spectra of a variety of light sources viewed through spectroscope.

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