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.3D.1	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.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	1,2,3,4,5,6,7	1,2,3,4,5,6,7

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

Unit Title
Work, Energy, and Momentum
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.2 The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.

Conceptual Understanding

H.P.2B The interactions among objects and their subsequent motion can be explained and predicted by analyzing the forces acting on the objects and applying Newton's laws of motion.

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.

Momentum	Elastic Collision	Impulse	Inelastic Collision	Law of Conservation of Momentum

Performance Indicators

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

H.P.2B.4 *Use mathematical and computational thinking* to derive the relationship between impulse and Newton's Second Law of Motion.

H.P.2B.5 *Plan and conduct controlled scientific investigations* to support the Law of Conservation of Momentum in the context of two objects moving linearly (p=mv).

H.P.2B.6 *Construct scientific arguments* to defend the use of the conservation of linear momentum in the investigation of traffic accidents in which the initial motions of the objects are used to determine the final motions of the objects.

H.P.2B.7 *Apply physics principles to design* a device that minimizes the force on an object during a collision and construct an explanation for the design.

H.P.3A.3 *Obtain information to communicate* how energy is conserved in elastic and inelastic collisions

*Science and Engineering Practices

Support for the guidance, overviews of learning 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 and use 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 metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data.

H.P.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning from observations, data, or informational texts

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 (2012) states that "observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them" (p. 84). *As potential energy decreases; kinetic energy increases.*

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). *The faster*

an object travels; the greater momentum it has.

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). *If the mass doubles, then the momentum doubles.*

4. Systems and systems models: The National Research Council (2012) states that "Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering" (p. 84). *The conservation of momentum is able to be established through models and mathematical models.*

5. Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations. *Momentum is conserved during a collision between two objects.*

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

Prior Knowledge

- 5.P.5 Forces
- 8.P.2 Forces, Newton's Laws of Motion
- 5.P.2 Properties of Matter (Mass)
- 6.P.3 Work, energy transfer, types of energy

Subsequent Knowledge

- N/A

Possible Instructional Strategies/Lessons

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

- Newton's Crash Test Dummy/Collision Lab This lab is a continuation of the investigation from the previous unit. Students make connections between momentum, impulse, and Newton's Second Law. Students must determine what type of collision has occurred. In addition to calculating sheet acceleration and force, students develop a mathematical model to solve for velocity using the Law of Conservation of Momentum. Students must also argue that momentum is conserved in the investigation of traffic accidents. The "Crash Test dummy" link can be found at http://w3.shorecrest.org/~Lisa_Peck/photoalbum/newton_crashdummy09/crash_dummy.html

- Understanding Car Crashes: It's Basic Physics! This program contains lesson plans that go along with a video on the Insurance Institute for Highway Safety's website. Students will learn about momentum and how it relates to traffic accidents, carry out experiments to investigate momentum in collisions, and construct scientific arguments using the law of conservation of momentum to explain what happens in collisions. Resources for these lessons can be found at https://education.ufl.edu/gjones/files/2013/04/teachers_guidePhysics.pdf.

- Public Service Announcement Students create a PSA to explain the necessities of wearing a seatbelt or using the airbag. They must design a device to assist in providing a change in momentum, or impulse, by minimizing the force. They must draw or sketch a diagram as a part of their explanation.

- Elastic and Inelastic Collisions with Happy and Sad Balls This demonstration and/or activity gives students the opportunity to communicate how the energy is conserved during collisions. A resource can be found here: https://www.sophia.org/tutorials/bill-nye-demonstration-happy-and-unhappy-ball

- Egg Drop Activity Apply physics principles to design a device that minimizes the force on an egg that is dropped from a predetermined height. Have students construct an explanation for the design. An internet search for this activity will provide a variety of lesson plans for this activity.

- Bouncing Balls Activity Students will determine that mass and velocity of the object will affect the amount of momentum. Also, students will scientifically defend surface type determine how energy is conserved in collisions. Link available at https://www.teachengineering.org/activities/view/cub_energy_lesson03_activity

- Momentum and Inelastic Collisions Students will demonstrate how kinetic energy is not conserved in the collision with the marble and the cup. Link available at https://www.biologycorner.com/physics/mechanics/lab_momentum_marble_cup.html

Resources

- Momentum Mr. Andersen explains the concept of momentum as mass times velocity. He also shows you how to solve simple momentum problems. He finally shows you how momentum is both conserved and relative (Anderson, 2011). This resource is available at http://www.bozemanscience.com/momentum

- Momentum Article: "How Much Momentum Does It Take to Stop a Running Back?" This article relates momentum to impulse and explains how a running back is more capable of moving swiftly. This article is located at http://www.scientificamerican.com/article/football-science-newtons-first/

- The Physics Classroom: Momentum and Impulse Connection This resource uses mathematical thinking to connect momentum, impulse, and Newton's Second Law. This resource is available at http://www.physicsclassroom.com/class/momentum/Lesson-1/Momentum-and-Impulse-Connection

- Explaining Elastic and Inelastic Collisions This is an excellent teaching demonstration for communicating energy conservation during collisions. This resource is available at http://practicalphysics.org/explaining-elastic-and-inelastic-collisions.html

- PhET Simulation: Collision Lab This interactive allows students to conduct investigations to defend the Law of Conservation of Momentum. This interactive is found at https://phet.colorado.edu/en/simulation/collision-lab

Sample Formative Assessment Tasks/Questions

Additional sample formative assessment tasks/question 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)

- Practice Problems - Students complete practice problems in their notebook. They can create their own momentum/collision problem. Teachers can review these problems with students by using Whiteboards, Snowballs, etc.

- Pictionary - Students draw sketches that resemble large momentum, small momentum, increased force, decreased force.

- Think-Pair-Share - Students work in pairs to determine the effects of increased and/or decreased forces on the momentum of an object. Also, students can work problems to determine the velocity of a second object when given the mass of the two objects and the velocity of the first object.

- Text-Dependent Questions on the "How Much Momentum Does It Take To Stop A Running Back?" - 1)Use the terms momentum, force, and velocity to explain how a 200-pound running back can escape a 250-pound tackler. 2) Explain how Newton's laws and momentum are related using an example in the article.

- Exit slips - Example) Using momentum, velocity, and conservation of momentum describe how a defensive player with a smaller mass can stop an offensive player with a greater mass.

Unit Title

Work, Energy, and Momentum

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.3A Work and energy are equivalent to each other. Work is defined as the product of displacement and the force causing that displacement; this results in the transfer of mechanical energy. Therefore, in the case of mechanical energy, energy is seen as the ability to do work. This is called the work-energy principle. The rate at which work is done (or energy is transformed) is called power. For machines that do useful work for humans, the ratio of useful power output is the efficiency of the machine. For all energies and in all instances, energy in a closed system remains constant.

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.

Work	Energy	Potential Energy (PE)	Mechanical Energy	Work-Energy Principle
Power	Gravitational Potential Energy (PE)	Displacement	Joule	Kinetic Energy
Efficiency	Horsepower	Machine	Mechanical Advantage	Watt

Performance Indicators

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

H.P.3A.1 *Use mathematical and computational thinking* to determine the work done by a constant force (W=Fd).

H.P.3A.2 *Use mathematical and computational thinking* to analyze problems dealing with the work done on or by an object and its change in energy.

H.P.3A.4 *Plan and conduct controlled scientific investigations* to determine the power output of the human body.

H.P.3A.5 *Obtain and communicate information* to describe the efficiency of everyday machines (such as automobiles, hair dryers, refrigerators, and washing machines).

***Science and Engineering Practices**

Support for the guidance, overviews of learning 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.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.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.

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). *If there is a large force exerted on an object in a short amount of time, then the amount of power is significantly large.*

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). *If the force doubles and the distance doubles, then the work quadruples.*

4. Systems and systems models: The National Research Council (2012) states that "Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering" (p. 84). *Graphs and mathematical models can be used to demonstrate the changes that occur in the work and power of the object.*

5. Energy and matter: Flows, cycles, and conservation. The National Research Council (2012) states "Fully develop energy transfers. Introduce nuclear substructure and conservation laws for nuclear processes" (p. 84). *Work cannot be done without energy. The Work-Energy Theorem maintains that energy is able to be conserved because of work.*

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

Prior Knowledge

- 6.P.3 Work, energy transfer
- 6.P.3 Work, energy transfer, types of energy

Subsequent Knowledge

- N/A

Possible Instructional Strategies/Lessons

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

- Introduction to Work and Energy Have students explore the relationship between force, work and energy by experiencing the forces involved in pulling, pushing, doing work, etc. Examples, explanations, and questions for possible activities can be found at http://www.physics.ucla.edu/k-6connection/forwpts.htm.

- Up the stairs work lab Students determine their weight in Newtons and calculate the work, power and horsepower, done, used and displayed by each student as the climb stairs at school. http://sciedmb.weebly.com/uploads/3/0/8/0/30809013/up_the_stairs.pdf

- Work and Power Lab Students will be able to use mathematical thinking to calculate the work and power done by the human body. Students will be able to calculate the horsepower of their body's activities and compare them to that of their favorite car, motorcycle, etc.

(See How Horsepower Works). This lab is available at https://bergmannscience.wikispaces.com/file/view/Work-Power+Lab.doc

- Comparing the Mechanical Advantage and Efficiency of Pulleys Students obtain information concerning the efficiency of pulleys decreases as the mechanical advantage increases. Link available at http://serc.carleton.edu/sp/mnstep/activities/34647.html

- Choosing Between Home Appliances: Benefits to the Planet and Your Wallet In this activity, students will be able to communicate which appliances are more efficient than others; therefore, better for the planet as well as their wallet. Link available at http://serc.carleton.edu/sisl/2012workshop/activities/70669.html

- Balloon Toss Lab In this activity, students will investigate the factors that effect the force of a collision. This can be done as a demonstration or a lab. This lab is available at http://www.physicsclassroom.com/getattachment/lab/momentum/m2tg.pdf

Resources

- How Horsepower Works This article explains specifically how the term horsepower was derived. Students will need this information to assist them in conducting investigations that determine the power output of the human body (see Work and Power Lab instructional strategies). This article is available at http://auto.howstuffworks.com/horsepower.htm

- Goodhousekeeping.com/appliances This website will assist students in finding information needed to help them compare efficiencies of appliances. Website available at http://www.goodhousekeeping.com/appliances/

- Machines, Mechanical Advantage, and Efficiency This video explains machines are able to transfer or transform energy. Also, it explains how efficiency is calculated, so that students may communicate the efficiency of everyday machines. This video is available at https://www.youtube.com/watch?v=wyNEJyiqcNw

- Momentum and Its Conservation This section of the Physics Classroom website has tutorial, animations and practice problems on momentum. This resource is available at http://www.physicsclassroom.com/class/momentum

Sample Formative Assessment Tasks/Questions

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- Work, Power, Efficiency Practice Problems - Students may volunteer to put problems on the board. Students may show work on whiteboards.
- Student-developed and directed commercial advertising the most efficient and economical machine (See Choosing Between Home Appliances in instructional strategies)
- Exit Slip Questions - Present students with a statement about work and energy, have them determine whether or not the statement is true or false. If it is true, explain why. If it is false, have them give a correct example.
- Cartoon - Have students create a cartoon that demonstrates the relationship between work and energy.

Unit Title
Work, Energy, and Momentum
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.3B Mechanical energy refers to a combination of motion (kinetic energy) and stored energy (potential energy). When only conservative forces act on an object and when no mass is converted to energy, mechanical energy is conserved. Gravitational and electrical potential energy can be modeled as energy stored in the fields created by massive objects or charged particles.				
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.**				
Energy	Mechanical Energy	Potential Energy (PE)	Gravitational Potential Energy	Equilibrium

Equilibrium Point	KInetic Energy	Chemical Potential Energy	Electric Potential	Electron Volts
Potential Difference	Simple Harmonic Motion			

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

H.P.3B.1 *Develop and use models* (such as computer simulations, drawings, bar graphs, and diagrams) to exemplify the transformation of mechanical energy in simple systems and those with periodic motion and on which only conservative forces act.
H.P.3B.2 *Use mathematical and computational thinking* to argue the validity of the conservation of mechanical energy in simple systems and those with periodic motion and on which only conservative forces act ($KE = ½ mv^2$, $PEg = mgh$, $PEe = ½ kx^2$)
H.P.3B.3 *Use drawings or diagrams* to identify positions of relative high and low potential energy in a gravitational and electrical field (with the source of the field being positive as well as negative and the charge experiencing the field being positive as well as negative)

***Science and Engineering Practices**
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S.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 other
S.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.

***Cross Cutting Concepts** (http://www.nap.edu/read/13165/chapter/8)
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2. Cause and Effect: The National Research Council (2012) states "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).prompt questions about relationships and the factors that influence them" (p. 84). *When potential energy decreases, kinetic energy increases.*

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

Prior Knowledge
● 6.P.3 Work, energy transfer, types of energy ● 6.P.3 Work, energy transfer, Kinetic and Potential Energy
Subsequent Knowledge
● N/A

Possible Instructional Strategies/Lessons **Strategies and lessons that will enable students to master the standard and/or indicator.**
● Energy Transformation with Everyday Toys There are five strategies present to allow students to develop models that exemplify energy transformation. Strategies available at http://littleshop.physics.colostate.edu/activities/atmos1/EnergyToys.pdf ● Crazy Coaster Challenge Students will research, construct, and use mathematical thinking to argue the validity of the conservation of energy. Teachers can provide a scenario to engage students, i.e. the district has provided an all-expense paid trip to Disney World so that students may apprentice a Disney Imagineer. They will research factors they wish to alter, construct the coaster from insulation tubing and/or other materials, and calculate the work, power, potential energy, and kinetic energy of the coaster. An example roller coaster can be found at http://www.instructables.com/id/Marble-Roller-Coaster/ ● Hooke's Law - 1D PhET simulation that has students stretch and compress springs to determine the relationship between force, displacement and energy. Simulation can be found at https://phet.colorado.edu/en/simulation/hookes-law.
Resources
● Energy and the Conservation of Energy This is an excellent resource to exemplify the transformation of energy. Resource available at http://www.cmmap.org/scienceEd/summercourse/summerCourse12/docs/MondayAM.pdf ● Build A Coaster This resource will assist students in developing models to exemplify the transformation of energy. Resource available at http://discoverykids.com/games/build-a-coaster/

- Design A Coaster This resource will assist students in developing models to exemplify the transformation of energy. Resource available at http://www.learner.org/interactives/parkphysics/coaster/

- Walter Lewin's Pendulum Demonstration   In this video, Walter Lewin demonstrates conservation of energy with a large pendulum. Resource available at https://www.youtube.com/watch?v=xXXF2C-vrQE

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)

- Students will create a commercial advertising how their coaster demonstrates the validity of the conservation of energy (see Crazy Coaster Challenge in Instructional Strategies)

- Practice Problems using the Conservation of Energy formula - Students may volunteer to put problem on board, whiteboard checks, snowballing, etc.

- Four Corner Exit Slip - After lesson have students use sticky notes to work with a partner to answer questions that are posted in 4 locations around the room. Have students choose 3 questions to answer. For example: What is one thing you must include in the design of a roller coaster?

- Give students a diagram of a roller coaster or an object undergoing simple harmonic motion. Have them label the locations of greatest and least kinetic energy, potential energy, acceleration, etc.

- Explain the energy transformations that take place when a person bungee jumps off of a bridge.

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