Crosswalk for Louisiana Student Standards for Science and NGSS: Physics

This document provides guidance to assist Chemistry teachers, schools, and systems with determining alignment to Louisiana Student Standards for Science for resources designed for the Next Generation Science Standards. This guidance document is considered a "living" document, as we believe that teachers and other educators will find ways to improve the document as they use it. Please send feedback to STEM@la.gov so that we may use your input when updating this guide.

Updated August 25, 2021

MOTION AND STABILITY: FORCES AND INTERACTIONS	HS-PS2-1
LSSS	**NGSS**
Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.	
Clarification Statement	
Physics: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. <u>Emphasis is on kinematics</u>, one-dimensional motion, <u>two-dimensional motion</u>, and macroscopic objects moving at non-relativistic speeds.	Physics: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on one-dimensional motion to macroscopic objects moving at non-relativistic speeds.
Science and Engineering Practice:	Analyzing and interpreting data
Disciplinary Core Ideas:	Forces and motion
Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS.PS2.A.a)	
Crosscutting Concepts:	Cause and Effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

Underlined sections denote* ***wording differences* *that appear in the Louisiana Student Standards for Science.*

<table>
<tr><th>MOTION AND STABILITY: FORCES AND INTERACTIONS</th><th>HS-PS2-2</th></tr>
<tr><th>LSSS</th><th>NGSS</th></tr>
<tr><td colspan="2">Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.</td></tr>
<tr><th colspan="2">Clarification Statement</th></tr>
<tr><td>Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle as well as systems of two macroscopic bodies moving in one dimension..</td><td>Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. Limited to systems of two macroscopic bodies moving in one dimension.</td></tr>
<tr><th>Science and Engineering Practice:</th><td>Using mathematics and computation thinking</td></tr>
<tr><th>Disciplinary Core Ideas:</th><td>Forces and motion</td></tr>
<tr><td>Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. (HS.PS2A.b)</td><td>Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.</td></tr>
<tr><td colspan="2">If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS.PS2A.c)</td></tr>
<tr><th>Crosscutting Concepts:</th><td>Systems and system models</td></tr>
<tr><td colspan="2">When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.</td></tr>
</table>

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MOTION AND STABILITY: FORCES AND INTERACTIONS	HS-PS2-3
LSSS	**NGSS**
Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.	
Clarification Statement	
Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it <u>by applying the impulse-momentum theorem.</u> Examples of a device could include a football helmet <u>or an airbag</u>. Emphasis is on qualitative evaluations and/or algebraic manipulations.	Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute. Limited to qualitative evaluations and/or algebraic manipulations.
Science and Engineering Practice:	Constructing explanations and designing solutions
Disciplinary Core Ideas:	Forces and motion
If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS.PS2A.c)	
	Defining and delimiting engineering problems
Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a)	
	Optimizing the design solution
Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade- offs) may be needed. (HS.ETS1C.a)	
Crosscutting Concepts:	Cause and Effect
Systems can be designed to cause a desired effect.	

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MOTION AND STABILITY: FORCES AND INTERACTIONS	**HS-PS2-4**
LSSS	**NGSS**
Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.	
Clarification Statement	
Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.	
Science and Engineering Practice:	Using mathematics and computational thinking
Disciplinary Core Ideas:	Types of interactions
Newton's Law of Universal Gravitation and Coulomb's Law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between objects <u>not in physical contact.</u> (HS.PS2B.a)	Newton's Law of Universal Gravitation and Coulomb's Law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between objects.
Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS.PS2B.b)	
Crosscutting Concepts:	Patterns
Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	

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MOTION AND STABILITY: FORCES AND INTERACTIONS	**HS-PS2-5**
LSSS	**NGSS**
Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.	
Clarification Statement	
Evidence of changes within a circuit can be represented numerically, graphically, or algebraically using Ohm's law. Emphasis is on designing and conducting investigations using qualitative evidence to determine the relationship between electric current and magnetic fields. Examples of evidence can include movement of a magnetic compass needle when placed in the vicinity of a current-carrying wire, and a magnet passing through a coil that turns on the light of a Faraday flashlight.	Limited to designing and conducting investigations with provided materials and tools.
Science and Engineering Practice:	Planning and carrying out investigations
Disciplinary Core Ideas:	Types of interactions
Forces that act over a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS.PS2B.b)	
	Definitions of energy
"Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (HS.PS3A.d)	
Crosscutting Concepts:	Cause and effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

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ENERGY	**HS-PS3-1**
LSSS	**NGSS**
Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.	
Clarification Statement	
Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations, systems of two or three components, and thermal energy.	Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations, systems of two or three components, and thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.
Science and Engineering Practice:	Using mathematics and computational thinking
Disciplinary Core Ideas:	Definitions of Energy
Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations; systems of two or three components; and thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.	
	Conservation of energy and energy transfer
Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS.PS3B.a) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS.PC3B.b)	
Mathematical expressions allow the concept of conservation of energy to be used to predict and describe system behavior. These expressions quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and velocity. (HS.PC3B.c)	Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
The availability of energy limits what can occur in any system. (HS.PC3B.d)	
Crosscutting Concepts:	Systems and system models
Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.	

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ENERGY	HS-PS3-2
LSSS	**NGSS**
Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects).	
Clarification Statement	
Examples of phenomena at the macroscopic scale could include the conversion of potential energy to kinetic and thermal energy, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.	Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.
Science and Engineering Practice:	Developing and using models
Disciplinary Core Ideas:	Definitions of energy
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. There is a single quantity called energy. A system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS.PS3A.a) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b) These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS.PS3A.c)	
Crosscutting Concepts:	Energy and matter
Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.	

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<table>
<tr><td colspan="2">ENERGY — HS-PS3-3</td></tr>
<tr><th>LSSS</th><th>NGSS</th></tr>
<tr><td colspan="2">Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.</td></tr>
<tr><td colspan="2">Clarification Statement</td></tr>
<tr><td>Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. <u>Focus of quantitative evaluations is limited to total output for a given input</u>. Emphasis is on devices constructed with <u>teacher approved materials.</u> Examples of devices <u>in physics</u> could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and <u>electric motors.</u></td><td>Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency. Limited to devices constructed with materials provided to students.</td></tr>
<tr><td colspan="2">Science and Engineering Practice: Constructing explanations and designing solutions</td></tr>
<tr><td colspan="2">Disciplinary Core Ideas: Definitions of energy</td></tr>
<tr><td colspan="2">At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b)</td></tr>
<tr><td colspan="2">Energy in chemical processes</td></tr>
<tr><td colspan="2">Although energy cannot be destroyed, it can be converted to other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a)</td></tr>
<tr><td colspan="2">Defining and delimiting engineering problems</td></tr>
<tr><td colspan="2">Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a)</td></tr>
<tr><td colspan="2">Crosscutting Concepts: Energy and matter</td></tr>
<tr><td colspan="2">Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.</td></tr>
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ENERGY	HS-PS3-4
LSSS	**NGSS**
Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).	
Clarification Statement	
Emphasis is on analyzing data from student investigations and using mathematical thinking appropriate to the subject to describe the energy changes quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.	Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.
Science and Engineering Practice:	Planning and carrying out investigations
Disciplinary Core Ideas:	Conservation and energy transfer
Energy cannot be created or destroyed, but it can be transported from one place to another, transformed into other forms, and transferred between systems. (HS.PS3B.b) Uncontrolled systems always evolve toward more stable states--that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS.PS3B.e)	
Energy in chemical processes and everyday life	Energy in chemical processes
When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.	
Crosscutting Concepts:	Systems and system models
Although energy cannot be destroyed, it can be converted to less useful other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a)	

Underlined sections denote* ***information* *that does not appear in both sets of standards.*

ENERGY	HS-PS3-5
LSSS	**NGSS**
Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.	
Clarification Statement	
Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.	
Science and Engineering Practice:	Developing and using models
Disciplinary Core Ideas:	Relationship between energy and forces
When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS.PS3C.a)	
Crosscutting Concepts:	Cause and Effect
Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.	

WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER	HS-PS4-1
LSSS	**NGSS**
Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.	
Clarification Statement	
Examples of data could include electromagnetic radiation traveling through a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. Emphasis is on algebraic relationships and describing those relationships qualitatively.	
Science and Engineering Practice:	Using mathematical and computational thinking
Disciplinary Core Ideas:	Wave properties
The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS.PS4A.a)	
Crosscutting Concepts:	Cause and effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER	HS-PS4-2
HS-PS4-2 DOES NOT APPEAR IN LOUISIANA STANDARDS	Evaluate questions about the advantage of using digital transmission and storage of information.
Clarification Statement	
HS-PS4-2 DOES NOT APPEAR IN LOUISIANA STANDARDS	Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.
Science and Engineering Practice:	Asking questions and designing solutions
Disciplinary Core Ideas:	Wave properties
HS-PS4-2 DOES NOT APPEAR IN LOUISIANA STANDARDS	Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.
Crosscutting Concepts:	Stability and change
HS-PS4-2 DOES NOT APPEAR IN LOUISIANA STANDARDS	Systems can be designed for greater or lesser stability.

WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER	HS-PS4-3
LSSS	**NGSS**
Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.	
Clarification Statement	
Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect. Quantum theory is not included.	
Science and Engineering Practice:	Engaging in argument from evidence
Disciplinary Core Ideas:	Wave properties
Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (HS.PS4A.b)	
	Electromagnetic radiation
Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS.PS4B.a)	
Crosscutting Concepts:	Systems and system models
Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales.	

WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER	HS-PS4-4
HS-PS4-4 DOES NOT APPEAR IN LOUISIANA PHYSICS STANDARDS - APPEARS IN PHYSICAL SCIENCE	Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter
Clarification Statement	
HS-PS4-4 DOES NOT APPEAR IN LOUISIANA PHYSICS STANDARDS - APPEARS IN PHYSICAL SCIENCE *(*with additional clarification)*	Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.
Science and Engineering Practice:	Obtaining, evaluating, and communicating information
Disciplinary Core Ideas:	Nuclear processes
HS-PS4-4 DOES NOT APPEAR IN LOUISIANA PHYSICS STANDARDS - APPEARS IN PHYSICAL SCIENCE	When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS.PS4B.b)
Crosscutting Concepts:	Energy and matter
HS-PS4-4 DOES NOT APPEAR IN LOUISIANA PHYSICS STANDARDS - APPEARS IN PHYSICAL SCIENCE	Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER	HS-PS4-5
HS-PS4-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.
Clarification Statement	
HS-PS4-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.
Science and Engineering Practice:	Obtaining, evaluating, and communicating information
Disciplinary Core Ideas:	Energy in chemical processes
HS-PS4-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.
	Electromagnetic radiation
HS-PS4-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	Photoelectric materials emit electrons when they absorb light of a high-enough frequency.
	Information technologies and instrumentation
HS-PS4-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.
Crosscutting Concepts:	Energy and matter
HS-PS4-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	Systems can be designed to cause a desired effect.