Introduction

Science, Technology & Engineering, and Environmental Literacy & Sustainability (STEELS) Standards guide the study of the natural and human-made world through inquiry, problem-solving, critical thinking, and authentic exploration. This document displays a curriculum framework for High School Physical Science. It is designed to focus curriculum and teaching, provide guidance for multiple approaches to curriculum development, encourage less reliance on textbooks as curriculum, and avoid activity-oriented teaching without focus/purpose.

Science Long Term Transfer Goals

In support of the Curriculum Framework, Long Term Transfer Goals (LTTG) provide the overarching practices that ground the foundation for a robust curriculum; thus, all curriculum should relate to one or more of the LTTGs detailed below – as they highlight the effective uses of understanding, knowledge, and skill that we seek in the long run; i.e., what we want students to be able to do when they confront new challenges – both in and outside of school.

Students will be able to engage as technological and engineering literate members of a global society, using their learning to:

1. Approach science as a reliable and tentative way of knowing and explaining the natural world and designed world.
2. Weigh evidence and use scientific approaches to ask questions, investigate, and make informed decisions.
3. Make and use observations to analyze relationships and patterns in order to explain phenomena, develop models, and make predictions.
4. Evaluate systems, in order to connect how form determines function and how any change to one component affects the entire system.
5. Explain how the natural and designed worlds are interrelated and the application of scientific knowledge and technology can have beneficial, detrimental, or unintended consequences.

Grade 9-12 Physical Science

Structure and Properties of Matter						
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Idea**	**Crosscutting Concepts**	**Vocabulary**
All forms of matter exist as a result of the combination or rearrangement of atoms.	How do particles combine to form the variety of matter one observes?	**3.2.9-12.A** **Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.**	**Developing and Using Models** Use a model to predict the relationships between systems or between components of a system.	Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	**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.	proton neutron electron atomic number mass number isotope electron affinity shielding effect electronegativity atomic radius ionization energy valence electrons electron shells octet rule orbital diagrams electron configuration orbitals sublevels periodic table patterns

All forms of matter exist as a result of the combination or rearrangement of atoms.	How do particles combine to form the variety of matter one observes?	**3.2.9-12.B** **Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.**	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	**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.	intermolecular forces ions physical properties coulomb's law Lewis dot structures lattice energy patterns
All forms of matter exist as a result of the combination or rearrangement of atoms.	How do particles combine to form the variety of matter one observes?	**3.2.9-12.C** **Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.**	**Constructing Explanations and Designing Solutions** Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**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.	reactants products types of bonds types of reactions reactivity patterns

All forms of matter exist as a result of the combination or rearrangement of atoms.	How do particles combine to form the variety of matter one observes?	**3.2.9-12.D** **Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.**	**Developing and Using Models** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	**Energy and Matter** 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.	energy transfers types of energy bond and binding energy models systems

Chemical Reactions

Big Idea	Essential Question	Standard	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts	Vocabulary
The atoms of some substances combine or rearrange to form new substances that have different properties.	How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?	**3.2.9-12.E** **Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.**	**Constructing Explanations and Designing Solutions** Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that	**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.	collision theory chemical reactions reaction rate reactants solutions temperature concentration solubility patterns scientific principles

				are matched by changes in kinetic energy.		
The atoms of some substances combine or rearrange to form new substances that have different properties.	How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?	**3.2.9-12.F** **Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.**	**Constructing Explanations and Designing Solutions** Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.	In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. 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.	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable.	equilibrium percent yield Le Chatelier's Principle design
The atoms of some substances combine or rearrange to form new substances that have different properties.	How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?	**3.2.9-12.G** **Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.**	**Using Mathematics and Computational Thinking** Use mathematical representations of phenomena to support claims.	The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Energy and Matter** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. **Connections to Nature of Science** Science assumes the universe is a vast single system in which basic laws are consistent.	molar mass balancing equations stoichiometry law of conservation of matter nuclear processes

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Nuclear Processers

Big Idea	Essential Question	Standard	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts	Vocabulary
Phenomena involving nuclei explain the formation of the elements, radioactivity, and the release of energy.	What forces hold nuclei together and mediate nuclear processes?	**3.2.9-12.H** **Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.**	**Developing and Using Models** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**Energy and Matter** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	isotopes nuclear fission radioactive decay stable nuclei unstable nuclei half-life types of radiation (alpha, beta, gamma) nuclear fusion models

Forces and Motion

Big Idea	Essential Question	Standard	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts	Vocabulary
A change in motion of interacting objects can be explained and predicted by forces.	How can one predict an object's continued motion, changes in motion, or stability?	**3.2.9-12.I** **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.**	**Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	Newton's second law accurately predicts changes in the motion of macroscopic objects.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	force system speed velocity acceleration mass net force vector scalar magnitude causality cause and effect
A change in motion of interacting objects can be explained and predicted by forces.	How can one predict an object's continued motion, changes in motion, or stability?	**3.2.9-12.J** **Use mathematical representations to support the claim that the total momentum of a system of objects is**	**Using Mathematics and Computational Thinking** Use mathematical representations of phenomena to describe explanations.	Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. If a system interacts with objects outside itself, the	**Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.	momentum impulse force conservation net force elastic collision inelastic collision

		conserved when there is no net force on the system.		total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.		system models
A change in motion of interacting objects can be explained and predicted by forces.	How can one predict an object's continued motion, changes in motion, or stability?	**3.2.9-12.K** **Apply scientific and engineering ideas to design, evaluate and refine a device that minimizes the force on a macroscopic object during a collision.**	**Constructing Explanations and Designing Solutions** Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.	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. **Defining and Delimiting an Engineering Problem:** 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. **Optimizing the Design Solution:** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the	**Cause and Effect** Systems can be designed to cause a desired effect.	force time impulse momentum collision acceleration design

				priority of certain criteria over others (trade-offs) may be needed.		

Types of Interactions

Big Idea	Essential Question	Standard	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts	Vocabulary
All forces between objects, regardless of size or direction, arise from only a few types of interactions.	What underlying forces explain the variety of interactions observed?	**3.2.9-12.L** **Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.**	**Using Mathematics and Computational Thinking** Use mathematical representations of phenomena to describe explanations.	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 distant 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.	**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.	gravitational force newton's law of gravitation Coulomb's Law electric force inverse square law field patterns
All forces between objects, regardless of size or direction, arise from only a few types of interactions.	What underlying forces explain the variety of interactions observed?	**3.2.9-12.** **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.**	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and	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 distant objects.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	electric current field circuit

			accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	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. “Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents.		
All forces between objects, regardless of size or direction, arise from only a few types of interactions.	What underlying forces explain the variety of interactions observed?	**3.2.9-12.N** **Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.**	**Obtaining, evaluating, and communicating information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.	**Structure and Function** Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.	molecular structure conductivity polarity state of matter friction

Definitions of Energy						
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Idea**	**Crosscutting Concepts**	**Vocabulary**
Energy can be modeled as either motions of particles or as being stored in force fields.	What is energy?	**3.2.9-12.O** **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.**	**Developing and Using Models** Create a computational model or simulation of a phenomenon, designed device, process, or system.	Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that 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. 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. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. Mathematical expressions, which quantify how the stored energy in a system	**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. **Connections to Nature of Science** Science assumes the universe is a vast single system in which basic laws are consistent.	kinetic energy mechanical energy potential energy energy transfer system conservation of energy first law of thermodynamics system models basic laws

				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.		
Energy can be modeled as either motions of particles or as being stored in force fields.	What is energy?	**3.2.9-12.P** **Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).**	**Developing and Using Models** Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that 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. At the macroscopic scale, energy manifests itself in multiple ways, such as in	**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.	energy kinetic energy potential energy conservation of energy first law of thermodynamics models

				motion, sound, light, and thermal energy. 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.		
Energy can be modeled as either motions of particles or as being stored in force fields.	What is energy?	**3.2.9-12.Q** **Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.**	**Constructing explanations and designing solutions** Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. Although energy cannot be destroyed, it can be converted to less useful forms—for example, to	**Energy and Matter** 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. **Connections to Engineering, Technology, and Applications of Science**	energy conservation of energy energy transfer mechanical energy kinetic energy potential energy technological systems

				thermal energy in the surrounding environment. 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 state.	Modern civilization depends on major technological systems. Engineers continuously modify these technologies	

Conservation of Energy and Energy Transfer

Big Idea	Essential Question	Standard	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts	Vocabulary
The total change of energy in any system is always equal to the total energy transferred into or out of the system.	What is meant by conservation of energy? How is energy transferred between objects or systems?	**3.2.9-12.R** **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).**	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. 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). Although energy cannot be destroyed, it can be converted to less useful forms—for example, to	**Systems and System Models** 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.	second law of thermodynamics thermal energy heat heat transfer systems closed system system models

				thermal energy in the surrounding environment.		

Relationship Between Energy and Forces

Big Idea	Essential Question	Standard	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts	Vocabulary
Forces between objects can result in transfer of energy between these objects.	How are forces related to energy?	**3.2.9-12.S** **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.**	**Developing and Using Models** Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	When two objects interacting through a field change relative position, the energy stored in the field is changed.	**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.	Coulomb's Law Lorentz force law field force

Wave Properties

Big Idea	Essential Question	Standard	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts	Vocabulary
Waves are repeating patterns of motion that transfer energy and information without transferring matter.	What are the characteristic properties and behaviors of waves?	**3.2.9-12.T** **Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**	**Using mathematics and computational thinking** Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	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.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	medium frequency wave wavelength longitudinal wave transverse wave wave speed
Waves are repeating patterns of motion that transfer energy and information without transferring matter.	What are the characteristic properties and behaviors of waves?	**3.2.9-12.U** **Evaluate questions about the advantages of using digital transmission and storage of information.**	**Engagement in argument from evidence** Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data	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	**Stability and Change** Systems can be designed for greater or lesser stability. **Technology, and Applications of Science**	digital transmission information storage wave behavior technological systems

			set, or the suitability of a design.	distances as a series of wave pulses.	Modern civilization depends on major technological systems. Engineers continuously modify these technologies.	
Waves are repeating patterns of motion that transfer energy and information without transferring matter.	What are the characteristic properties and behaviors of waves?	**3.2.9-12.V** **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.**	**Obtaining, evaluating, and communicating information** Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	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. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) 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.	**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.	electromagnetic radiation wave model of radiation particle model of radiation photon system models

Electromagnetic Radiation

Big Idea	Essential Question	Standard	Science and Engineering Practices	Disciplinary Core Idea	Cross-Cutting Concepts	Vocabulary
Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave pattern of changing electric and magnetic fields that interact with matter.	What is light? How can one explain the varied effects that involve light? What other forms of electromagnetic radiation are there?	**3.2.9-12.W** **Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.**	**Obtaining, evaluating, and communicating information** Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.	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.	**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.	electromagnetic wave wavelength frequency wave energy wave absorption systems

Information Technologies and Instrumentation

Big Idea	Essential Question	Standard	Science and Engineering Practices	Disciplinary Core Idea	Cross-Cutting Concepts	Vocabulary
Useful modern technologies and instruments have been designed based on an understanding of waves and their interactions with matter.	How are instruments that transmit and detect waves used to extend human senses?	**3.2.9-12.X** **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.**	**Obtaining, evaluating, and communicating information** Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy. 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. Photoelectric materials emit electrons when they absorb	**Cause and Effect** Systems can be designed to cause a desired effect. **Connections to Engineering, Technology, and Applications of Science** Science and engineering complement each other in the cycle known as research and development (R&D).	digital transmission wave interference systems technological devices systems

				light of a high-enough frequency. 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.		