Science, Technology, and Engineering Standards

Science and engineering provide people with knowledge and tools to understand and address many of the challenges of a rapidly changing world, thus enabling them to be **creative and practical problem solvers** (Maine Guiding Principle C). Science is a way of knowing about the world that enables people to both engage in the construction of new knowledge and to use information to achieve desired ends (NIH). Engineering enables people to systematically solve problems using scientific knowledge, to design and test solutions and evaluate them using agreed-upon and measurable criteria.

Science and Engineering Literacy

In the last few decades, much has been written about the critical role of science literacy in an equitable and just society. For example, the Board on Science Education within the National Academies of Science argue that

> “Science literacy is desirable not only for individuals, but also for the health and well-being of communities and society. More than just basic knowledge of science facts, contemporary definitions of science literacy have expanded to include understandings of scientific processes and practices, familiarity with how science and scientists work, a capacity to weigh and evaluate the products of science, and an ability to engage in civic decisions about the value of science.”

Here we recognize that, in addition to understanding and evaluating science knowledge and critiquing the development of that knowledge, learners must also develop literacy related to science and engineering practices and design. In other words, they should know about and be able to critique the processes by which engineers develop and test products in response to consumer, industrial, and/or civic needs. The Maine Science and Engineering Standards provide a framework for supporting K-12 students’ development as **self-directed lifelong learners** (Maine Guiding Principle B) who are able to apply knowledge from the domains of science and engineering to set goals and make decisions.

Understanding Controversy in Science

Individuals have ready access to abundant information in our modern global society. Consequently, they will encounter myriad arguments related to various scientific topics. Moreover, arguments will change over time, as new evidence becomes available and as people draw on scientific evidence to formulate arguments in shifting social contexts. It is therefore imperative that individuals understand that controversy within the scientific community is normal and has been historically productive. “True scientific controversy involves competing scientific ideas that are evaluated according to the standards of science — i.e., fitting the evidence, generating accurate expectations, offering satisfying explanations, inspiring research, etc...few theories fit our observations of the world perfectly. There is usually some anomalous observation that doesn't seem to fit with our current understanding. Scientists assume that by working at such anomalies, they'll either disentangle them to see how they fit with the current theory or contribute to a new theory” ("Even Theories Change." Understanding Science. University of California Museum of Paleontology. 23 July 2018 <http://www.understandingscience.org/article/alvarez_01>). One well documented example of productive controversy is the development of modern theories that explain and predict phenomena in the physical world. Newton originally posited a theory of mechanics that adequately explained phenomena as varied as projectile motion and planetary orbit. Centuries later, Einstein developed the theory of special relativity to account for additional phenomena related to electricity and magnetism. The need to account for and predict the effects of gravity spurred scientists to offer the theory of general relativity. Thus, “theory change is a community process of feedback, experiment, observation, and communication. It usually involves interpreting existing data in new ways and incorporating those views with new results" ("Even Theories Change." Understanding Science. University of California Museum of Paleontology. 23 July 2018 <http://www.understandingscience.org/article/alvarez_01>).

Becoming Critical and Engaged Consumers of Science and Engineering
As learners encounter diverse perspectives related to scientific issues, it is crucial that they become **integrative and informed thinkers** (Maine Guiding Principle E) able to discern reliable and valid information. Such information is generated through accepted scientific and engineering practices (e.g., analyzing and interpreting data, engaging in argument from evidence, etc.). Armed with knowledge and these skills, learners will be able to function as **responsible and involved citizens** (Maine Guiding Principle D) who utilize **clear and effective communication** strategies (Maine Guiding Principle A) to participate productively in decision making that impacts the broader community.

References:

National Research Council. 2012. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.

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Committee on Science Literacy and Public Perception of Science; Board on Science Education; Division of Behavioral and Social Sciences and Education; National Academies of Sciences, Engineering, and Medicine; Snow CE, Dibner KA, editors. Washington (DC): National Academies Press (US); 2016 Oct 14.

OUTLINE OF SCIENCE, TECHNOLOGY AND ENGINEERING STRANDS AND STANDARDS

Physical Sciences

- PS1 Matter and Its Interactions
- PS2 Motion and Stability: Forces and Interactions
- PS3 Energy
- PS4 Waves and Their Applications in Technologies

Life Sciences

- LS1 From Molecules to Organisms: Structures and Processes
- LS2 Ecosystems: Interactions, Energy, and Dynamics
- LS3 Heredity: Inheritance and Variation of Traits
- LS4 Biological Evolution: Unity and Diversity

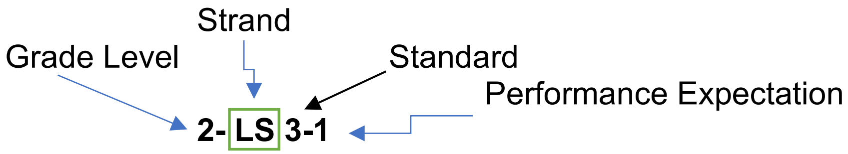
Earth and Space Sciences

- ESS1 Earth's Place in the Universe
- ESS2 Earth's Systems
- ESS3 Earth and Human Activity

Engineering, Technology, and Applications of Science

- ETS1 Engineering Design

HOW TO READ THE STANDARDS



COLOR SCHEME

Science & Engineering Practices (blue)
Disciplinary Core Ideas (orange)
Crosscutting Concepts (green)

Strand	Physical Science (PS)		
Standard	PS1: Matter and Its Interactions		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations			**2-PS1-1 Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.**

			Further explanation: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share. Planning and Carrying out Investigations, Structure and Properties of Matter, Patterns **<u>2-PS1-2</u> Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.** Further explanation: Examples of properties could include strength, flexibility, hardness, texture, and absorbency. Potential Maine connections include snow tires vs. regular tires and mittens made of varying materials (e.g. wool, cotton, Gortex, etc.) Analyzing and Interpreting Data, Structure and Properties of Matter, Cause and Effect **<u>2-PS1-3</u> Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.** Further explanation: Examples of pieces could include blocks, building bricks, or other assorted small objects. Constructing Explanations and Designing Solutions, Structure and Properties of Matter, Energy and Matter **<u>2-PS1-4</u> Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.** Further explanation: Examples of reversible changes could include materials such as water and butter at different temperatures. Potential Maine examples include snow and ice having reversible properties (e.g. water freezes and thaws which allows for ice fishing and skating in colder months). Examples of irreversible changes could include cooking an egg, freezing a plant leaf, heating paper and burning wood in a campfire or woodstove.

			Engaging in Argument from Evidence, Chemical Reactions, Cause and Effect

Strand	Physical Science (PS)		
Standard	PS1: Matter and Its Interactions		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations			**5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.** Further Explanation: Examples of evidence could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water. Investigate the science behind creating Maine maple sugar. Developing and Using Models, Structure and Properties of Matter, Scale, Proportion, and Quantity **5-PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.** Further Explanation: Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances. Investigate the conservation of mass when making fake snow and how the crystals form. Using Mathematics and Computational Thinking, Structure and Properties of Matter, Chemical Reactions, Cause and Effect **5-PS1-3 Make observations and measurements to identify materials based on their properties.** Further Explanation: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of

			properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property. Possibly examine Maine minerals. Planning and Carrying out Investigations, Structure and Properties of Matter, Scale, Proportion and Quantity **<u>5-PS1-4</u> Conduct an investigation to determine whether the mixing of two or more substances results in new substances.** Planning and Carrying out Investigations, Chemical Reactions, Cause and Effect

Strand	Physical Science (PS)
Standard	PS1: Matter and Its Interactions
	Early Adolescence
	Grades 6-8
Performance Expectations	**<u>MS-PS1-1</u> Develop models to describe the atomic composition of simple molecules and extended structures.** Further explanation: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, three-dimensional ball and stick structures, or computer representations showing different molecules with different types of atoms. Developing and using models; Obtaining, evaluating, and communicating information; structure and properties of matter; scale, proportion, and quantity **<u>MS-PS1-2</u> Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.** Further explanation: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride. Examine electrical conductivity differences between fresh water and sea water. Obtaining, evaluating, and communicating information; Analyzing and interpreting data; structure and properties of matter; chemical reactions; patterns

	MS-PS1-3 Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. Further explanation: Emphasis is on natural resources that undergo a chemical process to form synthetic material. Examples of new materials could include new medicines, foods, and alternative fuels (alternative plastics derived from potatoes and jet fuel made from trees). Other possible areas of study might include plastics from organics, advanced composites and wood products under development at UMO. Obtaining, evaluating, and communicating information; chemical reactions; structure and properties of matter; structure and function
	MS-PS1-4 Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. Further explanation: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium. Developing and using models; structure and properties of matter; definitions of energy; cause and effect
	MS-PS1-5 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. Further explanation: Emphasis is on the law of conservation of matter and on physical models or drawings, including digital forms that represent atoms. Developing and using models; chemical reactions; energy and matter
	MS-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. Further explanation: Emphasis is on design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride for road treatments in Maine winters. Constructing explanations and designing solutions; chemical reactions; developing possible solutions; optimizing the design solution; structure and function

Strand	Physical Science (PS)
Standard	PS1: Matter and Its Interactions
	Adolescence
	Grades 9-Diploma

Performance Expectations	**<u>HS-PS1-1</u> 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.** Further explanation: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen. Examples include the properties and bonding of water and the rusting of metals as found in guardrails, ship parts, etc. Consider the metal compounds found in fireworks. Developing and Using Models, structure and properties of matter, types of interactions, patterns
	<u>HS-PS1-2</u> 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. Further explanation: Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or carbon and hydrogen. Examples could include ocean salt formation, combustion (as found in the burning of fuels in Maine homes, cars and the trucking industry) or the detection of carbon monoxide in a home (complete vs incomplete combustion). Constructing Explanations and Designing Solutions, structure and properties of matter, chemical reaction, patterns
	<u>HS-PS1-3</u> 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. Further explanation: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension. Examples could consider why we salt roads in the winter, differences in melting points of water vs saltwater, the production of maple syrup or the strength of Maine minerals. Planning and Carrying out Investigations, structure and properties of matter, types of interactions, patterns
	<u>HS-PS1-4</u> Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends on the changes in total bond energy. Further explanation: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved. Developing and Using Models, structure and properties of matter, Energy and Matter
	<u>HS-PS1-5</u> 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. Further explanation: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules. Examples could include the varied rates of oxidation of metals in winter vs in summer or

	the rate of dissolution of calcium shells in the ocean due to an increase in carbon dioxide an increase in temperature from climate change. Constructing Explanations and Designing Solutions, Chemical Reactions, patterns
	HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. Further explanation: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products. Other examples to consider include the Kraft paper making process, soap making or rock candy formation. Constructing Explanations and Designing Solutions, structure and properties of matter, Chemical Reactions, Types of Interactions, Optimizing Design Solution patterns, cause and effect, scale, proportion, and quantity
	HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Further explanation: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques. Examples could include the proportion of ingredients combined in baked goods or the combustion of fuels. Using Mathematics and Computational Thinking, Chemical Reactions, Energy and Matter
	HS-PS1-8 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. Further explanation: Emphasis is on simple qualitative models, such as pictures or diagrams and on the scale of energy released in nuclear processes relative to other kinds of transformations. Examples could include radon gas in basements, thorium in white gas mantles or, historically, Wiscasset's Maine Yankee nuclear power plant and Fukushima in Japan. Developing and engineering practices, Nuclear Processes, patterns, cause and effect, scale, proportion, and quantity

Strand	Physical Science (PS)		
Standard	PS2: Motion and Stability: Forces and Interactions		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations	**K-PS2-1 Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.** Further explanation: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other. Planning and Carrying out Investigations, Forces and Motion, Types of Interactions, Relationship between Energy and Forces, Cause and Effect **K-PS2-2 Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.** Further explanation: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.		

	Analyzing and Interpreting Data, Forces and Motion, Defining Engineering Problems, Cause and Effect		

Strand	Physical Science (PS)		
Standard	PS2: Motion and Stability: Forces and Interactions		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.** Further Explanation: Examples could include an unbalanced force on one side of a ball can make it start moving and balanced forces pushing on a box from both sides will not produce any motion at all. Other examples can be found in a variety of Maine sports from ice skating, curling, skiing to sledding. Planning and Carrying Out Investigations, Forces and Motion, Types of Interactions, Cause and Effect **3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.** Further Explanation: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw. Other examples include dropping down in a skate park, snowboarding pipes and telemark skiing (slowing down, turns, etc.). Planning and Carrying out Investigations, Forces and Motion, Patterns		**5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down.** Further Explanation: "Down" is a local description of the direction that points toward the center of the spherical Earth. Engaging in Argument from Evidence, Types of Interactions, Cause and Effect

	<u>3-PS2-3</u> Ask questions to determine cause and effect relationships of electrical or magnetic interactions between two objects not in contact with each other. Further Explanation: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force. Asking Questions and Defining Problems, Types of Interactions, Cause and Effect **<u>3-PS2-4</u> Define a simple design problem that can be solved by applying scientific ideas about magnets.** Further Explanation: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other. Other examples include a magnetic latch for a container or device (Apple and magnetic plug for charger). Asking Questions and Defining Problems, Types of Interactions		

Strand	Physical Science (PS)
Standard	PS2: Motion and Stability: Forces and Interactions

	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-PS2-1 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.** Further explanation: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle. Constructing explanations and designing solutions; forces and motion; system and system models;
	MS-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. Further explanation: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units. Plan and carry out investigations; forces and motion; stability and change;
	MS-PS2-3 Ask questions about data to determine the factors that affect the strength of electrical and magnetic forces. Further explanation: Examples of devices that use electrical and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor. Possible explorations include the effects of living near high tension power lines, the similarities found in hydroelectric generators and wind turbines or the growing electric car market in Maine. Asking questions and defining problems; types of interactions; cause and effect;
	MS-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. Further explanation: Examples of evidence for arguments could include data generated from simulations or digital tools and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system. Examples include the gravitational effects of the moon on Maine tides. Engaging in argument from evidence; types of interactions; system and system models;
	MS-PS2-5 Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. Further explanation: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, electrically-charged pith balls, and maglev trains. Examples of investigations could include first-hand experiences or simulations. Plan and carry out investigations; types of interactions; cause and effect;

Strand	Physical Science (PS)
Standard	PS2: Motion and Stability: Forces and Interactions
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-PS2-1 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.** Further explanation: 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 moving object being pulled by a constant force. Examples could include the acceleration of a snowmobile in different gears (same mass with different forces creating different accelerations) or the comparison of gas mileage between a truck vs a truck hauling a boat (same acceleration with different masses). Analyzing and Interpreting Data, Types of Interactions, Forces and Motion, Cause and Effect
	HS-PS2-2 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. Further explanation: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. Examples could include jumping off a boat or canoe and the total momenta of all the various pieces exploding from fireworks. Using Mathematics and Computational Thinking, Forces and Motion, Systems and System Models
	HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. Further explanation: Examples of evaluation and refinement could include determining the success of a 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. Examples could also include the barriers on the sides of NASCAR tracks, truck safety hills on the sides of highways, bike helmets or car bumpers. Constructing Explanations and Designing Solutions, structure and properties of matter, Forces and Motion, Defining and Delimiting Engineering Problems, Optimizing the Design Solution, types of interactions, Cause and Effects
	HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. Further explanation: Emphasis is on both quantitative and conceptual descriptions of gravitational and electrical fields. Using Mathematics and Computational Thinking, Types of Interactions, Patterns

	HS-PS2-5 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. Further explanation: Examples could include wind turbines or generators along with any DC motorized toy. Planning and Carrying out an Investigation, Types of Interactions, Definitions of Energy, Cause and Effect
	HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. Further explanation: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors. Examples could also include composite material substitutes for wood and the structure of solar cells along with how they work. Obtaining, Evaluating, and Communicating Information, Structure and Property of Matter, Types of Interactions, Structure and Function

Strand	Physical Science (PS)		
Standard	PS3: Energy		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations	**K-PS3-1 Make observations to determine the effect of sunlight on Earth's surface.** Further explanation: Examples of Earth's surface could include sand, soil, rocks, and water. Potential Maine connections could also include beach sand in the sun vs. beach sand in the shade.		

	Planning and Carrying out Investigations, Conservation of Energy and Energy Transfer, Cause and Effect **K-PS3-2 Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.** Further explanation: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun. Constructing Explanations and Designing Solutions, Conservation of Energy and Energy Transfer, Cause and Effect		

Strand	Physical Science (PS)		
Standard	PS3: Energy		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations		**4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object.** Further Explanation: Examples include coasting on a bike down a hill or how bumping into someone or something when walking or running changes speed. Other examples include dropping into a skateboard bowl or off of a ramp. Constructing Explanations and Designing Solutions, Definitions of Energy, Cause and Effect	**5-PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, and motion, and to maintain body warmth) was once energy from the sun.** Further Explanation: Examples of models could include diagrams, and flow charts. Developing and Using Models, Energy in Chemical Processes and Everyday Life, Organization for Matter and

		4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. Planning and Carrying out Investigations, Definitions of Energy, Conservation of Energy and Energy Transfer, Cause and Effect **4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide.** Further Explanation: Emphasis is on the changes in the energy due to the changes in speed, not on the forces, as objects interact. These changes can be observed in playing pool or marbles. Asking Questions and Defining Problems, Definitions of Energy, Conservation of Energy and Energy Transfer, Relationship between Energy and Forces, Cause and Effect **4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.** Further Explanation: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound and a passive solar heater that converts light into heat. Such devices can be used to make s'mores or to turn on a small light when camping in the Maine woods. Examples of constraints could include the materials, cost, or time to design the device.	Energy Flow in Organisms, Energy and Matter

		Constructing Explanations and Designing Solutions, Natural Hazards, Conservation of Energy and Energy Transfer, Energy in Chemical Processes, Defining Engineering Problems, Cause and Effect	

Strand	Physical Science (PS)
Standard	PS3: Energy
	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.** Further explanation: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a whiffle ball versus a tennis ball. Consider different sized skiers or different vehicles from pulp trucks to personal cars. Analyzing and interpreting data; definitions of energy; scale, proportion, and quantity
	MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. Further explanation: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems. Developing and using models; definitions of energy; relationship between energy and forces; system and system models
	MS-PS3-3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. Further explanation: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup. Possible explorations could include insulating outerwear and clothing for winter sports or emergency shelters designed for Maine winters. Constructing explanations and designing solutions; definitions of energy; conservation of energy and energy transfer; defining and delimiting an engineering problem; developing possible solutions; energy and matter

		MS-PS3-4 Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. Further explanation: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added. Planning and carrying out investigations, Definitions of energy; conservation of energy and energy transfer; scale, proportion, and quantity
		MS-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. Further explanation: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of an object. Engaging in argument from evidence; conservation of energy and energy transfer; energy and matter

Strand	Physical Science (PS)
Standard	PS3: Energy
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-PS3-1 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.** Further explanation: Emphasis is on explaining the meaning of mathematical expressions used in the model. Examples could include wind turbines, hydroelectric or tidal power. Further examples could be found in FunTown USA roller coasters or any sport (e.g. why a hockey puck changes motion, a baseball being hit, etc.). Using Mathematics and Computational Thinking, Definitions of Energy, Conservation of Energy and Energy Transfer, Systems and System Models
	HS-PS3-2 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 position of particles (objects). Further explanation: 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. Developing and Using Models, Definitions of Energy, Energy and Matter

	HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. Further explanation: 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. Consider the Wind Blade Challenge or use of a solar oven when camping. Constructing Explanations and Designing Solutions, Definitions of Energy, Defining and Delimiting Engineering Problems, Energy and Matter
	HS-PS3-4 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). Further explanation: 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. Other examples can be found in heat pumps for radiant heat systems, insulation (to prevent heat transfer) or the use of hot rocks to warm a tent when camping. Planning and Carrying out an Investigation, Conservation of Energy and Energy Transfer, Energy in Chemical Processes, Systems and System Models
	HS-PS3-5 Develop and use a model of two objects interacting through electrical or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. Further explanation: 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. Developing and Using Models, Relationship between Energy and Forces, Cause and Effect

Strand	Physical Science (PS)		
Standard	PS4: Waves and Their Applications in Technologies for Information Transfer		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations		**1-PS4-1 Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.** Further explanation: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter	

		vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork. Planning and Carrying Out Investigations, Wave Properties, Cause and Effect **1-PS4-2 Make observations to construct an evidence-based account that objects can be seen only when illuminated.** Further explanation: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer (in Acadia National Park) with a flashlight. Illumination could be from an external light source or by an object giving off its own light. Constructing Explanations and Designing Solutions, Electromagnetic Radiation, Cause and Effect **1-PS4-3 Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.** Further explanation: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror). Planning and Carrying out Investigations, Electromagnetic Radiation, Cause and Effect **1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.** Further explanation: Examples of devices could include a light source to send signals,	

		paper cup and string "telephones," and a pattern of drum beats. Constructing Explanations and Designing Solutions, Information Technologies and Instrumentation	

Strand	Physical Science (PS)		
Standard	PS4: Waves and Their Applications in Technologies for Information Transfer		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations		**4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.** Further Explanation: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves. Use an oscilloscope app to illustrate the patterns in an animal call or musical instrument and engineer a pattern to mimic the call. Developing and Using Models, Wave Properties, Patterns **4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.** Further Explanation: Examples of Maine animal eyes at night such as coyotes, deer and foxes reflecting light from their retinas. Developing and Using Models, Electromagnetic Radiation, Patterns **4-PS4-3 Generate and compare multiple solutions that use patterns to transfer information.**	

		Further Explanation: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text or introduce basic computer code. Constructing Explanations and Designing Solutions, Information Technologies and Instrumentation, Optimizing the Design Solution, Patterns	

Strand	Physical Science (PS)
Standard	PS4: Waves and Their Applications in Technologies for Information Transfer
	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-PS4-1 Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.** Further explanation: Emphasis is on describing waves with both qualitative and quantitative thinking. Possibilities for exploration might include coastal wave erosion, effects of the wind turbines/farms on the air flow patterns and harmonics. Using mathematics and computational thinking; Obtaining, evaluating, and communicating information; wave properties; patterns
	MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. Further explanation: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions. Possibilities for explorations might include Maine's geographic location for utilizing solar power, power generation from ocean waves, possibility for extended farming seasons with artificial lighting. Developing and using models; wave properties; electromagnetic radiation; structure and function
	MS-PS4-3 Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. Further explanation: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in Wi-Fi devices, and conversion of stored binary patterns to make sound or text on a computer screen.

	Obtaining, evaluating, and communicating information; information technologies and instrumentation; structure and function

Strand	Physical Science (PS)
Standard	PS4: Waves and Their Applications in Technologies for Information Transfer
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** Further explanation: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. Examples include rainbows and how to aim when spearfishing. Using Mathematics and Computational Thinking, Wave Properties, Cause and Effect
	HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information. Further explanation: 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. Asking Questions and Defining Problems, Wave Properties, Stability and Change
	HS-PS4-3 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. Further explanation: 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. Engaging in Argument from Evidence, Wave Properties, Systems and System Models
	HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. Further explanation: 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. Arguments around evidence could be made for dangers of cell phone usage or living near high voltage power lines. Obtaining, Evaluating, and Communicating Information, Electromagnetic Radiation, Cause and Effect

	<u>HS-PS4-5</u> 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. Further explanation: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology. Obtaining, Evaluating, and Communicating Information, Wave Properties, Electromagnetic Radiation, Information Technologies and Instrumentation, Cause and Effect

Strand	Life Sciences (LS)		
Standard	LS1: From Molecules to Organisms: Structures and Processes		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations	**<u>K-LS1-1</u> Use observations to describe patterns of what plants and animals (including humans) need to survive.** Further explanation: Examples of patterns could include that animals need to take in food but plants do not, the different kinds of food needed by different types of animals, the requirement of plants to have light, and that all living things need water. Examples could include the pattern a bear makes when preparing to hibernate for winter, the seasonal patterns of trees losing and/or keeping their leaves. Analyzing and Interpreting Data, Organization for	**<u>1-LS1-1</u> Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.** Further explanation: Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; waterproofing boots, jackets, gloves thereby mimicking animal feathers and, detecting intruders by mimicking eyes and ears. Constructing Explanations and Designing Solutions, Structure and Function, Information Processing, Structure and Function **<u>1-LS1-2</u> Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.**	

	Matter and Energy Flow in Organisms, Patterns	Further explanation: Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring). Potential Maine connections include Maine animal sounds to signal their offspring (e.g. loons, moose, deer, coyotes, etc.) and how animals, especially birds, bring back food for their young. Obtaining, Evaluating, and Communicating Information, Growth and Development of Organisms, Patterns	

Strand	Life Sciences (LS)		
Standard	LS1: From Molecules to Organisms: Structures and Processes		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**<u>3-LS1-1</u> Develop models to describe that organisms have unique and diverse life cycles but all have in**	**<u>4-LS1-1</u> Construct an argument that plants and animals have internal and external structures that function to support survival,**	**<u>5-LS1-1</u> Support an argument that plants get the materials they need for growth chiefly from air and water.**

	common birth, growth, reproduction, and death. Further Explanation: Changes organisms go through during their life form a pattern. Potential Maine connections include frogs in vernal pools, Atlantic salmon life cycle and gestation vs. metamorphosis. Developing and Using Models, Growth and Development of Organisms, Patterns	**growth, behavior, and reproduction.** Further Explanation: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin found in Maine plants and animals. Engaging in Argument from Evidence, Structure and Function, Systems and System Models **4-LS1-2 Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.** Further Explanation: Emphasis is on systems of information transfer. Engaging in Argument from Evidence, Information Processing, Systems and System Models	Further Explanation: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil. Investigate Maine plants. Engaging in Argument from Evidence, Organization for Matter and Energy Flow in Organisms, Energy and Matter

Strand	Life Sciences (LS)
Standard	LS1: From Molecules to Organisms: Structures and Processes
	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-LS1-1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.**

	Further explanation: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells. Planning and carrying out investigations; structure and function; scale, proportion, and quantity
	MS-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function. Further explanation: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall. Developing and using models; structure and function; structure and function
	MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting sub-systems composed of groups of cells. Further explanation: Emphasis is on conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of sub-systems within a system and the normal functioning of those systems. Engaging in argument from evidence; structure and function; system and system models
	MS-LS1-4 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively. Further explanation: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury. Potential Maine connections could include herding of white-tail deer and caribou, vocalizations of moose and cardinals, and keystone species such as those on the coast (e.g. harbor seals and sea stars).
	MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. Further explanation: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting the growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than in small ponds. Examples could include winter and cold temperatures, hibernation (e.g. black bear), and the migration of hummingbirds and Canada geese. Constructing explanations and designing solutions; growth and development of organisms; cause and effect

	MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. Further explanation: Emphasis is on tracing movement of matter and flow of energy. Constructing explanations and designing solutions; organization for matter and energy flow in organisms; energy in chemical processes and everyday life; energy and matter
	MS-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. Further explanation: Emphasis is on describing that molecules are broken apart and put back together and that in this process energy is released. Developing and using models; organization for matter and energy flow in organisms; energy in chemical processes and everyday life; energy and matter
	MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. Obtaining, evaluating, and communicating information; information processing; cause and effect

Strand	Life Sciences (LS)
Standard	LS1: From Molecules to Organisms: Structures and Processes
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.** Further explanation: Emphasis is on protein synthesis from DNA to codon to amino acid sequence. Constructing Explanations and Designing Solutions, Structure and Function, Structure and Function
	HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. Further explanation: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system. Another example could be the water and nutrient intake in soft shell clams.

	Developing and Using Models, Structure and Function, Systems and System Models
	<u>HS-LS1-3</u> Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. Further explanation: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels. Another example is commonly observed in the daphnia heart rate response to changes in temperature, caffeine, alcohol, or nicotine. Planning and Carrying out Investigations, Structure and Function, Stability and Change
	<u>HS-LS1-4</u> Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. Developing and Using Models, Growth and Development of Organisms, Systems and System Models
	<u>HS-LS1-5</u> Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. Further explanation: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models. Models may focus on Maine based economy of photosynthetic organisms such as seaweeds, potatoes and pine trees. Developing and Using Models, Organization for Matter and Energy flow in Organisms, Energy and Matter
	<u>HS-LS1-6</u> Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. Further explanation: Emphasis is on using evidence from models and simulations to support explanations. Constructing Explanations and Designing Solutions, Organization for Matter and energy Flow in Organisms, Energy and Matter
	<u>HS-LS1-7</u> Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy. Further explanation: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration. An example could be a moose eating a lily pad, the lily pad producing energy for the moose and the breathing of oxygen by the moose to enable the process of cellular respiration. Developing and Using Models, Organization for Matter and Energy Flow in Organisms, Energy and Matter

Strand	Life Sciences (LS)		
Standard	LS2: Ecosystems: Interactions, Energy, and Dynamics		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations			**2-LS2-1 Plan and conduct an investigation to determine if plants need sunlight and water to grow.** Planning and Carrying out Investigations, Interdependent Relationships in Ecosystems, Cause and Effect **2-LS2-2 Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.** Further explanation: Examples of animals or insects that pollinate plants or disperse seeds could include bees, hummingbirds or bats. An example of a model could be using Velcro to show how seeds of burdocks are spread. Developing and Using Models, Interdependent Relationships in Ecosystems, Developing Possible Solutions, Structure and Function

Strand	Life Sciences (LS)		
Standard	LS2: Ecosystems: Interactions, Energy, and Dynamics		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**3-LS2-1 Construct an argument that some animals form groups that help members survive.**		**5-LS2-1 Develop a model to describe the movement of matter among plants, animals,**

	Further explanation: Maine animals that form groups such as coyotes, deer herds, turkeys, bees, moose, salmon and alewives migration. Engaging in Argument from Evidence, Social Interactions and Group Behaviors, Cause and Effect		**decomposers, and the environment.** Further Explanation: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth. Utilize Maine or Atlantic plants and animals to develop a model of a food chain or web. Developing and Using Models, Interdependent Relationships in Ecosystems, Cycles of Matter and Energy Transfer, Systems and System Models

Strand	Life Sciences (LS)
Standard	LS2: Ecosystems: Interactions, Energy, and Dynamics
	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** Further explanation: Emphasis is on cause and effect relationships between resources and the growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources. Analyzing and interpreting data; interdependent relationships in ecosystems; cause and effect
	MS-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. Further explanation: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial. Potential Maine connections include predation: coyotes and house cats with smaller prey or white tail deer and wolves; mutualism in the union of algae and fungus to form lichen; parasitism in deer ticks on dogs; and commensalism when barnacles attach to minke whales or a grey squirrel makes a nest in a red oak tree.

	Constructing explanations and designing solutions; interdependent relationships in ecosystems; patterns
	MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Further explanation: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems and on defining the boundaries of the system. Explore the reason behind burning blueberry fields biennially and the cycling of matter. Developing and using models; cycle of matter and energy transfer in ecosystems; energy and matter
	MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. Further explanation: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations and on evaluating empirical evidence supporting arguments about changes to ecosystems. Examples include the introduction of invasive species like the green crab or knotweed and their impact on native species. Explore the impacts of farming, urban sprawl and pollution. Engaging in argument from evidence; ecosystem dynamics, functioning, and resilience; stability and change
	MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services. Further explanation: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations. Consider the balance of conservation with the logging of forests or with the lobster and blueberry industries. Engaging in argument from evidence; ecosystem dynamics, functioning, and resilience; biodiversity and humans; developing possible solutions; stability and change

Strand	Life Sciences (LS)
Standard	LS2: Ecosystems: Interactions, Energy, and Dynamics
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** Further Explanation: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical

	comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets. Examples could include a look at historical data of the population of a species that has moved north into Maine, such as opossum, and how it has changed as the climate in Maine has changed. Observe data of the populations of harbor seals and the effect that a hunting ban has had on their population and the resulting increase in the number of large predatory sharks in the Gulf of Maine. Using Mathematics and Computational Thinking, Interdependent Relationships in Ecosystems, Scale, Proportion, and Quantity
	HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. Further explanation: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data. Examples could include a graphical analysis of historical data on the population of trout and/or landlocked salmon before and after the introduction of bass into Moosehead Lake. Or data on a variety of populations (biodiversity) affected by dredging for sea scallops. Using Mathematics and Computational Thinking, Interdependent Relationships in Ecosystems, Scale, Proportion, and Quantity
	HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. Further explanation: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments. An example could include a classroom lab activity around a Winogradsky Column with groups changing a variable such as temperature or light. Additional examples could look at the fermentation processes when blue-green algae is grown in aerobic and anaerobic environments. Constructing Explanations and Designing Solutions, Cycles of Matter and Energy Transfer in Ecosystems, Energy and Matter
	HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. Further Explanation: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem. An example could include an illustration of a food pyramid students may find in Maine (e.g. seaweed → snail → fish → shark, or grass → insects → turkeys → foxes). Using Mathematics and Computational Thinking, Cycles of Matter and Energy Transfer in Ecosystems, Energy and Matter
	HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

	Further explanation: Examples of models could include simulations and mathematical models. Models may include multi-media illustration of the carbon cycle to include a Maine ecosystem they are familiar with such as pond, seaside, farm, forest, etc. Developing and Using Models, Cycles of Matter and Energy Transfer, Energy in Chemical Processes, Systems and System Models
	<u>HS-LS2-6</u> Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. Further explanation: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise. Examples could include how the number of moose hunting licenses impacts other populations or how fishing limits or shortened seasons decreases the catch of many fish species and the effects on ground fish or smaller fish. Engaging in Argument from Evidence, Ecosystem Dynamics, Functioning, and Resilience, Stability and Change
	<u>HS-LS2-7</u> Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. Further explanation: Examples of human activities can include urbanization, building dams, and dissemination of invasive species. Potential Maine connections include the effects of: salting the roads in winter, introducing green crabs into coastal waters, introducing invasive species into Maine lakes, or examining historical data on water pollution in the Androscoggin during the height of mill activity, closing of mills and legislation on water quality. Constructing Explanations and Designing Solutions, Ecosystem Dynamics, Functioning, and Resilience, Biodiversity and Humans, Developing Possible Solutions, Stability and Change
	<u>HS-LS2-8</u> Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. Further explanation: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming. Examples could include turkeys flocking to evade hunters or Canada geese migrating to and through Maine for breeding purposes. Engaging in Argument from Evidence, Social Interactions and Group Behavior, Cause and Effect

Strand	Life Sciences (LS)		
Standard	LS3 Heredity: Inheritance and Variation of Traits		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations		**1-LS3-1 Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.** Further explanation: Examples of patterns could include features that plants or animals share. Examples of observations could include that leaves from the same kind of plant are the same shape but can differ in size and that a particular breed of dog looks like its parents but is not exactly the same. Constructing Explanations and Designing Solutions, Inheritance of Traits, Variation of Traits, Patterns	

Strand	Life Sciences (LS)		
Standard	LS3 Heredity: Inheritance and Variation of Traits		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.** Further Explanation: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than		

	humans, such as lupins, apples or garden plants. Analyzing and Interpreting Data, Inheritance of Traits, Variation of Traits, Patterns **<u>3-LS3-2</u> Use evidence to support the explanation that traits can be influenced by the environment.** Further Explanation: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; and, a pet dog that is given too much food and little exercise may become overweight. In addition, hydrangea grown under higher acidic conditions will cause the petals to turn blue. Constructing Explanations an Designing Solutions, Inheritance of Traits, Variation of Traits, Cause and Effect		

Strand	Life Sciences (LS)
Standard	LS3 Heredity: Inheritance and Variation of Traits
	Early Adolescence
	Grades 6-8
Performance Expectations	**<u>MS-LS3-1</u> Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of an organism.** Further explanation: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins. Developing and using models; inheritance of traits; variation of traits; structure and function
	<u>MS-LS3-2</u> Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. Further explanation: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and the resulting genetic variation. Connections can be made to Maine agricultural crops, i.e. strawberries, blueberries, and potatoes.

	Developing and using models; growth and development of organisms; inheritance of traits; variation of traits; cause and effect

Strand	Life Sciences (LS)
Standard	LS3 Heredity: Inheritance and Variation of Traits
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring** Further explanation: Emphasis is on the asking of clarifying questions about the general principles of genetics. An example is how cystic fibrosis (one of the most common autosomal recessive inherited diseases in Maine) is passed from parents to child. Asking Questions and Defining Problems, Structure and Function, Inheritance of Traits, Cause and Effect
	HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. Further explanation: Emphasis is on using data to support arguments for the way variation occurs. Provide data on specific mutations caused by environmental factors. Engaging in Argument from Evidence, Variation of Traits, Cause and Effect
	HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. Further explanation: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits. An example would be the population of red fox in Maine and the incidences of the red allele vs. the sable allele. Analyzing and Interpreting Data, Variation of Traits, Scale, Proportion, and Quantity

Strand	Life Sciences (LS)		
Standard	LS4 Biological Evolution: Unity and Diversity		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations			**2-LS4-1 Make observations of plants and animals to compare**

			the diversity of life in different habitats. Further Explanation: Emphasis is on the diversity of living things in each of a variety of different habitats. Potential Maine connections include Maine habitats (e.g. ocean, lake/pond, mountains, forests, cities, etc.) Planning and Carrying out Investigations, Biodiversity in Humans

Strand	Life Sciences (LS)		
Standard	LS4 Biological Evolution: Unity and Diversity		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**3-LS4-1 Analyze and interpret data from fossils to provide evidence of the organisms and environments in which they lived long ago.** Further Explanation: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms. Analyzing and Interpreting Data, Evidence of Common Ancestry and Diversity, Scale, Proportion, and Quantity **3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.** Further Explanation: Examples of cause and effect relationships could be plants that have		

	larger thorns than other plants may be less likely to be eaten by predators and animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring such as yellow spotted salamanders and newts. Constructing Explanations an Designing Solutions, Natural Selection, Cause and Effect **3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.** Further Explanation: Examples of evidence could include needs and characteristics of the organisms (such as loons) and habitats involved. The organisms and their habitats make up a system in which the parts depend on each other. Potential Maine connections include the introduction of Pike and Bass into areas that are non-native to the species and their impact on native trout and other native species. Engaging in Argument from Evidence, Inheritance of Traits, Variation of Traits, Scale, Proportion, and Quantity, Cause and Effect **3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.** Further Explanation: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms. Lobster migrate as a result of water temperature, Cod follow prey fish (Mackerel), Atlantic Salmon start life in streams and migrate to saltwater. Engaging in Argument from Evidence, Biodiversity and Humans, Ecosystem Dynamics, Functioning, and Resilience, Systems and System Models		

Strand	Life Sciences (LS)
Standard	LS4 Biological Evolution: Unity and Diversity
	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-LS4-1 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.** Further explanation: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in rock layers. Analyzing and interpreting data; evidence of common ancestry and diversity; patterns
	MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. Further explanation: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarities or differences of the gross appearance of anatomical structures. Constructing explanations and designing solutions; evidence of common ancestry and diversity; patterns
	MS-LS4-3 Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. Further explanation: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures. Analyzing and interpreting data; evidence of common ancestry and diversity; patterns
	MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. Further explanation: Emphasis is on using simple probability statements and proportional reasoning to construct explanations. Constructing explanations and designing solutions; natural selection; cause and effect
	MS-LS4-5 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. Further explanation: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, and gene

	therapy) and on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries. Obtaining, evaluating, and communicating information; natural selection; cause and effect
	MS-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. Further explanation: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time. Using mathematics and computational thinking; adaptation; cause and effect

Strand	Life Sciences (LS)
Standard	LS4 Biological Evolution: Unity and Diversity
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** Further explanation: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Obtaining, Evaluating, and Communicating Information, Evidence of Common Ancestry and Diversity, Patterns
	HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. Further explanation: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.

	Constructing Explanations and Designing Solutions, Adaptation, Cause and Effect
	<u>HS-LS4-3</u> Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. Further explanation: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations. Observe historical data for the distribution of humpback whales in the Gulf of Maine looking specifically at skin pigmentation. Analyzing and Interpreting Data, Natural Selection, Adaptation, Patterns
	<u>HS-LS4-4</u> Construct an explanation based on evidence for how natural selection leads to adaptation of populations. Further explanation: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations. Constructing Explanations and Designing Solutions, Adaptation, Cause and Effect
	<u>HS-LS4-5</u> Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. Further explanation: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species. Engaging in Argument from Evidence, Adaptation, Cause and Effect
	<u>HS-LS4-6</u> Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. Further explanation: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species. Using Mathematics and Computational Thinking, Biodiversity and Humans, Developing Possible Solutions, Cause and Effect

Strand	Earth and Space Sciences (ESS)		
Standard	ESS1 Earth's Place in the Universe		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations		**1-ESS1-1 Use observations of the sun, moon, and stars to describe patterns that can be predicted.** Further explanation: Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set and that stars other than our sun are visible at night but not during the day. Analyzing and Interpreting Data, The Universe and Its Stars, Patterns **1-ESS1-2 Make observations at different times of the year to relate the amount of daylight to the time of year.** Further explanation: Emphasis is on relative comparisons of the amount of daylight in the winter or summer to the amount in the spring or fall. Planning and Carrying out Investigations, Earth and the Solar System, Patterns	**2-ESS1-1 Use information from several sources to provide evidence that Earth events can occur quickly or slowly.** Further Explanation: Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly, and erosion of rocks, which occurs slowly. Examples of Maine phenomena (e.g. flash floods, erosion and tides). Constructing Explanations and Designing Solutions, The History of Planet Earth, Stability and Change

Strand	Earth and Space Sciences (ESS)		
Standard	ESS1 Earth's Place in the Universe		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations		**4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.** Further Explanation: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time and a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock. Constructing Explanations and Designing Solutions, The History of Planet Earth, Patterns	**5-ESS1-1 Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.** Engaging in Argument from Evidence, The Universe and its Stars, Scale Proportion and Quantity **5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.** Further Explanation: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months. Analyzing and Interpreting Data, Earth and the Solar System, Patterns

Strand	Earth and Space Sciences (ESS)
Standard	ESS1 Earth's Place in the Universe
	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-ESS1-1 Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.** Further explanation: Examples of models can be physical, graphical, or conceptual. Examples could incorporate latitude and season connections, why Lubec is the first town in the continental U.S. to see the sunrise, and tides (king, neap, spring). Developing and using models; the universe and its stars; earth and the solar system; patterns
	MS-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. Further explanation: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state). Developing and using models; the universe and its stars; earth and the solar system; systems and system models
	MS-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system. Further explanation: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models. Analyzing and interpreting data; earth and the solar system; scale, proportion, and quantity
	MS-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. Further explanation: Emphasis is on how analysis of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.

	Constructing explanations and designing solutions; the history of planet earth; scale, proportion, and quantity

Strand	Earth and Space Sciences (ESS)
Standard	ESS1 Earth's Place in the Universe
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.** Further explanation: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11- year sunspot cycle, and non-cyclic variations over centuries. Developing and Using Models, The Universe and its Stars, Energy in Chemical Processes and Everyday Life, Scale, Proportion and Quantity
	HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. Further explanation: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium). Constructing Explanations and Designing Solutions, The Universe and its Stars, Electromagnetic Radiation, Energy and Matter
	HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements. Further explanation: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime. Obtaining, Evaluating, and Communicating Information, The Universe and its Stars, Energy and Matter
	HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. Further explanation: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons. Using Mathematical and Computational Thinking, Earth and the Solar System, Scale, Proportion, and Quantity

	<u>HS-ESS1-5</u> Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. Further explanation: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions). Examples could also be found from looking at differences between coastal Maine and interior Maine rock types and their ages as evidence to explain the formation of land structures and plate boundaries that cause them. Engaging in Argument from Evidence, The History of Planet Earth, Plate Tectonics and Large-Scale System Interactions, Nuclear Processes, Patterns
	<u>HS-ESS1-6</u> Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. Further explanation: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces. Constructing Explanations and Designing Solutions, The History of Planet Earth, Stability and Change

Strand	Earth and Space Sciences (ESS)		
Standard	ESS2 Earth's Systems		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations	**<u>K-ESS2-1</u> Use and share observations of local weather conditions to describe patterns over time.** Further explanation: Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include graphing the number of sunny, windy, and rainy or snowy days in a month. Examples of patterns could		**<u>2-ESS2-1</u> Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.** Further Explanation: Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water and different designs for using shrubs, grass, and trees to hold back land. Constructing Explanations and Designing Solutions, Earth Materials and Systems,

	include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months. Analyzing and Interpreting Data, Weather and Climate, Patterns **K-ESS2-2 Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.** Further explanation: Examples of plants and animals changing their environment could include a squirrel digging in the ground to hide its food and tree roots can break concrete. Examples could include ways that humans change their environment to meet their needs (cutting down trees to provide heat, farming to provide food, and the process of snow removal, e.g. sanding/salting the roads, snowplowing, etc.). Engaging in Argument from Evidence, Biogeology, Human Impacts on Earth Systems, Systems and System Models		Optimizing the Design Solution, Stability and Change **2-ESS2-2 Develop a model to represent the shapes and kinds of land and bodies of water in an area.** Developing and Using Models, Plate Tectonics and the Large-Scale System Interactions, Patterns **2-ESS2-3 Obtain information to identify where water is found on Earth and that it can be solid or liquid.** Obtaining, Evaluating, and Communicating Information, The Roles of Water in Earth's Surface Processes, Patterns

Strand	Earth and Space Sciences (ESS)		
Standard	ESS2 Earth's Systems		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**3-ESS2-1 Represent data in tables and graphical displays to describe typical weather conditions expected**	**4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of**	**5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.**

	during a particular season. Further Explanation: Examples of data could include average temperature, precipitation, and wind direction Analyzing and Interpreting Data, Weather and Climate, Patterns **<u>3-ESS2-2</u> Obtain and combine information to describe climates in different regions of the world.** Obtaining, Evaluating, and Communicating Information, Weather and Climate, Patterns	**erosion by water, ice, wind, or vegetation.** Further Explanation: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow. Maine pot holes and frost heaves are evidence of the effects of weathering and explain why roads in Maine are repaved more frequently than roads in Florida. Planning and Carrying out Investigations, Earth Materials and Systems, Biogeology, Cause and Effect **<u>4-ESS2-2</u> Analyze and interpret data from maps to describe patterns of Earth's features.** Further Explanation: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes. Investigate the formation of the Appalachian Mountains and compare them to the formation of the Rocky or Cascade Mountain Ranges. Analyzing and Interpreting Data, Plate Tectonics and Large-Scale System Interactions, Patterns	Further Explanation: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system. Developing and Using Models, Earth's Materials and Systems, Systems and System Models **<u>5-ESS2-2</u> Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.** Using Mathematics and Computational Thinking, The Roles of Water in Earth's Surface Processes, Scale, Proportion, and Quantity

Strand	Earth and Space Sciences (ESS)
Standard	ESS2 Earth's Systems
	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process** Further explanation: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials. Potential Maine connections include Deer Isle granite, Rockland limestone, Maine tourmaline, Acadia National Park pink granite, along with Maine mining history at Bald Mountain or Katahdin Iron Works. Developing and using models, earth's materials and systems, stability and change
	MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. Further explanation: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate. Potential Maine connections include the Desert of Maine, glacial erratics, alluvial fans, Appalachian Trail and Baxter State Park, and the fjord on Mount Desert Island. Constructing explanations and designing solutions, earth's materials and systems, the roles of water in earth's surface processes, scale proportion and quantity
	MS-ESS2-3 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. Further explanation: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches). Potential Maine connections can be found in the Gulf of Maine, Georges Bank and the inner continental shelf. Analyzing and interpreting data, the history of planet earth, plate tectonics and large-scale system interactions, patterns
	MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

	Further explanation: Emphasis is on the ways in which water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical. Developing and using models, the roles of water in earth's surface processes, energy and matter
	MS-ESS2-5 Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. Further explanation: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation). Potential Maine connections include "Bombogenesis" snow storms, coastal fog, Nor'easters, sea smoke and valley fog. Planning and carrying out investigations, the roles of water in earth's surface processes, weather and climate, cause and effect
	MS-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. Further explanation: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations. Developing and using models, the roles of water in earth's surface processes, weather and climate, systems and system models

Strand	Earth and Space Sciences (ESS)
Standard	ESS2 Earth's Systems
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.** Further explanation: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion). An example could be to utilize Maine Geologic maps, including tectonic

	maps, as data to create a model to illustrate how Maine's land features or oceanic features were formed. Consider looking to Maine's glacial history, features formed and materials deposited by glaciers. Developing and Using Models, Plate Tectonics and Large-Scale System Interactions, Earth Materials and Systems, Stability and Change
	HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. Further explanation: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; and how the loss of wetlands causes a decrease in local humidity that further reduces the wetlands' extent. An example could consider timber harvesting practices related to erosion and water runoff issues, river damming, or coastal erosion of Maine's beaches and dunes. Analyzing and Interpreting Data, Earth Materials and Systems, Stability and Change
	HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. Further explanation: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments. Developing and Using Models, Earth Materials and Systems, Plate Tectonics and Large-Scale System Interactions, Wave Properties, Energy and Matter
	HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. Further explanation: Examples of the causes of climate change differ by timescale, over 1-10 years; large volcanic eruptions, ocean circulation; 10s to 100s of years: changes in human activity, ocean circulation, solar output; 10s a-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10s-100s of millions of years: long-term changes in atmospheric composition. Consider the climatic impacts of the Gulf stream and the Labrador currents on the Gulf of Maine, e.g. water temperature changes and fishing industry disruptions.

	Developing and Using Models, Earth and the Solar System, Earth Materials and Systems, Weather and Climate, Scale, Proportion, and Quantity
	HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. Further explanation: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide evidence for the connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, and frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids). Draw connections to Maine phenomena such as ice jams, frost heaves and potholes. Planning and Carrying Out Investigations, The Role of Water in Earth's Surface Processes, Structure and Function
	HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. Further explanation: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms. Developing and Using Models, Weather and Climate, Energy and Matter
	HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. Further explanation: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; and how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms. Engaging in Argument from Evidence, Weather and Climate, Biogeology, Stability and Change

Strand	Earth and Space Sciences (ESS)
Standard	ESS3 Earth and Human Activity
	Childhood

	Kindergarten	Grade 1	Grade 2
Performance Expectations	**K-ESS3-1 Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.** Further explanation: Examples of relationships could include that deer eat buds and leaves and therefore usually live in forested areas and that grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system. Examples could include coastal tidepools, humans in Maine live in insulated buildings for protection during cold months, or uninsulated structures during warm months (e.g. camping in a tent). Examples of animals that migrate include monarch butterflies, ducks, Canada geese, etc. Developing and Using Models, Natural Resources, Systems and System Models **K-ESS3-2 Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.** Further explanation: Emphasis is on local forms of severe weather. Examples could include local forms of severe weather (flooding, ice, blizzards, heat, etc.) and checking the weather forecast to determine proper clothing to wear. Asking Questions and Defining Problems, Obtaining, Evaluating, and Communicating Information, Natural Hazards, Defining and Delimiting an Engineering Problem, Cause and Effect		

	K-ESS3-3 Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment. Further explanation: Examples of human impact on land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles. Examples could also include what we can do to clean public areas (e.g. beaches, parks, lakes, trails, etc.). Obtaining, Evaluating, and Communicating Information, Developing Possible Solutions, Human Impacts on Earth Systems, Cause and Effect		

Strand	Earth and Space Sciences (ESS)		
Standard	ESS3 Earth and Human Activity		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**3-ESS3-1 Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.** Further Explanation: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods. Potential	**4-ESS3-1 Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.** Further Explanation: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; nonrenewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air	**5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.** Obtaining, Evaluating and Communicating Information, Human Impacts on Earth systems, Systems and System Models

	Maine connections include the construction of seawalls in southern Maine to prevent damage to homes from strong ocean storms. Engaging in Argument from Evidence, Natural Hazards, Cause and Effect	pollution from burning of fossil fuels. Investigate the pros and cons of heating homes with wood, fossil fuels, and solar energy. Investigate what a wind or solar farm is and why they are controversial in Maine. Obtaining, Evaluating, and Communicating Information, Natural Resources, Cause and Effect **<u>4-ESS3-2</u> Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.** Further Explanation: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity. Design a microburst resistant building or design a telephone/electric pole that could sustain less damage in an ice storm. Constructing Explanations and Designing Solutions, Natural Hazards, Designing Solutions to Engineering Problems, Cause and Effect	

Strand	Earth and Space Sciences (ESS)
Standard	ESS3 Earth and Human Activity
	Early Adolescence
	Grades 6-8
Performance Expectations	**<u>MS-ESS3-1</u> Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.** Further explanation: Emphasis is on how these resources are limited and typically non-renewable and on how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of

	organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock). Constructing explanations and designing solutions, natural resources, cause and effect
	MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. Further explanation: Emphasis is on how some natural hazards, such as volcanic eruptions, and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts). Analyzing and interpreting data, natural hazards, patterns
	MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. Further explanation: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land). Constructing explanations and designing solutions, human impacts on earth systems, cause and effect
	MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. Further explanation: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes. Engaging in argument from evidence, human impacts on earth systems, cause and effect **MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.** Further explanation: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or

	volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures. Asking questions and defining problems, global climate change, stability and change

Strand	Earth and Space Sciences (ESS)
Standard	ESS3 Earth and Human Activity
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** Further explanation: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised. Other examples include the impacts of climate change on Maine's ski industry, fishing industry, maple sugar industry and on sea levels or droughts. Constructing Explanations and Designing Solutions, Natural Resources, Natural Hazards, Cause and Effect
	HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. Further explanation: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use (for farming, timber industry, blueberry and potato crops), mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen. Engaging in Argument from Evidence, Natural Resources, Developing Possible Solutions
	HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. Further explanation: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning. Consider the effects of urban sprawl and the loss of farmland.

	Using Mathematics and Computational Thinking, Human Impacts on Earth Systems, Stability and Change
	HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. Further explanation: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean). Other examples include the use of propane-powered buses in Acadia (evaluate pros and cons). Constructing Explanations and Designing Solutions, Developing Possible Solutions, Stability and Change
	HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems. Further explanation: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition). Analyzing and Interpreting Data, Global Climate Change, Stability and Change
	HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. Further explanation: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations. Use and interpret graphs and data of carbon dioxide levels in the Gulf of Maine for oysters and sea scallops. Consider the impacts of ocean acidification on shellfish. Using Mathematics and Computational Thinking, Weather and Climate, Global Climate Change, Systems and System Models

Strand	Engineering, Technology, and Applications of Science (ETS)		
Standard	ETS1 Engineering Design		
	Childhood		
	Kindergarten	Grade 1	Grade 2

Performance Expectations	**K-2-ETS1-1 Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.** Asking Questions and Defining Problems, Defining and Delimiting Engineering Problems	**K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.** Developing and Using Models, Developing Possible Solutions, Structure and Function	**K-2-ETS1-3 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.** Analyzing and Interpreting Data, Optimizing the Design Solution

Strand	Engineering, Technology, and Applications of Science (ETS)		
Standard	ETS1 Engineering Design		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.** Asking Questions and Defining Problems, Defining and Delimiting Engineering Problems, Influence of Engineering, Technology, and Science on Society and the Natural World	**3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.** Constructing Explanations and Designing Solutions, Developing Possible Solutions, Influence of Engineering, Technology, and Science on Society and the Natural World	**3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.** Planning and Carrying out Explanations, Developing Possible Solutions, Optimizing the Design Solution

Strand	Engineering, Technology, and Applications of Science (ETS)
Standard	ETS1 Engineering Design
	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.** Further explanation: To solve a problem it needs to have clearly defined set goals and limits. The more limitations applied to a problem, the more elegant and successful the solution is likely to be. Limitations would take into account potential impacts on the environment, social/cultural norms, and allowable interactions. The application of science principles is to be used as a tool to verify solutions. Examples could include hydroelectric dams as a viable, cost effective and ecologically friendly way to generate electrical power. However, the dam holds fish populations from traveling freely through the environment. There is a need to provide a safe way for aquatic life to pass by the hydroelectric turbine in a way that does not impact the electrical generation, the original water flow of the river dammed, is cost effective to existing dam models, and has no negative impact on human populations. Asking questions and defining problems, defining and delimiting engineering problems, influence of science, engineering, and technology on society and the natural world
	MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. Further explanation: When designing a solution to a problem, there need to be many possible solutions explored, tested, verified, and compared, and the use of some tool to determine the validity of competing designs in meeting the design criteria. These tools would be used to make testing data understandable, comparable, and accessible. Engaging in argument from evidence, developing possible solutions
	MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. Further explanation: Testing and data is used to evaluate the solutions or part of the solutions that best solve the given problem. The data needs to be assessed and then used to modify, combine, and deny solutions and then retested to arrive at the best possible solution within the constraints of the problem. Examples could include tables, graphs, matrices, check lists, spreadsheets, public polls, Venn diagrams, mathematical models, etc. Analyzing and interpreting data, developing possible solutions, optimizing design solution
	MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

	Further explanation: Developing the proper test to verify which solutions meet and which excel when applied against the constraints. That test is then applied to a prototype or model to allow faults to be identified and then corrected, frequently the combination of two or more solutions can produce a better solution and then retest it to see if it is the best solution. Examples could include materials science testing (shear strength, compression testing, tension testing, etc.), weather testing (temperature, rain, snow, wind, sun exposure), wind tunnel, failure or destructive testing, mathematical models, etc. Developing and using models, developing possible solutions, optimizing design solution

Strand	Engineering, Technology, and Applications of Science (ETS)
Standard	ETS1 Engineering Design
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.** Further explanation: Examples of challenges include local and global climate change issues, biodiversity loss or United Nations sustainable development goals. Asking Questions and Defining Problems, Defining and Delimiting Engineering Problems
	HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. Further explanation: Examples could include transportation issues, dams, green energy and wind power in Maine. Constructing Explanations and Designing Solutions, Optimizing the Design Solution
	HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. Further explanation: Examples could include lobstering and exports of lobster, dry wells and water conservation in Maine, or saltwater intrusion in coastal Maine wells. Constructing Explanations and Designing Solutions, Developing Possible Solutions
	HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. Using Mathematics and Computational Thinking, Developing Possible Solutions, Systems and System Models