New York Science

Grades 9, 10, 11, 12

Adopted 2016

Structure and Properties of Matter

HS-PS1-1. **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.** HS-PS1-1

HS-PS1-3. **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.** HS-PS1-3

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.** HS-PS1-8

HS-PS2-6. **Communicate scientific and technical information about why the particulate-level structure is important in the functioning of designed materials.** HS-PS2-6

HS-PS1-9. **Analyze data to support the claim that the combined gas law describes the relationships among volume, pressure, and temperature for a sample of an ideal gas.** HS-PS1-9

HS-PS1-10. **Use evidence to support claims regarding the formation, properties and behaviors of solutions at bulk scales.** HS-PS1-10

Chemical Reactions

HS-PS1-2. **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.** HS-PS1-2

HS-PS1-4. **Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.** HS-PS1-4

HS-PS1-5. **Apply scientific principles and evidence to explain how the rate of a physical or chemical change is affected when conditions are varied.** HS-PS1-5

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.** HS-PS1-6

	HS-PS1-7.	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.** HS-PS1-7
	HS-PS1-11.	**Plan and conduct an investigation to compare properties and behaviors of acids and bases.** HS-PS1-11
	HS-PS1-12.	**Use evidence to illustrate that some chemical reactions involve the transfer of electrons as an energy conversion occurs within a system.** HS-PS1-12
Forces and Interactions	**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.** HS-PS2-1
	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.** HS-PS2-2
	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.** HS-PS2-3
	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.** HS-PS2-4
	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.** HS-PS2-5
Energy	**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.** HS-PS3-1
	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).** HS-PS3-2
	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.** HS-PS3-3
	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).** HS-PS3-4

	HS-PS3-5.	**Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** HS-PS3-5
	HS-PS3-6.	**Analyze data to support the claim that Ohm's Law describes the mathematical relationship among the potential difference, current, and resistance of an electric circuit.** HS-PS3-6
Waves and Electromagnetic Radiation	**HS-PS4-1.**	**Use mathematical representations to support a claim regarding relationships among the period, frequency, wavelength, and speed of waves traveling and transferring energy (amplitude, frequency) in various media.** HS-PS4-1
	HS-PS4-2.	**Evaluate questions about the advantages of using a digital transmission and storage of information.** HS-PS4-2
	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 (quantum theory), and that for some situations one model is more useful than the other.** HS-PS4-3
	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.** HS-PS4-4
	HS-PS4-5.	**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.** HS-PS4-5
	HS-PS4-6.	**Use mathematical models to determine relationships among the size and location of images, size and location of objects, and focal lengths of lenses and mirrors.** HS-PS4-6
Structure and Function	**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.** HS-LS1-1
	HS-LS1-2.	**Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** HS-LS1-2
	HS-LS1-3.	**Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis** HS-LS1-3
Matter and Energy in Organisms and Ecosystems	**HS-LS1-5.**	**Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** HS-LS1-5

	HS-LS1-7.	**Use a model to illustrate that aerobic 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.** HS-LS1-7
	HS-LS2-3.	**Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in ecosystems.** HS-LS2-3
	HS-LS2-4.	**Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** HS-LS2-4
	HS-LS2-5.	**Develop a model to illustrate the role of various processes in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.** HS-LS2-5
Interdependent Relationships in Ecosystems	**HS-LS2-1.**	**Use mathematical and/or computational representations to support explanations of biotic and abiotic factors that affect carrying capacity of ecosystems at different scales.** HS-LS2-1
	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.** HS-LS2-2
	HS-LS2-6.	**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.** HS-LS2-6
	HS-LS2-7.	**Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.** HS-LS2-7
	HS-LS2-8.	**Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.** HS-LS2-8
Inheritance and Variation of Traits	**HS-LS1-4.**	**Use a model to illustrate cellular division (mitosis) and differentiation.** HS-LS1-4
	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.** HS-LS3-1
	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, (3) mutations caused by environmental factors and/or (4) genetic engineering.** HS-LS3-2
	HS-LS3-3.	**Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.** HS-LS3-3

	HS-LS1-8. Use models to illustrate how human reproduction and development maintains continuity of life. HS-LS1-8
Natural Selection and Evolution	**HS-LS4-1.** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. HS-LS4-1
	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. HS-LS4-2
	HS-LS4-3. 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. HS-LS4-3
	HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. HS-LS4-4
	HS-LS4-5. 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. HS-LS4-5
Space Systems	**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. HS-ESS1-1
	D. Energy in Chemical Processes and Everyday Life ▪ Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary to HS-ESS1-1) PS3.D
	A. The Universe and Its Stars ▪ The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1) ESS1.A
	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. HS-ESS1-2
	B. Electromagnetic Radiation ▪ Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2) PS4.B

A. **The Universe and Its Stars ▪ The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1- 2)** `ESS1.A`

A. **The Universe and Its Stars ▪ The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2) (HS-ESS1-3)** `ESS1.A`

B. **Earth and the Solar System ▪ Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)** `ESS1.B`

HS-ESS1-3. **Communicate scientific ideas about the way stars, over their life cycle, produce elements.** `HS-ESS1-3`

A. **The Universe and Its Stars ▪ Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2),(HS- ESS1-3)** `ESS1.A`

HS-ESS1-4. **Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.** `HS-ESS1-4`

HS-ESS1-7. **Construct an explanation using evidence to support the claim that the phases of the moon, eclipses, tides and seasons change cyclically.** `HS-ESS1-7`

B. **(NYSED) Earth and celestial phenomena can be described by principles of relative motion and perspective. (HS-ESS1-7)** `ESS1.B`

History of Earth

HS-ESS1-5. **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.** `HS-ESS1-5`

C. **The History of Planet Earth ▪ Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)** `ESS1.C`

C. **Nuclear Processes ▪ (NYSED) Spontaneous radioactive decay follows a characteristic exponential decay law allowing an element's half-life to be used for radiometric dating of rocks and other materials. (secondary to HS-ESS1- 5), (secondary to HS-ESS1-6)** `PS1.C`

HS-ESS1-6. **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.** `HS-ESS1-6`

C. **The History of Planet Earth ▪ Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)** ESS1.C

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.** HS-ESS2-1

A. **Earth Materials and Systems ▪ Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1) (Note: This Disciplinary Core Idea is also addressed by HS-ESS2-2)** ESS2.A

B. **Plate Tectonics and Large-Scale System Interactions ▪ Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5),(HS-ESS2-1)** ESS2.B

B. **Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) (HS-ESS2-1)** ESS2.B

Earth's Systems

HS-ESS2-2. **Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to Earth's systems.** HS-ESS2-2

A. **Earth Materials and Systems ▪ Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes (HS-ESS2-2)** ESS2.A

D. **Weather and Climate ▪ The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2)** ESS2.D

D. **Weather and Climate ▪ The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4),(secondary to HS-ESS2-2)** ESS2.D

HS-ESS2-3. **Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.** HS-ESS2-3

A. **Earth Materials and Systems ▪ Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)** ESS2.A

B. **Plate Tectonics and Large-Scale System Interactions ▪ (NYSED) Residual heat from Earth's formation and the radioactive decay of unstable isotopes in Earth's interior continually generate energy that is absorbed by Earth's mantle and crust, driving mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)** ESS2.B

B. **Plate Tectonics and Large-Scale System Interactions ▪ (NYSED) Minerals are the building blocks of igneous, metamorphic, and sedimentary rocks and can be identified using physical and chemical characteristics. These rock types are evidence of stages of constant recycling of Earth material by surface processes and convection currents in the mantle. (HS-ESS2-3)** ESS2.B

A. **Wave Properties ▪ Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3)** PS4.A

HS-ESS2-5. **Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** HS-ESS2-5

C. **The Roles of Water in Earth's Surface Processes -The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)** ESS2.C

HS-ESS2-6. **Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.** HS-ESS2-6

D. **Weather and Climate ▪ Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6), (HS-ESS2-7)** ESS2.D

D. **Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6)** ESS2.D

HS-ESS2-7. **Construct an argument based on evidence about the coevolution of Earth's systems and life on Earth.** HS-ESS2-7

	E. Biogeology ▪ The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co- evolution of Earth's surface and the life that exists on it. (HS-ESS2-7) ESS2.E
Weather and Climate	**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. HS-ESS2-4
	B. Earth and the Solar System ▪ Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary to HS-ESS2-4) ESS1.B
	A. Earth Materials and Systems ▪ The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4) ESS2.A
	D. Weather and Climate - Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4) ESS2.D
	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 systems. HS-ESS3-5
	D. Global Climate Change Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) ESS3.D
	HS-ESS2-8. Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions. HS-ESS2-8
	D. Weather and Climate ▪ (NYSED) Concepts of density and heat energy can be used to explain observations of weather patterns (HS- ESS2-8). ESS2.D
Human Sustainability	**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. HS-ESS3-1
	A. Natural Resources ▪ Resource availability has guided the development of human society. (HS-ESS3-1) ESS3.A

B. **Natural Hazards ▪ Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)** ESS3.B

HS-ESS3-2. **Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.** HS-ESS3-2

A. **Natural Resources ▪ All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)** ESS3.A

B. **Developing Possible Solutions ▪ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary to HS-ESS3-2),(secondary to HS-ESS3-4)** ETS1.B

HS-ESS3-3. **Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.** HS-ESS3-3

Human Impacts on Earth Systems ▪ The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)

HS-ESS3-4. **Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.** HS-ESS3-4

Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)

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.** HS-ESS3-6

D. **Weather and Climate ▪ Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary to HS-ESS3- 6)** ESS2.D

D. **Global Climate Change ▪ Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)** ESS3.D

Engineering Design

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.** HS-ETS1-1

A. **Defining and Delimiting Engineering Problems ▪ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)** ETS1.A

A. **Defining and Delimiting Engineering Problems - Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS- ETS1-1)** ETS1.A

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.** HS-ETS1-2

C. **Optimizing the Design Solution Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade- offs) may be needed. (HS-ETS1-2)** ETS1.C

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.** HS-ETS1-3

B. **Developing Possible Solutions ▪ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)** ETS1.B

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.** HS-ETS1-4

B. **Developing Possible Solutions - Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)** ETS1.B