Massachusetts Science and Technology/Engineering

Grade 10

Adopted 2016

Earth and Space Sciences

ESS1. Earth's Place in the Universe ESS1

HS-ESS1-1. Use informational text to explain that the life span of the Sun over approximately 10 billion years is a function of nuclear fusion in its core. Communicate that stars, through nuclear fusion over their life cycle, produce elements from helium to iron and release energy that eventually reaches Earth in the form of radiation. HS-ESS1-1

HS-ESS1-2. Describe the astronomical evidence for the Big Bang theory, including the red shift of light from the motion of distant 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, which matches that predicted by the Big Bang theory (¾ hydrogen and ¼ helium). HS-ESS1-2

HS-ESS1-4. Use Kepler's Laws to predict the motion of orbiting objects in the solar system. Describe how orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. HS-ESS1-4

HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor. HS-ESS1-5

ESS2. Earth's Systems ESS2

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

HS-ESS2-3. Use a model based on evidence of Earth's interior to describe 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

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems over different time scales result in changes in climate. Analyze and interpret data to explain that long-term changes in Earth's tilt and orbit result in cycles of climate change such as Ice Ages. HS-ESS2-4

HS-ESS2-5. Describe how the chemical and physical properties of water are important in mechanical and chemical mechanisms that affect Earth materials and surface processes. HS-ESS2-5

HS-ESS2-6. Use a model to describe cycling of carbon through the ocean, atmosphere, soil, and biosphere and how increases in carbon dioxide concentrations due to human activity has resulted in atmospheric and climate changes. HS-ESS2-6

ESS3. Earth and Human Activity ESS3

HS-ESS3-1. Construct an explanation based on evidence for how the availability of key natural resources and changes due to variations in climate have influenced human activity. HS-ESS3-1

HS-ESS3-2. Evaluate competing design solutions for minimizing impacts of developing and using energy and mineral resources, and conserving and recycling those resources, based on economic, social, and environmental cost-benefit ratios. HS-ESS3-2

HS-ESS3-3. Illustrate relationships among management of natural resources, the sustainability of human populations, and biodiversity. HS-ESS3-3

HS-ESS3-5. Analyze results from global climate models to describe how forecasts are made of the current rate of global or regional climate change and associated future impacts to Earth systems. HS-ESS3-5

Biology

LS1. From Molecules to Organisms: Structures and Processes LS1

HS-LS1-1. Construct a model of transcription and translation to explain the roles of DNA and RNA that code for proteins that regulate and carry out essential functions of life. HS-LS1-1

HS-LS1-2. Develop and use a model to illustrate the key functions of animal body systems, including (a) food digestion, nutrient uptake, and transport through the body, (b) exchange of oxygen and carbon dioxide, (c) removal of wastes, and (d) regulation of body processes. HS-LS1-2

HS-LS1-3. Provide evidence that homeostasis maintains internal body conditions through both body-wide feedback mechanisms and small-scale cellular processes. HS-LS1-3

HS-LS1-4. Construct an explanation using evidence for why the cell cycle is necessary for the growth, maintenance, and repair of multicellular organisms. Model the major events of the cell cycle, including (a) cell growth and DNA replication, (b) separation of chromosomes (mitosis), and (c) separation of cell contents. HS-LS1-4

HS-LS1-5. Use a model to illustrate how photosynthesis uses light energy to transform water and carbon dioxide into oxygen and chemical energy stored in the bonds of sugars and other carbohydrates. HS-LS1-5

HS-LS1-6. Construct an explanation based on evidence that organic molecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form monomers that can further combine to form large carbon-based macromolecules. HS-LS1-6

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 new bonds form resulting in new compounds and a net transfer of energy. HS-LS1-7

LS2. Ecosystems: Interactions, Energy, and Dynamics LS2

HS-LS2-1. Analyze data sets to support explanations that biotic and abiotic factors affect ecosystem carrying capacity. HS-LS2-1

HS-LS2-2. Use mathematical representations to support explanations that biotic and abiotic factors affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem. HS-LS2-2

HS-LS2-4. Use a mathematical model to describe the transfer of energy from one trophic level to another. Explain how the inefficiency of energy transfer between trophic levels affects the relative number of organisms that can be supported at each trophic level and necessitates a constant input of energy from sunlight or inorganic compounds from the environment. HS-LS2-4

HS-LS2-5. Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. HS-LS2-5

HS-LS2-6. Analyze data to show ecosystems tend to maintain relatively consistent numbers and types of organisms even when small changes in conditions occur but that extreme fluctuations in conditions may result in a new ecosystem. Construct an argument supported by evidence that ecosystems with greater biodiversity tend to have greater resistance to change and resilience. HS-LS2-6

HS-LS2-7. Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health. HS-LS2-7

LS3. Heredity: Inheritance and Variation of Traits LS3

HS-LS3-1. Develop and use a model to show how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. HS-LS3-1

HS-LS3-2. Make and defend a claim based on evidence that genetic variations (alleles) may result from (a) new genetic combinations via the processes of crossing over and random segregation of chromosomes during meiosis, (b) mutations that occur during replication, and/or (c) mutations caused by environmental factors. Recognize that mutations that occur in gametes can be passed to offspring. HS-LS3-2

HS-LS3-3. Apply concepts of probability to represent possible genotype and phenotype combinations in offspring caused by different types of Mendelian inheritance patterns. HS-LS3-3

HS-LS3-4(MA). Use scientific information to illustrate that genetic traits of individuals, and the presence of specific alleles in a population, are due to interactions of genetic factors with environmental factors. HS-LS3-4(MA)

LS4. Biological Evolution: Unity and Diversity LS4

HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence, including molecular, anatomical, and developmental similarities inherited from a common ancestor (homologies), seen through fossils and laboratory and field observations. HS-LS4-1

HS-LS4-2. Construct an explanation based on evidence that Darwin's theory of evolution by natural selection occurs in a population when the following conditions are met: (a) more offspring are produced than can be supported by the environment, (b) there is heritable variation among individuals, and (c) some of these variations lead to differential fitness among individuals as some individuals are better able to compete for limited resources than others. HS-LS4-2

HS-LS4-4. Research and communicate information about key features of viruses and bacteria to explain their ability to adapt and reproduce in a wide variety of environments. HS-LS4-4

HS-LS4-5. Evaluate models that demonstrate how changes in an environment may result in the evolution of a population of a given species, the emergence of new species over generations, or the extinction of other species due to the processes of genetic drift, gene flow, mutation, and natural selection. HS-LS4-5

Introductory Physics

PS1. Matter and Its Interactions PS1

HS-PS1-8. Develop a model to illustrate the energy released or absorbed during the processes of fission, fusion, and radioactive decay. HS-PS1-8

PS2. Motion and Stability: Forces and Interactions PS2

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force. HS-PS2-1

HS-PS2-2. Use mathematical representations to show that the total momentum of a system of interacting objects is conserved when there is no net force on the system. HS-PS2-2

HS-PS2-3. Apply scientific principles of motion and momentum 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 both qualitatively and quantitatively describe and predict the effects of gravitational and electrostatic forces between objects. HS-PS2-4

HS-PS2-5. 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

HS-PS2-9(MA). Evaluate simple series and parallel circuits to predict changes to voltage, current, or resistance when simple changes are made to a circuit. HS-PS2-9(MA)

HS-PS2-10(MA). Use free-body force diagrams, algebraic expressions, and Newton's laws of motion to predict changes to velocity and acceleration for an object moving in one dimension in various situations. HS-PS2-10(MA)

PS3. Energy PS3

HS-PS3-1. Use algebraic expressions and the principle of energy conservation to calculate the change in energy of one component of a system when the change in energy of the other component(s) of the system, as well as the total energy of the system including any energy entering or leaving the system, is known. Identify any transformations from one form of energy to another, including thermal, kinetic, gravitational, magnetic, or electrical energy, in the system. HS-PS3-1

HS-PS3-2. Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields. HS-PS3-2

HS-PS3-3. Design and evaluate a device that works within given constraints to convert one form of energy into another form of energy. HS-PS3-3

HS-PS3-4a. Provide evidence that when two objects of different temperature are in thermal contact within a closed system, the transfer of thermal energy from higher temperature objects to lower temperature objects results in thermal equilibrium, or a more uniform energy distribution among the objects and that temperature changes necessary to achieve thermal equilibrium depend on the specific heat values of the two substances. HS-PS3-4A

HS-PS3-5. Develop and use a model of magnetic or electric fields to illustrate the forces and changes in energy between two magnetically or electrically charged objects changing relative position in a magnetic or electric field, respectively. HS-PS3-5

PS4. Waves and Their Applications in Technologies for Information Transfer PS4

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling within various media. Recognize that electromagnetic waves can travel through empty space (without a medium) as compared to mechanical waves that require a medium. HS-PS4-1

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 involving resonance, interference, diffraction, refraction, or the photoelectric effect, one model is more useful than the other. HS-PS4-3

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

Chemistry

PS1. Matter and Its Interactions PS1

HS-PS1-1. Use the periodic table as a model to predict the relative properties of main group elements, including ionization energy and relative sizes of atoms and ions, based on the patterns of electrons in the outermost energy level of each element. Use the patterns of valence electron configurations, core charge, and Coulomb's law to explain and predict general trends in ionization energies, relative sizes of atoms and ions, and reactivity of pure elements. HS-PS1-1

HS-PS1-2. Use the periodic table model to predict and design simple reactions that result in two main classes of binary compounds, ionic and molecular. Develop an explanation based on given observational data and the electronegativity model about the relative strengths of ionic or covalent bonds. HS-PS1-2

HS-PS1-3. Cite evidence to relate physical properties of substances at the bulk scale to spatial arrangements, movement, and strength of electrostatic forces among ions, small molecules, or regions of large molecules in the substances. Make arguments to account for how compositional and structural differences in molecules result in different types of intermolecular or intramolecular interactions. HS-PS1-3

HS-PS1-4. Develop a model to illustrate the energy transferred during an exothermic or endothermic chemical reaction based on the bond energy difference between bonds broken (absorption of energy) and bonds formed (release of energy). HS-PS1-4

HS-PS1-5. Construct an explanation based on kinetic molecular theory for why varying conditions influence the rate of a chemical reaction or a dissolving process. Design and test ways to alter various conditions to influence (slow down or accelerate) rates of processes (chemical reactions or dissolving) as they occur. HS-PS1-5

HS-PS1-6. Design ways to control the extent of a reaction at equilibrium (relative amount of products to reactants) by altering various conditions using Le Chatelier's principle. Make arguments based on kinetic molecular theory to account for how altering conditions would affect the forward and reverse rates of the reaction until a new equilibrium is established. HS-PS1-6

HS-PS1-7. Use mathematical representations and provide experimental evidence to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Use the mole concept and proportional relationships to evaluate the quantities (masses or moles) of specific reactants needed in order to obtain a specific amount of product. HS-PS1-7

HS-PS1-9(MA). Relate the strength of an aqueous acidic or basic solution to the extent of an acid or base reacting with water as measured by the hydronium ion concentration (pH) of the solution. Make arguments about the relative strengths of two acids or bases with similar structure and composition. HS-PS1-9(MA)

HS-PS1-10(MA). Use an oxidation-reduction reaction model to predict products of reactions given the reactants, and to communicate the reaction models using a representation that shows electron transfer (redox). Use oxidation numbers to account for how electrons are redistributed in redox processes used in devices that generate electricity or systems that prevent corrosion. HS-PS1-10(MA)

HS-PS1-11(MA). Design strategies to identify and separate the components of a mixture based on relevant chemical and physical properties. HS-PS1-11(MA)

PS2. Motion and Stability: Forces and Interactions PS2

HS-PS2-6. Communicate scientific and technical information about the molecular-level structures of polymers, ionic compounds, acids and bases, and metals to justify why these are useful in the functioning of designed materials. HS-PS2-6

HS-PS2-7(MA). Construct a model to explain how ions dissolve in polar solvents (particularly water). Analyze and compare solubility and conductivity data to determine the extent to which different ionic species dissolve. HS-PS2-7(MA)

HS-PS2-8(MA). Use kinetic molecular theory to compare the strengths of electrostatic forces and the prevalence of interactions that occur between molecules in solids, liquids, and gases. Use the combined gas law to determine changes in pressure, volume, and temperature in gases. HS-PS2-8(MA)

PS3. Energy PS3

HS-PS3-4b. Provide evidence from informational text or available data to illustrate that the transfer of energy during a chemical reaction in a closed system involves changes in energy dispersal (enthalpy change) and heat content (entropy change) while assuming the overall energy in the system is conserved. HS-PS3-4B

Technology/Engineering

ETS1. Engineering Design ETS1

HS-ETS1-1. Analyze a major global challenge to specify a design problem that can be improved. Determine necessary qualitative and quantitative criteria and constraints for solutions, including any requirements set by society. HS-ETS1-1

HS-ETS1-2. Break a complex real-world problem into smaller, more manageable problems that each can be solved using scientific and engineering principles. HS-ETS1-2

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, aesthetics, and maintenance, as well as social, cultural, and environmental impacts. HS-ETS1-3

HS-ETS1-4. Use a computer simulation to model the impact of a proposed solution to a complex real-world problem that has numerous criteria and constraints on the interactions within and between systems relevant to the problem. HS-ETS1-4

HS-ETS1-5(MA). Plan a prototype or design solution using orthographic projections and isometric drawings, using proper scales and proportions. HS-ETS1-5(MA)

HS-ETS1-6(MA). Document and present solutions that include specifications, performance results, successes and remaining issues, and limitations. HS-ETS1-6(MA)

ETS2. Materials, Tools, and Manufacturing ETS2

HS-ETS2-1(MA). Determine the best application of manufacturing processes to create parts of desired shape, size, and finish based on available resources and safety. HS-ETS2-1(MA)

HS-ETS2-2(MA). Explain how computers and robots can be used at different stages of a manufacturing system, typically for jobs that are repetitive, very small, or very dangerous. HS-ETS2-2(MA)

HS-ETS2-3(MA). Compare the costs and benefits of custom versus mass production based on qualities of the desired product, the cost of each unit to produce, and the number of units needed. HS-ETS2-3(MA)

HS-ETS2-4(MA). Explain how manufacturing processes transform material properties to meet a specified purpose or function. Recognize that new materials can be synthesized through chemical and physical processes that are designed to manipulate material properties to meet a desired performance condition. HS-ETS2-4(MA)

ETS3. Technological Systems ETS3

HS-ETS3-1(MA). Model a technological system in which the output of one subsystem becomes the input to other subsystems. HS-ETS3-1(MA)

HS-ETS3-2(MA). Use a model to explain how information transmitted via digital and analog signals travels through the following media: electrical wire, optical fiber, air, and space. Analyze a communication problem and determine the best mode of delivery for the communication(s). HS-ETS3-2(MA)

HS-ETS3-3(MA). Explain the importance of considering both live loads and dead loads when constructing structures. Calculate the resultant force(s) for a combination of live loads and dead loads for various situations. HS-ETS3-3(MA)

HS-ETS3-4(MA). Use a model to illustrate how the forces of tension, compression, torsion, and shear affect the performance of a structure. Analyze situations that involve these forces and justify the selection of materials for the given situation based on their properties. HS-ETS3-4(MA)

HS-ETS3-5(MA). Analyze how the design of a building is influenced by thermal conditions such as wind, solar angle, and temperature. Give examples of how conduction, convection, and radiation are considered in the selection of materials for buildings and in the design of a heating system. HS-ETS3-5(MA)

HS-ETS3-6(MA). Use informational text to illustrate how a vehicle or device can be modified to produce a change in lift, drag, friction, thrust, and weight. HS-ETS3-6(MA)

ETS4. Energy and Power Technologies ETS4

HS-ETS4-1(MA). Research and describe various ways that humans use energy and power systems to harness resources to accomplish tasks effectively and efficiently. HS-ETS4-1(MA)

HS-ETS4-2(MA). Use a model to explain differences between open fluid systems and closed fluid systems. Determine when it is more or less appropriate to use one type of system instead of the other. HS-ETS4-2(MA)

HS-ETS4-3(MA). Explain how differences and similarities between hydraulic and pneumatic systems lead to different applications of each in technologies. HS-ETS4-3(MA)

HS-ETS4-4(MA). Calculate and describe the ability of a hydraulic system to multiply distance, multiply force, and effect directional change. HS-ETS4-4(MA)

HS-ETS4-5(MA). Explain how a machine converts energy, through mechanical means, to do work. Collect and analyze data to determine the efficiency of simple and complex machines. HS-ETS4-5(MA)