# Plymouth Public Schools' Science and Technology/Engineering Program High School Earth Science Learning Standards

STE0042 Earth Science Honors
STE0043 Earth Science College Prep 1
STE0044 Earth Science College Prep 2

An Introduction to the Massachusetts Department of Elementary and Secondary Education Science and Technology/Engineering Curriculum Framework

Effective teaching and learning in science fosters engagement and has rigor, relevance, and coherence embedded within. It couples practice with content to give the context for performance. A program with these components encourages students to analyze and explain phenomena and experience; engages with practices to build, use, and apply knowledge; and builds a storyline over time and among disciplines. The state standards that form this program are outcomes that reflect what a student should know and be able to do as a result of instruction. Science and engineering practices, which are included in these standards, are not teaching strategies; they are important learning goals and skills to be learned, also as a result of instruction. The standards listed below are not intended to represent an exhaustive list of all that could be included in our district's science program, nor should this list prevent students from going beyond the standards where appropriate. (Excerpts from Curriculum Framework)

Disciplinary Core Ideas – Earth and Space Science

Earth and space science standards build from middle school to explain additional and more complex phenomena related to Earth processes and systems, interactions among Earth's systems, and interactions of Earth's systems and human actions. More specifically, these standards help students understand the universe and its stars, Earth and the solar system, and the history of planet Earth, including the processes responsible for the formation, evolution, and workings of the solar system and universe. Students will also work towards developing an explanation for the phenomena related to Earth materials and systems, plate tectonics and large-scale system interactions, the roles of water in Earth's surface processes, and weather and climate. Students develop models to understand the complex and significant interdependencies between humans and the rest of Earth's systems through the impacts of natural hazards, our dependencies on natural resources, and the significant environmental impacts of human activities. Particular emphasis is placed on developing and using models; constructing explanations; and obtaining, evaluating, and communicating information. (Excerpts from Curriculum Framework)

ESS1. Earth's Place in the Universe

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.

State Assessment Boundary:
Specific stages of the life of a star, details of the many different nucleosynthesis pathways for stars of differing masses, or calculations of energy released are not expected in state assessment.

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 (3/4 hydrogen and 1/4 helium).

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.

Clarification Statements:
1. Kepler's Laws apply to human-made satellites as well as planets, moons, and other objects.
2. Calculations involving Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.

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.

Clarification Statement:
Examples include the ages of oceanic crust (less than 200 million years old) increasing with distance from mid-ocean ridges (a result of plate spreading at divergent boundaries) and the ages of North American continental crust (which can be older than 4 billion years) increasing with distance away from a central ancient core (a result of past plate interactions at convergent boundaries).

ESS2. Earth's Systems

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.

Clarification Statement:
Examples can include how decreasing the amount of glacial ice reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice; 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 wetland extent.

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.

Clarification Statements:
1. Emphasis is on both a two-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by gravity and thermal convection.
2. 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.

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.

Clarification Statement:
Examples of the causes of climate change differ by timescale: large volcanic eruption and ocean circulation over 1-10 years; changes in human activity, ocean circulation, and solar output over tens to hundreds of years; changes to Earth's orbit and the orientation of its axis over tens to hundreds of thousands of years; and, long-term changes in atmospheric composition over tens to hundreds of millions of years.

State Assessment Boundary:
Changes in climate will be limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution in state assessment.

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.

Clarification Statements:

1. Examples of mechanical mechanisms involving water include stream transportation and deposition, erosion using variations in soil moisture content, and frost wedging by the expansion of water as it freezes.
2. Examples of chemical mechanisms involving water include chemical weathering and recrystallization (based on solubility of different materials) and melt generation (based on water lowering the melting temperature of most solids).

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 gradual atmospheric and climate changes.

ESS3. Earth and Human Activity

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.

Clarification Statements:

1. Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils (such as river deltas), high concentrations of minerals and fossil fuels, and biotic resources (such as fisheries and forests).
2. Examples of changes due to variations in climate include changes to sea level and regional patterns of temperature and precipitation.

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.

Clarification Statement:
Examples include developing best practices for agricultural soil use, mining (for metals, coal, tar sands, and oil shales), and pumping (for petroleum and natural gas).

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

Clarification Statements:

1. Examples of factors related to the management of natural resources include costs of resource extraction and waste management, per-capita consumption,

and the development of new technologies.
2. Examples of factors related to human sustainability include agricultural efficiency, levels of conservation, and urban planning.
3. Examples of factors related to biodiversity include habitat use and fragmentation, and land and resource conservation.

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.

Clarification Statement:
Climate model outputs include both climate changes (such as precipitation and temperature) and associated impacts (such as on sea level, glacial ice volumes, and atmosphere and ocean composition).