Introduction

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

Science Long Term Transfer Goals

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

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

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

Grade 9-12 Earth & Space Science

The Universe and Its Stars							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
We can infer information about stars based on observations we make from Earth.	What is the universe, and what goes on in stars?	**3.3.9-12.A** **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 in the form of radiation.**	**Developing and Using Models** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary)	**Scale Proportion and Quantity** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.	fusion nucleus energy radiation mass lifetime solar flare sunspot cycle core	
We can infer information about stars based on observations we make from Earth.	What is the universe, and what goes on in stars?	**3.3.9-12.B** **Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, the motion of distant galaxies, and the composition of matter in the universe.**	**Constructing explanations and designing solutions** Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they	The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gasses, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. 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	**Energy and Matter** Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems.	electromagnetic/light spectrum radiation Big Bang Theory cosmic microwave background supernova interstellar redshift	

			did in the past and will continue to do so in the future.	releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. 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)			
We can infer information about stars based on observations we make from Earth.	What is the universe, and what goes on in stars?	**3.3.9-12.C** **Communicate scientific ideas about the way stars, over their life cycle, produce elements.**	**Obtaining, Evaluating, and Communicating Information** Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. 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.	**Energy and Matter** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	nucleosynthesis conservation mass electromagnetic/light spectrum emission and absorption spectra elements atoms nuclei protons neutrons supernova	

Earth and the Solar System							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
Observations of the sky can be explained by predictable patterns of the movement of Earth, moon, sun and planets.	What are the predictable patterns caused by Earth's movement in the solar system?	**3.3.9-12.D** **Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.**	**Using Mathematical and Computational Thinking** Use mathematical or computational representations of phenomena to describe explanations.	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.	**Scale Proportion and Quantity** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).	orbit gravity satellites laws trajectory eccentricity ellipse (foci, axis)	
Observations of the sky can be explained by predictable patterns of the movement of Earth, moon, sun and planets.	What are the predictable patterns caused by Earth's movement in the solar system?	**3.3.9-12.E** **Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.**	**Developing and Using Models** Use a model to provide mechanistic accounts of phenomena.	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. 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. The foundation for Earth's global climate	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	intensity orbit climate axis rotation ice age tectonic activity circulation glaciation energy	

				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 reradiation into space.			
The History of Planet Earth							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
We can infer Earth's planetary history by features we observe today.	How do people reconstruct and date events in Earth's planetary history?	**3.3.9-12.F** **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.**	**Engaging in Argument from Evidence** Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.	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. 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. Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.	**Patterns** Empirical evidence is needed to identify patterns	plate tectonics continental drift erosion crust mid-ocean ridges plate interactions radiometric dating magma subduction	
We can infer Earth's planetary history by features we observe today.	How do people reconstruct and date events in Earth's planetary history?	**3.3.9-12.G** **Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of**	**Constructing Explanations and Designing Solutions** Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and	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.	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable.	asteroid meteor meteorite radiometric dating radioactive decay erosion and plate	

		Earth's formation and early history.	data support the explanation or conclusion	Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary)		tectonics impact craters	
Earth Materials and Systems							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
Changes we observe on Earth are the result of energy flowing and matter cycling between interconnected systems (the geosphere, hydrosphere, atmosphere, and biosphere).	How and why is Earth constantly changing? How do Earth's major systems interact?	**3.3.9-12.H** **Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems.**	**Analyzing and Interpreting Data** Analyze data using computational models in order to make valid and reliable scientific claims.	Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. 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.	**Stability and Change** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	climate geosphere hydrosphere atmosphere biosphere feedback greenhouse gases glacial ice runoff erosion ground water humidity radiation	
Changes we observe on Earth are the result of energy flowing and matter cycling between interconnected	How and why is Earth constantly changing? How do Earth's major systems interact?	**3.3.9-12.I** **Develop a model based on evidence of Earth's interior to describe the cycling of matter by**	**Developing and Using Models** Develop a model based on evidence to illustrate the relationships	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	**Energy and Matter** Energy drives the cycling of matter within and between systems.	magnetic field core mantle crust	

systems (the geosphere, hydrosphere, atmosphere, and biosphere).		**thermal convection.**	between systems or between components of a system.	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. The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.		seismic waves earthquakes plate tectonics convection energy radioactive decay solid liquid seismic/magnetic density plate boundaries magnetic field polar reversal	
Plate Tectonics and Large-Scale System Interactions							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
Plate tectonics explains the past and current movements and features of the rocks at Earth's surface.	Why do the continents move, and what causes earthquakes and volcanoes?	**3.3.9-12.J** **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.**	**Developing and Using Models** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. 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. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.	**Stability and Change** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible	mountains valleys plateaus trenches ridges seamounts volcanism mountain building	

						tectonic uplift weathering erosion	
The Roles of Water in Earth's Surface Processes							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
Water's presence and properties impact Earth's ecosystems and surface features.	How do the properties and movements of water shape Earth's surface and affect its systems?	**3.3.9-12.K** **Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.**	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	The 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.	**Structure and Function** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.	heat capacity density solid liquid Gas vapor polarity (molecular structure) air stream table transportation deposition soil moisture chemical weathering rust	

Weather and Climate							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things.	What regulates weather and climate?	**3.3.9-12.L** **Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.**	**Developing and Using Models** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Energy and Matter** The total amount of energy and matter in closed systems is conserved.	carbon cycle hydrosphere atmosphere geosphere biosphere carbon dioxide	
Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things.	What regulates weather and climate?	**3.3.9-12.M** **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.**	**Using Mathematics and Computational Thinking** Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.	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) 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.	**Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.	Hydrosphere atmosphere cryosphere geosphere biosphere atmospheric CO2 photosynthetic biomass ocean acidification	

Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things.	What regulates weather and climate?	**3.3.9-12.S** **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**	**Analyzing and Interpreting Data** Analyze data using computational models in order to make valid and reliable scientific claims.	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.	**Stability and Change** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	sea-level climate model temperature precipitation pH reversible	
Biogeology							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
Life and the planet's nonliving systems impact one another	How do living organisms alter Earth's processes and structures?	**3.3.9-12.N** **Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.**	**Engaging in Argument from Evidence** Construct an oral and written argument or counter-arguments based on data and evidence.	Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. 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.	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable.	coevolution atmospheric composition photosynthetic organisms biosphere weathering respiration deposition feedback mechanisms	

Natural Resources							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
All materials, energy, and fuels that humans use are derived from natural sources, some of which are renewable over time and others are not.	How do humans depend on Earth's resources?	**3.3.9-12.O** **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.**	**Constructing Explanations and Designing Solutions** Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	Resource availability has guided the development of human society. 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.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	environmental factors hazard population size and migration patterns causal relationships correlational relationships	
Natural Hazards							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
Natural processes can cause sudden or gradual changes to Earth's systems, some of which may	How do natural hazards affect individuals and societies?	**3.3.9-12.P** **Evaluate competing design solutions for developing, managing, and utilizing energy**	**Engaging in Argument from Evidence** Evaluate competing design solutions to a real-world problem	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	**Influence of Science, Engineering, and Technology on Society and the Natural World** Engineers continuously modify	cost-benefit ratios mineral energy reserve constraints	

adversely affect humans.		**and mineral resources based on cost-benefit ratios.**	based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	change the balance of these factors. 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)	these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. Analysis of costs and benefits is a critical aspect of decisions about technology.		
Human Impact on Earth Systems							
Big Idea	**Essential Question**	**Standard**	**Science and Engineering Practices**	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**	**Vocabulary**	**Assessment Anchors Eligible Content**
Human activities in agriculture, industry, and everyday life has an impact on the land, rivers, ocean, and air.	How do humans change the planet?	**3.3.9-12.Q** **Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.**	**Using Mathematics and Computational Thinking** Create a computational model or simulation of a phenomenon, designed device, process, or system.	The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.	**Stability and Change** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible	natural resource ecosystem sustainability biodiversity population feedback stabilizes destabilizes system	
Human activities in agriculture, industry, and everyday life has an impact on the land, rivers, ocean, and air.	How do humans change the planet?	**3.3.9-12.R** **Evaluate or refine a technological solution that reduces the impact of human activities on natural**	**Constructing Explanations and Designing Solutions** Design or refine a solution to a complex real-world problem,	Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. When evaluating solutions, it is important to take into account a range of constraints,	**Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system.	tradeoffs benefits/costs/risks stability	

		systems.	based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)			