Science and Engineering Practices

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<th>Developing and Using Models</th>
<th>Using Mathematical and Computational Thinking</th>
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<td>Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).</td>
<td>Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools</td>
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<td>Develop a model based on evidence to illustrate the relationships between systems or between components of a system.</td>
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<td>Students are designing and executing experiments based on their hypothesis. Students are writing hypothesis in if… then… because format, all written by the student.</td>
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<td>Students can differentiate between English System and Metric System units. Students know metric prefixes and the value associated with each.</td>
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Pacing Guides create a realistic time frame for instruction and assessment. They establish paced, student learning expectations and provide a starting point for the implementation of the Michigan State Standards.

Revised 8.2017
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<td>- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.</td>
<td>- I CAN provide evidence and support for the Big Bang Theory and that the universe is expanding.</td>
<td>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.</td>
<td>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.</td>
<td>Communicate scientific ideas about the way stars, over their life cycle, produce elements.</td>
<td>Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.</td>
<td>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.</td>
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<td>- 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.</td>
<td>- I CAN explain how the different elements in the universe formed from stars.</td>
<td>Clarification: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun’s core to release energy that eventually reaches Earth.</td>
<td>Clarification: 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.</td>
<td>Clarification: 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).</td>
<td>Clarification: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons. Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.</td>
<td>Clarification: 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.</td>
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<td>- 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.</td>
<td>- I CAN provide evidence and support for the Big Bang Theory and that the universe is expanding.</td>
<td>- I CAN explain why planets orbit stars and how moons and human-made satellites orbit planets.</td>
<td>- I CAN use Newtonian gravitational laws to predict the motion of objects in space.</td>
<td>- I CAN use explain Kepler’s laws of orbital motion to explain the movement of objects in solar systems.</td>
<td>- I CAN provide evidence to explain Earth’s formation.</td>
<td>- I CAN explain Earth’s early history based on current available scientific knowledge.</td>
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**I CAN Statements**

- I CAN explain how the energy from nuclear fusion in the sun’s core reaches Earth.
- I CAN explain the life span of the sun using scientific evidence.

**Standards 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.

**Standards 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.

**Standards HS ESS1.3**

Communicate scientific ideas about the way stars, over their life cycle, produce elements.

**Standards HS ESS1.4**

Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

**Standards 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.
Science and Engineering Practices

Engaging in Argument from Evidence
- Engaging in argument from evidence in 9–12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.
- Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.

Developing and Using Models
- Modeling in 9–12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

Engaging in Argument from Evidence
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- Construct an oral and written argument or counter-arguments based on data and evidence.

Constructing Explanations and Designing Solutions
- Constructing explanations and designing solutions in 9–12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
- Construct and revise 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.

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Revised 8.2017

### Earth Space

#### Standard HS ESS1.5

- □ I CAN explain the evidence used to describe past and current movements of continental and oceanic crust.
- □ I CAN explain the theory of plate tectonics and how it relates to the ages of crustal rocks.

### Science

#### Standard 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.

#### Standard HS LS2.3

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

### Disciplinary Core Ideas

- 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.
- 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.
- 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.
- 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.
- 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.

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Using Mathematics and Planning and Carrying Out Investigations
Constructing Explanations Analyzing and Interpreting Data

- Models of basic assumptions, on types, how much, (including students' own used based on mathematical and in the design: decide a variety of sources to make valid and reliable data. Simple computational simulations are created and the basis for evidence, evidence obtained from mathematical) in order 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.
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### Earth Space

#### Unit #5
**Earth’s Systems**

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<td>☐ I CAN explain the properties of water and its effects on Earth’s materials and surface properties based off of scientific evidence.</td>
</tr>
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</table>

**Standard HS ESS2.5**

Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

**Clarification:** Emphasis on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrological 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, or 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).

**Disciplinary Core Ideas**

- 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.
- 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.
- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- 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.
- 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.
- 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.

### Science

#### Unit 6
**Weather and Climate**

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<td>☐ I CAN use a computational simulation to illustrate the relationships between natural resource management, the sustainability of human populations, and biodiversity.</td>
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**Standard HS ESS3.1**

Create a computational simulation to illustrate the anthropogenic impacts on the water cycle as climate change continues to alter Earth’s natural processes. Use a variety of data to explain the changes in temperature and precipitation. Analyze data to illustrate the relationships among Earth’s systems.

**Clarification:** Emphasis on the potential effects of human activities on the water cycle. Examples of such activities include agriculture, urbanization, deforestation, and the development of new technologies. The results of changes in climate can affect populations or drive mass migrations.

**Disciplinary Core Ideas**

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#### Developing and Using Models
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- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
- Use a model to provide mechanistic accounts of phenomena.

#### Analyzing and Interpreting Data
- Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
- Analyze data using computational models in order to make valid and reliable scientific claims.

#### Constructing Explanations and Designing Solutions
- Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent supporting sources of evidence consistent with scientific knowledge, principles, and theories.
- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

#### Engaging in Argument from Evidence
- Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s).
- Arguments may also come from current scientific or historical episodes in science.
- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).

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### Introduction to Your Science Pacing Guide

The Science Pacing Guide is based on the Next Generation Science Standards, and the I CAN statements are tailored to the needs of the students in the Lansing School District. For easy access to the actual state standards as well as supporting information and resources visit the official Next Generation Science Standards website at: www.nextgenscience.org.

Pacing Guides create a realistic time frame for instruction and assessment. They establish paced, student learning expectations and provide a starting point for the implementation of the Michigan State Standards.

The following tips may be helpful as you begin using the Pacing Guide:

- Introduce 9-week content skills according to the Pacing Guide.
- Once a skill is mastered, continue to practice it.
- Continue to reinforce skills and concepts throughout the year until mastery is achieved.
- Skills can be introduced earlier than listed, but no later, and can be assessed at any point after introduction.
- Compare your current pace to the Pacing Guide and adjust as needed.
- Become familiar with sequencing at previous and subsequent grade levels.
- The website, www.nextgenscience.org, can be used to find more information and to better understand Michigan State Standards.
- The electronic version of the Pacing Guides can be found on the Lansing School District homepage www.lansingschools.net under Quicklinks.
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<th>Disciplinary Core Ideas</th>
<th>Earth Space</th>
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<td>Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.</td>
<td>▶️ I CAN describe how carbon cycles through the hydrosphere, atmosphere, geosphere, and biosphere.</td>
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<td>▶️ I CAN use cost-benefit ratios to evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources.</td>
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<td>Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.</td>
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**Standard HS ESS2.6**

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

**Clarification:** 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.

**Standard 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.

**Clarification:** Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, open ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth’s orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition. Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperature, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.

**Standard HS ESS3.4**

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

**Clarification:** 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).

**Standard 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.

**Clarification:** Examples of evidence, for both data and climate output models, 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). Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.

**Standard HS ESS3.2**

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

**Clarification:** 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, 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.