HS.ESS-SS Space Systems

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Students who demonstrate understanding can:

a. Construct explanations from evidence about how the stability and structure of the sun change over its lifetime at time scales that are short (solar flares), medium (the hot spot cycle), and long (changes over its 10-billion-year lifetime). [Clarification Statement: Evidence for long-term changes includes the Hertzsprung-Russell Diagram.]

b. Use mathematical, graphical, or computational models to represent the distribution and patterns of galaxies and galaxy clusters in the Universe to describe the Sun's place in space.

c. Construct explanations for how the Big Bang theory accounts for all observable astronomical data including the red shift of starlight from galaxies, cosmic microwave background, and composition of stars and nonstellar gases.

d. Obtain, evaluate, and communicate information about the process by which stars produce all elements except those elements formed during the Big Bang. [Clarification Statement: Nuclear fusion within certain stars produce atomic nuclei lighter than and including iron; heavier elements are produced when certain massive stars achieve a supernova stage and explode.]

e. Use mathematical representations of the positions of objects in the Solar System to predict their motions and gravitational effects on each other. [Assessment Boundary: Mathematical representations, which include Kepler's Laws, should not deal with more than 2 bodies.]

f. Analyze evidence to show how changes in Earth's orbital parameters affect the intensity and distribution of sunlight on Earth's surface, causing cyclical climate changes that include past Ice Ages. [Assessment Boundary: Orbital parameters are limited to change in orbital shape and orientation of the planetary axis.]

g. Construct explanations for how differences in orbital parameters, combined with the object's size and composition, control the surface conditions of other planets and moons within the solar system.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 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.

- Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution. (f)

Using Mathematical and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use statistical and mathematical techniques and structure data (e.g., displays, tables, graphs) to find regularities, patterns (e.g., fitting mathematical curves to data), and relationships in data. (b)
- Use simple limit cases to test mathematical expressions, computer programs or algorithms, or simulations to see if a model "makes sense" by comparing the outcomes with what is known about the real world. (e)

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 knowledge, principles, and theories.

- Construct and revise explanations and arguments based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories) and peer review. (a),(c),(g)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on 6–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- Critically read scientific literature adapted for classroom use to identify key ideas and major points and to evaluate the validity and reliability of the claims, methods, and designs. (d)

Disciplinary Core Ideas

ESS1.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. (a)
- The sun is one of more than 200 billion stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the universe. (b)
- The spectra and brightness of stars are used to identify their compositional elements, movements, and distances from Earth and to develop explanations about the formation, age, and composition of the universe. The Big Bang theory is supported by the fact that it provides an explanation of observations of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (c)
- 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. (c),(d)

ESS1.B: Earth and the Solar System

- Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (e)
- Cyclic changes in the shape of Earth's orbit around the sun, together with changes in the orientation of the planet's axis of rotation, have altered the intensity and distribution of sunlight falling on Earth. These changes, both occurring over tens to hundreds of thousands of years, cause cycles of ice ages and other gradual climate changes. (f),(g)

Crosscutting Concepts

Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (b)

Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (e),(g)

Energy and Matter

The total amount of energy and matter in closed systems is conserved. Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (a),(c),(d),(f)

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Connections to other DCIs in this grade-level: **HS.PS-NP, HS.PS-ER, HS.PS-E, HS.PS-FM, HS.PS-FE, HS.PS-IF**	
Articulation to DCIs across grade-levels: **1.PC, 5.SSS, MS.ESS-SS**	
Common Core State Standards Connections: [Note: these connections will be made more explicit and complete in future draft releases]	
ELA –	
W.9-10.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
RI.9-10.1	Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
W.9-10.9(b)	Draw evidence from literary or informational texts to support analysis, reflection, and research.
W.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
SL.11-12.2	Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.
W.11-12.9(b)	Draw evidence from literary or informational texts to support analysis, reflection, and research.
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Mathematics –	
MP.2	Reason abstractly and quantitatively
MP.4	Model with mathematics
MP.5	Use appropriate tools strategically
S.ID	Summarize, represent, and interpret data on a single count or measurement variable; Summarize, represent, and interpret data on two categorical and quantitative variables
S.IC	Make inferences and justify conclusions from sample surveys, experiments, and observational studies
G.MG	Apply geometric concepts in modeling situations
F.IF	Interpret functions that arise in applications in terms of the context
F.BF	Build a function that models a relationship between two quantities
F.LE	Construct and compare linear, quadratic, and exponential models and solve problems