**Connecting to the *Next Generation Science Standards***

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| **Next Generation Science Standards****HS-ESS1 Earth's Place in the Universe****HS.Space Systems** |
| **Performance Expectation(s)*****The chart below makes one set of connections between the instruction outlined in this article and the NGSS. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities. The activities outlined in this article are just one step toward reaching the performance expectations listed below.******HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.******HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.*** |
| **Dimension** | **Name and *NGSS* code/citation** | **Specific Connections to Classroom Activity** |
| **Science and Engineering Practices** | **[Developing and Using Models](http://www.nap.edu/openbook.php?record_id=13165&page=56)**[**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).**](http://www.nap.edu/openbook.php?record_id=13165&page=56)* [**Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1)**](http://www.nap.edu/openbook.php?record_id=13165&page=56)

**[Using Mathematical and Computational Thinking](http://www.nap.edu/openbook.php?record_id=13165&page=64)**[**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 for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.**](http://www.nap.edu/openbook.php?record_id=13165&page=64)* [**Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4)**](http://www.nap.edu/openbook.php?record_id=13165&page=64)

**[Constructing Explanations and Designing Solutions](http://www.nap.edu/openbook.php?record_id=13165&page=67)**[**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.**](http://www.nap.edu/openbook.php?record_id=13165&page=67)* [**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 did in the past and will continue to do so in the future. (HS-ESS1-2)**](http://www.nap.edu/openbook.php?record_id=13165&page=67)
* [**Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6)**](http://www.nap.edu/openbook.php?record_id=13165&page=67)

**[Engaging in Argument from Evidence](http://www.nap.edu/openbook.php?record_id=13165&page=71)**[**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.**](http://www.nap.edu/openbook.php?record_id=13165&page=71)* [**Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5)**](http://www.nap.edu/openbook.php?record_id=13165&page=71)

**[Obtaining, Evaluating, and Communicating Information](http://www.nap.edu/openbook.php?record_id=13165&page=74)**[**Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.**](http://www.nap.edu/openbook.php?record_id=13165&page=74)* [**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). (HS-ESS1-3)**](http://www.nap.edu/openbook.php?record_id=13165&page=74)

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* **Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6)**
 | **Students develop models to predict solar flares and show relationships among variables between systems and their components in the natural world.****Through the lecture, discussion, and exercises students obtain, evaluate, and communicate information related to the Aurora Borealis.**  |
| **Disciplinary Core Ideas** | **[ESS1.A: The Universe and Its Stars](http://www.nap.edu/openbook.php?record_id=13165&page=173)*** [**The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)**](http://www.nap.edu/openbook.php?record_id=13165&page=173)
* [**The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2), (HS-ESS1-3)**](http://www.nap.edu/openbook.php?record_id=13165&page=173)
* [**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. (HS-ESS1-2)**](http://www.nap.edu/openbook.php?record_id=13165&page=173)
* [**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. (HS-ESS1-2), (HS-ESS1-3)**](http://www.nap.edu/openbook.php?record_id=13165&page=173)

**[ESS1.B: Earth and the Solar System](http://www.nap.edu/openbook.php?record_id=13165&page=175)*** [**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. (HS-ESS1-4)**](http://www.nap.edu/openbook.php?record_id=13165&page=175)

**[PS3.D: Energy in Chemical Processes and Everyday Life](http://www.nap.edu/openbook.php?record_id=13165&page=128)*** [**Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. *(secondary to HS-ESS1-1)***](http://www.nap.edu/openbook.php?record_id=13165&page=128)

**[PS4.B: Electromagnetic Radiation](http://www.nap.edu/openbook.php?record_id=13165&page=133)*** [**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 to HS-ESS1-2)***](http://www.nap.edu/openbook.php?record_id=13165&page=133)
 | **Students learn that the heat in the core of the sun causes convection near the surface, which generates magnetic fields. These fields can get twisted and tangled, causing the release of energy that produces solar flares and/or the ejection of billion-ton clouds of plasma called Coronal Mass Ejections or CMEs. In approximately 40 hours when an Earth-directed CME reaches Earth, it can cause disturbances in Earth’s magnetic field, which accelerate charged particles into the polar regions where they cause the dramatic and dazzling phenomenon known as the Northern Lights.** |
| **Crosscutting Concept(s)** | **[Patterns](http://www.nap.edu/openbook.php?record_id=13165&page=85)*** [**Empirical evidence is needed to identify patterns. (HS-ESS1-5)**](http://www.nap.edu/openbook.php?record_id=13165&page=85)

**[Scale, Proportion, and Quantity](http://www.nap.edu/openbook.php?record_id=13165&page=89)*** [**The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)**](http://www.nap.edu/openbook.php?record_id=13165&page=89)
* [**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). (HS-ESS1-4)**](http://www.nap.edu/openbook.php?record_id=13165&page=89)

**[Energy and Matter](http://www.nap.edu/openbook.php?record_id=13165&page=94)*** [**Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)**](http://www.nap.edu/openbook.php?record_id=13165&page=94)
* [**In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)**](http://www.nap.edu/openbook.php?record_id=13165&page=94)

**[Stability and Change](http://www.nap.edu/openbook.php?record_id=13165&page=98)*** [**Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)**](http://www.nap.edu/openbook.php?record_id=13165&page=98)

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* **Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)**
 | **Students use data to make predictions about solar activity and examine the accuracy of their predictions.**  |
| **Common Core State Standards of Mathematics** | **Reason abstractly and quantitatively. (MP.2)****Model with mathematics (MP.4)****Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HSN-Q.A.1)****Define appropriate quantities for the purpose of descriptive modeling. (HSN-Q.A.2)****Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HSN-Q.A.3)****Interpret expressions that represent a quantity in terms of its context. (HSA-SSE.A.1)****Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HSA-CED.A.2)****Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HSA-CED.A.4)****Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. (HSF-IF.B.5)****Represent data on two quantitative variables on a scatter plot, and describe how those variables are related. (HSS-ID.B.6)****Represent and model with vector quantities. (HSN.VM.A)****Perform operations on vectors. (HSN.VM.B)** | **Students use units, define quantities, and choose the level of accuracy appropriate.****Students create and solve equations.****Students model with vector quantities and perform operations on vectors.**  |