**Stanford NGSS Integrated Curriculum: An Exploration of a Multidimensional World**

**Unit 2: Travelling Through Space**

**Essential Question:** What forces keep the parts of our solar system together and how can we use this knowledge to plot a telescope route through space?

**Total Number of Instructional Days:** 31.5 – 34.5

**Unit 2 Pop-Out**

How Power Influences Science

(*Implement after project*)

**Group Culminating Project:**

Create a solar system model and propose a route for a new telescope through space.

**Individual Culminating Project**

Create a presentation to pitch your proposed route for the new telescope.

**Lift-Off Task:**

Our Solar System

**Task 2:**

A Solar System Model

**Task 3:**

Gravity in the Galaxies

**Task 4:**

Invisible Forces

Connect to the Culminating Project using the Project Organizer

**Task 1:**

A Sun-Earth-Moon Model

**Storyline for Unit 2**

In this unit, students are exploring both physics and space science concepts, from electromagnetism to the Sun-Earth-Moon system. This unit’s project combines both of these disciplines, as students learn everything they can about the solar system and various forces to help them chart a route for a new telescope through space. The Lift-Off Task asks students to draw off their own prior knowledge to generate questions around the phenomenon of our solar system—questions that they will continue to explore throughout this unit.

As students pool their prior knowledge in the Lift-Off Task, they will likely create a list of different things they might find in a solar system. However, in order to chart a telescope route through the solar system, it is not enough to just know what is there—they must find out where things are and how they are laid out within the system. The best way to visualize such a large system is to create a model. In Task 1, students will practice modeling with the smaller sub-system of the Sun-Earth-Moon system. In doing so, they will discover explanations for a lot of the phenomena they experience on Earth.

In Task 2, students use the modeling skills they practiced in the previous task to develop a model of the entire solar system. Unlike in the last task, however, students now focus on the scale aspect of developing models. By analyzing data on the scale properties of objects in the solar system, they will find that while the solar system is huge, they can use math to model it on a smaller scale. This class model they create provides the perfect stage within which to plot their telescope route.

At this point, students have a model of the solar system so they can begin to visualize where their telescope route may be. However, the parts of the solar system are not stationary…they move! In Task 3, students examine what factors affect the motion of objects within the solar system—specifically gravity. Using prior knowledge of gravity from Unit 1 and new simulation models, students build an understanding that gravity helped to create the solar system and gravity continues to maintain its structure and motion.

While gravity is one invisible force to consider, magnetism is another invisible force that must be understood to plot a safe telescope route. In Task 4, students conduct investigations to prove that magnetic fields do exist and can explain various phenomena that they experience. They will then use this information to create a strong magnetic field that protects their telescope as it travels through space, as well as predict how the telescope will behave in space due to its magnetic field.

By the end of the unit, groups will have collectively constructed a complete class-wide solar system model. Once students are complete with all tasks, each group makes an informed decision on the route they think the new telescope should take and how they will protect it as it moves through space. These routes can be presented within the class-wide model. Lastly, each student will individually create a presentation that pitches their group’s route, describing the forces and energy both used and encountered on this trip and justifying why their route is the best route.

**Three-Dimensional Breakdown of the Performance Expectations**

This unit was developed to align with, teach, and assess students’ understanding and skills related to these Performance Expectations. Below, we have mapped out the disciplinary core ideas, crosscutting concepts, and science and engineering practices addressed in this unit. Aspects of the dimensions that are not explicitly addressed in this unit are crossed out.

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| **Performance Expectations** | **Scientific and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-ESS1-1 Develop and use a model** **of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.**[Clarification Statement: Examples of models can be physical, graphical, or conceptual.] | Developing and Using Models  * Develop and use a model to describe phenomena. | ESS1.A: The Universe and Its Stars  * Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.  ESS1.B: Earth and the Solar System  * This model of the solar system can explain eclipses of the sun and the moon. Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. | Patterns  * Patterns can be used to identify cause-and-effect relationships. |
| **MS-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.**[Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).] [*Assessment Boundary: Assessment does not include Kepler’s Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.*] | Developing and Using Models  * Develop and use a model to describe phenomena. | ESS1.A: The Universe and Its Stars  * ~~Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.~~  ESS1.B: Earth and the Solar System  * The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. * The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. * All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. | Systems and System Models  * Models can be used to represent systems and their interactions. |
| **MS-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system.**[Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object’s layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.]  [*Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.*] | Analyzing and Interpreting Data  * Analyze and interpret data to determine similarities and differences in findings. | ESS1.B: Earth and the Solar System  * The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. | Scale, Proportion, and Quantity  * Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. |
| **MS-PS2-3**.**Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.**[Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [*Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.*] | Asking Questions and Defining Problems  * Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. | PS2.B: Types of Interactions  * Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. | Cause and Effect  * Cause and effect relationships may be used to predict phenomena in natural or designed systems. |
| **MS-PS2-4**. **Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.** [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [Assessment Boundary: Assessment does not include Newton’s Law of Gravitation or Kepler’s Laws. | **Engaging in Argument from Evidence**   * Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. | **PS2.B: Types of Interactions**   * Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. | **Systems and System Models**   * Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. |
| **MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.** [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [Assessment Boundary: Assessment is limited to electric and magnetic fields, and is limited to qualitative evidence for the existence of fields.] | **Planning and Carrying Out Investigations**   * Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. | **PS2.B: Types of Interactions**   * Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). | **Cause and Effect**   * Cause and effect relationships may be used to predict phenomena in natural or designed systems. |
| **MS-PS3-2. Develop a model** **to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.**[Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate’s hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [*Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.*] | Developing and Using Models  * Develop a model to describe unobservable mechanisms. | PS3.A: Definitions of Energy  * A system of objects may also contain stored (potential) energy, depending on their relative positions.  PS3.C: Relationships Between Energy and Forces  * When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. | **Systems and System Models**   * Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. |

**Connections to Common Core Math and ELA Standards:**

Over the course of this unit, students will gain knowledge and skills in science, as well as in math and English-language arts. Below we list the Common Core ELA and Math standards for middle school and 8th grade that are relevant to the curriculum tasks in this unit. Within the curriculum, there are opportunities to incorporate components of the following ELA and Math Standards:

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| **Middle School Common Core ELA Standards** | | **Unit Task** |
| **Key Ideas and Details** | CCSS.ELA-Literacy.RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. | Task 3  Culminating Project |
| CCSS.ELA-Literacy. RST. 6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. | Task 1  Task 4 |
| **Integration of Knowledge and Ideas** | CCSS.ELA-Literacy.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). | Task 1  Task 3  Task 4  Culminating Project |
| **Text Types and Purposes** | CCSS.ELA-Literacy.WHST.6-8.1: Write arguments focused on discipline content. | Task 3  Culminating Project |
| **Research to Build and Present Knowledge** | CCSS.ELA-Literacy.WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. | All Unit |
| **Presentation of Knowledge and Ideas** | CCSS.ELA-Literacy.SL.8.5: Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. | Task 1  Task 2  Culminating Project |

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| **8th Grade Common Core Math Standards** | | **Unit Task** |
| **Mathematical Practice** | CCSS.MATH.MP.2: Reason abstractly and quantitatively. | Task 2  Task 3 |
| CCSS.MATH.MP.4: Model with mathematics. | Task 1  Task 2  Task 3 |

**Connections to English Language Development (ELD) Standards:**

We acknowledge that language development is a key component of disciplinary understanding and helps to support more rigorous and equitable outcomes for diverse students. This curriculum thus takes into account both the receptive and productive language demands of the culminating projects and strives to increase accessibility by including scaffolds for language development and pedagogical strategies throughout learning tasks. We aim to support language acquisition through the development of concept maps; utilizing sentence frames; implementing the Critique, Correct, and Clarify technique; employing the Stronger Clearer strategy; and fostering large and small group discussions.

The California ELD Standards are comprised of two sections: the standards and a rubric. Outlined below are the standards from Section One that are met within this curriculum. For additional information, please refer to: https://www.pausd.org/sites/default/files/pdf-faqs/attachments/SS\_ELD\_8.pdf.

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| **Eighth Grade ELD Standards** | | |
| **Part I: Interacting in Meaningful Ways** | A: Collaborative | 1.Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics |
| 2. Interacting with others in written English in various communicative forms (print, communicative technology, and multimedia) |
| 3. Offering and justifying options, negotiating with and persuading others in communicative exchanges |
| 4. Adapting language choices to various contexts (based on task, purpose, audience, and text type) |
| B: Interpretive | 5. Listening actively to spoken English in a range of social and academic contexts |
| 6. Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language |
| 7. Evaluating how well writers and speakers use language to support ideas and arguments with details or evidence depending on modality, text type, purpose, audience, topic, and content area |
| 8. Analyze how writers and speakers use vocabulary and other language resources for specific purposes (to explain, persuade, entertain, etc.) depending on modality, text type, purpose, audience, topic, and content area |
| C: Productive | 9. Expressing information and ideas in formal oral presentations on academic topics |
| 10. Writing literary and informational texts to present, describe, and explain ideas and information, using appropriate technology |
| 11. Justifying own arguments and evaluating others’ arguments in writing |
| 12. Selecting and applying varied and precise vocabulary and other language resources to effectively convey ideas |
| **Part II: Learning About How English Works** | A: Structuring Cohesive Texts | 1. Understanding text structure |
| 2. Understanding cohesion |
| B: Expanding and Enriching Ideas | 3. Using verbs and verb phrases |
| 4. Using nouns and noun phrases |
| 5. Modifying to add details |
| C: Connecting and Condensing Ideas | 6. Connecting ideas |
| 7. Condensing ideas |

**Connections to Environmental Awareness:**

Over the course of this curriculum, students will explore content related to various environmental principles and concepts that examine the interactions and interdependence of human societies and natural systems. In accordance with the *Education and the Environment Initiative (EEI),* tasks throughout this curriculum explore many of *California’s Approved Environmental Principles and Concepts.*

Because the context of this unit revolves around the solar system as a whole and the content mainly emphasizes physics concepts, this unit does not explicitly examine the interactions of humans and natural systems. In later units, we will outline the EEI principles relevant to the unit in this section of the unit overview.