Unit Summary
This unit is broken down into three sub-ideas: the universe and its stars, Earth and the solar system, and the history of planet Earth. Students examine the Earth's place in relation to the solar system, the Milky Way galaxy, and the universe. There is a strong emphasis on a systems approach and using models of the solar system to explain the cyclical patterns of eclipses, tides, and seasons. There is also a strong connection to engineering through the instruments and technologies that have allowed us to explore the objects in our solar system and obtain the data that support the theories explaining the formation and evolution of the universe. Students examine geosciences data in order to understand the processes and events in Earth's history. The crosscutting concepts of *patterns*, *scale, proportion, and quantity* and *systems and systems models* provide a framework for understanding the disciplinary core ideas. Students are expected to demonstrate proficiency in *developing and using models* and *analyzing and interpreting data*. Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on MS-ESS1-1, MS-ESS1-2, and MS-ESS1-3.
Student Learning Objectives
Generate and analyze evidence (through simulations or long term investigations) to explain why the Sun's apparent motion across the sky changes over the course of a year. (ESS1.B) *[Clarification Statement: This SLO is based on a disciplinary core idea found in the Framework. It is included as a scaffold to the following SLO.]*
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.]* **(MS-ESS1-1)**
Develop and use a model that shows how gravity causes smaller objects to orbit around larger objects at increasing scales, including the gravitational force of the sun causes the planets and other bodies to orbit around it holding together the solar system. (ESS1.A; ESS1.B) *[Clarification Statement: This SLO is based on disciplinary core ideas found in the Framework. It is included as a scaffold to the following SLO.]*
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.]* **(MS-ESS1-3)**
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.]* **(MS-ESS1-2)**

Quick Links		

Unit Sequence	
Part A: *What pattern in the Earth–sun–moon system can be used to explain lunar phases, eclipses of the sun and moon, and seasons?*	
Concepts	**Instructional Tools/Materials/Technology/Resources/Learning Activities/Assessment**
● Patterns in the apparent motion of the sun, moon, and stars in the sky can be observed, described, predicted, and explained with models. ● The Earth and solar system 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 can be used to identify cause-and-effect relationships that exist in the apparent motion of the sun, moon, and stars in the sky. ● Science assumes that objects and events in the solar system systems occur in consistent patterns that are understandable through measurement and observation.	**Learning Activities:** Guided reading Exploration activities: lunar cycle, seasonal tilt-and-whirl, Eclipses, cycle of Earth, moon and stars. Content videos note taking claim-evidence reasoning concept review game ***Materials****: Lunar Phase Cards, plastic baggie, Computer, projector, Lamp, shade-less, Light bulb, 150 watts , Extension cord, Golf tee, table tennis ball, Hot glue gun, Black paper, Hot glue sticks, Tape, North Star, , Earth, Sun, Moon Cards, Clamp lamp with bulb, Hole puncher, 13mYarn, Cycles of the Moon, Earth, and Sun, STEMscopedia, Lunar Phase Tabs, Rotation, Revolution, and Eclipses, Graphic Organizer, Glue stick, Plate, paper 9 , Cardstock, white, 8 x 11, Construction paper, black, 12x 18, Spongeper group, paint, tempera, lightest gray, Color pencil, Scissors* **Formative Assessment**

	Students who understand the concepts are able to: ● Students will develop and use a physical, graphical, or conceptual model to describe patterns in the apparent motion of the sun, moon, and stars in the sky. **Summative Assessment:** • Concept attainment quiz • Unit assessment **Alternative Assessment** ● PBL result **Benchmark Assessments**

Unit Sequence	
Part B: *What is the role of gravity in the motions within galaxies and the solar system?*	
Concepts	**Instructional Tools/Materials/Technology/Resources/Learning Activities/Assessment**
• Gravity plays a role in the motions within galaxies and the solar system. • Gravity is the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. • 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. • Models can be used to represent the role of gravity in the motions and interactions within galaxies and the solar system. • Science assumes that objects and events in the solar systems occur in consistent patterns that are understandable through measurement and observation.	**Learning Activities:** Guided reading Exploration activities: Big Bang Play, Gravity's Pull, Milky Way and Beyond Content videos note taking claim-evidence reasoning concept review game ***Materials***: *Formation of Our Solar System Timeline Cards, Scissors, Baggie, zipper topper, Galaxy Labels, Sash, cloth, strips, 6 cm x 2 m, Twine, heavy, Meter stick, Hole punch, Marker, permanent, Poster board, Tape, masking, Galaxy Shapes, Container of iron filings, Round pan, Paper or cloth towel, Plastic bowl , Marble, Computer with Interne, STEMscopedia, Main Concepts Notes, Reading Summary Sticky Notes Chart, Solar System Timeline Cards, Pencil, String, Washer, Cardstock, white, Color pencils* **Formative Assessment** *Students who understand the concepts are able to:* • Students develop and use models to explain the relationship between the tilt of Earth's axis and seasons.

	Summative Assessment: • Concept attainment quiz • Unit assessment **Alternative Assessment** ● PBL result **Benchmark Assessments**

Unit Sequence	
Part C: *What are the scale properties of objects in the solar system?*	
Concepts	**Instructional Tools/Materials/Technology/Resources/Learning Activities/Assessment**
• Objects in the solar system have scale properties. • Data from Earth-based instruments, space-based telescopes, and spacecraft can be used to determine similarities and differences among solar system objects. • 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. • • Time, space, and energy phenomena in the solar system can be observed at various scales, using models to study systems that are too large. • • Engineering advances have led to important discoveries in space science, and scientific discoveries have led to the development of entire industries and engineered systems.	**Learning Activities:** Guided reading Exploration activities: Our Solar System, Gravity, Planets: Giants and Dwarfs, Scientific Investigation: Investigating Orbits Content videos note taking claim-evidence reasoning concept review game ***Materials**: Formation of Our Solar System Timeline Cards, Scissors, Baggie, zipper topper, Galaxy Labels, Sash, cloth, strips, 6 cm x 2 m, Twine, heavy, Meter stick, Hole punch, Marker, permanent, Poster board, Tape, masking, Galaxy Shapes, Container of iron filings, Round pan, Paper or cloth towel, Plastic bowl , Marble, Computer with Internet, STEMscopedia, Main Concepts Notes, Reading Summary Sticky Notes Chart, Solar System Timeline Cards, Pencil, String, Washer, Cardstock, white, Color pencils* **Formative Assessment** *Students who understand the concepts are able to:* • Analyze and interpret data to determine similarities and differences among objects in the solar system.

	Summative Assessment: • Concept attainment quiz • Unit assessment **Alternative Assessment** ● PBL result **Benchmark Assessments**

What it Looks Like in the Classroom
At the beginning of the unit, students will develop and use mathematical, physical, graphical or conceptual models to describe the cyclical patterns of lunar phases, eclipses of the sun and moon, and seasons. Students can use mathematics to create scale models of the solar system to investigate relative distances between the planets and their orbits around the sun or to represent the distance from the sun to the Earth during different Earth seasons. Students can also use physical models to examine the phases of the moon using a light source and a moon model to view the various shapes of the moon as it orbits the earth. Students may also keep a lunar calendar for one month and analyze the results by looking for differences and patterns. Using a model of the sun, Earth, and moon, students can view the positions of these planetary objects during a solar or lunar eclipse. To investigate seasons, students can simulate the position and tilt of the Earth as it revolves around the sun, using computer simulations, hands-on models, and videos. Students will explore, through the development and use of models, the role of the force of gravity in explaining the motions within our solar system and the Milky Way Galaxy. As part of their study of the solar system and its components, including the sun, planets and their moons, and asteroids, they will use models and examine simulations to determine how gravity holds these systems together. To visualize how gravity pulls objects down towards its center, students can experiment with dropping spheres of different masses but of the same diameter as a way to determine that gravity acts on both objects and that they drop at the same rate. If technology is available, students can measure the acceleration of the objects as they fall from various heights. Students will be able to determine that the objects speed up as they fall, therefore proving that a force is acting on them. If motion detectors are not available for student use, they could observe these using simulations. After students have had opportunities to participate in the investigations, they should prepare multimedia visual displays the present their findings. As part of their presentation, students will use mathematical models or simulations that show the relationship between relative sizes of objects in the solar system and the size of the gravitational force that is being exerted on the object. They should be able to compare and contrast the weight of an object if it were on the surface of different-sized planets that have very different masses. Students will gather evidence that every object in the solar system is attracted to every other object in the solar system with a force that is related to the mass of the objects and the distance between the objects. They should extend this understanding of gravity to explain why objects in the solar system do not simply flow away from each other. Students should also make connections between their understanding of the force of gravity

and the formation of the solar system from a cloud of dust and gas. As part of their mathematical model of the solar system, students will use variables to represent numbers and write expressions when solving a problem involving the role of gravity in the motions within galaxies and within the solar system. The variable can represent an unknown number or any number in a specified set.

Students will also analyze and interpret data from Earth-based instruments to determine the scale properties of objects within our solar system. Examples of models that students could use include physical (such as the analogy of distance along a football field or computer visualization of elliptical orbits), conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state). Students can construct scale models of the solar system that will help them visualize relative sizes of objects in the system as well as distances between objects. Students can use graphs or tables to make comparisons between the size and gravitational pull of the planets and their moons.

Connecting English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Include multimedia components and visual displays in presentations to describe the cyclical patterns of lunar phases, eclipses of the sun and moon, seasons, and the role of gravity in the motions within galaxies and the solar system. The presentation needs to clarify claims and findings and emphasize salient points.
- Cite specific textual evidence to support analysis of science and technical text about scale properties of objects in the solar system.
- Integrate quantitative or technical information expressed in words in a text about scale properties of objects in the solar system with a version of that information expressed visually in a flowchart, diagram, model, graph, or table.

Mathematics

- Reason quantitatively and abstractly about the sizes of an object's layers, surface features, and orbital radius where appropriate.
- Use mathematics to model the motion of the sun, moon, and stars in the sky and the role of gravity in the motions within galaxies and the solar system.
- Understand the concept of a ratio and use ratio language to describe a ratio relationship between the measurements of the cyclical motion between at least two bodies in the solar system and the relative sizes of objects and/or distances between objects and the impact of gravity on the motion of these objects.
- Recognize and represent proportional relationships between the measurement of patterns in the cyclical motion of the sun, moon, and stars in the sky and mathematical proportions relative to the sizes of objects and the effect of gravity on the motion of these objects.
- Use variables to represent numbers and write expressions when solving a problem involving the role of gravity in the motions within galaxies and within the solar system. Understand that a variable can represent an unknown number, or depending on the problem, any number in a specified set.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Research on Student Learning

The ideas "the sun is a star" and "the earth orbits the sun" appear counter-intuitive to elementary-school students. The ideas "the sun is a star" and "the earth orbits the sun" and are not likely to be believed or even understood in elementary grades. Whether it is possible for elementary students to understand these concepts even with good teaching needs further investigation.

Explanations of the day-night cycle, the phases of the moon, and the seasons are very challenging for students. To understand these phenomena, students should first master the idea of a spherical earth, itself a challenging task. Similarly, students must understand the concept of "light reflection" and how the moon gets its light from the sun before they can understand the phases of the moon. Finally, students may not be able to understand explanations of any of these phenomena before they reasonably understand the relative size, motion, and distance of the sun, moon, and the earth (NSDL, 2015).

Prior Learning

By the end of Grade 5, students understand that:

- Earth's orbit and rotation and the orbit of the moon around Earth cause observable patterns.

- Certain features on Earth can be used to order events that have occurred in a landscape.

Future Learning

- Light spectra from stars are used to determine their characteristics, processes, and life cycles.
- Solar activity creates the elements through nuclear fusion.
- The development of technologies has provided astronomical data that provide empirical evidence for the Big Bang theory.
- Kepler's Laws describe common features of the motions of orbiting objects.
- Observations from astronomy and space probes provide evidence for explanations of solar system formation.
- Changes in Earth's tilt and orbit cause climate changes such as ice ages.

Connections to Other Units

Grade 6 Unit 4: Forces and Motion

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- 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.

Grade 6 Unit 5: 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.
- 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.
- 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).

Grade 7 Unit 8: Earth Systems

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

Sample of Open Education Resources
NASA Solar System Exploration: This link will connect you to NASA's Solar system Exploration website. The website offers a wide variety of student activities. Seasons Interactive provides students with the opportunity to investigate how Earth's angle of inclination affects three factors: the angle of incoming sunlight, average daily temperatures and the Sun's ecliptic path. Three preset values for the angle of inclination are available (corresponding to the values of Earth, Venus and Uranus). Additionally, users may select an angle value from a sliding scale. Users can control the speed of the simulation or may pause it when needed. Students are able to compare the heights of the ecliptic paths during the course of the year by checking the "Trace Sun's Path" box. From this information, students will be able to construct an explanation for the occurrence of seasons. Exercises with solutions are included, as well as a self-assessment located below the simulation. Teachers should be aware of several weaknesses in the simulation. First, the model allows students to reverse the motion of the Earth around the Sun which could lead to misconceptions. Secondly, the model overemphasizes the elliptical path of the Earth which often leads to the misconception that seasons are caused by distance from the Sun. Lastly, while the Sun is shown moving across the sky during the day (from Earth's view), the stars are left static during the night. In Eclipse Interactive, students investigate both lunar and solar eclipses by manipulating up to three independent variables: Moon's tilt from orbit, Earth-Moon distance and size of the Moon. By viewing the effects of changes to these variables, students will be able to construct explanations for solar and lunar eclipses. The model includes both top and side views of the Earth-Moon system during the Moon's revolution. In addition, students can toggle to show outlines of the Earth and Moon. Teachers should note that the simulation has been designed as a single screen model that automatically moves between solar and lunar eclipses without any indication of time. As a result, younger students may become confused and will need to be reminded about the duration of lunar months. The simulation includes bare-bones introductory content, how-to instructions, the interactive model itself, related exercises, and solutions to the exercises. One minor inconvenience is the lack of a reset button. The Pull of the Planets is part of a thematic series of lessons highlighting the Juno mission to Jupiter. It is a traditional hands-on activity that models how gravitational forces can keep planets and asteroids in orbit within the Solar System. Using a stretchable fabric held in place with an embroidery hoop, students work with spheres of various materials to explore how mass and sizes affect the strength of gravitational forces. Background materials, including a materials sheet, aid teachers in organizing this activity.

Appendix A: NGSS and Foundations for the Unit
Generate and analyze evidence (through simulations or long term investigations) to explain why the Sun's apparent motion across the sky changes over the course of a year. (ESS1.B)
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.]* **(MS-ESS1-1)**
Develop and use a model that shows how gravity causes smaller objects to orbit around larger objects at increasing scales, including the gravitational force of the sun causes the planets and other bodies to orbit around it holding together the solar system. (ESS1.A; ESS1.B)
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.]* **(MS-ESS1-3)**
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.]* **(MS-ESS1-2)**

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

Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models ● Develop and use a model to describe phenomena. (MS-ESS1-1),(MS-ESS1-2) **Analyzing and Interpreting Data** ● Analyze and interpret data to determine similarities and differences in findings. (MS-ESS1-3)	**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. (MS-ESS1-1) ● Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2) **ESS1.B: Earth and the Solar System** ● The solar system consists of the sun and a collection of objects, including planets, their moons,	**Patterns** ● Patterns can be used to identify cause-and-effect relationships. (MS-ESS1-1) **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-ESS1-3) **Systems and System Models** ● Models can be used to represent systems and their interactions. (MS-ESS1-2)

	and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2),(MS-ESS1-3) ● 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. (MS-ESS1-1) ● The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS-ESS1-2)	- ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** ● Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. (MS-ESS1-3) - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** ● Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-ESS1-1),(MS-ESS1-2)

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-3) **RST.6-8.1** 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). (MS-ESS1-3) **RST.6-8.7** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ESS1-1),(MS-ESS1-2) **SL.8.5**	Reason abstractly and quantitatively. (MS-ESS1-3) **MP.2** Model with mathematics. (MS-ESS1-1),(MS-ESS1-2) **MP.4** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS1-1),(MS-ESS1-2),(MS-ESS1-3) **6.RP.A.1** Recognize and represent proportional relationships between quantities. (MS-ESS1-1),(MS-ESS1-2),(MS-ESS1-3) **7.RP.A.2** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS1-2) **6.EE.B.6**

	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS1-2)* **7.EE.B.6**