Quinton Township School

5th Grade

Science

Unit 6 Summary: Interactions within the Earth, Sun, and Moon System

May/ June

What patterns do we notice when observing the sky?

In this unit of study, students develop an understanding of patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. The crosscutting concepts of ***patterns, cause and effect***, and ***scale, proportion, and quantity*** are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in ***analyzing and interpreting data*** and ***engaging in argument from evidence***. Students are also expected to use these practices to demonstrate an understanding of the core ideas.

This unit is based on 5-PS2-1, 5-ESS1-1, and 5-ESS1-2.

Student Learning Objectives

Support an argument that the gravitational force exerted by Earth on objects is directed down. ***[Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.]*** [Assessment Boundary: Assessment does not include mathematical representation of gravitational force.] **(5-PS2-1)**

Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth. ***[***Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).***]*** **(5-ESS1-1)**

Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. ***[Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.]*** [Assessment Boundary: Assessment does not include causes of seasons.***]*** **(5-ESS1-2)**

Objectives Aligned with National Geographic Resources: Approximate Time Frame: (42 days)

- Describe the gravitational force of Earth acting on an object near Earth (2 days)

- Gather data to support an argument that the gravitational force exerted by Earth on objects is directed down (3 days)
- Describe how the Earth, sun, and moon move in space and as a system. (1 day)
- Relate gravitational force to the motions of Earth, the sun, and the moon in space. (2 days)
- Recognize that the sun is a star that appears larger and brighter than other stars because it is the star closest to Earth.(2 days)
- Understand that stars range greatly in their distance from Earth.(2 days)
- Investigate to show that the apparent brightness of a light-emitting object varies with distance from the observer.(2 days)
- Use data from the investigation to support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth.(3 days)
- Explain that Earth rotates on its axis once every 24 hours to cause the day/night cycle.(1 day)
- Demonstrate that Earth rotates on its axis once every 24 hours to cause the day/night cycle. (2 days)
- Explain what causes the apparent motion of the sun across the sky. (2 days)
- Demonstrate the different positions of the sun at different times of day. (2 days)
- Demonstrate that the rotation of Earth about an axis causes observable changes in patterns of shadows over time. (2 days)
- Collect and record information using tools, including a meterstick and a clock. (2 days)
- Recognize that the orbit of Earth around the sun causes observable patterns such as the sequence of seasons over time. (2 days)
- Represent data in a graph to reveal patterns of seasonal changes in the length of day and night (2 days)
- Describe how Earth's orbit around the sun causes observable patterns in the positions of the stars at different times of the year. (2 days)
- Represent data in a graphical display that reveals the patterns of change in the seasonal appearance of some stars in the night sky. (2 days)
- Use the graphical display to describe patterns of data. (2 days)
- Describe the moon's motions, including rotation, orbiting of Earth, and apparent movement across the sky. (2 days)
- Explain why moon phases occur. (2 days)
- Describe the pattern of the moon's phases. (2 days)

Quick Links

Unit Sequence	
Part A: What effect does Earth's gravitational force have on objects?	
Concepts	**Formative Assessment**
· Cause-and-effect relationships are routinely identified and used to explain change. · The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.	***Students who understand the concepts are able to:*** · Identify cause-and-effect relationships in order to explain change. · Support an argument with evidence, data, or a model. · Support an argument that the gravitational force exerted by Earth on objects is directed down. ("Down" is a local description of the direction that points toward the center of the spherical Earth.) ***(Assessment does not include mathematical representation of gravitational force.).***

Unit Sequence	
Part B: What effect does the relative distance from Earth have on the apparent brightness of the sun and other stars?	
Concepts	**Formative Assessment**
· Natural objects exist from the very small to the immensely large. · The sun is a star that appears larger and brighter than other stars because it is closer. · Stars range greatly in their distance from Earth.	***Students who understand the concepts are able to:*** · Support an argument with evidence, data, or a model. · Support an argument that differences in the apparent brightness of the sun compared to that of other stars is due to their relative distances from Earth. ***(Assessment is limited to relative distances, not sizes, of stars, and does not include other factors that affect apparent brightness, such as stellar masses, age, or stage.)***

Unit Sequence	
Part C: What patterns do we notice when observing the sky?	
Concepts	**Formative Assessment**

· Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena. · The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its north and south poles, cause observable patterns. These include: ü Day and night ü Daily changes in the length and direction of shadows ü Different positions of the sun, moon, and stars at different times of the day, month, and year.	***Students who understand the concepts are able to:*** · Sort, classify, communicate, record, and analyze simple rates of change for natural phenomena using similarities and differences in patterns. · Represent and record data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. · Represent and record data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. ***(Assessment does not include causes of seasons.)*** Examples of patterns could include: ü The position and motion of Earth with respect to the sun. ü Selected stars that are visible only in particular months. ● Exit Tickets ● Journal Responses ● End of Unit Assessment ● End of the year Benchmark Assessment	

What It Looks Like in the Classroom

In this unit of study, students explore the effects of gravity and determine the effect that relative distance has on the apparent brightness of stars. They also collect and analyze data in order to describe patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

To begin the progression of learning in this unit, students explore the effects of gravity by holding up and releasing a variety of objects from a variety of heights and locations. Students should record and use their observations to describe the interaction that occurs between each object and the Earth. In addition, students should use their observations as evidence to support an argument that the gravitational force exerted by the Earth on objects is directed "down" (towards the center of the Earth), no matter the height or location from which an object is released.

Next, students investigate the effect of distance on the apparent brightness of stars. Using information from a variety of print or digital sources, students learn that natural objects vary in size, from very small to immensely large. Stars, which vary in size, also range greatly in their distance from the Earth. The sun, which is also a star, is much, much closer to the Earth than any other star in the universe. Once students understand these concepts, they should explore the effect of distance on the apparent brightness of the sun in relation to other stars. This can be accomplished by modeling the effect using a light source, such as a bright flashlight. As students vary the distance of the light from their eyes, they should notice that the farther away the light is, the less bright it appears. Observations should again be recorded and used as evidence to support the argument that the differences in the apparent brightness of the sun compared to that of other stars is due to their relative distances from the Earth.

To continue the progression of learning, students investigate the following observable patterns of change that occur due to the position and motion of the Earth, sun, moon, and stars.

- **Day and night:** This pattern of change is a daily, cyclical pattern that occurs due to the rotation of the Earth every 24 hours. Students can observe model simulations using online or digital resources, or they can create models in class of the day/night pattern caused by the daily rotation of the Earth.

- **The length and direction of shadows:** These two interrelated patterns of change are daily, cyclical patterns that can be observed and described through direct observation. Students need the opportunity to observe a stationary object at chosen intervals throughout the day and across a few days. They should measure and record the length of the shadow and record the direction of the shadow (using drawings and cardinal directions), then use the data to describe the patterns observed.

- **The position of the sun in the daytime sky:** This daily, cyclical pattern of change can also be directly observed. Students will need the opportunity to make and record observations of the position of the sun in the sky at chosen intervals throughout the day and across a few days. Data should then be analyzed in order to describe the pattern observed.

- **The appearance of the moon in the night sky:** This cyclical pattern of change repeats approximately every 28 days. Students can use media and online resources to find data that can be displayed graphically (pictures in a calendar, for example), which will allow them to describe the pattern of change that occurs in the appearance of the moon every four weeks.
- **The position of the moon in the night sky:** This daily, cyclical pattern of change can be directly observed, but students would have to make observations of the position of the moon in the sky at chosen intervals throughout the night, which is not recommended. Instead, students can use media and online resources to learn that the moon, like the sun, appears to rise in the eastern sky and set in the western sky every night.
- **The position of the stars in the night sky:** Because the position of the stars changes across the seasons, students will need to use media and online resources to learn about this pattern of change.

Whether students gather information and data from direct observations or from media and online sources, they should organize all data in graphical displays so that the data can be used to describe the patterns of change.

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts

Students should use information from print and digital sources to build their understanding of:

- The Earth's gravitational force on objects.
- The differences in the apparent brightness of the sun compared to that of other stars due to their relative distances from Earth.
- Patterns of change that occur due to the position and motion of the Earth, sun, moon, and stars.

As students read and gather information from multiple sources, they should integrate and use the information to answer questions and support their thinking during discussions and in their writing.

Mathematics

Students reason abstractly and quantitatively when analyzing and using data as evidence to describe phenomena, including:

- The Earth's gravitational force pulls objects "down" (toward the center of the Earth).
- The differences in the apparent brightness of the stars are due to their relative distances from Earth.
- Patterns of change, such as the day/night cycle, the change in length and direction of shadows during the day, the apparent motion of the sun across the daytime sky and the moon across the nighttime sky, the changes in the appearance of the moon over a period of four weeks, and the seasonal changes in the position of the stars in the night sky.

Students will model with mathematics as they graphically represent data collected from direct observations and from multiple resources throughout the unit, and as they describe relative distances of the sun and other stars from the Earth. Students might also express relative distances between the Earth and stars using numbers that can be expressed using powers of 10.

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" is challenging for students.

Explanations of the day-night cycle 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

Grade 1 Unit 1: Patterns of Change in the Sky

- Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.
- Seasonal patterns of sunrise and sunset can be observed, described, and predicted.

Grade 3 Unit 2: Forces and Motion

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.)
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)

Grade 3 Unit 3: Electrical and Magnetic Forces

- Objects in contact exert forces on each other.
- Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.

Future Learning

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 6 Unit 6: Astronomy

- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.
- 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.
- 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.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

Connections to Other Units
N/A

Sample of Open Education Resources
National Geographic Learning- Teacher's Guide- "Gravity on Earth" pages 154-155 (2 days) National Geographic Learning- Teacher's Guide- "Gravity" pages 156-157 (2 days) National Geographic Learning- Teacher's Guide- "Earth, Sun, and Moon" pages 158-159 (2 days) National Geographic Learning- Teacher's Guide- "Our Star- The Sun" pages 160-161 (4 days) National Geographic Learning- Teacher's Guide- "Apparent Brightness" pages 162-163 (2 days) National Geographic Learning- Teacher's Guide- "Day and Night" pages 164-165 (2 days) National Geographic Learning- Teacher's Guide- "Apparent Motion" pages 166-167 (2 days) National Geographic Learning- Teacher's Guide- "Sunlight and Shadows" pages 168-169 (2 days) National Geographic Learning- Teacher's Guide- "Revolution and the Seaons" pages 170-171 (2 days) National Geographic Learning- Teacher's Guide- "Graph Hours of Daylight" pages 172-173 (2 days) National Geographic Learning- Teacher's Guide- "Earth's Orbit and the Night Sky" pages 174-175 (2 days) National Geographic Learning- Teacher's Guide- "Represent Data" pages 176-177 (2 days) National Geographic Learning- Teacher's Guide- "Moon Motions" pages 178-179 (2 days) National Geographic Learning- Teacher's Guide- "Moon Phases" pages 180-183 (4 days) National Geographic Learning- Teacher's Guide- "Astrobiologist and Science Educator" pages 184-187 (2 days) **Enhancement Lessons:** Gravity and Falling Objects: PBS Learning Media lesson where students investigate the force of gravity and how all objects, regardless of mass, fall to the ground at the same rate. NASA's Solar System Exploration website contains several resources that educators and students can use to make sense of the night sky.

Our Super Star: PBS Learning Media lesson that guides students to understand the basic facts about the Sun, model the mechanics of day and night, and use solar energy to make a tasty treat.

Teacher Professional Learning Resources

Resources from the National Geographic Kit:

Penlights

Tissue paper

Globe

Flashlight

Clay

Lamp

Enhancement Resources:

Unsharpened pencil

Eraser

Coin

Crumpled paper

Rubber ball

Ruler

Tape

Meterstick

Poster board

Pencil

Colored pencil

Graph paper

Data table

Craft stick

Framework for K-12 Science Education, **Developing and Using Models**: This section of the Framework provides a deeper explanation of what it means for students to develop and use

models. Modeling is especially important when concepts are too large or too small for students to have direct experience.

APPENDIX F: Science and Engineering Practices in the NGSS, The Framework uses the term "practices," rather than "science processes" or "inquiry" skills for a specific reason: We use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice. (NRC Framework, 2012, p. 30). Appendix F provides further clarification of each science and engineering practice as well as specific details about what each looks like in each grade band.

NGSS Crosscutting Concepts: Stability and Change

The presenter was Brett Moulding, director of the Partnership for Effective Science Teaching and Learning. Mr. Moulding began the web seminar by defining stability and change and discussing the inclusion of this concept in previous standards documents such as the National Science Education Standards (NSES). Participants brainstormed examples of science phenomena that can be explained by using the concept of stability and change. Some of their ideas included Earth's orbit around the Sun, carrying capacity of ecosystems, and replication of DNA. Mr. Moulding then discussed the role of stability and change within NGSS. Participants again shared their ideas in the chat, providing their thoughts about classroom implementation of this crosscutting concept.

NGSS Core Ideas: Earth's Place in the Universe

The presenter was Julia Plummer from Penn State University. The program featured strategies for teaching about Earth science concepts that answer questions such as "What goes on in stars?" and "What patterns are caused by Earth's movements in the solar system?"

Dr. Plummer began the presentation by discussing what students should know about the disciplinary core idea of Earth's Place in the Universe. She talked about using the scientific and engineering practices to help engage students. Participants shared their ideas about applying this core idea to the classroom, and then Dr. Plummer shared strategies for effective instruction. She also discussed the importance of spatial thinking for students to begin thinking scientifically about these concepts.

Continue the discussion in the community forums.

Appendix A: NGSS and Foundations for the Unit

Support an argument that the gravitational force exerted by Earth on objects is directed down. ***[Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.]*** *[*Assessment Boundary: Assessment does not include mathematical representation of gravitational force.] **(5-PS2-1)**
Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth. ***[***Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).***]*** **(5-ESS1-1)**
Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. ***[Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.]*** ***[***Assessment Boundary: Assessment does not include causes of seasons.***]*** **(5-ESS1-2)**
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	Disciplinary Core Ideas	Crosscutting Concepts

Developing and Using Models · Develop a model using an example to describe a scientific principle. (5-ESS2-1) **Engaging in Argument from Evidence** · Support an argument with evidence, data, or a model. (5-PS2-1), (5-ESS1-1) **Analyzing and Interpreting Data** · Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)	**PS2.B: Types of Interactions** · The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1) **ESS1.A: The Universe and its Stars** · The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1) **ESS1.B: Earth and the Solar System** · The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)	**Cause and Effect** · Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1) **Scale, Proportion, and Quantity** · Natural objects exist from the very small to the immensely large. (5-ESS1-1) **Patterns** · Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)

English Language Arts	Mathematics
Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (5-PS2-1), (5-ESS1-1) **RI.5.1** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-ESS1-1) **RI.5.7** Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s). (5-ESS1-1) **RI.5.8** Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-PS2-1), (5-ESS1-1) **RI.5.9** Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (5-PS2-1), (5-ESS1-1) **W.5.1** Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. (5-ESS1-2) **SL.5.5**	Reason abstractly and quantitatively. (5-ESS1-1),(5-ESS1-2) **MP.2** Model with mathematics. (5-ESS1-1,(5-ESS1-2)) **MP.4** Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. (5-ESS1-1) **5.NBT.A.2** Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. (5-ESS1-2) **5.G.A.2**