Fifth Grade Companion Document
5-Unit 4: Position and Motion of Objects in the Sky

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Introduction to the K-7 Companion Document
An Instructional Framework

Overview

The Michigan K-7 Grade Level Content Expectations for Science establish what every student is expected to know and be able to do by the end of Grade Seven as mandated by the legislation in the State of Michigan. The Science Content Expectations Documents have raised the bar for our students, teachers and educational systems.

In an effort to support these standards and help our elementary and middle school teachers develop rigorous and relevant curricula to assist students in mastery, the Michigan Science Leadership Academy, in collaboration with the Michigan Mathematics and Science Center Network and the Michigan Science Teachers Association, worked in partnership with Michigan Department of Education to develop these companion documents. Our goal is for each student to master the science content expectations as outlined in each grade level of the K-7 Grade Level Content Expectations.

This instructional framework is an effort to clarify possible units within the K-7 Science Grade Level Content Expectations. The Instructional Framework provides descriptions of instructional activities that are appropriate for inquiry science in the classroom and meet the instructional goals. Included are brief descriptions of multiple activities that provide the learner with opportunities for exploration and observation, planning and conducting investigations, presenting findings and expanding thinking beyond the classroom.

These companion documents are an effort to clarify and support the K-7 Science Content Expectations. Each grade level has been organized into four teachable units- organized around the big ideas and conceptual themes in earth, life and physical science. . The document is similar in format to the Science Assessment and Item Specifications for the 2009 National Assessment for Education Progress (NAEP). The companion documents are intended to provide boundaries to the content expectations. These boundaries are presented as “notes to teachers”, not comprehensive descriptions of the full range of science content; they do not stand alone, but rather, work in conjunction with the content expectations. The boundaries use seven categories of parameters:

a. **Clarifications** refer to the restatement of the “key idea” or specific intent or elaboration of the content statements. They are not intended to denote a sense of content priority. The clarifications guide assessment.
b. **Vocabulary** refers to the vocabulary for use and application of the science topics and principles that appear in the content statements and expectations. The terms in this section along with those presented

within the standard, content statement and content expectation comprise the assessable vocabulary.

c. **Instruments, Measurements and Representations** refer to the instruments students are expected to use and the level of precision expected to measure, classify and interpret phenomena or measurement. This section contains assessable information.
d. **Inquiry Instructional Examples** presented to assist the student in becoming engaged in the study of science through their natural curiosity in the subject matter that is of high interest. Students explore and begin to form ideas and try to make sense of the world around them. Students are guided in the process of scientific inquiry through purposeful observations, investigations and demonstrating understanding through a variety of experiences. Students observe, classify, predict, measure and identify and control variables while doing “hands-on” activities.
e. **Assessment Examples** are presented to help clarify how the teacher can conduct formative assessments in the classroom to assess student progress and understanding
f. **Enrichment and Intervention** is instructional examples the stretch the thinking beyond the instructional examples and provides ideas for reinforcement of challenging concepts.
g. **Examples, Observations, Phenomena** are included as exemplars of different modes of instruction appropriate to the unit in which they are listed. These examples include reflection, a link to real world application, and elaboration beyond the classroom. These examples are intended for instructional guidance only and are not assessable.
h. **Curricular Connections and Integrations** are offered to assist the teacher and curriculum administrator in aligning the science curriculum with other areas of the school curriculum. Ideas are presented that will assist the classroom instructor in making appropriate connections of science with other aspects of the total curriculum.

This Instructional Framework is NOT a step-by-step instructional manual but a guide developed to help teachers and curriculum developers design their own lesson plans, select useful portions of text, and create assessments that are aligned with the grade level science curriculum for the State of Michigan. It is not intended to be a curriculum, but ideas and suggestions for generating and implementing high quality K-7 instruction and inquiry activities to assist the classroom teacher in implementing these science content expectations in the classroom.

5th Grade Unit 4:
Position and Motion of Objects in the Sky

Content Statements and Expectations

Code	Statements & Expectations	Page
E.ES.M.6	**Seasons – Seasons result from annual variations in the intensity of sunlight and length of day due to the tilt of the axis of the Earth relative to the plane of its yearly orbit around the sun.**	1
E.ES.05.61	Demonstrate and explain seasons using a model.	1
E.ES.05.62	Explain how the revolution of the Earth around the sun defines a year.	2
E.ST.M.1	**Solar system – The sun is the central and largest body in our solar system. Earth is the third planet from the sun in a system that includes other planets and their moons, as well as smaller objects, such as asteroids and comets.**	3
E.ST.05.11	Design a model of the solar system that shows the relative distances and positions of the planets, dwarf planets, comets and asteroids to the sun.	3
E.ST.M.2	**Solar System Motion – Gravity is the force that keeps most objects in the solar system in regular and predictable motion.**	4
E.ST.05.21	Describe the motion of planets and moons in terms of rotation on axis and orbits due to gravity.	4
E.ST.05.22	Explain the phases of the moon.	5
E.ST.05.23	Explain the apparent motion of the stars (constellations) and the sun across the sky.	6
E.ST.05.24	Explain lunar and solar eclipses.	7
E.ST.05.25	Explain the tides of the oceans as they relate to the gravitational pull and orbit of the moon.	8

5 – Unit 4: Position and Motion of Objects in the Sky

Big Ideas (Key Concepts)

- The sun is the central and largest body in the solar system.
- The sun's warming of the Earth and tilt of the Earth on its axis has an important connection to the seasons.
- Earth's motion is the basis for measuring time.
- Objects in the sky move in regular and predictable patterns around the Sun.
- The sun, stars and constellations appear to move in predictable patterns across the sky.
- Gravity is the force that keeps the planets in orbit around the sun and without it planets would continue in a straight path.

Clarification of Content Expectations

Standard: Earth Systems

Content Statement – E.ES.M.6
Seasons – Seasons result from annual variations in the intensity of sunlight and length of day due to the tilt of the axis of the Earth relative to the plane of its yearly orbit around the sun.

Content Expectations

E.ES.05.61 Demonstrate and explain seasons using a model.

Instructional Clarifications

1. Demonstrate is to describe, explain, or illustrate by experiments, examples, or practical application the causes of the seasons on Earth.
2. The Earth has a 23.5 degree tilt to its axis.
3. The Earth revolves or orbits around the sun in an elliptical (but nearly circular) pattern.
4. The Earth's axis always points toward the North Star causing the North Pole to tilt toward the sun during a portion of its revolution around the sun and away from the sun during the rest of its revolution around the sun. When the northern hemisphere is tilted toward the sun, it receives more direct sunlight. When the southern hemisphere is pointed toward the sun, the northern hemisphere receives less direct sunlight. This causes winter in the northern hemisphere. Halfway between summer and

winter are spring and fall; the daylight and nighttime hours are equal in length.

5. The intensity of sunlight on the Earth is related to the tilt of the axis of the Earth.
6. The Earth gets the same amount of light each day, but since the Earth is tilted on its axis, the light is unevenly divided into two hemispheres. The hemisphere that is tilted toward the sun and is receiving more of the direct light is experiencing spring and summer. The hemisphere that is tilted away from the sun is receiving less direct light is experiencing fall and winter.
7. A common misconception is that the distance between the Earth and the sun causes the seasons.

Assessment Clarifications

1. The Earth is tilted on its axis.
2. The Earth revolves or orbits around the sun.
3. The Earth's axis always points toward the North Star causing the North Pole to tilt toward the sun during a portion of its revolution around the sun and away during a portion. When the northern hemisphere is tilted toward the sun, it receives longer periods of daylight and experiences summer. When the southern hemisphere is pointed toward the sun, the northern hemisphere receives shorter periods of daylight and experiences winter.
4. As the Earth moves along its flat orbit around the sun part of the Earth is more directly exposed to the sun due to the tilt. The angle at which the sun's rays strike each part of the Earth changes as the Earth moves through its orbit. When the North Pole is tilted toward the sun, the sun's rays strike the Northern Hemisphere more directly so it receives a higher concentration of solar energy and is warmer. This would be the summer season. The opposite would be true for winter.
5. Spring and fall occur between summer and winter when the day and nighttime hours of sunlight are equal and the angle at which the sun's rays strike the Earth are in between summer and winter.

E.ES.05.62 Explain how the revolution of the Earth around the sun defines a year.

Instructional Clarifications

1. Explain is to clearly describe by means of illustrations (drawing), demonstrations, written reports, or verbally how the revolution of the Earth around the sun defines a year.
2. The Earth revolves around the Sun.
3. It takes 365.25 days or one year for the Earth to complete one revolution of the sun.
4. Every four years an extra day is added to the calendar to keep the calendar the same as Earth's movements. This is defined as leap year.

Assessment Clarification

1. It takes one year for the Earth to complete one revolution of the sun.

Standard: Earth in Space and Time

Content Statement – E.ST.M.1

Solar system – The sun is the central and largest body in our solar system. Earth is the third planet from the sun in a system that includes other planets and their moons, as well as smaller objects, such as asteroids and comets.

Content Expectation

E.ST.05.11 Design a model of the solar system that shows the relative distances and positions of the planets, dwarf planets, comets and asteroids to the sun.

Instructional Clarifications

1. Design means to make drawings, preliminary sketches, or plans of a model to describe the positions and distances of planets and other objects to the sun.
2. The Sun is the largest body in our solar system.
3. The Sun is at the center of our solar system.
4. Our solar system is made up of planets, dwarf planets, moons, asteroids and comets.
5. Planets, dwarf planets, plutoids, comets and asteroids orbit the sun. Moons orbit the planets.
6. There are currently eight planets and three or four* (depending on the source) identified plutoids and dwarf planets in our solar system. Dwarf planets and plutoids are smaller, orbit the sun, have enough mass and gravity to maintain their spherical shape, but do not have a clear/clean orbit, as do planets. Plutoids are located beyond Neptune. Dwarf planets are located within the asteroid belt between Mars and Jupiter. This demonstrates how science knowledge is changing and the information from scores of years ago is changed through further research and evidence.
7. The Earth is the third planet from the Sun in our Solar system. The planets have a specific location and path within the solar system. From the sun, the order of the planets is Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. All planets orbit the sun in a counterclockwise and elliptical (but nearly circular) path.
8. Asteroids are small rocky bodies that orbit the Sun. Most asteroids orbit the sun in a belt located between Mars and Jupiter.
9. Comets are objects, which contain ice and dust. As they get closer to the Sun, they develop a tail. Comets have highly elliptical orbits around the Sun.
10. Students' models will be limited to comparing the position and motion of the different planets and other objects in our solar system with the sun being the largest and at the center.

Assessment Clarification

1. Students' models will be limited to comparing the position and distances of the planets, dwarf planets, comets and asteroids with the sun being the largest and at the center.
2. There are currently eight planets and three* dwarf planets in our solar system. Pluto is located beyond Neptune. Eris, discovered in 2005 is located on the outer edge of the solar system. Ceres is a large asteroid located within the asteroid belt between Mars and Jupiter. (*This number will change, as more information is available.)
3. The Earth is the third planet from the Sun in our Solar system. The planets have a specific location and path within the solar system. From the sun, the order of the planets is Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. All planets orbit the sun in a counterclockwise and elliptical (but nearly circular) path.
4. Asteroids are small rocky bodies that orbit the Sun. More than 100,000 asteroids orbit the sun in a belt located between Mars and Jupiter.
5. Comets are objects, which contain ice and dust. As they get closer to the Sun, they develop a tail. Comets have highly elliptical orbits around the Sun.

Standard: E.ST.M.2

Solar System Motion – Gravity is the force that keeps most objects in the solar system in regular and predictable motion.

Content Expectations

E.ST.05.21 Describe the motion of planets and moons in terms of rotation on axis and orbits due to gravity.

Instructional Clarifications

1. Describe means to tell or depict in spoken or written words the motion of planets and moons.
2. Planets in our solar system orbit the sun. Each planet has its own orbital period, which defines a year on each planet.
3. Planets rotate on their axes. Each planet has its own rotational period, which defines a day on each planet.
4. All objects exert a gravitational force on other objects. The strength of the force is related to the mass of the object and the distance between the objects.
5. Planets move in an elliptical (but nearly circular) orbit around the sun due to gravity between the sun and the planet.
6. Planets stay in their orbit and do not go out into space because gravity pulls the object into a curved path instead of flying off in a straight line.

7. Planets stay in a circular orbit and do not crash into the sun because they do not have enough speed to escape the Sun's gravity but have enough speed to not be pulled in by the Sun's gravity.
8. A moon is a natural satellite.
9. A natural satellite is a celestial body that orbits a larger body.
10. Six of the planets in our solar system have smaller bodies or moons that orbit them. All moons rotate on their axes but have different patterns of rotation.
11. Our moon is a natural satellite that orbits the Earth.
12. Technically, the Earth could be considered to be a moon of the Sun.
13. The Earth's gravity keeps the moon in orbit and the sun's gravity keeps the planets orbiting around it.

Assessment Clarifications

1. Planets in our solar system orbit the sun. Each planet has its own orbital period, which defines a year on each planet.
2. Planets rotate on their axes. Each planet has its own rotational period, which defines a day on each planet.
3. Planets move in an orbit around the sun due to gravity between the sun and the planet.
4. Planets stay in an orbit and do not go out into space because gravity pulls the object into a curved path instead of flying off in a straight line.
5. A moon is a natural satellite.
6. A natural satellite is a celestial body that orbits a larger body.
7. Six of the planets in our solar system have smaller bodies or moons that orbit them. All moons rotate on their axes.
8. Our moon is a natural satellite that orbits the Earth.

E.ST.05.22 Explain the phases of the moon.

Instructional Clarifications

1. Explain means to clearly describe by means of illustrations (drawing), demonstrations, written reports, or verbally how moon phases relate to the position of the moon in its orbit around the Earth.
2. The moon revolves around the Earth.
3. The moon rotates on its axis.
4. The moon only completes one rotation during each orbit around the Earth. The moon revolves once around the Earth in about 27.3 days or about one month. The moon's rotation and revolution equal approximately one month.
5. Because the rotation and revolution of the moon take the same amount of time, observers on Earth always see the same side of the moon.
6. The moon reflects light from the Sun and that amount is constant. The sun always lights half of the moon.
7. The light we see when we look at the moon depends on the moon's location in its orbit. From Earth, people see only the portions lit by the sun that are facing Earth.
8. The different portions of the lit half facing the Earth as the moon revolves around the Earth cause the apparent change in the moon's shape.

9. Moon phases follow a predictable pattern each month: new moon, waxing crescent, first quarter, waxing gibbous, full moon, waning gibbous, third-quarter, and waning crescent.
10. A common misconception is that the moon is only visible at night. The moon's rise has an approximate one-hour difference each day. The moon rises in the daytime and appears to move across the daytime sky.

Assessment Clarifications

1. The moon revolves around the Earth.
2. The moon rotates on its axis.
3. The moon only completes one rotation during each orbit around the Earth. The moon revolves once around the Earth in about one month. Thus, the moon's rotation and revolution equal approximately one month.
4. Because the rotation and revolution of the moon take the same amount of time, observers on Earth always see the same side of the moon.
5. The moon reflects light from the Sun. The sun always lights half of the moon.
6. The revolution of the moon around the Earth makes the moon appear as if it is changing shape in the sky.
7. The different portions of the lit half facing the Earth as the moon revolves around the Earth cause this apparent change in the moon's shape.

E.ST.05.23 Explain the apparent motion of the stars (constellations) and the sun across the sky.

Instructional Clarifications

1. Recognize is to identify or perceive that nighttime objects and the sun appear to move across the sky.
2. The Earth rotates in a counterclockwise direction (west to east).
3. Because of the Earth's rotation, the moon and the sun appear to move across the sky in a regular pattern. They seem to rise in the east, move across the sky and set in the west.
4. Constellations are composed of stars.
5. The movement of the Earth as it turns on its axis makes the constellations appear to move through the sky. In the northern hemisphere all of the constellations seem to move around a point that is directly above the Earth's North Pole. A star located directly above the North Pole (Polaris) does not seem to move. In the southern hemisphere, all constellations appear to move around a point directly above the South Pole.
6. Because the Earth is in different positions as it revolves around the sun, different constellations are seen at different times of the year and in different positions. People living in the northern or southern hemisphere see different constellations.

Assessment Clarifications

1. The Earth rotates in a counterclockwise direction (west to east).
2. Because of the Earth's rotation, the moon and the sun appear to move across the sky in a regular pattern. They seem to rise in the east, move across the sky and set in the west.

3. The movement of the Earth as it turns on its axis makes the constellations appear to move through the sky. In the northern hemisphere all of the constellations seem to move around a point that is directly above the Earth's North Pole. A star located directly above the North Pole (Polaris) would not seem to move. In the southern hemisphere, all constellations appear to move around a point directly above the South Pole.
4. Because the Earth is in different positions as it revolves around the sun, different constellations are seen at different times of the year and in different positions. People living in the northern or southern hemisphere see different constellations.

E.ST.05.24 Explain lunar and solar eclipses.

Instructional Clarifications

1. Explain means to clearly describe by means of illustrations (drawing), demonstrations, written reports, or verbally how lunar and solar eclipses are based on the relative positions of the Earth, moon and sun, and the orbit of the moon.
2. A lunar eclipse occurs when the sun, Earth and moon are aligned with the Earth in the middle. The moon then passes through the Earth's shadow. The moon is not able to reflect the Sun's light because the light it is blocked. The Earth's shadow falls on the moon. An eclipse of the moon occurs only when there is a full moon, when the Earth is between the moon and the sun.
3. A total lunar eclipse is rare because the tilt of the moon's orbit reduces the chance that the sun, Earth and moon will align in the same plane.
4. A solar eclipse occurs when the moon passes between the sun and the Earth so that the sun's light is blocked. A solar eclipse happens only when there is a new moon. The moon's shadow falls on the Earth.
5. A solar eclipse does **not** happen every month because the moon's orbit is tilted about 5 degrees. The moon usually passes between the between the Earth and the sun either too high or too low for its shadow to fall on the Earth.

Assessment Clarifications

1. A lunar eclipse occurs when the sun, Earth and moon are aligned with the Earth in the middle. The moon then passes through the Earth's shadow. The moon is not able to reflect the sun's light because the light it is blocked. The Earth's shadow falls on the moon. An eclipse of the moon occurs only when there is a full moon, when the Earth is between the moon and the sun.
2. A solar eclipse occurs when the moon passes between the sun and the Earth so that the sun's light is blocked. A solar eclipse happens only when there is a new moon. The moon's shadow falls on the Earth.
3. An eclipse does not happen each month because the moon's orbit is tilted a little above or below the Earth's orbit.

E.ST.05.25 Explain the tides of the oceans as they relate to the gravitational pull and orbit of the moon.

Instructional Clarifications

1. Explain is to clearly describe by means of illustrations (drawing), demonstrations, written reports, or verbally how tides are related to gravitational pull and the orbit of the moon.
2. A tide is the rise and fall of the ocean's surface caused mainly by the moon's gravitational pull on Earth.
3. The Earth has a gravitational pull on the moon and the moon has a gravitational pull on the Earth. Because the Earth is more massive, it has a greater pull of gravity that keeps the moon revolving around the Earth. The moon's weaker gravitational pull affects the Earth by causing tides.
4. The moon's pull of gravity on the side of the Earth facing the moon makes the easily movable waters of the oceans on that side bulge out toward the moon. This bulge is called a high tide. At the same time, another high tide is formed on the opposite side because this is the furthest point from the moon where gravitational pull is the weakest on the Earth. The water that is drawn in to make the bulge at these two points comes from the remaining water at the opposite points on Earth. These lower levels are called low tides.
5. Because of the Earth's rotation every 24 hours, the Earth has two high tides and two low tides every 24 hours at different points on Earth. Every point on Earth experiences two high tides and two low tides every 24 hours.
6. Because the moon rises about 50 minutes later each day, high tide and low tide change times each day.

Assessment Clarifications

1. A tide is the rise and fall of the ocean's surface caused mainly by the moon's gravitational pull on Earth.
2. The Earth has a gravitational pull on the moon and the moon has a gravitational pull on the Earth. Because the Earth is more massive, it has a greater pull of gravity that keeps the moon revolving around the Earth. The moon's weaker gravitational pull affects the Earth by causing tides.
3. The moon's pull of gravity on the side of the Earth facing the moon makes the easily movable waters of the oceans on that side bulge out toward the moon. This bulge is called a high tide. At the same time, another high tide is formed on the opposite side because this is the furthest point from the moon where gravitational pull is the weakest on the Earth. The water that is drawn in to make the bulge at these two points comes from the remaining water at the opposite points on Earth. These lower levels are called low tides.
4. Because of the Earth's rotation every 24 hours, the Earth has two high tides and two low tides every 24 hours at different points on Earth.
5. Because the moon rises about 50 minutes later each day, the high tide and low tide times change each day.

Inquiry Process, Inquiry Analysis and Communication, Reflection and Social Implications

Inquiry Process
S.IP.05.11 Generate scientific questions based on observations, investigations, and research concerning the position and motion of objects in the sky.
S.IP.05.13 Use tools and equipment (models) appropriate to scientific investigations for the position and motion of objects in the sky.
S.IP.05.15 Construct charts and graphs from data and observations dealing with the position and motion of objects in the sky.
S.IP.05.16 Identify patterns in data dealing with the position and motion of objects in the sky.
Inquiry Analysis and Communication
S.IA.05.12 Evaluate data, claims, and personal knowledge through collaborative science discourse about the position and motion of objects in the sky.
S.IA.05.13 Communicate and defend findings of observations and investigations about the position and motion of objects in the sky using evidence.
S.IA.05.15 Use multiple sources of information on the position and motion of objects in the sky to evaluate strengths and weaknesses of claims, arguments, or data.
Reflection and Social Implications
S.RS.05.11 Evaluate the strengths and weaknesses of claims, arguments, and data regarding the reasons for the position and motion of objects in the sky.
S.RS.05.13 Identify the need for evidence in making scientific decisions about the position and motion of objects in the sky.
S.RS.05.15 Demonstrate scientific concepts concerning the position and motion of objects in the sky through various illustrations, performances, models, exhibits, and activities.

Vocabulary

Critically Important – State Assessable	Instructionally Useful
seasons tilt axis revolution rotation solar system planet dwarf planet asteroids comets gravity gravitational pull phases stars constellations lunar solar eclipse tides	latitude model circular elliptical apparent motion satellite celestial

Instruments, Measurements, Representations

models		
thermometers	temperature	degrees Celsius
rulers, meter sticks	distance	centimeters, meters

Instructional Framework

*The following Instructional Framework is an effort to clarify possible units within the K-7 Science Grade Level Content Expectations. The Instructional Framework provides descriptions of instructional activities that are appropriate for inquiry science in the classroom and meet the instructional goals. Included are brief descriptions of multiple activities that provide the learner with opportunities for exploration and observation, planning and conducting investigations, presenting findings, and expanding thinking beyond the classroom. The Instructional Framework is **NOT** a step-by-step instructional manual, but a guide intended to help teachers and curriculum developers design their own lesson plans, select useful and appropriate resources and create assessments that are aligned with the grade level science curriculum for the State of Michigan.*

Instructional Examples

Earth Systems
Seasons: E.ES.05.61, E.ES.05.62

Objectives

- Demonstrate how seasons are caused by variations in the intensity of sunlight due to the tilt of the Earth on its axis and its revolution around the sun.
- Understand how the angle at which sunlight hits the Earth's surface produces a variation in temperatures or concentration of solar energy.
- Illustrate how the Earth's axis is tilted toward the north star (Polaris) as it revolves around the sun.
- Explain that a year is defined as one complete revolution (orbit) around the sun.

Engage and Explore

- Display pictures of the four seasons. Discuss the characteristics of each season. What is the students' favorite season? Have any students lived in a location with fewer than four seasons? As a pre-assessment, individually or in collaborative groups, instruct students to draw a picture to explain the cause of the seasons in their journals. Share ideas. Record questions that may have been generated during the class discussion. (E.ES.05.61, S.IP.05.11)
- Demonstrate the seasons using activities and discussions. Materials needed: a globe that rotates around a tilted axis, small table lamp, small nail with a large head, and tape. Place a sign on the floor labeled north. Identify north using a compass for accuracy. Place the lamp (without its shade) in the middle of the floor. The lamp represents the sun. Find the

location of the school on the globe and tape the nail, head side down, on the location. Place the globe on the ground, about 1.5 m away from the lamp, on the side opposite north. The light bulb should be the same height as the middle of the globe. Darken the room. The globe should tilt toward north. This is summer position for the northern hemisphere. Center the nail in the light from the lamp. As a class, discuss the appearance of the nail's shadow. Measure and record the length of the shadow. Rotate the globe; one rotation represents one day (24 hours). Notice during part of the rotation the nail is in the light (daylight hours) and during part of the rotation it is in the dark (night). Move the globe counter clockwise a quarter "revolution" around the lamp. This is fall. Make sure the globe is tilted toward north. Repeat observations as the globe continues in its orbit around the lamp (winter and spring). Record observations and data of the length of the nail's shadow and the amount of daylight during each season in student journals. Make a class chart, summarizing observations. Using the data, discuss observations. During which season is the nail's shadow the shortest? The longest? Explain that a short shadow indicates strong, direct sunlight. A long shadow indicates weaker sunlight at an angle. During which season is the nail in the sunlight the longest when you rotate the globe? During which season(s) do you get about the same amount of sunlight and darkness? In general, the more sunlight at a direct angle creates a warmer day. Identify one complete revolution of the globe (Earth) around the lamp (sun) as a year. Record questions generated during class discussions. Hint: If four globes are available, all four can be set up and used at the same time with four groups of students making observations and rotating after a few minutes. The best place to observe the amount of daylight and darkness is just above the globe's North Pole. (E.ES.05.61, E.ES.05.62, S.IP.05.11, S.IP.05.15, S.IA.05.12, S.RS.05.15)

- As students explore the concepts of direct sunlight and sunlight at an angle, they construct charts and share in discussions to defend their observations. (Using the term "indirect" instead of slanted may create misconceptions.) Give each group of students a flashlight with a length of cardboard tube taped to the end. On a piece of paper, shine the flashlight tube at a 90-degree angle (perpendicular) to the paper. Trace the lighted shape. Tilt the flashlight tube to a 45-degree angle. Observe and trace the lighted shape. Continue to explore different angles and the shapes of the lighted area. The amount of light coming through the tube is constant, just as the light coming from the sun is constant. What happens to the amount of light at different angles on the paper? Which condition is closest to summertime? Winter? Discuss and draw conclusions in groups. Record ideas in student journals. (E.ES.05.61, S.IA.05.12)
- Students explore the differences in the temperature of direct and slanted sunlight and draw conclusions from multiple sets of data. Give each group of students, two matched thermometers, (be sure to check that they are the same at room temperature) and two pieces of the same sized pieces of cardboard. Cover each piece of cardboard with black

paper. Staple a pocket from black paper for the thermometer on each piece of cardboard so that the top of the thermometer is near the end of the cardboard and the bulb is inside the pocket. On a sunny day, lay one thermometer flat in the sun (i.e., on a windowsill). It will receive sunlight at an angle. Prop the other thermometer on some books next to the first thermometer so that the sun strikes it directly. Hint: Students can tape a nail head on the cardboard and lift the cardboard to an angle until the nail no longer makes a shadow. This indicates direct rays of the sun. Students record the temperatures on each thermometer every minute. Which thermometer has the higher temperatures? What does this indicate about direct sunlight and slanted sunlight (sunlight at an angle)? Record observations and conclusions in student journals. Caution: do not allow the temperature in the thermometer to rise too high. Note: If a sunny day is not available, a 100-watt or higher bulb can be used. (E.ES.05.61, S.IP.05.11, S.IP.05.13, S.IA.05.14)

Explain and Define

- Students share and discuss their findings from their investigations into temperature from direct and indirect light.
- The difference between rotation and revolution is reviewed and clarified.
- Students create classroom definitions and illustrations for rotation, revolution, axis, orbit, direct sunlight, slanted sunlight or sunlight at an angle.
- Students develop charts and illustrations to describe the causes of seasons.

Elaborate and Apply

- In cooperative groups, students develop a model to show that the seasons are the result of variations in the intensity of sunlight caused by the tilt of the Earth on its axis. They further develop their model to include how the Earth's yearly revolution around the sun affects seasonal changes. (E.ES.05.61, E.ES.05.62, S.RS.05.15)
- Using their models, challenge students to explain questions such as: "During June in the Northern Hemisphere, the days are long and the nights are short. Why do the days become longer as you move north? Is there a place where the sun does not set at all? Using your model, demonstrate your answer." (E.ES.05.61, E.ES.05.62)
- Throughout the school year, record sunrise and sunset weekly and make observations of the angle of sunlight based on a reference point. At the end of the school year, consolidate data and draw conclusions about the hours of sunlight within the different seasons. Relate conclusions to the intensity of sunlight, hours of sunlight and time of year and what they have learned about the seasons. (E.ES.05.61)

Evaluate Student Understanding

Formative Assessment Examples

- Write vocabulary words and illustrations on cards with definitions on the back (E.ES.05.61, E.ES.05.61)
- Record observations, data and conclusions in student journals (E.ES.05.61)
- Participate in cooperative group activities and discussions (E.ES.05.61)

Summative Assessment Examples

- Draw conclusions to the reason for seasons based on evidence obtained during activities and research. Write an essay to explain the reason for seasons based on evidence (E.ES.05.61, E.ES.05.62)
- Create a model that explains the reason for seasons (E.ES.05.61, E.ES.05.62)
- Create a story book for fourth grade students that explains the seasons (E.ES.05.61, E.ES.05.62)

Enrichment

- Explore how various cultures celebrate the seasons.
- Explore how early Native Americans explained day and nighttime observations.
- Introduce students to real-life females and minority scientists who are involved in aerospace or astronomy.
- Visit a planetarium to further students' understanding of the seasons.
- Respond to the statement, "The northern hemisphere tilts toward the sun in the summer and tilts away from the sun in the winter."
- Investigate daylight savings time.
- Investigate how the Earth's movements define time.
- Make a sundial and place it outside and compare the length and position of the shadow through the seasons and during the time change from and to Daylight Savings Time.

Intervention

- Pair students with responsible partners to assist with activities, explanations, and conclusions
- Repeat the globe/light activity several times
- View video clips to reinforce concepts
- Act out the concepts taught regarding the seasons through skits and songs
- Read non-fiction books to support concepts

Examples, Observations, Phenomena (Real World Context)

Many naïve ideas are perpetuated through observations and assumptions about the day and night sky. It is important that students become aware of misinformation in their everyday lives. Find examples to share with the class. Discuss why pictures or models can be incorrect or misleading. For example, in many of the illustrations regarding the seasons, the sun is nearly the same size as the Earth and its distance is very close to the Earth. It isn't possible to draw the sun and Earth in their correct relative sizes and distances. It is important to point these examples out to students.

Students are familiar with the seasons and seasonal changes. They observe the daylight hours getting longer or shorter, the temperature changes associated with the seasons, the height of the sun in the sky during summer and winter, and animal and foliage behavior during the seasons.

Seasons can be related to the need for alternative energy sources and the impact that the seasons have on our natural resources.

Relate global warming concerns and issues to evidence of climate and seasonal changes.

Literacy Integration

Reading

R.WS.05.04 know the meanings of words encountered frequently in grade-level reading and oral language contexts.

R.IT.05.02 identify and describe informational text patterns including compare/contrast, cause/effect, and problem/solution.

R.CM.05.02 retell through concise summarization grade-level narrative and informational text.

R.CM.05.04 apply significant knowledge from grade-level science, social studies, and mathematics texts.

Examples of trade books available for learning about seasons are:

Weather and Climate by Barbara Taylor, 2002
The Four Seasons by Annie Jones, 2006
The Complete Book of Seasons by Sally Tagholm, 2002

Writing

W.GN.05.03 write a position piece that demonstrates understanding of central ideas and supporting details (e.g., position/evidence organizational pattern) using multiple headings and subheadings.

- Write a paper regarding the causes of seasons using supporting details gained from activities and investigation.

Speaking

WS.DS.05.01 engage in interactive, extended discourse to socially construct meaning in book clubs, literature circles, partnerships, or other conversation protocols.

Instructional Examples

Earth in Space and Time

Solar System: E.ST.05.11, E.ST.05.21, E.ST.05.22, E.ST.05.23, E.ST.05.24, E.ST.05.25

Objectives

- Describe the position and motion of planets, dwarf planets, comets, and asteroids as they orbit the sun.
- Describe the motion planets and moons within the solar system.
- Explain moon phases.
- Explain the apparent motion of the stars (constellations) and the sun across the sky.
- Explain lunar and solar eclipses.
- Explain how the gravitational pull and the orbit of the moon affect ocean tides.

Engage and Explore

Note: Students have difficulty comprehending how vast space really is, and how large the planets and our moon are compared with everyday objects. In order for students to gain an understanding of visible objects in the sky, it helps to begin with activities that introduce scale. The first exploration is a review and extension of concepts (sun, moon, Earth model) introduced in fourth grade but provides an important foundation for learning new concepts.

- Divide students into groups of three or four. Give each group a ball of clay (each group receives a different amount of clay). Instruct students to divide the ball into fifty equal-sized balls. Students will then choose one average-sized ball. Tell them to combine the other 49 pieces into one large ball. Challenge them to determine what their model represents. Explain that although each group's model contains different-sized objects, each model is to scale (49:1). The students have constructed a model of the Earth and its moon. Our moon is closest object in the sky. Next, ask students to predict the ratio of the Earth's diameter to that of the moon. Through collaboration, students discover that the Earth's diameter is roughly four times that of the moon. (3.7:1). Each group should calculate the same ratio. Finally, challenge students to estimate how far apart the moon and Earth should be in their scale model system. Each group should arrive at consensus, set up their Earth-moon system and measure the distances. Record all measured distances. Assure students that each group will have its own correct answer based on the scale used. The correct answer is that the distance between the Earth and moon is approximately thirty times the Earth's diameter. Students will calculate how close their prediction was to the actual distance. (The next closest object in space is Venus, which is 3000 Earth diameters away.) (E.ST.05.11, S.IP.05.13, S.IP.05.16, S.RS.05.15)

- Students use tools and equipment (models) to investigate the position and motion of objects in the sky. As students begin to formulate ideas about the enormous distances and sizes of objects in space, they investigate a scale of the solar system. It is difficult to place both the planetary sizes and distances within one scale model because of the enormity of distances compared to miniscule size of the planets. One model, however, "The Thousand Yard Model" or "Earth as a Peppercorn" is one that can be easily introduced to students. (Remember that most scale models still contain Pluto as a planet, so the activity will need adjustment.) Gather necessary "planets;" Sun (any ball 8" in diameter), Mercury (a pinhead through a piece of paper), Venus (a peppercorn), Earth (a peppercorn 0.08 inch diameter), Mars (a second pinhead), Jupiter (a chestnut or pecan 0.90 inch diameter), Saturn (a hazelnut or acorn, 0.70 inch diameter), Uranus (peanut or coffee bean, 0.30 inch diameter), Neptune (second peanut or coffee bean). Using common objects helps students remember. Challenge students to predict which object represents which planet/sun and the order from the sun. After sharing the correct order and size, ask "How much space will be needed to create the solar system to scale?" Accept and record all answers. Give a clue: The Earth is eight thousand miles wide and the peppercorn is 0.08 of an inch. The sun is 800,000 miles wide. In this model, one inch equals a hundred thousand miles. That means that one-yard equals 3,600,000 miles! The distance between the sun and the Earth is 93 million miles or 26 yards in this model. Through discussion and initial research of planetary distances, students develop a solar system model. They construct charts from data and identify patterns of solar system objects. Students will evaluate their claims and models through collaborative discourse. After determining their best model, students share their solar system models outside. After the group presentations, the teacher presents the "peppercorn" scale. (Approximately a thousand yards is needed to complete the model.) Practice pacing so that one pace (two steps) equals one yard. Give "planets" to students. Place the sun down and march away as follows. 10 paces for Mercury. Another 9 paces for Venus. Another 7 paces for Earth. (26 paces total.) Another 9 paces to Mars. Another 95 paces to Jupiter. Another 112 paces to Saturn. Another 249 paces to Uranus. Another 281 paces to Neptune. (Pluto would be another 242 paces beyond Neptune.) Students will have marched more than one half mile. The total distance is 1,019 paces. A mile is 1760 yards. (This scale is accurate in size and distance.)(E.ST.05.11, S.IP.05.13, S.IP.05.16, S.IA.05.12)
- Distribute cards with sun and the names of the planets written on them to nine students. Give additional students cards with planetary objects written on them: Pluto (dwarf planet), Ceres (dwarf planet), Eris (dwarf planet), 5-6 students receive asteroid cards and 4-5 students receive

comet cards. Go outside. Planets line up in order from the sun. Students estimate the distances based on prior knowledge. (The distances used in this activity are smaller but to scale. This activity does not compare size and distance.) The teacher provides the following distances: Mercury is 4 paces from the sun; Venus is 7 paces from the sun; Earth is 10 paces from the sun; Mars is 15 paces; Jupiter is 52 paces; Saturn is 95 paces; Uranus is 191 paces; Neptune is 301 paces. Using sticks, mark each planet's position. Students with dwarf planet cards and asteroid cards take their position within the solar system. Students with comet cards can take a position anywhere within or outside the solar system. Several students will run at a constant speed from the sun to Eris. Discuss the distances between planets and the time it takes to travel between the planets. Notice how close the inner planets are to one another. Instruct all students to begin orbiting the sun in a counter clockwise direction at the same pace. They may also rotate on their axis. (Real orbits aren't exactly circular.) The comets will orbit in a highly elliptical pattern. Why do some orbits take longer? Additional students can participate as moons. Moons orbit their planets (only Mercury and Venus do not have moons) and spin on their axis. Adjustments can be made to regulate the speed of the planets' revolution (i.e., Jupiter should take 12 times as long to revolve as the Earth – Jupiter year vs. Earth year) but observing the effect of distances and position is the purpose of this activity. They should realize, however, that planets do not orbit at the same speed. Students summarize their learning by creating illustrations to demonstrate the position and motion of space objects around the sun. (E.ST.05.11, S.IP.05.11, S.IP.05.16, S.IA.05.13, S.RS.05.15)

- Students identify patterns in information and data regarding the motion of planets and moons in terms of rotation and orbits. Students create charts of the planetary days (rotation) and years (revolution). They compare data and evaluate the strengths and weaknesses of data and previous activities regarding position and motion of solar system objects. (E.ST.05.21, S.IP.05.16, S.IP.05.15, S.IA.05.15)
- After completing preliminary activities, challenge the students to consider, "How do planets and moons stay up there?" Allow students time to research and conclude that there is connection between gravitational force and orbital motion. Students participate in an activity to demonstrate the gravitational force that makes objects go in a circular path. Thread a string through a rubber ball; tie a knot on the outside of the ball. Thread the other end of the string through a straw and tie a roll of tape to that end. Hold the straw and swing the ball at a constant speed in a circle so that it orbits the straw. The string represents the force preventing the ball from flying off. Pull on the roll of tape to simulate a shorter orbit. Discuss what would happen if gravity did not exist or if the string is cut. Students develop and test a hypothesis about the relationship between the length of a planet's year and its distance from the sun using different ball/string combinations. (E.ST.05.21, S.RS.05.13)

Explain and Define

- Students demonstrate their understanding of the position of the planets, dwarf planets, asteroids and comets through illustrations and written explanations. (E.ST.05.11, S.RS.05.15)
- Students create operational definitions of the gravitational force that keeps planets and moons in an orbital path. (E.ST.05.21)

Elaborate and Apply

- In fourth grade, students investigated the predictable cycle of the moon. In fifth grade, students build on their understanding of moon phases. They explore the position and motion of objects in the sky and study how they relate to moon phases. Students generate questions about moon phases based on nightly observations of the moon over several months. A moon calendar can be started in the fall so data is available during the solar system unit. (E.ST.05.22, S.IP.05.11, S.IP.05.15)
- Students use tools and equipment to create a model to visualize, demonstrate and explain moon phases. Equipment: Styrofoam ball on a craft stick painted half black (vertical) per student to represent the moon, a bright light bulb to represent the sun, and students' heads to represent the Earth. Hold the moon ball in the left hand with an outstretched arm. The white side of the ball is always facing the student. (The black side is the side of the moon that we never view from Earth.) Ask, "How much of the ball do you see at one time?" (Half) Darken the room. Turn on the bright light and look at the ball from several angles. Is any part of the ball illuminated? Describe the location of the lit part in relation to the bright light. Instruct that the moon orbits the Earth each month. Stand facing the light. Hold the moon ball outstretched in front so it appears a little left of the light. Is a lit area visible on the moon? Students should see a small crescent on the right side of the moon. Slowly turn to the left (counterclockwise), keeping the ball outstretched. If a student's head blocks the light from the bulb, tell them to raise the ball slightly so the light can reach it. Observe how the illuminated part of the ball varies as its position changes. Move the ball around its orbit several times to observe patterns. Discuss and draw conclusions from observations. The moon reflects light from the sun, half of the moon is illuminated at all times, we see half of the moon at all times, but we can only observe the part of the moon that is illuminated. Students illustrate or create a model to explain the apparent phases when the moon is in various positions in its orbit around the Earth. (E.ST.05.22, S.IP.05.13, S.IP.05.15, S.IA.05.12, S.IA.05.13, S.RS.05.15)
- Elaborate on position and motion of objects in the sky by investigating the apparent motion of the stars and the sun. Challenge the students to think about objects in the sky. Which objects are moving? Which objects are stationary? How do we know? Over a period of a week, students make hourly observations of the sun's location in the sky and the moon's location in the sky (with reference to a stationary object such as a

rooftop). Students can use their fists to measure distance above the horizon. Students collect and organize data into charts. Based on their observations, students generate questions and develop a claim or hypothesis about the movement or apparent movement of the sun and stars in the sky. They conduct a simple investigation to test their claims. Students will use reference materials, activities, interviews, online research, etc. to test and provide evidence of the strengths and weaknesses of their claims. They present their findings to the class. The class will evaluate the strengths and weaknesses of the groups' claims, arguments and data regarding the reasons that the sun and stars appear to move across the sky. (E.ST.05.23, S.IP.05.11, S.IP05.13, S.IP.05.15, S.IP.05.16, S.IA.05.12, S.IA.05.13, S.IA.05.15, S.RS.05.11, S.RS.05.13, S.RS.05.15)

- To elaborate on their understanding of Earth, moon, sun systems, students explore eclipses. Repeat the moon phases activity with the moon ball directly in the sight line from the eye to the light. Close one eye so the view is only from one location on Earth. Students observe the illuminated portion of the moon ball as it passes directly in front of the sun. Record observations. In which phase is the moon? (New) The moon blocks the light from the sun. The shadow of the moon falls on the Earth (face). This is a solar eclipse when the moon passes directly in front of the sun. Move the moon model until the moon falls into the shadow of the student's head. What phase should the moon show? (Full) This is a lunar eclipse when the moon passes through the shadow of the Earth. Continue moving the moon ball until it makes one revolution (one month). Using this model, how often would we experience a lunar eclipse or solar eclipse? (once per month during a full moon and once during a new moon) Eclipses are rare events. Using a hula-hoop to represent the path of the moon's orbit, hold it parallel at eye level. In this position, Earth would experience an eclipse twice a month. The moon's orbit is at a slight angle. Tilt the hula-hoop at a slight angle (5 degree) to show that path of the moon above and below eye level (the ecliptic). Repeat the activity with the moon ball passing above and below eye level when in the new and full moon phases. They only time that an eclipse occurs is when the sun, moon and Earth are in a straight line. This is when the moon is crossing the point at which it moves above or below the ecliptic. Remind students, also, that the moon and the Earth are very far apart (30 Earth diameters) compared to the model in the classroom. Give students flashlights and different sized balls to create their own models of lunar and solar eclipses. (E.ST.05.24, S.RS.05.15)
- Elaborate on the position and gravitational pull of the Earth – moon system by investigating the cause and effects of tides. Conduct research and create models, diagrams or activities to demonstrate ocean tides. (E.ST.05.25, S.IA.05.13, S.RS.05.15)

Evaluate Student Understanding

Formative Assessment Examples

- Apply concepts of scale to an Earth-moon model. (E.ST.05.11)
- Demonstrate understanding through illustrations and models of the position of objects in the solar system. (E.ST.05.11, E.ST.05.21)
- Create moon journals and illustrations of phases of the moon. (E.ST.05.22)
- Share results of simple investigations to demonstrate the apparent motion of the sun and stars across the sky. (E.ST.05.23)
- Display models or demonstrations of eclipses and tides. (E.ST.05.24, E.ST.05.25)
- Monitor learning through observations of student discussions and participation. (E.ST.05.11, E.ST.05.21, E.ST.05.22, E.ST.05.23, E.ST.05.24, E.ST.05.25)

Summative Assessment Examples

- Draw a diagram of the solar system that includes the correct position of planets, dwarf planets, comets, and asteroids. (E.ST.05.11)
- Explain and illustrate rotation and revolution of planet and moons. (E.ST.05.21)
- Write a paragraph explaining how moon phases occur. (E.ST.05.22)
- Explain the difference between the apparent and the actual motion of the sun and stars across the sky. (E.ST.05.23)
- Demonstrate a lunar and a solar eclipse with illustrations or models. (E.ST.05.24)
- Draw a diagram and explain how the gravitational pull of the moon causes ocean tides. (E.ST.05.25)

Enrichment

- Investigate daylight savings.
- Research planets, moons, and other solar system objects. Create travel brochures for space travel in the solar system.
- Research space missions. Plan a mission to Mars.
- Research the possibility of life on other planets.
- Visit a planetarium.
- Create constellations and stories.
- Investigate galaxies and the possibility of life within other solar systems.
- Investigate the appearance of the Earth from the moon. Does the Earth have phases like the moon?
- Further investigate the different kinds of eclipses and the historical and cultural perspectives of eclipses.
- Investigate tides and their effect on ocean communities.
- Create a web quest that includes information from the space unit.
- Research the technology used by scientists to obtain information from space.
- Research contributions of scientists throughout history and across cultures. Examples include Ptolemy, Copernicus, Galileo, Steven Hawking, Neil deGrasse Tyson, Henrietta Leavitt, and Maria Mitchell.

Intervention

- Pair students during reading and writing activities.
- Use student journals to record ideas, questions, and daily notes.
- Provide extra practice during activities and demonstrations.
- Create vocabulary and concept cards that include definitions, illustrations, and everyday examples.
- Create graphic organizers to define and review concepts.
- Use a variety of visual diagrams and pictures to supplement activities.

Examples, Observations, and Phenomena (Real World Context)

Students are aware of objects in the sky that can be seen in the day and nighttime sky. Because they have been making observations since they were young children, they may have developed their own ideas to explain natural phenomena. It is important that students become aware of their naïve ideas and begin to resolve them through the activities and research while they study the motion and position of objects in the solar system. An interesting phenomenon for students to reason through and demonstrate is why we have approximately the same hours of daylight on April 21st as we do on August 21st. Early November (fall) also has approximately the same hours of day light as early February (winter).

Students cannot directly observe the planets and their moons. They do, however, have a natural curiosity about space. Movies, books, newspaper articles, and games enhance student understanding and interest.

It is common to find misinformation in movies, stories and other media regarding space, space travel, and distant galaxies. Students should be aware of how this misinformation can cause misconceptions. Share news articles regarding space research and technological advances. NASA websites are full of information for students who are interested in space and space travel.

Literacy Integration

Reading

R.WS.05.04 know the meanings of words encountered frequently in grade-level reading and oral language contexts.

R.IT.05.02 identify and describe informational text patterns including compare/contrast, cause/effect, and problem/solution.

R.CM.05.02 retell through concise summarization grade-level narrative and informational text.

R.CM.05.04 apply significant knowledge from grade-level science, social studies, and mathematics texts.

Examples of trade books available for learning about the position and motion of objects in the sky are:

America in Space by Steven Dick et al, 2007
Our Solar System by Seymour Simon, 2007
Don't Know Much About the Solar System, by Kenneth C. Davis and Pedro Martin, 2004
Earth, Moon, Sun by Peter Riley, 2006
Will the Sun Ever Burn Out? by Rosalind Mist, 2006

Writing

W.GN.05.03 write a position piece that demonstrates understanding of central ideas and supporting details (e.g., position/evidence organizational pattern) using multiple headings and subheadings.

- Write a paper regarding the causes of seasons using supporting details gained from activities and investigation.

Speaking

WS.DS.05.01 engage in interactive, extended discourse to socially construct meaning in book clubs, literature circles, partnerships, or other conversation protocols.

Mathematics Integration

Numbers and Operations

N.FL.05.05 Solve applied problems involving multiplication and division of whole numbers.

N.ME.05.09 Understand percentages as parts out of 100, use % notation, and express a part of the whole as a percentage.

Measurement

M.UN.05.04 Convert measurement of length, weight, area. Volume, and time within a given system using easily manipulated numbers.

Data and Probability

D.RE.05.02 Construct line graphs from tables of data; include axis labels and scale.

D.AN.05.03 Given a set of data, find and interpret the mean (using the concept of fair share) and mode.