Science Curriculum

Grade Eight Unit Four:
FOSS Planetary Science
Course Description

The students in the eighth grade Science course will develop a conceptual understanding of Science topics using hands-on instruction, interactive notebooking, observations of and interactions with natural phenomena and the use of engineering and design processes to identify problems, plan, test and revise possible solutions. In Life Science, students will explore the interaction of human body systems to maintain stability, how growth and development can be affected by genetic factors in sexually reproducing organisms, and how organisms have changed over time due to environmental and genetic factors both by examining the fossil record and examining structural similarities between organisms. In Physical Science, students will explore wave motion, as well as how the force of gravity affects the kinetic energy of object on Earth’s surface. In Earth Science, students will explore Earth’s place in the Universe, as well as the unique characteristics of other celestial bodies.

Teachers may choose from a variety of instructional approaches that are aligned with 3 dimensional learning to achieve this goal. These approaches include:

<table>
<thead>
<tr>
<th>Inquiry Kit Instruction (modified)</th>
<th>Challenge Based Instruction</th>
<th>5 E Instructional Model (BSCS)</th>
<th>Culturally Relevant Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-Based Instruction</td>
<td>Tinkering Pedagogy</td>
<td>Learning Progressions</td>
<td>Knowledge Integration</td>
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<tr>
<td>Model-based Reasoning</td>
<td>Place-based Instruction</td>
<td>Meaningful Expertise Instruction</td>
<td>Emergent Investigations (RSS)</td>
</tr>
</tbody>
</table>

PATerson PUBLIC SCHOOLS
### Pacing Chart

*Please note that pacing is based upon 240 minutes per 6 day cycle.*

<table>
<thead>
<tr>
<th>Unit</th>
<th>Course Title</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Course Introduction with Engineering and Design Practices</td>
<td>10</td>
</tr>
<tr>
<td>Unit 2</td>
<td>FOSS Human Systems Interactions</td>
<td>36</td>
</tr>
<tr>
<td>Unit 3</td>
<td>FOSS Heredity &amp; Adaptations</td>
<td>36</td>
</tr>
<tr>
<td>Unit 4</td>
<td>FOSS Planetary Science</td>
<td>40</td>
</tr>
<tr>
<td>Unit 5</td>
<td>FOSS Waves</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>New Jersey Student Learning Assessment Science Review</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Final Project</td>
<td>10</td>
</tr>
</tbody>
</table>

### Unit Summary

In this unit of study, students will explore Earth’s place in our solar system and the larger universe. They will gather observational data regarding Moon phases to determine trends in lunar movement. Students will use simulations to gather data to support arguments about Earth’s shape, its movement and the factors that contribute to seasonal weather changes. They will conduct in depth research regarding Earth’s Moon, and create scale models of the Moon and its orbital distance from Earth. Students study crater impact data to forecast future impact events. They will argue from evidence to support theories of the origin of our solar system. They use scale models to develop an understanding of the size of our solar system. They compare temperature and atmospheric data for the eight planets and study satellite images to search for evidence of water. Students use spectrosopes to observe radiant spectra and learn how astronomers use light as their primary source of data regarding deep space.

### Student Learning Objectives

1. **Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.** *[Clarification Statement: Examples of models can be physical, graphical, or conceptual.]* (MS-ESS1-1)

2. **Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.** *[Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of*
models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students’ school or state).] [Assessment Boundary: Assessment does not include Kepler’s Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.] (MS-ESS1-2)

### 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)

### Construct an explanation based on evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales.

[Clarification Statement: Emphasis is on how processes change Earth’s surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.] (MS-ESS2-2)

### Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

[Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).] (MS-ESS3-2)

### Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

[Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.] (MS-PS4-1)
<table>
<thead>
<tr>
<th>NJDOE Learning Objective and Standard</th>
<th>Essential Questions</th>
<th>Content Related to DCI's</th>
<th>Sample Activities</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Investigation 1 Part 1: Where Am I?</strong></td>
<td>What can be seen from 100 m altitude? 1000 m? 10,000 m?</td>
<td>• Location or position can be described in terms of a frame of reference. • Point of view is the position from which a visual observation is made. • Altitude is the distance above Earth’s surface. • Elevation is the distance above sea level</td>
<td>Session Assessment: Survey Students use web-based images centered on their school to observe and describe where they are as their point of view moves away from Earth’s surface in powers of ten. When students retreat to a distance of 10,000 km above their school, they can see that they are on Earth, a planet surrounded by the darkness of space. The ideas of frame of reference and point of view are incorporated into their description of where they are. Embedded Assessment: Response Sheet</td>
<td>Science Resources Book Images and Data Videos and Slide Shows: “White House Views Collection” Note: Requires use of Google Earth. Please contact the Science department to arrange for software download to teacher computer if necessary.</td>
</tr>
<tr>
<td><strong>2. Investigation 1 Part 2: Moon Watch</strong></td>
<td>How does the Moon change day by day?</td>
<td>• The Moon can be observed both day and night.</td>
<td>Students go outdoors, turn their gazes away from Earth, and discover the Moon. After observing the shape, tilt, color, size, and location of the Moon, students share what they know about how the Moon changes over time. To check their ideas, students start a Moon log to chart daily changes in the Moon’s appearance. Embedded Assessment: Scientific Practices</td>
<td></td>
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<td></td>
<td><em>MS-ESS1-1</em></td>
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<td><em>MS-ESS1-1</em></td>
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</table>
| 3. **Investigation 2 Part 1: Sailing Ships** | How do observations of ships at sea provide evidence of Earth’s shape? | • Line of sight is the straight, unimpeded path taken by light from an object to an eye.  
• Objects appear to sink when they move across the ocean and slip below the horizon on a curved surface. | Students are asked to generate evidence that Earth is a sphere. They sail a small ship across models of flat and spherical Earths. They work with a multimedia simulation of ships sailing across a flat sea and a curved sea. Students develop a rational argument for a spherical Earth.  
Embedded Assessment:  
Response Sheet  
Scientific Practices | Science Resources Book:  
“The First Voyage of Columbus” (optional)  
“Eratosthenes: First to Measure the Earth” (optional)  
Videos and Slide Shows:  
“Astro Blog”  
“Latitude & Longitude”  
“Earth Models”  
“Round Earth/Flat Earth”  
“Libertad” |
|---|---|---|---|---|
| **Part 1:** Sailing Ships | Students gather evidence to support an argument regarding Earth’s shape.  
**MS-ESS1-1** |  |  |  |
| **Part 2:** Earth/Sun Relationships | What causes day and night? | • At all times, half of Earth is illuminated (day), and half is dark (night).  
• Daytime and nighttime are the result of Earth’s rotation on its axis.  
• Earth’s axis tilts at an angle of 23.5° and points toward the North Star. | After writing an explanation for what causes day and night, students imagine one of their eyes as an observer on Earth and position themselves around a lamp to observe night and day. Students discover that rotation of Earth results in day and night and, in the process, figure out which direction Earth rotates on its axis. The day/night mechanism is reinforced with globes. Students also learn about the tilt of Earth’s axis and Earth’s yearly rotation around the Sun.  
Embedded Assessment:  
Quick write  
Benchmark Assessment:  
*Investigations 1-2 I-Check* | Videos and Slide Shows:  
“Day/Night” (optional) |
| 5. **Investigation 3 Part 1: Summer Heat** | Why is it hotter in summer? | Students use simulations to model and predict variance in the inheritance of certain traits in a given population. | The lower the angle at which light strikes a surface, the lower the density of the light energy.  
Beam spreading affects the intensity of solar radiation on Earth’s surface. | Students investigate the variables that describe seasons. They observe that a flashlight beam shining directly perpendicular to the floor produces a round spot, and the same beam directed at an angle produces an elongated, oval spot. The area covered by the same beam of light changes, depending on the angle. Beam spreading is introduced as the mechanism that affects the energy density of light falling on Earth’s surface. Students find that beam spreading and duration of sunshine are the main variables that affect the temperature during the seasons.  
**Embedded Assessment:**  
Quick write Response Sheet |
|---|---|---|---|---|
| 6. **Investigation 3 Part 2: Day Length** | Why are there more hours of sunlight in the summer? | Students graph data regarding day length around the globe. They analyze these graphs to determine patterns and develop an explanation to account for the variation in day length in different locations | The tilt of Earth’s axis and Earth’s revolution around the Sun results in seasons.  
The duration of daylight at a position on Earth’s surface varies as Earth revolves around the Sun, due to the tilt of Earth’s axis. | Students read an account of day length around the planet and graph the duration of daylight throughout the year. They determine that tilt of Earth on its axis, and the invariable angle of the tilt, can account for variable day length. They determine that the tilt and direction of Earth’s axis and Earth’s position in its orbit around the Sun account for seasons.  
**Embedded Assessment:** |

**Science Resources Book:**  
Images and Data “Seasons on Earth”  
Videos and Slide Shows: “Seasons” “Latitude & Longitude”
<table>
<thead>
<tr>
<th>Grade Eight Unit Four: FOSS Planetary Science</th>
<th>Instructional Days: 40</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quick write</strong> Response Sheet</td>
<td>Benchmark Assessment: <em>Investigations 3 I-Check</em></td>
</tr>
<tr>
<td>Students explore the Moon’s surface features and mythology concerning the Moon’s creation to generate a shared body of knowledge to inform future research. Students conduct follow up research based upon areas of interest.</td>
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<tr>
<td><strong>What is visible on Moon?</strong></td>
<td><strong>Students focus on the Moon’s surface features. They study an image of the Moon to observe and catalog the major features. They also read a myth that originated in Maori culture to explain the appearance of the Moon. Students then generate a set of questions about the Moon, organize them into categories, and use them to guide their continued inquiry into the Moon.</strong></td>
</tr>
</tbody>
</table>
| - The Moon has surface features that can be identified in telescope images: craters, maria, and mountains.  
- The Moon, Earth’s satellite, is slightly more than one-fourth Earth’s diameter and orbits at a distance of about 384,000 kilometers. | **Embedded Assessment:**  
**Scientific Practices** |
| **8. Investigation 4 Part 2: How Big/How Far?** | |
| Students use mathematical calculations to create a scaled model of the Earth and Moon system. | |
| **What does a scaled Earth/Moon model look like?** | **Students explore the Earth/Moon relationship by creating a scaled model of the system. Using a small globe as a starting point, they calculate the diameter of a ball to represent the companion Moon, and then position it at the right distance to represent the Moon’s orbital distance.** |
| - Scale is the size relationship between a representation of an object and the object.  
- Scale can be expressed as a ratio when an object and its representation are measured in related units. | **Embedded Assessment:**  
**Scientific Practices** |
| **Science Resources Book:**  
“Lunar Myths” Images and Data  
Online Activities:  
“Rona/Moon Animation” | **Science Resources Book:**  
“For All Mankind” DVD |
9. **Investigation 5 Part 1: Observed Patterns**  
Students develop an explanation for moon phases and moonrise based upon observational data.  
**MS-ESS1-1**

| What Moon-phase pattern can be observed? | • The Moon goes through phases: “new” to “full” and back to “new” in a 4-week cycle.  
• The Moon shines as a result of reflected light from the Sun. Half of the Moon is always illuminated (except during a lunar eclipse).  
• The Moon revolves around Earth once in 4 weeks, resulting in the Moon’s rising about 50 minutes later each day.  
• The revolution of the Moon around Earth and the rotation of Earth on its axis account for the phases of the Moon and the time of day (or night) when the Moon is visible. | Students update and study their Moon Logs to determine the sequence of changes. They learn phase vocabulary, then study moonrise. Students use small polystyrene balls and a light source to simulate Moon phases. They incorporate their small globes into the system to obtain another point of view on Moon-phase mechanics. Finally, they use a light source and a large Moon globe to study Sun/Earth/Moon relationships, including eclipses.  
Embedded Assessment:  
Quick write  
Scientific Practices | Science Resources Book:  
“Moonrise/Sunrise Data”  
Online Activity:  
“Moon Orientation”  
“Lunar Calendar” |

10. **Investigation 5 Part 2: Moon-Phase Models**  
Students use models to further develop an explanation for moon phases.  
**MS-ESS1-1**

| What causes Moon phases? | • The Moon shines as a result of reflected light from the Sun. Half of the Moon is always illuminated (except during a lunar eclipse).  
• Moon phase depends on how much of the Moon’s illuminated surface is visible from Earth, which is determined by the relative positions of Earth and the Moon. | Students complete a Moon-phase sheet that displays images of phases from two points of view simultaneously. To help them visualize the points of view, students assemble an Earth-Moon model, using their globes and polystyrene balls, and work with a Moon-phase puzzle.  
Embedded Assessment:  
Response Sheet | Science Resources Book:  
“Measuring Time with Calendars”  
“Calculating the Observance of Ramadan”  
“Phases of the Moon Sequence Puzzle” (optional)  
Online Activity:  
“Day/Night”  
“Moon Puzzle” |
<table>
<thead>
<tr>
<th>Grade Eight Unit Four: FOSS Planetary Science</th>
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<tbody>
<tr>
<td>Moon in their orbits around the Sun. • The revolution of the Moon around Earth and the rotation of Earth on its axis account for the phases of the Moon and the time of day (or night) when the Moon is visible.</td>
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</tbody>
</table>

11. **Investigation 5 Part 3: Moon-Phase Simulation**
Students use simulations to refine their explanation of moon phases.

**MS-ESS1-1**

What causes Moon phases?
• Moon phase depends on how much of the Moon’s illuminated surface is visible from Earth, which is determined by the relative positions of Earth and the Moon in their orbits around the Sun.
• The revolution of the Moon around Earth and the rotation of Earth on its axis account for the phases of the Moon and the time of day (or night) when the Moon is visible.

Students work with multimedia simulations—“Phases of the Moon” and “Lunar Calendar”—to reinforce their understanding of what causes the phases of the Moon.

**Embedded Assessment:**
Quick write Response Sheet

**Benchmark Assessment:**
Investigations 4-5 I-Check

**Science Resources Book:**
“Earth’s Moon”

**Online Activity:**
“Phases of the Moon” “Lunar Calendar”

12. **Investigation 6 Part 1: Moon Craters**
Students use experimental data to support an argument concerning the origin of the Moon’s craters.

**MS-ESS3-2**

Are Moon craters the result of volcanoes or impacts?
• Craters of various sizes and types result when meteoroids of various sizes impact the surface of planets and satellites.
• Craters can be categorized by size and physical characteristics: simple,

Students are introduced to the historical controversy regarding the origin of the craters on the Moon: impacts or volcanism? Students design experiments using flour and marbles or rocks to investigate different variables and determine if impact events could be responsible for the extensive cratering on the Moon’s surface.

**Science Resources Book:**
“Craters: Real and Simulated”

**Online Activity:**
“Crater Formation on the Moon”
### Grade Eight Unit Four: FOSS Planetary Science

<table>
<thead>
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<th>Instructional Days: 40</th>
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<tbody>
<tr>
<td>complex, terraced, ringed (or basin), and flooded.</td>
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<table>
<thead>
<tr>
<th>13. <em>Investigation 6 Part 2: Moon Craters</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Students analyze Moon impact data and compare to data from Earth to predict the likelihood of another Earth impact.</td>
</tr>
<tr>
<td>• Earth and the Moon have been, and continue to be, subjected to the same rate of bombardment by meteoroids.</td>
</tr>
<tr>
<td>• Earth’s record of impacts has been erased by the actions of wind, water, and tectonic activity.</td>
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<tr>
<td>Students scrutinize the Moon’s maria to determine the frequency of major impacts since mare formation 4 billion years ago. They use these data to determine the number of major Earth impacts over the same period and to determine the frequency of such events on Earth.</td>
</tr>
<tr>
<td>Embedded Assessment: Scientific Practices</td>
</tr>
<tr>
<td>Benchmark Assessment: <em>Investigations 6 I-Check</em></td>
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<tr>
<td>Science Resources Book: Images and Data</td>
</tr>
<tr>
<td>“The Impact That Ended the Reign of the Dinosaurs”</td>
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<tr>
<td>“Gene Shoemaker: Astrogeologist” (optional)</td>
</tr>
<tr>
<td>Video: <em>Asteroids: Deadly Impact</em></td>
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<tr>
<td>Online Activity:</td>
</tr>
<tr>
<td>“Model Craters”</td>
</tr>
<tr>
<td>“Crater Formation on the Moon”</td>
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</tbody>
</table>

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<tbody>
<tr>
<td>Students compare cosmic objects and sort them into several categories based upon their shared characteristics.</td>
</tr>
<tr>
<td>• The solar system includes the Sun; eight planets and their satellites; and a host of smaller objects, including dwarf planets, asteroids, comets, Kuiper Belt objects, and Oort Cloud matter.</td>
</tr>
<tr>
<td>Students generate drawings depicting all the objects in the solar system. They then work in pairs with a set of cosmos cards that represent objects in the universe. Students use images and information to organize the cards, including putting them in order based on distance from Earth. To do so, students learn to think of celestial distance in astronomical units and light-years. They analyze cosmos objects that fall into three categories:</td>
</tr>
<tr>
<td>Science Resources Book:</td>
</tr>
<tr>
<td>“The Cosmos in a Nutshell”</td>
</tr>
<tr>
<td>Online Activity:</td>
</tr>
<tr>
<td>“Space Units”</td>
</tr>
<tr>
<td>“Cosmos Card Sort” (optional)</td>
</tr>
</tbody>
</table>
| Investigation 7 Part 2: Origins | Where did the solar system come from? | The solar system formed during a sequence of events that started with a nebula of dust and gas. The Moon formed after a massive collision between the forming Earth and a planetesimal about the size of Mars. | Students study and sequence ten Solar System Origin cards, starting with a nebula. As a result of reasoning and class discussion, students determine the cards' most likely sequence, which should vary only slightly from nebula, contracting, heating, disk forms, Sun turns on, condensing, accreting, gas giants, rocky planets, and flinging. Students are presented with four theories to explain the formation of our Moon: capture, daughter, big impact, and sisters. After seeing video animations of the four theories, students choose and defend one of the theories. | Science Resources Book: “How Earth Got and Held Its Moon”  
| 15. Investigation 8 Part 1: Where Are the Planets? | Where are the planets in the solar system? | The distance between solar system objects is enormous. | Students attempt to understand the relative sizes and spacing of the planets and the Sun. First they determine how big to make the Sun and how far away to place it to be a proportional companion for their 12 cm Earth globe. Next they make a model of the inner solar system, scaled 1 cm = 1 million km. Finally they imagine a 1m Sun in | Science Resources Book: Images and Data  
Online Activity: “Space Missions”  
Note: Requires use of Google Earth. Please contact the Science department to arrange |
### Grade Eight Unit Four: FOSS Planetary Science

<table>
<thead>
<tr>
<th>Instructional Days: 40</th>
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**their classroom, and place the planets on a map of their community.**

**Embedded Assessment:**

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**16. Investigation 8 Part 3: Where Is the Water?**

Students gather evidence to support a claim regarding the presence of water on other planets in the solar system.

**MS-ESS2-2**

Please note: Investigation 8 Part 2 was intentionally omitted from the course guide.

<table>
<thead>
<tr>
<th>Where is here water in the solar system?</th>
<th>• Images can convey information about the presence and history of liquid water on planetary surfaces.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students study satellite images of typical water-related landforms on Earth. They identify bodies of liquid water (ocean, lake, river) and deposits of ice and snow, as well as landforms that suggest the presence of water at earlier times. They search images of planets and satellites for evidence of water on extraterrestrial bodies in the solar system.</td>
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</table>

**Embedded Assessment:**

**Science Notebook Entry**

**Benchmark Assessment:**

**Investigations 7-8 I-Check**

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**17. Investigation 9 Part 1: Light Spectra**

Students explore how light is used by astronomers to determine the characteristics of distant cosmic objects.

**MS-PS4-1**

<table>
<thead>
<tr>
<th>Why is light important to astronomy?</th>
<th>• A spectroscope analyzes the wavelengths of light (spectrum) coming from a light source.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students learn that most of the information used by astronomers comes to them as light. Students learn that light travels in waves of many different wavelengths, and the wavelength determines its color. They use a spectroscope to observe the radiant spectra of a number of light sources, including the Sun, fluorescent lamps, and incandescent lamps. They learn that bright emission lines and dark absorption lines in a spectrum</td>
<td></td>
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</table>

**Science Resources Book:**

“Hunt for Water Using Spectra”

**Online Activity:**

“Properties of Light”

“Comparing Spectra”
<table>
<thead>
<tr>
<th>Investigation 10 Part 3: What is Our Cosmic Address?</th>
<th>What is our cosmic address?</th>
<th>Location can be described in relation to a frame of reference.</th>
<th>Students review what they have learned in the course and restate their cosmic address.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students gather evidence to support a claim regarding the presence of water on other planets in the solar system.</td>
<td></td>
<td></td>
<td>Embedded Assessment: Quick write</td>
</tr>
<tr>
<td>MS-ESS1-1</td>
<td></td>
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<td>Benchmark Assessment: Posttest</td>
</tr>
</tbody>
</table>

Please note: Investigation 9 Part 2 and Investigation 10 Parts 1 & 2 were intentionally omitted from the course guide.

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### Unit Project/Lab Performance Assessment

**Touchdown** Design and build a shock-absorbing system that will protect two “astronauts” when they land - in resource folder

### 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.

### Modifications for differentiation at all levels

*(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.)*

- Restructure lesson using UDL principals ([http://www.cast.org/our-work/about-udl.html#VXmoXcfD_UA](http://www.cast.org/our-work/about-udl.html#VXmoXcfD_UA))
- Structure lessons around questions that are authentic, relate to students’ interests, social/family background and knowledge of their community.
Grade Eight Unit Four: FOSS Planetary Science

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- 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.

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.

Students of all ages may hold the view that the world was always as it is now, or that any changes that have occurred must have been sudden and comprehensive. The students in these studies did not, however, have any formal instruction on the topics investigated. Moreover, students taught by traditional means are not able to construct coherent explanations about the causes of natural hazards. ([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.
- A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions).
Humans cannot eliminate the hazards but can take steps to reduce their impacts.

Light transfers energy from place to place.

**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.
- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years.
- Studying these objects can provide information about Earth’s formation and early history.
- Natural hazards and other geologic events have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations.
- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.
- The wavelength and frequency of a wave are related to one another by the speed $P$ of the wave, which depends on the type of wave and the medium through which it is passing.
- Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.
- Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other.
- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons.
- The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat).
- Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.
- Photoelectric materials emit electrons when they absorb light of a high enough frequency.
- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.
- The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
### Grade Eight Unit Four: FOSS Planetary Science

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- The Big Bang theory is supported by observations of distant galaxies receding from our own, by the measured composition of stars and nonstellar gases, and by maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy.
- Heavier elements are produced when certain massive stars achieve a supernova stage and explode.
- The abundance of liquid water on Earth’s surface and its unique combination of physical and chemical properties are central to the planet’s dynamics. These properties include water’s exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.

### Interdisciplinary Connections

#### 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.
- Cite specific textual evidence in data used to support the analysis of natural hazards and to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
- Integrate quantitative or technical information about natural hazards and forecasting future catastrophic events that is expressed visually (e.g., in a flowchart, diagram, model, graph, or table). Use the integrated text and visual displays to analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

#### 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.

- Analyze and interpret data on natural hazards by reasoning abstractly (manipulating symbols abstractly) and quantitatively (while attending to the meaning of those symbols) to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

- Use variables to represent numbers and write expressions for the locations, magnitudes, and frequencies of natural hazards and how these data can be used to forecast future catastrophic events and inform the development of technologies to mitigate their effects. The variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.

- Use variables to represent quantities for the location, magnitudes, and frequencies of natural hazards and how these data can be used to forecast future catastrophic events and inform the development of technologies to mitigate their effects. Construct simple equations and inequalities to solve problems by reasoning about the quantities.
### Grade Eight Unit Four: FOSS Planetary Science

**Instructional Days:** 40

#### Vocabulary

<table>
<thead>
<tr>
<th>Investigation 1: Where Am I?</th>
<th>Investigation 3: Seasons</th>
<th>Investigation 6: Craters</th>
<th>Investigation 7: Beyond the Moon</th>
</tr>
</thead>
<tbody>
<tr>
<td>altitude</td>
<td>solar eclipse</td>
<td>waning</td>
<td>meteoroid</td>
</tr>
<tr>
<td>bird’s-eye view</td>
<td>third-quarter Moon</td>
<td>waxing</td>
<td>planet</td>
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<tr>
<td>elevation</td>
<td></td>
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<td>simple craters</td>
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<tr>
<td>frame of reference</td>
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<td>solar system</td>
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<td>location</td>
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<td>point of view</td>
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<td>Investigation 2: A Round, Spinning Earth</td>
<td>axis</td>
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<td>equator</td>
<td>North Star</td>
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<td>horizon</td>
<td>solar energy</td>
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<td>latitude</td>
<td>solstice</td>
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<td>line of sight</td>
<td>star</td>
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<td>North Star</td>
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<tr>
<td>Investigation 5: Phases of the Moon</td>
<td>first-quarter Moon</td>
<td>diameter</td>
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<td>full Moon</td>
<td>ejecta</td>
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<td>gibbous</td>
<td>flooded crater</td>
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<td>lunar eclipse</td>
<td>gravity</td>
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<td>new Moon</td>
<td>mare (maria)</td>
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<td>phase</td>
<td>meteor</td>
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<td>meteorite</td>
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</tbody>
</table>

**Keywords:**
- meteoroid
- planet
- simple craters
- solar system
- astronomical unit
- big bang theory
- black hole
- cosmos
- dwarf planet
- galaxy
- Kuiper Belt
- light-year
- Milky Way
- nebula
- plutoid
- satellite
- star cluster
- supernova
### Educational Technology Standards

<table>
<thead>
<tr>
<th>8.1.8.A.1, 8.1.8.B.1, 8.1.8.C.1, 8.1.8.D.1, 8.1.8.E.1, 8.1.8.F.1</th>
</tr>
</thead>
</table>

#### Technology Operations and Concepts
- Create professional documents (e.g., newsletter, personalized learning plan, business letter or flyer) using advanced features of a word processing program.

  **Example**: Create a brochure to advertise your levee design.

#### Creativity and Innovation
- Synthesize and publish information about a local or global issue or event on a collaborative, web-based service.

  **Example**: Publish a blog regarding hurricane preparedness.

#### Communication and Collaboration
- Participate in an online learning community with learners from other countries to understand their perspectives on a global problem or issue, and propose possible solutions.

  **Example**: Use Empatico.org to collaborate with students from other countries who have experienced hurricanes.

#### Digital Citizenship
- Model appropriate online behaviors related to cyber safety, cyber bullying, cyber security, and cyber ethics.

  **Example**: Use Diigo.com to have a monitored and appropriate online conversation about an article.

#### Research and Information Literacy
- Gather and analyze findings using data collection technology to produce a possible solution for a content-related or real-world problem.

  **Example**: Use NOAA or AMS websites to gather data about hurricane frequency, location, etc.

#### Critical Thinking, Problem Solving, Decision Making
- Use an electronic authoring tool in collaboration with learners from other countries to evaluate and summarize the perspectives of other cultures about a current event or contemporary figure.

  **Example**: Utilize Voicethread to create a narrative account of a hurricane event.

### Career Ready Practices

Career Ready Practices describe the career-ready skills that all educators in all content areas should seek to develop in their students. They are practices that have been linked to increase college, career, and life success. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study.

#### CRP1. Act as a responsible and contributing citizen and employee
- Career-ready individuals understand the obligations and responsibilities of being a member of a community, and they demonstrate this understanding every day through their interactions with others. They are conscientious of the impacts of their decisions on others and the environment around them. They think about the near-term and long-term consequences of their actions and seek to act in ways that contribute to the betterment of their teams,
families, community and workplace. They are reliable and consistent in going beyond the minimum expectation and in participating in activities that serve the greater good.

**Example:** Participate as an active and ethical member of class discussions and projects. Teacher can explore how decision making and behaviors can impact the broader community in specific science related examples, such as limiting littering, choosing to recycle, etc.

**CRP4. Communicate clearly and effectively and with reason.**

Career-ready individuals communicate thoughts, ideas, and action plans with clarity, whether using written, verbal, and/or visual methods. They communicate in the workplace with clarity and purpose to make maximum use of their own and others’ time. They are excellent writers; they master conventions, word choice, and organization, and use effective tone and presentation skills to articulate ideas. They are skilled at interacting with others; they are active listeners and speak clearly and with purpose. Career-ready individuals think about the audience for their communication and prepare accordingly to ensure the desired outcome.

**Example:** Students can develop and present well supported arguments via short presentations, during group work and gallery walks.

**CRP5. Consider the environmental, social and economic impacts of decisions.**

Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact and/or mitigate negative impact on other people, organization, and the environment. They are aware of and utilize new technologies, understandings, procedures, materials, and regulations affecting the nature of their work as it relates to the impact on the social condition, the environment and the profitability of the organization.

**Example:** Participate as an active an ethical member of class discussions and projects. Teacher can explore how decision making and behaviors can impact the broader community in specific science related examples, such as limiting littering, choosing to recycle, etc.

**CRP6. Demonstrate creativity and innovation.**

Career-ready individuals regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization.

**Example:** Engineering tasks provide many opportunities for student to use creative and innovative approaches.

**CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.**

Career-ready individuals readily recognize problems in the workplace, understand the nature of the problem, and devise effective plans to solve the problem. They are aware of problems when they occur and take action quickly to address the problem; they thoughtfully investigate the root cause of the problem prior to introducing solutions. They carefully consider the options to solve the problem. Once a solution is agreed upon, they follow through to ensure the problem is solved, whether through their own actions or the actions of others.

**Example:** Gather evidence to support a claim and identify reasoning that is being applied.

**CRP11. Use technology to enhance productivity.**

Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring new technology. They are proficient with ubiquitous technology applications. They understand the inherent risks-personal and organizational-of technology applications, and they take actions to prevent or mitigate these risks.
Example: Utilize Google Apps for Education suite to access and complete assignments. The teacher can use Google Classroom to identify age and subject appropriate resource materials that can be linked directly. A variety of apps or web based platforms (Tellagami, PowToons, Glogster, Padlet) can be used to generate multimedia content.

CRP12. Work productively in teams while using cultural global competence.

Career-ready individuals positively contribute to every team, whether formal or informal. They apply an awareness of cultural difference to avoid barriers to productive and positive interaction. They find ways to increase the engagement and contribution of all team members. They plan and facilitate effective team meetings.

Example: Students must be given regular opportunities to work with groups in a variety of settings for discussion, projects, etc.
Grade Eight Unit Four: FOSS Planetary Science

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**WIDA Proficiency Levels:** At the given level of English language proficiency, English language learners will process, understand, produce or use:

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
</table>
| 6- Reaching | - Specialized or technical language reflective of the content areas at grade level  
- A variety of sentence lengths of varying linguistic complexity in extended oral or written discourse as required by the specified grade level  
- Oral or written communication in English comparable to proficient English peers |
| 5- Bridging | - Specialized or technical language of the content areas  
- A variety of sentence lengths of varying linguistic complexity in extended oral or written discourse, including stories, essays or reports  
- Oral or written language approaching comparability to that of proficient English peers when presented with grade level material. |
| 4- Expanding | - Specific and some technical language of the content areas  
- A variety of sentence lengths of varying linguistic complexity in oral discourse or multiple, related sentences or paragraphs  
- Oral or written language with minimal phonological, syntactic or semantic errors that may impede the communication, but retain much of its meaning, when presented with oral or written connected discourse, with sensory, graphic or interactive support |
| 3- Developing | - General and some specific language of the content areas  
- Expanded sentences in oral interaction or written paragraphs  
- Oral or written language with phonological, syntactic or semantic errors that may impede the communication, but retain much of its meaning, when presented with oral or written, narrative or expository descriptions with sensory, graphic or interactive support |
| 2- Beginning | - General language related to the content area  
- Phrases or short sentences  
- Oral or written language with phonological, syntactic, or semantic errors that often impede the communication when presented with one to multiple-step commands, directions, or a series of statements with sensory, graphic or interactive support |
| 1- Entering | - Pictorial or graphic representation of the language of the content areas  
- Words, phrases or chunks of language when presented with one-step commands directions, WH-, choice or yes/no questions, or statements with sensory, graphic or interactive support |
## Language Development Supports For English Language Learners

### To Increase Comprehension and Communication Skills

| Environment |  |
|-------------|  |
| - Welcoming and stress-free | - Integrates learning centers and games in a meaningful way |
| - Respectful of linguistic and cultural diversity | - Provides opportunities to practice and refine receptive and productive skills in English as a new language |
| - Honors students’ background knowledge | - Integrates meaning and purposeful tasks/activities that: |
| - Sets clear and high expectations |  |
| - Includes routines and norms |  |
| - Is thinking-focused vs. answer-seeking |  |
| - Offers multiple modalities to engage in content learning and to demonstrate understanding |  |
| - Includes explicit instruction of specific language targets |  |
| - Provides participation techniques to include all learners |  |

### Sensory Supports*  
- Real-life objects (reallia) or concrete objects  
- Physical models  
- Manipulatives  
- Pictures & photographs  
- Visual representations or models such as diagrams or drawings  
- Videos & films  
- Newspapers or magazines  
- Gestures  
- Physical movements  
- Music & songs

### Graphic Supports*  
- Graphs  
- Charts  
- Timelines  
- Number lines  
- Graphic organizers  
- Graphing paper

### Interactive Supports*  
- In a whole group  
- In a small group  
- With a partner such as **Turn-and-Talk**  
- In pairs as a group (first, two pairs work independently, then they form a group of four)  
- In triads  
- Cooperative learning structures such as **Think-Pair-Share**  
- Interactive websites or software  
- With a mentor or coach

### Verbal and Textual Supports  
- Labeling  
- Students’ native language  
- Modeling  
- Reiterations  
- Paraphrasing  
- Summarizing  
- Guiding questions  
- Clarifying questions  
- Probing questions  
- Leveled questions such as **What? When? Where? How? Why?**  
- Questioning prompts & cues  
- Word Banks  
- Sentence starters  
- Sentence frames  
- Discussion frames  
- Talk moves, including **Wait Time**

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*Adapted from Understanding the WIDA English Language Proficiency Standards: A Resource Guide. 2007 Edition. Board of Regents of the University of Wisconsin System, on behalf of the WIDA Consortium—www.wida.us.
**Building Equity in Your Teaching Practice**

How do the essential questions highlight the connection between the big ideas of the unit and equity in your teaching practice?

<table>
<thead>
<tr>
<th>CONTENT INTEGRATION</th>
<th>KNOWLEDGE CONSTRUCTION</th>
<th>PREJUDICE REDUCTION</th>
<th>EQUITABLE PEDAGOGY</th>
<th>EMPOWERING SCHOOL CULTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers use examples and content from a variety of cultures &amp; groups.</td>
<td>Teachers help students understand how knowledge is created and influenced by cultural assumptions, perspectives &amp; biases.</td>
<td>Teachers implement lessons and activities to assert positive images of ethnic groups &amp; improve intergroup relations.</td>
<td>Teachers modify techniques and methods to facilitate the academic achievement of students from diverse backgrounds.</td>
<td>Using the other four dimensions to create a safe and healthy educational environment for all.</td>
</tr>
</tbody>
</table>

- **This unit / lesson is connected to other topics explored with students.**
- **There are multiple viewpoints reflected in the content of this unit / lesson.**
- **The materials and resources are reflective of the diverse identities and experiences of students.**
- **The content affirms students, as well as exposes them to experiences other than their own.**
- **This unit / lesson provides context to the history of privilege and oppression.**
- **This unit / lesson addresses power relationships.**
- **This unit / lesson helps students to develop research and critical thinking skills.**
- **This curriculum creates windows and mirrors* for students.**
- **This unit / lesson helps students question and unpack biases & stereotypes.**
- **This unit / lesson helps students examine, research and question information and sources.**
- **The curriculum encourages discussion and understanding about the groups of people being represented.**
- **This unit / lesson challenges dominant perspectives.**
- **The instruction has been modified to meet the needs of each student.**
- **Students feel respected and their cultural identities are valued.**
- **Additional supports have been provided for students to become successful and independent learners.**
- **Opportunities are provided for student to reflect on their learning and provide feedback.**
- **There are opportunities for students to connect with the community.**
- **My classroom is welcoming and supportive for all students?**
- **I am aware of and sensitive to the needs of my students and their families.**
- **There are effective parent communication systems established. Parents can talk to me about issues as they arise in my classroom.**

Culturally Relevant Pedagogy Examples

<table>
<thead>
<tr>
<th>Everyone has a Voice: Create a classroom environment where students know that their contributions are expected and valued.</th>
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</thead>
<tbody>
<tr>
<td><strong>Example:</strong> Norms for sharing are established that communicate a growth mindset for mathematics. All students are capable of expressing mathematical thinking and contributing to the classroom community. Students learn new ways of looking at problem solving by working with and listening to each other.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Run Problem Based Learning Scenarios: Encourage scientifically productive discourse among students by presenting problems that are relevant to them, the school and/or the community.</th>
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</thead>
<tbody>
<tr>
<td><strong>Example:</strong> Using a Place Based Education (PBE) model, students explore science concepts while determining ways to address problems that are pertinent to their neighborhood, school or culture.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Encourage Student Leadership: Create an avenue for students to propose problem solving strategies and potential projects.</th>
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<tbody>
<tr>
<td><strong>Example:</strong> Students can deepen their understanding of engineering criteria and constraints by creating design challenges together and deciding if the problems fit the necessary criteria. This experience will allow students to discuss and explore their current level of understanding by applying the concepts to relevant real-life experiences.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Present New Concepts Using Student Vocabulary: Use student diction to capture attention and build understanding before using academic terms.</th>
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<tbody>
<tr>
<td><strong>Example:</strong> Teach science vocabulary in various modalities for students to remember. Use multi-modal activities, analogies, realia, visual cues, graphic representations, gestures, pictures and cognates. Directly explain and model the idea of vocabulary words having multiple meanings. Students can create the Word Wall with their definitions and examples to foster ownership.</td>
</tr>
</tbody>
</table>

Appendix A: NGSS-S and Foundations for the Unit

| 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 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) |
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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)

Construct an explanation based on evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales. [Clarification Statement: Emphasis is on how processes change Earth’s surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.] (MS-ESS2-2)

Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).] (MS-ESS3-2)

Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.] (MS-PS4-1)

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
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<tbody>
<tr>
<td>Using Mathematics and Computational Thinking</td>
<td>ESS1.A: The Universe and Its Stars</td>
<td>Patterns</td>
</tr>
<tr>
<td>• Use mathematical representations to describe and/or support scientific conclusions and design solutions. (MS-PS4-1)</td>
<td>• 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)</td>
<td>• Patterns can be used to identify cause-and-effect relationships. (MS-ESS1-1)</td>
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<td>• Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2), (MS-PS4-1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scale, Proportion, and Quantity</td>
</tr>
<tr>
<td>Developing and Using Models</td>
<td>Analyzing and Interpreting Data</td>
<td>Constructing Explanations and Designing Solutions</td>
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<tr>
<td>- Develop and use a model to describe phenomena. (MS-ESS1-1),(MS-ESS1-2)</td>
<td>- Analyze and interpret data to determine similarities and differences in findings. (MS-ESS1-3)</td>
<td>- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future. (MS-ESS2-2)</td>
</tr>
<tr>
<td><strong>Developing and Using Models</strong></td>
<td><strong>Analyzing and Interpreting Data</strong></td>
<td><strong>Constructing Explanations and Designing Solutions</strong></td>
</tr>
<tr>
<td><strong>Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2)</strong></td>
<td><strong>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. (MS-ESS1-2),(MS-ESS1-3)</strong></td>
<td><strong>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)</strong></td>
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<td>40</td>
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</table>

- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)

**PS4.A: Wave Properties**

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1)

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**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)

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<table>
<thead>
<tr>
<th>English Language Arts</th>
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- Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-3), (MS-ESS2-2), (MS-ESS3-2) **RST.6-8.1**
- Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS2-2) **WHST.6-8.2**
- 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), (MS-ESS3-2) **RST.6-8.7**
- Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and Reason abstractly and quantitatively. (MS-ESS1-3), (MS-ESS2-2), (MS-ESS3-2), (MS-PS4-1) **MP.2**
- Model with mathematics. (MS-ESS1-1), (MS-ESS1-2), (MS-PS4-1) **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**
- Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS4-1) **6.RP.A.1**
- Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS4-1) **6.RP.A.3**
- Recognize and represent proportional relationships between quantities. (MS-ESS1-1), (MS-ESS1-2), (MS-ESS1-3), (MS-PS4-1) **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
<table>
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<tr>
<td>add interest. (MS-ESS1-1), (MS-ESS1-2), (MS-ESS2-2), (MS-PS4-1) <strong>SL.8.5</strong></td>
<td>number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS1-2), (MS-ESS2-2), (MS-ESS3-2) <strong>6.EE.B.6</strong></td>
</tr>
<tr>
<td>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), (MS-ESS2-2), (MS-ESS3-2) <strong>7.EE.B.6</strong></td>
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<thead>
<tr>
<th><strong>Suggested Field Trips</strong></th>
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<tbody>
<tr>
<td>American Museum of Natural History’s Hayden Planetarium, Newark Museum’s Planetarium, PANTHER Planetarium</td>
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