MIDDLE SCHOOL EARTH SCIENCE: SPACE SCIENCE

Standards Bundle

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon potential for related phenomena that can be used throughout a unit.

MS-ESS1-1 Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. (SEP: 2; DCI: ESS1.A, ESS1.B; CCC: Patterns) [Clarification Statement: Examples of models can be physical, graphical, or conceptual.]

MS-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. (SEP: 2; DCI: ESS1.A, ESS1.B; CCC: Systems) [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-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system. (SEP: 4; DCI: ESS1.B; CCC: Scale/Prop., Technology) [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.]

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

Patterns in the motion of objects in the solar system can be observed, described, predicted and explained. These patterns are responsible for seasons, eclipses, moon phases, and the apparent relative motion of objects in the sky. Even though the planets, moons, and the sun are vastly different in size and scale, each has its own gravity, which acts on all these objects. The sun's gravity keeps all planets in a predictable orbit around it.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- It is cold outside in the winter even when the sun is out.
- Mom drives me to school the same way each day, but for a week or two each fall, the sun shines right in her eyes so much that she can barely see to drive.
- The days are "longer" in the summer than they are in the winter.

- The moons of other planets also exhibit phases.
- The solar system would be affected if the Sun were bigger or smaller.
- Eclipses do not happen every month.
- Sometimes the moon appears to be as big as the sun.
- When South Dakota is having winter, Australia, Brazil and South Africa are having summer.
- The moon appears to change shape during the phases.

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena. **Analyzing and Interpreting Data** • Analyze and interpret data to determine similarities and differences in findings.	**ESS1.A: The Universe and Its Stars** • Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** • This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. • The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.	**Patterns** • Patterns can be used to identify cause-and-effect relationships. **Systems and System Models** • Models can be used to represent systems and their interactions. **Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Our galaxy is the Milky Way, which is one of many in the universe. Within the Milky Way, Earth exists as part of our solar system. The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit due to gravity around the sun. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. The sun's gravity keeps Earth in its orbit around the sun and the Earth's gravity holds our moon in its orbit. Patterns of the apparent motion of the sun, the moon, and the stars in the sky can be observed, described, predicted and explained with models.

Every object in the universe has mass and mass exerts a gravitational pull on other objects. Gravitational forces are always attractive and the mass of an object determines how strong the gravitational pull is. The gravitational force between any two masses depends on the size of the masses, the larger the mass, the larger the gravitational force. An example of two large masses is the Earth and the moon. Because Earth and the moon are both relatively large, they have a great gravitational force between them and cannot move independently of one another. The gravitational pull on the moon toward the center of the earth and the forward speed of the moon's original motion causes the moon to move in an elliptical pattern around the Earth. The same relationship is true for the sun and the other planets that orbit it.

The orbits of the planets and moons are predictable and students should be able to detect their patterns by analyzing their motion. Students should be able to create and use a model to explain gravity's role in the orbits of the planets around the sun and moons around the planets. Emphasis for the model is on gravity as the force that holds together the solar system, 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 their school or state).

Arguments can be constructed and presented that support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. For example, students can research and gather information about the masses of each planet in a system and provide an explanation for the placement of each planet in relation to Earth. Examples of evidence for arguments could include data generated from simulations or digital tools, and charts displaying mass, strength of interaction, distance from the sun, and orbital periods of objects within the solar system.

Students can use models to describe the patterns of the lunar phases and cycle. This includes the moon's orbit around the earth and how the sun illuminates the moon. It takes a little longer than 27 days for the moon to orbit one complete time around the Earth. The moon is always half lit by the sun even though on Earth we see different portions of this light (moon phases). This is because it depends on how the earth and moon are positioned at that point in time. Students can explain why the moon appears to change over time in a predictable pattern and how this phenomenon occurs.

When the sun, moon and Earth are in straight alignment, an eclipse occurs. Solar eclipses are rare. A solar eclipse occurs when the moon is between the sun and the earth and the moon casts a shadow on the Earth. This occurs during a new moon. A lunar eclipse is more common than a solar eclipse. A lunar eclipse occurs when the earth is between the sun and the moon and the moon passes through the Earth's shadow. This occurs during a full moon.

On Earth, we have four seasons which are spring, summer, fall, and winter. These seasons occur because Earth is tilted in its orbit around the sun. Around the month of June the north pole is tilted toward the sun and around the month of December the south pole is tilted toward the sun. As the Earth spins on its axis and orbits the sun, the amount of sunlight the earth is receiving changes. For instance, during summer in the Northern Hemisphere, Earth is tilted toward the sun, so we receive sunlight for a longer amount of time. In the winter, the northern hemisphere is tilted away from the sun and receives sunlight for a shorter amount of time each day. Seasons in the southern hemisphere are also predictable, but are generally opposite of the northern hemisphere. Students should be able to construct an explanation for why the Earth experiences different seasons at different times of the year. As Earth orbits the sun, its tilted axis always points in the same direction. So, throughout the year, different parts of Earth get the sun's direct rays. Sometimes it is the North Pole tilting toward the sun (around June) and sometimes it is the South Pole tilting toward the sun (around December).

It is summer in June in the Northern Hemisphere because the sun's rays hit that part of Earth more directly than at any other time of the year. It is winter in December in the Northern Hemisphere, because that is when it is the South Pole's turn to be tilted toward the sun.

Scale properties of objects in the solar system can be analyzed and interpreted from data collected from various sources. There is an emphasis 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.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.

Resources to inform your formative assessment.

http://stemteachingtools.org/brief/30
http://stemteachingtools.org/brief/41
http://stemteachingtools.org/pd/sessionb

SEP Developing and Using Models

- In a darkened room, use a lamp and a styrofoam ball on stick to demonstrate a lunar eclipse to another student.
- Draw a diagram of the relative positions of the earth on its axis and the sun during each season.

SEP Analyzing and Interpreting Data

- Analyze the differences between the inner planets and the outer planets and explain why the differences exist?

CCC Patterns

- What patterns are observed in moon phases?
- What causes a solar eclipse?
- What causes a lunar eclipse?

CCC Systems and System Models

- Draw a model of the relative positions of the earth on its axis and the sun during each season.
- Draw a model of the parts of the solar system.
- Use a model to explain why the moon appears to change shape (phases).

CCC Scale, Proportion, and Quantity

- Analyze the differences between the inner planets and the outer planets and explain why the differences exist?

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain-size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Develop and use a model** of the Earth-sun-moon system to explain the *patterns* of the motion of the sun, the moon, and the earth.
- **Construct an explanation** of the *solar system* to explain solar and lunar eclipses of the sun and moon.
- **Develop and use a model** to show the *pattern* of the seasons are a result of the tilt of the earth on its axis.
- **Compare and contrast** how seasons are caused by the differential intensity of sunlight on different latitudes of the Earth across the year.
- **Develop and use a model** to describe that the solar system is a *system* consists of the sun and a collection of objects, including planets, their moons, and asteroids.
- **Construct an explanation** for how objects in our solar *system* are held in orbit around the sun by its gravitational pull on them.