Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

8-4.1 Summarize the characteristics and movements of objects in the solar system (including planets, moons, asteroids, comets, and meteors).
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: Most of these objects in the solar system are being dealt with for the first time. Students in 4th grade (4-3.1) recalled that Earth is one of many planets in the solar system that orbit the Sun. Revolution and rotation as movements have also been studied (4-3.4, 5). In 4th grade (4-3.2), students compared the properties (including they type of surface and atmosphere) and the location of Earth to the Sun, which is a star, and the Moon. No other planets or moons have been studied. A complete study of the properties of the Moon that make it unique among other moons in the solar system is studied in high school Earth Science (ES-2.2).

It is essential for students to know that objects that are found in the *solar system* have characteristics based on surface features and atmosphere (if there is one). These objects have movement, usually some type of orbit/revolution and possibly rotation also.

Planets
- Planets may have a terrestrial or rocky surface or a gaseous surface. Gaseous planets are considerably larger than terrestrial planets.
- Planets may have rings. Some planets have a unique surface characteristic, for example color or an atmospheric storm.
- Movement of planets is based on revolution around the Sun and rotation on the planet's axis.

Moons
- Moons are studied in relation to the planet they orbit. Not all planets have moons.
- Most are rocky bodies covered with craters, but some have unique characteristics.
- Movement of moons is based on revolution around their planets.

Asteroids
- Most asteroids are rocky bodies that orbit in a region in the solar system known as the asteroid belt between Mars and Jupiter.
- They vary in size and shape.
- Movement is based on their revolution around the Sun.
- Some asteroids outside the asteroid belt have orbits that cross Earth's orbit; scientists monitor the positions of these asteroids.

Comets
- Comets have a main body or head (ices of water, methane and ammonia and dust) and a tail that emerges as the comet gets closer to the Sun during its orbit.
- The tail always points away from the Sun. Comets have unique long, narrow elliptical orbit.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

Meteoroids

- Meteoroids are chunks of rock that move about within the solar system.
- Location and movement result in the different terms:
  - Meteor – when the chunk of rock burns up in a planet's atmosphere; or
  - Meteorite – when the chunk of rock strikes the surface of a planet or moon.

It is not essential for students to know specific data about each planet, for example, exact distance from the Sun, time of revolution or rotation or the diameter. Students do not need to identify the names of or number of moons a planet has.

Assessment Guidelines:

The objective of this indicator is to *summarize* the characteristics and movements of objects in the solar system; therefore, the primary focus of assessment should be to generalize major points about characteristics and movements of planets, moons, asteroids, comets and meteors. However, appropriate assessments should also require students to *interpret* a diagram of the objects in the solar system; *compare* objects in the solar system; *classify* objects in the solar system based on characteristics; *classify* by sequencing planets in order from the Sun or by size; or *identify* an object in the solar system based on its unique characteristics or movements.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

8-4.2 Summarize the characteristics of the surface features of the Sun: photosphere, corona, sunspots, prominences, and solar flares.
Taxonomy level: 2.4-A, B Understand Factual & Conceptual Knowledge

Previous/Future knowledge: In 1st grade (1-3.1), the Sun was a feature in the daytime sky. In 4th grade (4-3.2), the Sun, a star, is compared to Earth. Studying nuclear fusion in stars and the formation of elements from that fusion is part of high school Earth Science (ES-2.4).

It is essential for students to know the characteristics of the surface features of the Sun.
The Sun's atmosphere includes the photosphere and the corona:

- The *photosphere* emits light and is the most prominent layer of the Sun's atmosphere.
- During a total eclipse when the photosphere is blocked, the *corona*, the outer layer of the Sun's atmosphere that looks like a white halo, can be seen.

Other features on or above the Sun's surface are sunspots, prominences, and solar flares.

- *Sunspots* are areas of gas on the sun that are cooler than the surrounding gases and therefore do not give off as much light and appear as dark spots on the photosphere.
- *Prominences* are huge, looping eruptions of gas, usually near sunspots, that arch out from the photosphere into the outer layers of the Sun's atmosphere.
- *Solar flares* are explosions of hot gas that occur when prominences connect. They shoot from the Sun's surface releasing tremendous amounts of energy into space.

It is not essential for students to know the layers of the Sun's interior, nor the specific temperature data of the Sun's layers. The nuclear fusion process that releases the light and heat does not need to be explained. Since the chromosphere is so seldom visible, it is not being dealt with in this indicator.

Assessment Guidelines:
The objective of this indicator is to *summarize* the characteristics of the surface features of the Sun; therefore, the primary focus of assessment should be to generalize major points about these characteristics (including photosphere, corona, sunspots, prominences, and solar flares). However, appropriate assessments should also require students to *interpret* a diagram containing these features; *compare* these features; or *identify* the feature based on its unique characteristics.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

8-4.3 Explain how the surface features of the Sun may affect Earth.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: In 1st grade (1-3.2), the Sun is recognized as the source of light and heat on Earth. In 4th grade (4-3.3, 4-3.4), students also explained the Sun's affects on Earth and relate heat and light to seasons.

It is essential for students to know that:

- The Sun's photosphere radiates light and heat from its surface and some of it reaches Earth.
- The corona sends out electrically charged particles, called *solar wind*. Most of these particles do not reach Earth's surface because of the atmosphere and the magnetic field around Earth.
- Near the poles, the *auroras* can form when these charged particles cause gases in the atmosphere to glow.
- Solar flares and prominences increase the particles in the solar wind that in turn affect magnetic storms in Earth's atmosphere.
- Magnetic storms often disrupt radio, telephone, and television signals.

It is not essential for students to know the entire spectrum of radiation that comes from the Sun, or the theories of the effects of sunspot activity on Earth's climate over time.

Assessment Guidelines:
The objective of this indicator is to *explain* how the surface features of the Sun may affect Earth; therefore, the primary focus of assessment should be to construct a cause-and-effect model of the various solar features on Earth. However, appropriate assessments should also require students to *infer* a solar feature based on a description of an event on Earth; or *recognize* terms that would identify a particular cause or effect.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

8-4.4 Explain the motions of Earth and the Moon and the effects of these motions as they orbit the Sun (including day, year, phases of the Moon, eclipses, and tides).
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: Eclipses are a new concept to the content at this grade level. In 4th grade (4-3.5), students explained the effects of the rotation of Earth. The effect on the length of a shadow based on the position of the Sun in the sky during the day was studied in 4th grade (4-3.7). In 1st grade (1-3.4), the patterns of change in the Moons appearance were illustrated but not related to motion. In 4th grade (4-3.6), students illustrated the phases of the Moon and the effect of the Moon on tides but not the Sun's effect.

It is essential for students to know that Earth and the Moon both revolve and rotate and these motions have effects that can be observed on Earth.

Day
- A *day* is based on the 24 hours it takes Earth to rotate.
- Earth rotates on its *axis* counterclockwise from west to east; as a result, the Sun appears to rise in the east and set in the west.

Year
- A *year* is based on the 365¼ days it takes Earth to revolve around the Sun.
- Earth revolves around the Sun in an *elliptical orbit*.

Lunar Movement
- The Moon revolves with Earth around the Sun as the Moon is revolving around Earth.
- The Moon revolves around Earth in 29½ Earth days.
- Similarly to Earth, as the Moon revolves, it is rotating or spinning on its axis.
- The rotation time for the Moon is a little over 27 Earth days.
- Because the Moon rotates and revolves in nearly the same amount of time, the same side of the Moon always faces Earth.

Phases of the Moon
- As the position of the Moon changes as it revolves around Earth, the observations of the Moon from Earth are seen as *phases* (new moon, waxing crescent, first quarter, waxing gibbous, full moon, waning gibbous, third quarter, waning crescent)
- The cause of the *phases of the Moon* depends on how much of the sunlit side of the Moon faces Earth.

Eclipses
- *Eclipses* of the Sun and Moon are a result of an alignment of Earth, Sun, and Moon.
- *A solar eclipse* occurs when the Moon is directly in-between the Sun and Earth, blocking the Sun's light casting a shadow over a certain area on Earth.
- *A lunar eclipse* occurs when Earth is directly in-between the Sun and the Moon, blocking the Sun's light so that Earth's shadow hits the Moon casting a shadow over the Moon.

Tides

- *Tides* are changes in the surface levels of Earth's ocean water caused by the effects of the Moon's and Sun's gravity on Earth. The effects of tides are most noticeable along ocean shorelines.
- As the Moon orbits Earth, the waters of Earth closest to the Moon bulge outward toward the Moon; this bulge is the *high tide*. Another high tide occurs on the opposite side of Earth. *Low tides* occur in the areas between the two high tides.
- When the Sun and the Moon are aligned the high tides are higher and the low tides are lower; these are called *spring tides*. When the Sun and the Moon are at right angles to each other, the high and low tides, there is the least difference in the tidal range at the shore; these tides are called *neap tides*.

It is not essential for students to know the various calendars that result from interpretation of Earth's day and year or the lunar cycle calendars, or about time zones around Earth.

Assessment Guidelines:
The objective of this indicator is to *explain* the motions of Earth and the Moon and the effects of these motions as they orbit the Sun; therefore, the primary focus of assessment should be to construct a cause-and-effect model of Earth and lunar movements with their results. However, appropriate assessments should also require students to *interpret* diagrams of the movements or the effects that result from the movement; *illustrate* the phases of the moon in sequence; or *identify* periods of time related to Earth or lunar movements.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

8-4.5 Explain how the tilt of Earth's axis affects the length of the day and the amount of heating on Earth's surface, thus causing the seasons of the year.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: In 4th grade (4-3.4), students explained how the tilt of Earth's axis and revolution around the Sun resulted in seasons, but not the effect of direct or indirect rays of the Sun on the amount of heating that takes place.

It is essential for students to know that:

- The angle of the Sun's rays due to the position of Earth in its orbit, the tilt of Earth's axis, and the number of daylight hours causes the differences in the seasons.
- The number of daylight hours changes throughout the year because as Earth revolves around the Sun, the tilt of its axis (23½ degrees) determines the amount of time that the Sun is shining on that portion of Earth. The tilt remains at the same angle and points at the same direction as Earth revolves around the Sun.
- If the tilt of Earth is toward the Sun, there is a longer length of day, the season is summer. If it is neither tilted toward or away from the Sun, the length of day and night is equal, the season is fall and spring. If the tilt of Earth is away from the Sun, there is a shorter length of day, the season is winter.
- Earth has *seasons* because its axis is tilted in the same direction as it moves around the Sun not because of any distance difference between the Sun and Earth.
- The combination of direct rays from the Sun that strike Earth at higher angles (closer to 90 degrees) and more daylight hours causes the hemisphere of Earth tilted toward the Sun to have warmer temperatures.
- The combination of indirect rays from the Sun that strike Earth at lower angles and less hours of daylight in the hemisphere of Earth angled away from the Sun have cooler temperatures.
- The day when the tilt of Earth causes the length of day to be the longest or the shortest, a *solstice* occurs. This is the start of summer and winter.
- The day when the tilt of Earth causes the length of day and night to be equal, an *equinox* occurs. This is the start of spring and autumn.

NOTE TO TEACHER: Students may have a misconception about the distance between Earth and the Sun causing Earth to be warmer or cooler since their experiences have shown them that the closer something is to a heat source the warmer/hotter it gets. This is not the case with seasons on Earth.

It is not essential for students to know the specific dates that each season begins. Students might discuss the height of the Sun above the horizon at various seasons of the year, but it is not essential to this indicator.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

Assessment Guidelines:

The objective of this indicator is to *explain* the tilt of Earth's axis affects the length of the day and the amount of heating on Earth's surface, thus causing the seasons; therefore, the primary focus of assessment should be to construct a cause-and-effect model of how Earth's tilt results in varied daylight hours and unequal heating of Earth's hemispheres and seasonal change. However, appropriate assessments should also require students to *interpret* diagrams of unequal heating resulting from the tilt; *illustrate* the position of Earth with its tilted axis at various seasons; or *recall* when solstices and equinoxes occur.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

8-4.6 Explain how gravitational forces are influenced by mass and distance.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: The pull of gravity and its effect on motion was introduced in 3rd grade (3-5.4). In 5th grade (5-5.1), students will identify gravity as a force that affects motion. High school Physical Science and Physics will continue the study of gravity as related to acceleration, projectile motion, and gravitational potential energy.

It is essential for students to know that the force of *gravity* is a pull between all objects in the universe. This force is influenced by the mass of the objects and the distance between them.

- A more massive object has the greater pull on the less massive objects; the Sun being most massive object in the solar system has the greatest pull on objects, like planets, in the solar system.
- The closer the distance between objects the greater the pull; the Moon has a greater effect on Earth's tides than the Sun because it is closer to Earth.
- These two factors of gravitational force have numerous applications on motions of celestial bodies, for example the gravitational pull between the Sun and the planets and between Earth and its Moon cause distinct motions between and among these bodies (8-4.7).

It is not essential for students to know the inverse square law relationship of gravity to distance or mass. The concept of acceleration due to gravity is also not essential to the indicator.

Assessment Guidelines:
The objective of this indicator is to *explain* how gravitational forces are influenced by mass and distance; therefore, the primary focus of assessment should be to construct a cause-and-effect model of objects varying these factors. However, appropriate assessments should also require students to *interpret* diagrams that show varying aspects of these factors; or *infer* how a change in one factor would change the force of gravity.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

8-4.7 Explain the effects of gravity on tides and planetary orbits.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: Tides as an effect of the Moon was illustrated in 4th grade (4-3.6), but being an effect of the pull of gravity is new conceptual material. Gravity effecting planetary orbits is a new concept in this grade. High school Earth Science students will study further the effect of gravity on the formation and shapes of galaxies (ES-2.8).

It is essential for students to know that tides and planetary orbits are caused by the pull of gravity.

Effects of Gravity on Tides

- The Moon being closer to Earth than the Sun (distance) has the greatest pulling effect on *tides*, the rise and fall of ocean water in this case.
- The Sun also pulls on Earth and
  - can combine its force with the Moon causing even higher tides, *spring tides*
  - or can be a right angles, pulling against the Moon's pull, causing very little tidal change, *neap tides*.

Effects of Gravity on Planetary Orbits

- The Sun's gravitational attraction, along with the planet's inertia (continual forward motion), keeps the planets moving in *elliptical orbits* (Earth's orbit is slightly oval) and determines how fast they orbit.
- Planets nearer the Sun move/orbit faster than planets farther from the Sun because the gravitational attraction is greater.
- When a planet is farther from the Sun, the gravitational attraction between them decreases and the planet moves/orbits slower.

It is not essential for students to know how gravitational force causes the high tides on both sides of Earth, or how to produce an elliptical orbit using two foci.

Assessment Guidelines:
The objective of this indicator is to *explain* the effects of gravity's pull on tides and planetary orbits; therefore, the primary focus of assessment should be to construct a cause-and-effect model that varies the effect of the pull of gravity in different ways. However, appropriate assessments should also require students to *interpret* diagrams that show varying aspects of tidal pull or planetary orbits; *infer* how a change in the force of gravity would change other factors; or *recognize* the factors that keep planets in orbit around the Sun.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

8-4.8 Explain the difference between mass and weight by using the concept of gravitational force.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: Students were introduced to the use of a balance for measuring mass (2-1.2, and also in math), and mass as a property of solids and liquids (2-4.1), in 2nd grade. The use of the spring scale was introduced in 6th grade (6-1.1). This concept of the difference between mass and weight, although they are related, is new to this grade. Students may come with a misconception that they are the same since instruction in previous grades has dealt with objects on Earth where there is very little difference noted in the measurement of mass and weight and the standard English units are the same.

It is essential for students to know that the concept of gravitational force can be used to explain the difference between mass and weight.

Mass
- *Mass* is the amount of matter in an object; it does not depend on forces acting on it.
- Mass is the same no matter where the object is located as long as the object does not gain or lose any of its matter.
- An object that has mass can be pulled on by gravitational force.
- Mass is measured on a balance.

Weight
- W*eight* is a measure of the pull of gravity on an object.
- Weight is related to mass but they are not the same.
- Weight on Earth is based on the pull of gravity toward the center of Earth.
- Weight can change on Earth since the pull of gravity is not the same everywhere.
- Weight is measured using a *spring scale*.
- Weight can change if an object is located on another object in space, for example, the Moon or Mars.
- The mass of that larger object determines the pull of gravity and therefore the weight of the object.
- Weight may change due to the change in gravitational force, but mass stays the same.

It is not essential for students to calculate weight differences between an object on Earth and the Moon, or convert mass in kilograms to weight in newtons.

Assessment Guidelines:
The objective of this indicator is to *explain* the difference between mass and weight using the concept of gravitational force; therefore, the primary focus of assessment should be to construct a cause-and-effect model that shows how gravitational force affects mass and weight but makes them different. However, appropriate assessments should also require students to *compare* mass and weight; or *infer* whether an object would be heavier or lighter based on gravitational pull.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

8-4.9 Recall the Sun's position in the universe, the shapes and composition of galaxies, and the distance measurement unit (light year) needed to identify star and galaxy locations.

Taxonomy level: 1.2-A Remember Factual Knowledge

Previous/Future knowledge: This indicator contains new conceptual material. Students will expand on this knowledge in high school Earth Science as they then develop understanding of the classifications of stars (ES-2.5), the life cycle of stars (ES-2.7), and how gravity and motion affect the formation and shapes of galaxies (ES-2.8).

It is essential for students to know that:

- The Sun is a star in the Milky Way galaxy located in a spiral arm about two-thirds of the way from the center of the galaxy.
- *Galaxies* are made up of gas, dust, and billions of stars and have different shapes –
  - *elliptical* – spherical or flattened disks,
  - *spiral* – a nucleus of bright stars and two or more spiral arms, or
  - *irregular* – no definite shape
- Because distances in space are so great that conventional numbers are too large to work with, astronomers use a unit of measurement called *light year* to measure the distance to stars and galaxies in space. The distance in one light year is equal to the distance light travel in one year.

NOTE TO TEACHER: Students may come with a misconception that the Milky Way galaxy is in the solar system because they may have seen the band of stars in the night sky. The relationship between objects within the solar system and those out in the universe is an important concept to form accurately at this time.

It is not essential for students to know other characteristics of the Milky Way galaxy, or how galaxies came to have their shapes, or the characteristics of the stars in the various galaxies. The study of stars, their magnitudes, classifications and life cycle, is not included with this indicator. Using the measurement, astronomical unit, and parallax to determine distances in space is also not necessary.

Assessment Guidelines:

The objective of this indicator is to *recall* the Sun's position in the universe, the shapes and composition of galaxies, and the measurement unit light year; therefore, the primary focus of assessment should be to remember what is needed to identify star and galaxy locations. However, appropriate assessments should also require students to *identify* the name of Earth's galaxy or the meaning of light year.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

8-4.10 Compare the purposes of the tools and the technology that scientists use to study space (including various types of telescopes, satellites, space probes, and spectroscopes).
Taxonomy level: 2.6-B Understand Conceptual Knowledge

Previous/Future knowledge: This indicator is mostly new material for this grade. Only, the purpose of telescopes, in general, as a tool of astronomy is recognized in 4th grade (4-3.8).

It is essential for students to know that astronomers use telescopes, satellites, space probes, and spectroscopes to make observations and collect data about objects in the solar system and outside of the solar system. These tools and the associated technology that allow astronomers to analyze and interpret the data help scientists learn about the solar system and about the universe.

Telescopes
- Refracting and reflecting *optical telescopes* collect visible light, then use convex lenses or mirrors to focus the light producing larger, brighter images of distant objects in space.
- *Radio telescopes* receive radio waves emitted from objects in space, including waves from very distant stars and galaxies; it can receive information in any weather and during day or night.
- Other telescopes "read" infrared or x-ray signals but have to be placed where Earth's atmosphere does not block or absorb the signals.

Satellites
- *Satellites* are placed in orbit around Earth with special instruments and telescopes that collect information from space which is sent back to Earth where it is interpreted.
- Data gathered from satellites are not hampered by Earth's atmosphere.

Space probes
- *Space probes* contain instruments to collect data and travel out of Earth's orbit to explore places that would be too dangerous for astronomers; the instruments that a probe contains depends upon the space mission.

Spectroscopes
- *Spectroscopes* collect the light from distant stars and separate that light into bands of different colors; by studying these bands, astronomers identify the elements in a star.

It is not essential for students to know how the light waves are refracted and reflected within each optical telescope. The names of specific telescopes, satellites, or space probe missions are not necessary.

Astronomy: Earth and Space Systems

8-4 The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)

Assessment Guidelines:

The objective of this indicator is to *compare* the purposes of the tools and technology used to study space; therefore, the primary focus of assessment should be to detect similarities and differences between various types of telescopes, satellites, space probes, and spectroscopes. However, appropriate assessments should also require students to *identify* a tool based on a given purpose; *compare* optical telescopes to a radio telescope; *illustrate* the uses of different tools and technology: or *recognize* the appropriate tool or technology required for a particular task.