Astronomy - Part 2
Sun, Earth and Moon
STUDY GUIDE

S6E2. Obtain, evaluate, and communicate information about the effects of the relative positions of the sun, Earth, and moon.

a. Develop and use a model to demonstrate the ***phases of the moon*** by showing the relative positions of the sun, Earth, and moon.
b. Construct an explanation of the cause of ***solar and lunar eclipses***.
c. Analyze and interpret data to relate the ***tilt of the Earth*** to the distribution of sunlight throughout the year and its effect on ***seasons***.

KEY TERMS

- **axis** – An imaginary line that passes through Earth's center and North and South poles, about which Earth rotates.
- **rotation** – The spinning motion of a planet about its axis.
- **revolution** – The movement of an object around another object.
- **orbit** – The path of an object as it revolves around another object in space.
- **latitude** – The distance north or south from the equator, measured in degrees.
- **solstice** – The two days of the year on which the noon sun is directly overhead at either 23.5 degrees South or 23.5 degrees North.
- **vernal equinox** – The day of the year that marks the beginning of spring in the Northern Hemisphere.
- **autumnal equinox** – The day of the year that marks the beginning of fall in the Northern Hemisphere.
- **phase** – One of the different shapes of the moon as seen from the earth.
- **eclipse** – The partial or total blocking of one object by another.
- **solar eclipse** – The blocking of sunlight to Earth that occurs when the moon is between the sun and Earth.
- **umbra** – The darkest part of a shadow.
- **penumbra** – The part of a shadow surrounding the darkest part.
- **lunar eclipse** – The blocking of sunlight to the moon that occurs when Earth is directly between the sun and moon.
- **tide** – The daily rise and fall of Earth's waters on shores.
- **phase** - The appearance of the illuminated portion of the Moon as seen by an observer, usually on Earth.
- **new moon** - The phase of the moon occurring when it passes between the earth and the sun and is invisible or visible only as a narrow crescent at sunset.
- **full moon** - The moon when it is visible as a fully illuminated disk.
- **first quarter moon** - The phase of the moon which is most easily spotted by the casual observer. You see the moon in this phase in the south as the Sun sets.
- **third quarter moon** - Three weeks after the new moon, we again can see half of the illuminated part. This is usually called third quarter, or last quarter moon.
- **waxing crescent** - A crescent moon moving towards a full moon.
- **waning gibbous** - More than half, but less than fully illuminated, and moving towards a new moon.
- **spring tide** - A tide with the greatest difference between high and low tide that occurs when the sun and the moon are aligned in a line with Earth.
- **neap tide** - A tide with the least difference between low and high tide that occurs when the sun and moon pull at right angles to each other.

PHASES OF THE MOON

	1. The moon **rotates** on its axis at the same pace as it **revolves** around Earth. As a result, the moon always keeps the same side pointed toward us throughout its orbit. Astronomers call the side we see from Earth the "nearside of the moon," and the side we never see from Earth the "far side of the moon." The moon orbits the earth, so it is called a satellite of Earth. The moon is a natural satellite.
	2. During the moon's cycle, the actual shape of the moon never changes. It is always a sphere. However, it appears to change shape. We only see the moon because sunlight reflects back to us from its surface; it has no light source of its own. Gravitational forces between the moon and the earth keep the moon in orbit. Remember the moon does not produce light. But it does reflect light from the sun, which is how we are able to see it from Earth. (Only stars produce light and they are called **luminous** for that reason.) What changes is the portion of the moon that can be seen from Earth. Half of the moon is always illuminated by the sun. The half of the moon facing the sun is always lighted; but the lighted side does NOT always face Earth.
	3. As the moon circles Earth, the amount of its disk facing us that is lighted by the sun changes, altering how much of the lunar surface appears bright and how much is in darkness. The changes are known as phases, and repeat in a specific cycle. These are the primary phases: New Moon, First Quarter, Full Moon, Last Quarter. (It takes 27-30 days to go from one New Moon to the next.)
	4. Sometimes the moon looks like a full circle. That is called a 'full moon'. At other times we see a crescent shaped moon, because we can only see the edge of the part that is lit by the sun. Remember that we can only see the part of the moon that reflects the sun's light. How much of that we can see depends upon the position of the moon in its orbit.
	5. During the time it takes to move from one phase to another, the amount of the moon's surface lighted by the sun changes gradually; it's not an abrupt change from one phase to the next. There are times during the cycle when the moon can be seen during the day. These times are predictable.

TIDES ***and the Earth, Moon and Sun***	
	6. All surfaces of Earth are pulled toward the moon and the sun. The oceans, which are liquid, are greatly affected by two forces of nature: 1. the gravitational pull of the sun and moon, and 2. the centrifugal forces the earth applies as it spins. Since the moon is four hundred times closer to Earth, it has more influence on tides than does the sun.
	7. The daily rise and fall of Earth's waters on its coastlines are called **tides**. During high tide the water level will reach its highest point on a beach. Some sandy beaches become nothing more than a thin line barely wide enough for even one person to walk the shore. But, gradually the water will begin to flow back toward the sea. When the water reaches its lowest point this is called low tide. We have learned that surface currents are caused by winds, and deep currents are caused by water density. Tides are different. **Tides are caused by the interaction of Earth, the moon, and the sun**.
	8. Low tide occurs roughly at moonrise and high tide with a high moon. This corresponds to the simple gravity model of two tidal bulges, however, at most places moon and tides have a phase shift.
	9. The key to understanding how the tides work is to understand the relationship between the motion of our planet and the Moon and Sun. As the Earth spins on its own axis, ocean water is kept at equal levels around the planet by the Earth's gravity pulling inward and centrifugal force pushing outward. However, the Moon's gravitational forces are strong enough to disrupt this balance by accelerating the water towards the Moon. This causes the water to 'bulge.' As the Moon orbits our planet and as the Earth rotates, the bulge also moves. The areas of the Earth where the bulging occurs experience ***high tide*** and the other areas are subject to a ***low tide***.
	10. Between each high tide, there is a low tide. There are usually 2 high and 2 low tides occur each 24 hours and 50 minutes, because that is how long it takes the moon to rotate around Earth.
	11. The gravity of the moon pulls on every particle of Earth. However, the moon's gravitational pull on Earth decreases with distance from the moon. As a result, different parts of Earth are pulled more strongly toward the moon than other parts are. In addition, the pull on liquids is much more noticeable than the pull on solids, because liquids move more easily. Even the liquid in a carton of milk is slightly pulled by the moon's gravity.

	12. **Neap tides** are especially weak tides. Because the moon & sun are perpendicular (right angles) to each other, their gravity causes the bulges to cancel each other out. When the gravitational forces of the moon and the sun are perpendicular to one another (with respect to the Earth), Neap tides occur during quarter moons.
	13. **Spring tides** are especially strong tides (they do not have anything to do with the season Spring). They occur when the Earth, the Sun, and the Moon are in a line. The gravitational forces of the Moon and the Sun both contribute to the tides. Spring tides occur during the full moon and the new moon. The Moon & the Sun's gravitational force combine to create a particularly strong tide.
	14. Tidal changes are different in various parts of the world. Near the equator, there is very little noticeable change because a large volume of water is spread out over a wide range. The highest tides in the world are at the Bay of Fundy in Nova Scotia. The bay is very narrow, so water rushing in from the ocean can rise and fall up to 20 meters a day.

SOLAR AND LUNAR ECLIPSES

	15. **Eclipses**, whether solar or lunar, occur because of the periodic alignments of the sun, Earth, and moon.
	16. A **solar eclipse** happens when the moon casts a shadow on Earth, fully or partially blocking the sun's light in some areas. A solar eclipse can only occur during a new moon, when the sun and the moon are aligned. In a total eclipse, the disk of the sun is fully obscured by the moon. In partial and annular eclipses only part of the sun is obscured.
	17. During a solar eclipse, the moon casts two shadows on Earth. The first shadow is called the **umbra** (UM bruh). This shadow gets smaller as it reaches Earth. It is the dark center of the moon's shadow. The second shadow is called the **penumbra** (pe NUM bruh). The penumbra gets larger as it reaches Earth. People standing in the penumbra will see a partial eclipse. People standing in the umbra will see a total eclipse.

	18. A **total solar eclipse**, or a complete blocking out of the sun's light, can only be seen from the area on the earth's surface that enters the moon's umbra, the smaller shadow. People viewing the eclipse from the area of the earth's surface that enters the penumbra, the larger shadow, will see only a partial blocking of the sun. The sun, moon and Earth must be in a direct line. As seen from Earth, the Moon and the Sun, appear to be the same size in the sky. So if the two are exactly lined up, the Moon can hide the Sun from our sight. In this position, the Moon is in a new phase.
	19. The people who see the total solar eclipse are in the center of the moon's shadow when it hits Earth. The sky becomes very dark, as if it were night. Solar eclipses happen once every 18 months and only last for a few minutes.
	20. During a **partial solar eclipse**, the sun, moon and Earth are not exactly lined up. The sun appears to have a dark shadow on only a small part of its surface.
	21. An **annular eclipse** happens when the moon is farthest from Earth. Because the moon is farther away from Earth, it seems smaller. It does not block the entire view of the sun. The moon in front of the sun looks like a dark disk on top of a larger sun-colored disk. This creates what looks like a ring around the moon.
	22. The moon moves in an orbit around Earth, and at the same time, Earth orbits the sun. Sometimes Earth moves between the sun and the moon. When this happens, Earth blocks the sunlight that normally is reflected by the moon. *(This sunlight is what causes the moon to shine.)* Instead of light hitting the moon's surface, Earth's shadow falls on it causing an eclipse of the moon or **lunar eclipse**. A lunar eclipse can occur only when the moon is full.
	23. A **total lunar eclipse** occurs when the moon and the sun are on exact opposite sides of Earth. Although the moon is in Earth's shadow, some sunlight reaches the moon. The sunlight passes through Earth's atmosphere, which causes Earth's atmosphere to filter out most of the blue light. This makes the moon appear red to people on Earth.
	24. A **partial lunar eclipse** happens when only a part of the moon enters Earth's shadow. In a partial eclipse, Earth's shadow appears very dark on the side of the moon facing Earth. What people see from Earth during a partial lunar eclipse depends on how the sun, Earth and moon are lined up.
	25. A lunar eclipse usually lasts for a few hours. At least two partial lunar eclipses happen every year, but total lunar eclipses are rare. It is safe to look at a lunar eclipse.

TILT OF THE EARTH and SEASONS

	26. A hemisphere is a half of the Earth. The Earth can be divided into four hemispheres: Eastern Hemisphere, Western Hemisphere, Northern Hemisphere, and Southern Hemisphere.
	27. It takes approximately 365 ¼ days for the earth to move around the sun. We get our year based on this movement. While the earth is revolving around the sun it is also spinning on an axis tilted at 23.5 degree. The spin of the earth is its rotation. We do not feel this motion; instead it appears as if the sun is moving. We observe the sun as it "follows a path". The path the sun traces is called the ecliptic. It is a result of Earth's orbital motion around the sun. The Earth's orbit around the sun is NOT a perfect circle. It is an ellipse, which looks more like a flat oval.
	28. An axis is an invisible line around which an object rotates, or spins. The points where an axis intersects with an object's surface are the object's north and south poles.
	29. The tilt causes sunlight to fall more intensely on different parts of the Earth during various parts of the year. The difference in heating of Earth's surface and the length of daylight hours caused by Earth's tilt produces the **seasons.**
	30. The seasons are not caused by how close the earth is to the sun. In fact, the earth is closest to the sun around January 3 (brrrr) and farthest away from the sun around July 4 (whew it's hot). These are estimates because seasons do not always happen at the same time everywhere on Earth.
	31. Seasons are short periods of climate change caused by changes in the amount of solar radiation (sunlight) an area receives. The four main seasons are Spring, Summer, Fall and Winter.

	32. The earth's rotation around the sun determines the seasons. Seasons in the Northern Hemisphere are the opposite in the Southern Hemisphere. Equinoxes occur when parts of the earth experience equal amounts of daylight and dark—in the spring and fall. Solstices occur on days experiencing the most sunlight (summer solstice) and the least sunlight (winter solstice).
	33. Earth has seasons because of the (23.5°) tilt of its axis of rotation. In the Northern Hemisphere, at summer solstice the sun is closest to the North Pole (around June 22). At winter solstice, the sun is closest to the South Pole (around December 22). In the Southern Hemisphere, the names are changed. At equinox, the sun is directly over the equator. Autumnal equinox is around September 22. Spring equinox is around March 22.
	34. Summer occurs in the hemisphere tilted toward the Sun, when its radiation (sunlight) strikes Earth at a higher angle. The number of daylight hours is greater for the hemisphere experiencing Summer. The hemisphere receiving less radiation (sunlight) experiences Winter.
	35. If the Earth was not tilted . . . There would no longer be seasons as we know them. The temperature and precipitation pattern would not vary much. It would still be warm at the equator and cold at the poles. Across the Earth it would be like it is in the middle of fall or spring but it would last all year every year. Areas today that have wet, dry, warm and cold seasons would have a fairly constant weather all year whether it be wet, dry, warm and/or cold.

OUR SUN

	36. The sun is the source of all **energy** for our solar system.
Video - The Sun Video - Characteristics of the Sun	37. The sun, our star, is at the center of the solar system. We need its warmth and light to survive. Without the energy supplied by the sun, Earth would be a cold and inhospitable planet. Our world would have no liquid water, no weather, and no life. The sun's light is not the only reason we should be thankful. Its gravity also holds our solar system together.

	38. Our sun is an ordinary star. It is just one of billions of stars in our galaxy alone. However, as our own star, the sun holds special status for us and is essential to our existence. As stated before, the sun's gravity holds the solar system together, and nuclear fusion within the sun supplies the energy for life on Earth. Without the sun, Earth would be a drastically different place.
	39. The sun has 99.8% of all the mass in our solar system. Things that have more mass have more gravity. This is why all other objects in the system orbit the sun.
	40. The sun is composed of 75% hydrogen and 25% helium. The huge amount of energy the sun gives off comes from nuclear fusion. Our nuclear power plants use nuclear fission, where large, unstable atoms are broken apart and give off energy. In nuclear fusion, the opposite happens. Two hydrogen atoms, the smallest atoms in existence, combine together to make one helium atom. When this happens, a small amount of mass is lost and it is converted to energy according to Einstein's equation E equals m c squared. The huge amounts of energy produced are released in the form of heat and light, both of which reach the earth. The sun is estimated to be about five billion years old and it has enough hydrogen fuel to burn for about another 5 billion years.
	41. The sun's atmosphere is composed of three parts. The photosphere, chromosphere and corona.
	42. The photosphere is the inner layer that we see when we look at the sun.
	43. The chromosphere is the middle layer. It gives off a reddish color but is only visible during an eclipse. This is because the photosphere usually is so powerful that it overshadows the weaker light of the chromosphere. However, during an eclipse the photosphere is blocked by the moon so we can see the chromosphere.
	44. The corona is the outer layer and looks like a white halo around the sun. For the same reasons as with the chromosphere, it is only visible during a solar eclipse when the photosphere can't overpower it because the photosphere is blocked by the moon. The corona sends out solar wind which is basically a stream of charged particles. These particles are usually blocked by our atmosphere and magnetic field. However, the magnetic field has opening at the north and south pole that allow the solar wind to enter our atmosphere where it hits gas particles that cause light to be given off. This light is the southern and northern lights, or aurora borealis, visible near the poles.

	45. The surface of the sun has three main features: sunspots, prominence, and solar flares.
	46. Sunspots are small, dark areas on the sun's surface. They appear dark because they are cooler than the areas around them and hotter things in nature are brighter. While small relative to the size of the sun, and cool relative to hotter areas on the sun's surface, each sunspot can be as big as the earth and still several thousand degrees. The number of sunspots varies predictably over a 10 year cycle and this correlates with weather patterns on earth. We see more varied weather when there are lots of sunspots.
	47. Prominences are reddish loops of gas that connect sun spots. When these loops come in contact with each other, they can connect creating solar flares where explosions of hydrogen gas are sent into space. This increases the solar wind and increases the magnetic storms in our atmosphere, as it cannot filter out the higher volume of solar wind. This disrupts lots of signals we send out including tv, radio, and satellite.

VIDEOS:

The Sun
http://cms.gavirtualschool.org/DEV17/Science/MSScience6/Videos/EarthSunMoon/suncaptivate.mp4

Characteristics of the Sun
http://cms.gavirtualschool.org/DEV17/Science/MSScience6/Videos/EarthSunMoon/ess05_vid_sunbasics_300_raw.mp4

Phases of Moon
https://www.youtube.com/watch?v=AQ5vty8f9Xc&list=PL8dPuuaLjXtPAJr1ysd5yGIyiSFuh0mIL&index=4

Eclipse
https://www.youtube.com/watch?v=PRgua7xceDA&index=5&list=PL8dPuuaLjXtPAJr1ysd5yGIyiSFuh0mIL

Tide: https://www.youtube.com/watch?v=KlWpFLfLFBI&list=PL8dPuuaLjXtPAJr1ysd5yGIyiSFuh0mIL&index=8