AIAA

AEROSPACE MICRO-LESSON

Easily digestible Aerospace Principles revealed for K-12 Students and Educators. These lessons will be sent on a bi-weekly basis and allow grade-level focused learning. - AIAA STEM K-12 Committee

HOW LONG IS A DAY?

While it seems obvious that a day is twenty-four hours long, it is not necessarily that simple. There are four different ways to define a day: by the apparent motion of the sun at any given time (called the solar day), by the apparent motion of the sun averaged over the year (called the mean solar day), by the length of time it takes for the earth to turn 360 degrees on its axis (called the sidereal day), and using the scientific definitions of the units of time (called the standard day).

Next Generation Science Standards (NGSS): Space Systems, Patterns and Cycles

- Discipline: Earth and the solar system
- Crosscutting Concept: Patterns
- Science & Engineering Practice: Analyzing and interpreting data

GRADES K-2

1-ESS1-1. Use observations of the sun, moon, and stars to describe patterns that can be predicted.

1-ESS1-2. Make observations at different times of year to relate the amount of daylight to the time of year.

Ask your class: Who knows what time is? Can anyone explain time? Can we list units of time that we already know? (Make a list - seconds, minutes, hours, days, weeks, months, years.) How old are you? Five? Six? What does that mean? It means that you have traveled around the sun (five - or whatever) times! Who knows when their birthday is? So, you know that on a certain day in a certain month, you were born. There are twelve months in a year, let's name them. (Months - the word comes from moon - originally indicated the length of time that it took the moon to go from new to full and back to new again. Now we use that idea to create regular time periods of about 30 days.) What season were you born? Were you born in winter, spring, summer or fall? Here in the Northern Hemisphere-- hemisphere means half the earth, so we live in the northern half of the earth - we have winter starting in December, spring starting in March, summer starting in June and autumn starting in September. What season is your birthday?

GRADES K-2 (CONTINUED)

The Earth is tipped on its axis 23.5 degrees. As the earth travels around the sun, our angle to the sun changes, giving us seasons. (Do a short demonstration with a ball or two.) Days in winter are short and nights are long. The shortest day and longest night of the year are called the Winter, or December solstice, and it happens around December 20-22. The longest day and shortest night occur on the Summer or June solstice, around June 20-23. The first day of spring is called the Vernal (means green) equinox, and it is a day when days and nights are about the same length for the whole world. The first day of autumn is called the autumnal equinox, about September 20-22.

Ancient people could see seasons change. They knew when to plant seeds to grow food and when to harvest food. They used the sun to tell them the time of day, do you know how? (Take answers.) That is right. When the sun came up, it was morning. When the sun got high in the sky, it was lunchtime and when the sun was setting it was the end of the day - time to stop work, eat, relax, and get ready for bed. How do you know what time things happen? Do you have a favorite television show that comes on at a certain time? What is your favorite time of the day?

Class experiment: Keep a class chart with sunrise and sunset times on it for several months. Make a chart that shows the change in daylight. You can also take a photograph outside at the same time once a week and note the changes to the shadows as time goes by. You can also measure the shadow of the school flagpole or other such object at a regular time - after lunch, or during recess or PE time once a week and have the class record the length of the shadow on their class chart.

An excellent introduction to chronology (the measurement of time), is the book *A Second Is a Hiccup* by Hazel Hutchins. The author compares each of unit of time to an activity such as a hiccup taking about a second, a minute is 60 hops, an hour is enough time to build a sandcastle, etc. The rhyming text and references to familiar activities keep the topic from overwhelming young students. You might read the book with your class (or find a read-aloud video such as this one to share with the class: A Second is a Hiccup Read Aloud) and then brainstorm a list of other events or actions that would fit into each time segment that is mentioned. You could also try some of the examples from the book or your list and see if students are able to complete them in the specified time. For more of a challenge, you might measure the distance walked in a minute, and then multiply that by the number of minutes in a day to see how far you would have traveled if you kept going.

Grades 3-5

5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

To model the motion of the Earth around the sun, first ask the students to each take a sheet of paper and draw a constellation--any picture will do, really. Then, hang these up around the classroom, on all four walls at regular intervals. Now, using either a light or a ball for the sun, place it in the center of the room and put a dot or paper star on the northern wall of the room. Walk a globe around the light source/ball/model sun and show the class how the tilt of the earth affects the way light strikes the globe. Stop at each of the points where an equinox or solstice takes place and explain. Then, take one more walk around the sun and point out that the nighttime 'view' in each location is different - different pictures or constellations will be visible in different seasons.

Class project: if you have a window in the classroom that faces east or west, you can do this in the class. Or, you can assign this project to the students: take a strip of paper, 3" by 8.5" will do (a strip of sheet paper) and tape it into the windowsill of an east or west facing window, on the sill. Make a dot at the midpoint of the strip. Each day – in the mornings if the window is in the east, or the evenings if in the west, stand at the midpoint and note where the sun is rising or setting, and make a mark on the strip of paper to indicate the location of sunrise or sunset. Over about a month, the observer should see the sunrise moving along the horizon. Which way is it moving? What will happen at the winter or summer solstice? Where will it be on the equinox?

Class project: Draw an analemmatic sundial using chalk, in a sunny place outside. This will help your class understand the relationship to time and the sun's movement across the sky: https://plus.maths.org/content/analemmatic-sundials-how-build-one-and-why-they-work.

Ever wonder why we have 24 hours in the day or 60 minutes to an hour? Read the history of time here: https://blog.klockit.com/2014/10/15/the-ancient-babylonian-origins-of-modern-time/.

One full day is twenty-four hours long. Of the twenty-four hours, on average about half are daytime, when the sun is above the horizon, and the other half are nighttime, when the sun is below the horizon. The word "day" can mean either the full twenty-four-hour day or just the part when the sun is above the horizon; this can be very confusing if we are not careful. During the summertime, the part of the day when the sun is above the horizon is more than half the full day while the nighttime is less than half the full day. During the wintertime,

GRADES 3-5 (CONTINUED)

these are reversed: the nighttime is more than half the full day and the daytime is less than half the full day.

It would be an interesting exercise to look at the times of sunrise and sunset in different places on the earth and compare them to how far north and south the places are and the time of year. One web site which gives this information is http://www.sunrisesunset.com/.

Another research idea is to search for statistics related to a 24-hour period. For example, lightning strikes the Earth 8 million times a day and 7 million pizzas are eaten in America every day. What other cool facts could your students discover? A book to begin your search with is *The World in One Day* by Russell Ash.

GRADES 6-8

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.

Standard time is the time that one reads off one's watch or from a clock. It is set by the International Earth Rotation and Reference Systems Service (IERS), which is a worldwide group of laboratories which monitor the rotation of the earth. One standard day is 86,400 seconds long (86,400 = 60 x 60 x 24).

Local solar time is the time of day measured by the position of the sun. Solar noon is the time at which the sun is directly south (or directly north, if in the Southern Hemisphere) of the zenith. Other solar times are measured relative to solar noon. Solar time varies with longitude by four minutes of time for every degree of longitude. Solar time also varies with the time of year because of the ellipticity of the earth's orbit around the sun.

Local mean solar time is the time of day measured by the position of the sun but averaged out over the course of the year. It varies with longitude but not with the time of year.

One sidereal day is the amount of time required for the earth to rotate 360 degrees on its axis. This is significantly less than one standard day (in fact, it is 23 hours, 56 minutes, and 4.1 seconds). The difference is caused by the fact that in one solar day, the earth has moved about a degree farther along in its orbit around the sun. For the sun to be directly overhead the same point on the earth two days in a row, the earth needs to have turned 361 degrees: 360 degrees for a full rotation plus one extra degree to account for its progress in its orbit. If

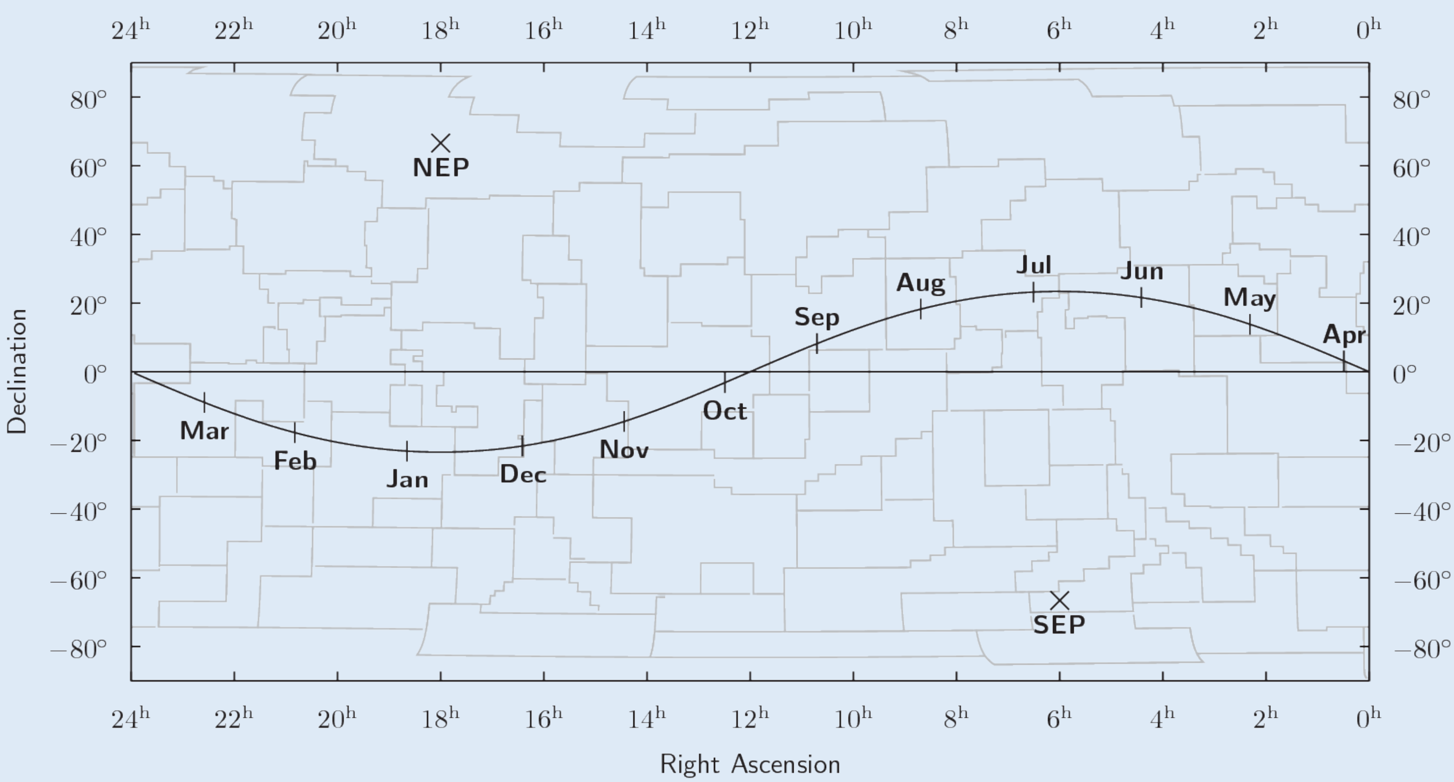
GRADES 6-8 (CONTINUED)

you do the math, you find that the ratio of one sidereal day to one standard day is equal to 365.2425 to 366.2425. The number 365.2425 is the number of days in a year, accounting for leap years.

GRADES 9-12

[HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.](#) (This is the most closely related standard, since divisions of time are based on the Earth's rotation around the sun.)

The difference between local solar time and local mean solar time is shown by a graph called the "equation of time." Confusingly, it is neither an equation nor applicable to time in general, being restricted to the earth's rotation. It looks like this:



https://in-the-sky.org/article.php?term=equation_of_time

The graph shows the local solar time minus the local mean solar time. When it is negative, the sun lags "behind" a fictitious "average sun" and noon local solar time comes later than

GRADES 9-12 (CONTINUED)

noon local mean solar time. This is incredibly difficult to visualize and it is extremely easy to confuse the meanings of the plus and minus signs.

If the equation of time is plotted versus the latitude of the point on the earth's surface directly underneath the sun, the result is a curve called the "analemma." One can usually find an analemma drawn on globes of the earth. Wikipedia has an excellent article on it: https://en.wikipedia.org/wiki/Analemma.

Sixty Years Ago in the Space Race:

August 16, 1960: United States Air Force Captain Joe Kittinger jumped from a balloon at an altitude of 102,800 feet and landed safely with a parachute about 15 minutes later.