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.

CALENDARS

People have used calendars to mark the passage of days, seasons, and years literally since time immemorial. Today in the United States we use the Gregorian calendar, with its familiar twelve months of 28-31 days each and with a leap year every four years more-or-less. But people have not always used this calendar; in fact, even today people in different cultures use different calendars. This lesson explores a few of them.

Next Generation Science Standards (NGSS):
Disciplinary Core Idea: Earth and Space Sciences.
Crosscutting Concept: Patterns.
Science & Engineering Practice: Obtaining, evaluating, and communicating information.

GRADES K-2

NGSS: Earth's place in the universe: Use observations of the sun, moon, and stars to describe patterns that can be predicted.

What day is it today? It may be Monday, Tuesday, Wednesday, Thursday, or Friday; if you are reading this on a weekend it will be Saturday or Sunday.

People use calendars to help organize their lives. We do different things on different days; imagine how boring life would be if we did the same thing every day. A calendar helps us to figure out what to do on what day.

In addition to the days of the week, calendars help us to track the seasons. The weather is hot during the summer and cold during the winter; a calendar tells us when the summer and winter are coming so that we can prepare for them. The calendar also tells you when school will be out!

The names of the days of the week come from thousands of years of tradition. The days of the week are named after astronomical bodies (Sunday from the Sun, Monday from the Moon, and Saturday from Saturn) and, in English, the names of Germanic pagan gods and goddesses (Tuesday from Tiw, Wednesday from Woden or Odin, Thursday from Thor, and Friday from Freya). The Spanish and French languages name most of their weekdays after planets, which got their names from ancient Roman gods and goddesses. Monday is "lunes" or "lundi," named after the Latin word for Moon ("luna"); Tuesday is "martes" or

GRADES K-2 (CONTINUED)

"mardi," from Mars; Wednesday is "miércoles" or "mercredi," named after Mercury; Thursday is "jueves" or "jeudi," named after Jupiter; and Friday is "viernes" or "vendredi," named after Venus. The exceptions are Sunday, which is called "Domingo" in Spanish and "Dimanche" in French, meaning "the Lord's day"; and Saturday, which in Spanish is "sabado" meaning "Sabbath." The name "Sabbath" comes from ancient Hebrew and comes from their word for "seventh." Saturday in French is called "samedi," which comes from "Saturn."

Other traditions include naming the full moons throughout the year. Cultures around the world have given various names to the full moons over the course of history. Many early American colonists adopted these names from the Algonquin tribes, but other tribes used different names for some moons depending on their surroundings and how the seasons affected the tribe. For instance, northern tribes might refer to February as the Snow Moon or the Hunger Moon (since the heavy snow made it hard to hunt for food). You may have heard the phrase, "once in a blue moon," to refer to something that occurs very rarely. A blue moon actually refers to a second full moon falling within a calendar month, which doesn't happen very often.

GRADES 3-5

NGSS: Earth's place in the universe: 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.

Last week (or two weeks ago) it was 2017. Now it is 2018. What has changed? Not much in the physical world. In our society, though, we have changed over from one year to the next and from December to January.

People have been using calendars since before the beginning of history. Indeed, history—the recording of events in an organized fashion—needs a calendar to distinguish between when one event happened and when another event happened.

The weekly calendar that we use is the result of thousands of years of tradition. Our seven-day week comes from the ancient Babylonians and Hebrews, by way of Christianity; it may have started even earlier with the Sumerians. It was not always this way, though; in ancient Rome the people used an eight-day week called a "nundinal cycle"; they changed

GRADES 3-5 (CONTINUED)

from this to a seven-day week over the course of about two hundred years, in the second and third centuries AD. In 1794, during the French Revolution when people were trying out new things and breaking with traditions, they experimented with using a ten-day week but it did not work out and after about 12 years they went back to the traditional calendar. The names of the week days, described in the K-2 lesson, reflect the richness of this tradition.

The calendar that the United States uses is called the Gregorian Calendar. It got its name because it was set forth by Pope Gregory XIII in 1582 on the advice of his astronomers. They wanted a calendar in which the seasons would start around the same date every year. The calendar which they had been using, called the Julian Calendar (after Julius Caesar), had been in use for more than 1,200 years. The slight difference between the length of a year in the Julian Calendar and the amount of time it takes for the Earth to travel around the Sun once had accumulated so that the calendar was off from the Earth's movement by ten days. Countries which adopted the Gregorian Calendar immediately went from October 4, 1582 to October 15, 1582 overnight; there were no days with dates of October 5 through October 14 that year in those countries. Other countries, including England and its colonies (which included the United States at that point), did not make the change until September 2, 1752, which was followed the next day by September 14.

GRADES 6-8

NGSS: Earth's Place in the Universe: 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.

A calendar is based on the rotation of the Earth on its axis, which defines the day, and the revolution of the Earth around the Sun, which defines the year. Extending this to the Moon and to other planets and their moons poses an interesting challenge.

One "day" on the Moon, from sunrise to the next sunrise, takes about 29½ of our Earth days. People cannot stay awake for 14 Earth days straight; nor can we sleep for 14 Earth days straight. People living on the Moon will therefore need to decide on an artificial "day" of roughly 24 hours which will measure their sleeping and waking. Do you think it should be exactly 24 hours, so that the "days" on the Moon are synchronized with the days

GRADES 6-8 (CONTINUED)

on the Earth, or about 25 hours 17 minutes, so that there are exactly 28 lunar "days" from one sunrise to the next, or some other duration? There is no single correct answer; any solution that all the moon colonists agree and can live with will work.

On Mars the solution is much easier. A "day" on Mars, often called a "sol," is 24 hours, 39 minutes, 35.2 seconds long. People can function rather easily with a day of this length; in fact, the team operating the Curiosity rover on Mars lived by Martian sols for some months; teams operating earlier Mars landing and rover missions also did this.

One Martian year, which is the time it takes for Mars to go around the Sun once, is 668.5991 sols, or almost 687 Earth days. The standard Martian year, then, is 668 sols in length while a Martian leap year is 669 sols. Because of the gravitational attraction from the other planets, the eccentricity of Mars' orbit is slowly changing and the length of its year is slowly increasing, by a little less than a tenth of a second per year. (This is an entirely different phenomenon from the slowing down of the Earth's rotation, which is a result of the tidal forces caused by the Moon's gravitational attraction.) This may not seem like much, but it is enough to throw the calendar off by a full sol after about 1330 years. (The calendar will be off by 0.1 seconds after one year, by 0.3 seconds after two years, by 0.6 seconds after three years, and so on, up to being off by 88777.8 seconds after 1332 years. One sol is 88775.2 seconds long.)

There have been several Martian calendars devised over the last century or so. They all need to deal with the Martian year being between 668 and 669 sols long; where they differ is in their treatment of leap years and the definitions of months. Two of the most detailed are the Darian calendar, which uses 24 months of 27 or 28 days each, and the Davidian calendar, which uses 12 months of 55 or 56 days each.

Calendars on other worlds like Mercury (where a day is twice as long as a year and the Sun moves backward in the sky briefly) or Jupiter (where a "day" is only about ten hours long) are interesting to think about but of less practical need. Nobody is going to live on these worlds any time soon. A calendar on a moon of Jupiter or Saturn also presents an interesting problem: a "day" is as long as a "month" (the time it takes the moon to move around its host planet). The host planet also stays in the same position in the sky at all times but it presents phases to the moon, much as the Moon does to the Earth, but as the host planet is much larger it dominates the moon's sky.

GRADES 9-12

NGSS: Earth's Place in the Universe: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

To be useful, a calendar needs at least two things: a "long" counter that changes fairly slowly but does not repeat and a "short" counter that changes every day and starts over with each change to the "long" counter. (One can make an analogy with the tens and higher digits of a number being like the "long" counter and incrementing every time the ones digit changes from a "9" to a "0".) Most, if not all, calendars have an intermediate counter as well; this intermediate counter changes less rapidly than the "short" counter but restarts every time the "long" counter increments. In the Gregorian calendar, which the United States and most of the rest of the world uses, the "long" counter is the year number, the "short" counter is the day of the month, and in between them are the months themselves. That the months go by names rather than numbers does not make them any less of a counter. Finally, a calendar usually needs a starting point or "epoch," which marks the zero point of its long counter.

The first calendars were based on the phases of the Moon. Every time people saw a new Moon in the western sky at sunset, they started a new month on their calendar. The seasons, matching the slow north-and-south movement of the Sun from week to week and month to month (not to mention the changes between cold and hot weather in farther north latitudes), gave them the notion of a year. This didn't work out exactly; the time from one new Moon to the next is just over 29 ½ days, so some months might be 29 days long while others would be 30 days long. If there was bad weather, the sighting of the new Moon might be delayed, making one month longer and the next one shorter. In addition, one year—the time from the start of a season to the start of that season a year later—is just under 365 ¼ days, or almost eleven days longer than twelve months.

As kingdoms were established, the "long" count came to be the name of the current king. Ancient chronicles report events using this method, such as an invasion of Judah from Egypt "in the fifth year of King Rehoboam."

It is worth pointing out that there is no such thing as "the correct calendar." A calendar is an artificial system of measuring time; as long as everybody knows what a particular date in a calendar means, it works. We value having the seasons start on or near the same date each year, which makes the Gregorian Calendar more useful for us, but this does not make the Islamic Calendar with its 354-day "years" wrong. The Islamic Calendar has the

GRADES 9-12 (CONTINUED)

advantage for Muslims of having the month of Ramadan (when they fast during daylight hours) move around the seasons over the course of thirty years, so that at some times the period of daylight will be longer and at other times it will be shorter.

The fictitious system of "Star Dates" used in the Star Trek television series, however, has problems. People have tried without success to connect it to a consistent set of dates.

Sixty Years Ago in the Space Race:

January 4: After three months in orbit, the Soviet Sputnik I space probe re-entered the Earth's atmosphere.

January 12: United States President Eisenhower, having received a letter from Soviet Premier Khrushchev suggesting that outer space be reserved for peaceful use, proposed this publicly.