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AEROSPACE MICRO-LESSON

Easily digestible aerospace principles for K-12 Students and Educators for grade-level focused learning.

OBSERVING THE MOON

The Moon is the Earth's only observable natural satellite. It goes around the earth about once a month; indeed, the word "month" is related to the word "moon." Some calendars, most notably the Jewish and Muslim calendars, still use the sighting of the new moon (or the calculation as to when it should be first visible) to mark the beginning of a new month. Here are some tips about observing the moon that may be of interest.

Next Generation Science Standards (NGSS):

- Discipline: Earth and the Solar System
- Crosscutting Concept: Patterns
- Science & Engineering Practice: Constructing Explanations

GRADES K-2

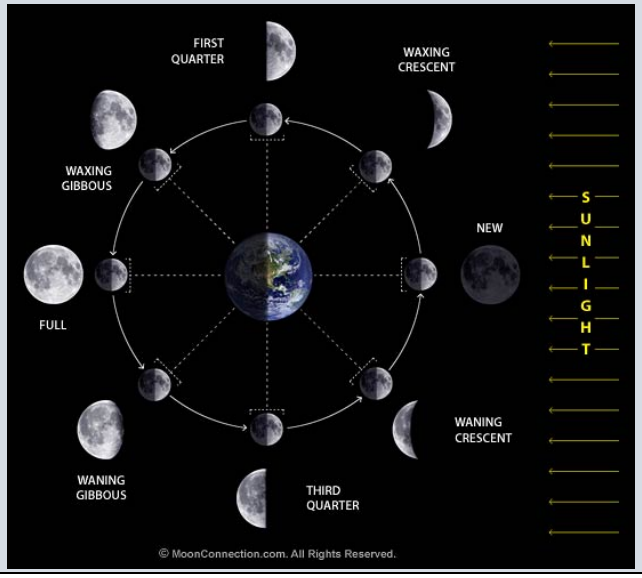
1-ESS1-1. Use observations of the sun, moon, and stars to describe patterns that can be predicted.

I invite the students to go out several (clear) evenings in a row between the new moon and the full moon to observe where the moon is in the sky. They should go out at about the same time every evening to minimize the effects of the earth's rotation. In the early evening, just after the sun has set, the sun is always in the west just below the horizon. The new moon is in the western sky, near the sun. As the days progress, the moon gets farther and farther to the east, farther away from the sun in its orbit.

They can also observe the phases of the moon. Shortly after the new moon, the moon appears as a thin crescent; as it moves farther from the sun in the sky the crescent gets thicker and thicker. At the half moon (confusingly called the "first quarter" because the month is a quarter of the way over), the moon is directly south at sunset, ninety degrees from the sun. As it moves farther to the east in the sky, it becomes gibbous and gets fatter and fatter. Finally, at full moon, it is a complete circle.

A fun activity to share with your class is to create a model of the moon phases using Oreo cookies. (For directions and additional information on moon phases, visit https://spaceplace.nasa.gov/oreo-moon/en/.) Or you can illustrate it with simple objects such as a globe, a ball, and a flashlight or lamp. NASA JPL has a lesson plan for this type of modeling: https://www.jpl.nasa.gov/edu/teach/activity/moon-phases/.

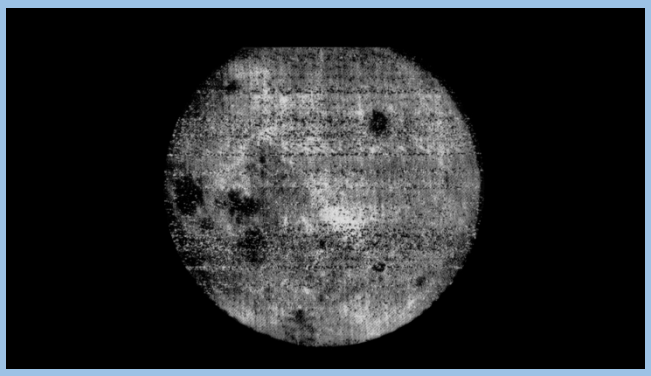
Diagrams of the earth, moon, and sun that illustrate this process are readily available. Here is one such diagram:



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.

In addition to the Grades K-2 activities, I invite the students to notice that the moon keeps the same side facing the earth. This is because the period of the moon—the amount of time it takes to go around the earth once—is exactly equal to the length of the moon's day—the amount of time it takes to make one full rotation on its axis. In fact, from the beginning of history until 1959, nobody knew at all what the far side of the moon looked like. In 1959, Lunik 3 (also called Luna 3) photographed the far side of the moon and transmitted the pictures back to earth.



(Visit https://moon.nasa.gov/resources/26/first-photo-of-the-lunar-farside/ for more images from Luna 3 and from NASA's Lunar Reconnaissance Orbiter.)

Another thing to look for is which way is "up" in the sky. The "face" of the "man in the moon" will provide a very handy reference for this. When the moon is in the south, at the half-moon, "up" in the sky points towards the north. When the moon is towards the west (crescent phases), "up" in the sky points towards the north-east and the moon appears to be turned clockwise from its orientation at the half-moon. When the moon is towards the east (gibbous phases and the full moon), "up" in the sky is pointing more towards the west and the moon appears to be turned counter-clockwise from its orientation at the half- moon.

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.

Grades 6-8 educators may also find the grades 3-5 lesson relevant. Additionally, the Wikipedia article on Lunik 3 is very interesting in its own right.

Sometimes, when the moon is quite new, one can see the dark part of the moon glowing very faintly. This is because of "earthshine." Earthshine is light from the sun which is reflected off the earth and lights up the moon. When we see a new moon or a very thin crescent, somebody on the moon would look up and see an almost full earth. Later in the month, the phase of the earth seen by somebody on the moon would be smaller and there is much less earthshine to illuminate the dark part of the moon. An explanation (with images and a poem) is available from NASA at https://earthobservatory.nasa.gov/images/83782/earthshine.

Enterprising students can get up before sunrise for a week or two after the full moon and see the phases of the moon reversed. Because the sun is about to rise in the east, the full moon will be setting in the west. As the days progress, the moon will move farther to the

east in the sky. The moon's orbit always carries it from west to east; the earth's rotation swamps the effect, though, and causes the moon to rise in the east and set in the west like everything else in the sky.

GRADES 9-12

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

Eclipses happen when the earth, the moon, and the sun line up with each other perfectly. In a lunar eclipse, the shadow of the earth falls on the moon; in a solar eclipse, the shadow of the moon falls on the earth. (The roundness of the earth's shadow on the moon was one of the proofs that the ancients used to show that the earth was round, not flat.) Thus, a lunar eclipse can only happen at a full moon while a solar eclipse can only happen at a new moon.

The plane of the moon's orbit around the earth is tilted by about 5.1 degrees with respect to the ecliptic, which is the plane of the earth's orbit around the sun. This means that at a new moon, the moon usually passes above or below the direct line between the earth and the sun and there is no solar eclipse. Similarly, at a full moon, the moon usually passes below or above the direct line between the earth and the sun (extended through the earth and beyond) and there is no lunar eclipse. Only when a new moon or a full moon happens at the point in its orbit where the plane of the orbit crosses the ecliptic is there an eclipse. This is why eclipses usually happen about six months apart and lunar and solar eclipses usually happen together. Unfortunately, the next couple of lunar eclipses (July 4 and November 29, 2020) will not be very noticeable. They will be penumbral eclipses, with the Earth's shadow causing only a slight darkening of the moon's appearance. The next total eclipse will be May 26, 2021 (https://www.timeanddate.com/eclipse/map/2021-may-26 has a map of eclipse visibility map).

Because the moon's orbit around the earth is not perfectly circular, sometimes it moves faster in its orbit than it rotates and sometimes it moves more slowly in its orbit than it rotates. This means that it does not present exactly the same face to the earth all the time; it appears to "rock" back and forth slightly. Also, because the plane of the moon's orbit is not the same as the plane of its equator, it also appears to "rock" up and down slightly. These slight rocking motions are called "librations." The motions of the moon, both its rotation about its axis and its revolution in its orbit around the earth, are considerably more

complicated than this. Interested students can look up the “Orbit of the Moon” article in Wikipedia.

Sixty Years Ago in the Space Race:

June 20. 1960

Manned tests of the Mercury environmental control system began. (See fig. 38.) The subjects were clothed in pressure suits and subjected to postlanding conditions for 12 hours without serious physiological effects. The purpose of this test was to evaluate human tolerance, and the results indicated that no modification to the system were necessary. However, the postlanding ventilation conditions would continue to be monitored and requirements for any modifications would be evaluated.

NASA Space Task Group, *Project Mercury [Quarterly] Status Report No. 7 for Period Ending July 31, 1960*.