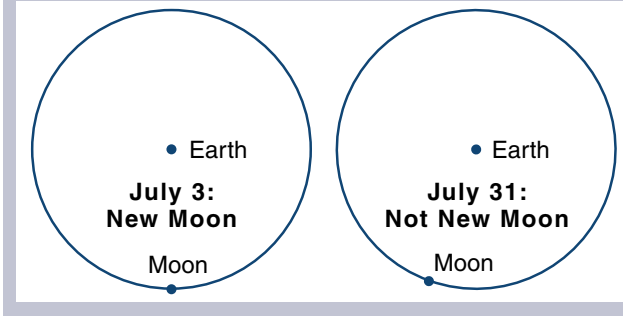
Dance of the planets and our Moon

by Bob Riddle

This summer, the visible planets will put on quite a display, giving us not only the opportunity to compare relative orbital motions, but to also see some beautiful arrangements and conjunctions among the planets, stars, and our Moon. Some of the celestial activity will conveniently take place during the early evening hours and some during the early morning predawn hours. Use the accompanying calendar to follow the Moon and planets during our summer months.

This summer, your students can do an evening Moon watch that will introduce them to interesting relationships among orbiting objects such as the Earth–Moon system, the Earth and the Sun, or the other planets in our solar system. During the first week or so of each of our summer months, the waxing crescent Moon will be near Mars, Saturn, or the star Regulus over the western horizon during the early evening at sunset. With careful observation, students may notice that 28 days later—the length of a lunar cycle—the Moon will again be a waxing crescent, but not in exactly the same location over the horizon. Students may also notice that the phase appearance is not exactly the same. The Moon, after 28 days, has not returned to the "starting" location, but will actually take one or two more days to do so. This is because the Earth is revolving around the Sun at the same time the lunar cycle happens, so it takes a little more time for the Moon to return to the same Earth-Moon-Sun arrangement for the new Moon phase to happen (see Figure 1). In reality, this may be easier to model by using planetarium-type software than from observation (see Resources for freeware astronomy programs).

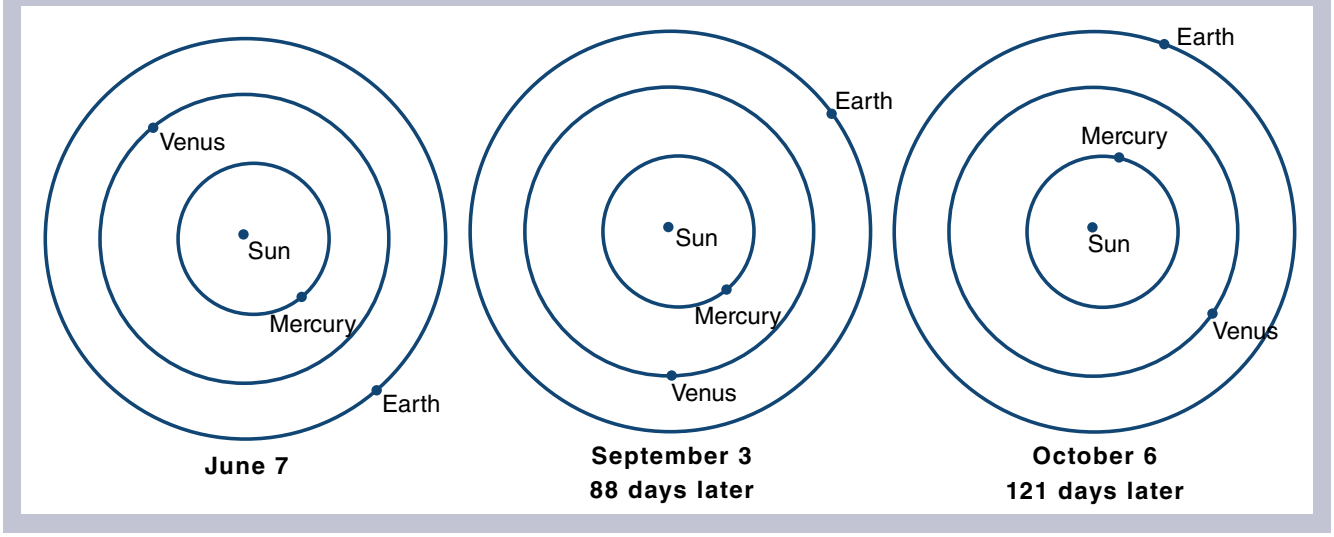
FIGURE 1 The Earth–Moon relationship after one lunar cycle of 28 days



What period is it?

Students observing the lunar cycle are investigating the difference between the terms *sidereal period* and *synodic period,* terms that apply not only to the Earth and Moon, but to all orbiting objects. The *sidereal period* of an object is a motion measured or timed with respect to the stars. For planets, the sidereal period is its orbital period—how long it takes to revolve around the Sun with respect to background stars. For example, we know that Mars takes approximately 1.89 Earth

FIGURE 2 Synodic vs. sidereal with the Earth and Mercury



years to orbit the Sun, or return to the same stars or constellation in the background. In many textbooks showing a typical planet data table, the sidereal period is the value given as the planet's length of year.

The *synodic period* of an object is measured with respect to the Sun's position, and it is the time it takes for the Sun to return to the same location, or for the planet or our Moon to return to the same arrangement with the Earth and Sun. Figure 1 illustrates the difference in the sidereal and synodic periods of our Moon. After 28 days of lunar cycle combined with 28 days of Earth revolution, the Moon is not back in the new Moon lineup, but will be after an additional day or so of Earth revolution. This gives us the synodic month and is in effect what our monthly calendar is based on. The length of the sidereal month is 27.33 days, and the length of the synodic month is 29.5 days.

If you think that summer goes by quickly, consider that during our summer months of June, July, and August, Mercury cycles through a complete year! Figure 2 shows the positions of the Earth, Mercury, and Venus over a 121-day period in 2008. On the left side, the image shows that on June 7 Mercury will be at inferior conjunction—like a new Moon phase. Coincidentally, Venus will be on the opposite side of the Sun near superior conjunction. By September 3, 88 days or one Mercurian year later, Mercury will have returned to the same location, thus completing one sidereal year, as shown in the center image. However, it will take approximately an additional 33 days before Mercury is back to the same position relative to the Earth and the Sun as it was on June 7. The synodic period for Mercury is 118 days, while the sidereal period is 88 days.

Another way to think about synodic and sidereal periods is to consider the Earth as it rotates and revolves. One complete rotation of the Earth is 24 hours, 56 minutes, and 4.09 seconds. However, we measure the length of rotation as equal to 24 hours, and refer to this as the solar day. Remember that the Earth is also revolving as it rotates, so as in the Moon and Mercury examples, there is an additional time period before the Sun or a star is lined up as it was at the start of the timing.

Celestial events

June

3 New Moon
7 Mercury at inferior conjunction
Moon near Mars
8 Moon near Regulus and Saturn
9 Venus at superior conjunction
Moon near Saturn
10 First-quarter Moon
12 Moon near Spica
13 Uranus at west quadrature
Moon near Spica
16 Moon very near Antares

18 Full Moon
19 Mercury ends retrograde motion
20 Moon near Jupiter
June solstice (7:59 p.m. EDT)
Pluto at opposition
24 Summer solstice on Mars
26 Last-quarter Moon
27 Uranus begins retrograde motions
30 Moon near the Pleiades
Mars near Regulus

July
1 Mercury at west elongation
Mars very near Regulus
2 2008 is half over
3 New Moon
4 Earth at aphelion (4:00 a.m. EDT)
Moon near Beehive Cluster
5 Moon west of Mars, Saturn, and Regulus
6 Moon east of Mars, Saturn, and Regulus
9 Jupiter at opposition
10 First-quarter Moon
Moon near Spica
Mars very near Saturn
11 Venus at perihelion
13 Moon near Antares
16 Moon west of Jupiter
17 Moon east of Jupiter
18 Full Moon
25 Last-quarter Moon
27 Moon west of Pleiades
28 Moon east of Pleiades
29 Mercury at superior conjunction
31 *Cassini* flyby of Titan

August
1 New Moon
Solar eclipse
2 Moon near Venus
3 Moon near Saturn
4 Moon near Mars
6 Moon near Spica
Venus near Regulus
8 First-quarter Moon
10 Moon near Antares
11 *Cassini* Enceladus flyby
12 Perseid meteor shower
Moon west of Jupiter
13 Moon east of Jupiter
Venus very near Saturn
15 Neptune at opposition
Mercury very near Saturn
16 Full Moon
Partial lunar eclipse
20 Mercury very near Venus
23 Last-quarter Moon
Moon near the Pleiades
25 Moon near Elnath
27 Moon near Gemini twins
30 New Moon

Questions for students

1. What is a lunar cycle? *(A lunar cycle is the regular changing appearance of the Moon and may be measured from any phase during the cycle, but is typically thought of as the time it takes to go from new Moon to the next new Moon. This is 28 days in length.)*
2. Early in June, the planets and the star Regulus will be higher above the western horizon at sunset than at the end of June. What is happening? *(As the Earth revolves around the Sun, the sky slowly shifts toward the west. What is seen over the south at a certain time at the beginning of a month will be seen further west at the same time at the end of the month. Celestial objects will rise approximately four minutes earlier each day or about two hours earlier each month.)*
3. Explain how the solar day can be four minutes longer than the actual rotation period of the Earth. *(During the time the Earth rotates once, it has moved about one degree along its orbit around the Sun. In order for the Sun or a star to return to its "starting" point, the Earth would have to rotate one additional degree, or about four minutes of time.)*
4. How much does the Earth move along its orbit in one day? *(The Earth travels 360° in 365 days, or 0.986° each day.)*

Resources

Celestia (freeware)—*www.shatters.net/celestia*
Home planet (freeware)—*www.fourmilab.ch/homeplanet*
Monthly star maps—*www.skymaps.com*
SFA star charts—*www.midnightkite.com/starcharts.html*
Stellarium (freeware)—*www.stellarium.org*

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