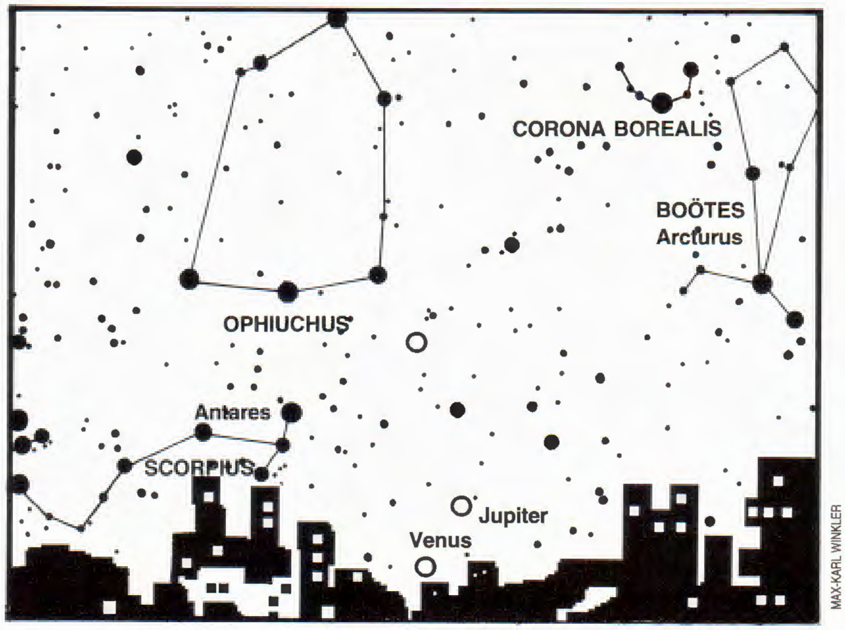
A timely discussion of a topic that affects us all.

Marking time



LOOKING SOUTHWEST AT 7:30 P.M. ON SEPTEMBER 30, 1994.

When we want to know the time, we can usually glance at a watch or clock for an adequate approximation that will suit our needs. In some instances, however, we may not have access to a time piece, or our circumstances may require a more accurate estimation of the time or an accurate measurement of a time span. We may even want to determine the time for a different location here on Earth, or for some distant region in the universe that requires a completely different temporal frame of reference. Determining time in these cases is a little more complicated.

Throughout the coming year, this column will examine temporal issues and explore the concepts of Earth- and sky-based time. While in school, your students will encounter many different situations that require timing to various degrees of accuracy. They may attend a swim meet with a clock that is accurate to a hundredth of a second, conduct a physics experiment that requires timing accurate to the microsecond, or even set an egg timer in home economics to bake a soufflé. They may also encounter supercomputers used to measure the period of an orbiting satellite, listen in as astronomers discuss the age of another galaxy, or, while on a wilderness field trip, they may need to calculate the time of day without the help of a watch.

I hope that through this and upcoming columns you will gain enough insight about time to further your understanding of its relationship to science.

Right on time

It is said that time is nature's way of keeping everything from happening at once. Time, therefore, might be defined as a forward-flowing sequence of events. In modern-day life, we break down time by units that we use to distinguish the order of events in the past, present, or future. Historically, we have used the apparent and real motions of the Earth, Moon, and Sun to mark time. The fairly recent refinement of our Earth-motion time-measurement system has led to the international use of Standard Time.

Wait a second

The international unit of time, known as the *second*, was adopted by the General Conference of Weights and Measures in 1964. Because precise time measurement requires a referent with a regular, measurable rhythm, the General Conference defined the second in terms of the emissions caused by the transition between a cesium 133 atom's energy levels. A cesium atom emits or absorbs radiation of specific wavelengths as it passes from one energy state to another.

The cesium 133 atom was chosen because its radiation has a stable frequency of 9,192,631,770 Hz, providing an accurate reference. Since the frequency, the number of hertz, tells how many vibrations occur per second, a second is the time for 9,192,631,700 vibrations.

More precisely, the General Conference stated, "The standard to be employed is the transition between two hyperfine levels F = 4, $M_f = 0$ and F = 3, $M_f = 0$ of the fundamental states $2S_{1/2}$ of the atom of cesium 133 undisturbed by external fields, and the value of 9,192,631,770 Hz is assigned."[1]

A zone of your own

Our 24-hour, cyclical time system centered on the Royal Observatory (0° Longitude) in Greenwich, England, is known as Greenwich Mean Time (GMT) or, in astronomical terms, Universal Time (UT).

The Earth is divided into 24 time zones, each 15° wide and centered on meridians of longitude (known as central meridians) spaced at 15° intervals east and west of the prime meridian. These time zones are the attempted ideal, but in practice the time zones frequently follow political lines, such as borders or geographical features. The maximum longitude east or west of the prime meridian is 180°. The line of longitude located

180° from the prime meridian is known as the international date line. Each calendar day begins at midnight, so that when it is Sunday just west of the line, it is Saturday just east of it.

Through the establishment of the time zones, every location on the Earth's surface has a standardized time relative to a specific location—Greenwich, England.

Additionally, with this system, it is easy to determine time at another location. However, there is sometimes a need, especially for the astronomer, to determine time more precisely for your location. This is known as local time, and is based quite literally on your position on the Earth's surface. Local time differs from standard time in that all across a time zone, the clock time is the same regardless of whether you live near the eastern edge, the center, or the western edge of the 15°-wide time zone; while local time is based on specific longitude.

Using my location as a model, complete the "My Time Card" for your location. In this example, 1100 UT is used as a reference. What is the exact local time at your longitude? What is the exact local time if Daylight Savings Time is being observed?

To determine your local time, obtain the following information about your locale: its longitude, the name of your time zone, and the longitude of the central meridian for your time zone (EST = 75°, CST = 90°, MST = 105°, PST = 120°). Then convert the standard time (GMT or UT) given into your specific local time. This conversion will allow you to determine the exact time that a celestial event will occur at your longitude if you know when it will occur in standard time.

Next month you will learn more about time based on the apparent motion of the sky—which, in fact, is the basic foundation for determining time. Soon, when you are asked the time, you will know more about what you mean when you answer.

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My Time Card[2]

Longitude: 94.35°W

Name of standard time zone: Central

Standard time zone meridian: 90° W

Standard time when it is 11h UT: [UT - (90°/15°)] = 0500 (5:00 a.m.)

Local mean time when it is 11h UT: [UT - (94.35°/15°)] = 0431 (4:31 a.m.)

Daylight savings time when it is 11h UT: [ST + 1] = 0600 (6:00 a.m.)

Evening planets

Jupiter: Low over the western horizon at sunset.

Venus: Very low over the southwestern horizon at sunset.

Moon phases

September
New Moon - September 5
First Quarter - September 12
Full Moon - September 19
Last Quarter - September 27

October
New Moon - October 4
First Quarter - October 11
Full Moon - October 19
Last Quarter - October 27

References

1. Shipman, J.T., and Wilson, J.D. (1992). *Fundamentals of Physical Science*. Lexington, MA: D.C. Heath and Company.
2. Ottewell, G. (1994). "My Time Card" based on "Personal Reminder" from the *Astronomical Calendar*. Greenville, SC: Furnam University.