EXPLANATORY NOTES

For all practical purposes the measure of time in ancient years was tied to the position of the sun in the sky. However, in relatively recent history we have moved toward reckoning time in a more uniform manner so that the time when the sun is at its highest point above the horizon (i.e. noon) shifts from day to day.

Nevertheless, many activities are still sensitive to the availability, or absence, of sunlight or twilight. For the tabulated dates the table provided herewith lists the times of sunrise, noon, sunset, and various stages of twilight. These times are given in standard time (or daylight savings time if the day in the week is marked with an asterisk) for the specific location listed at the top of the page. The listed times apply only to the specified location (or, for the time of noon, any location with the specified longitude). Also listed: the times when the sun appears due east and due west, the percentage of the moon's disc that appears to be illuminated at 9 PM, and two solar parameters: the equation of time and the sun's declination.

Accuracy: The times listed are in Civil Time, which is tied to Coordinated Universal Time (UTC). However, the computations needed are chiefly based on mean solar time (UT1). UTC itself tracks atomic time, but has one-second adjustments as needed to keep UTC within 0.9 seconds of UT1. Future adjustments in the UTC time scale can only be estimated. Also, to a minor extent, some of the computations depend on Terrestrial Time (a replacement for Ephemeris Time); this tracks rigorously with atomic time (i.e. without one-second adjustments). Finally, the calculated times in UT1 may be off by up to about 0.1 seconds. In total, errors over the next few years may approach two seconds. But note that observing the time when the sun transits (i.e. noon) with one-second accuracy requires professional equipment, timing other events such as sunrise or sunset involves many unpredictable factors, and twilight times can never be timed exactly from observations. Therefore, the times should be rounded to the nearest minute, but are given to the nearest second so that the rates of daily changes may be judged more accurately. However, prior to August 30, 2015, the computer program used to calculate the rising, setting, and twilight times had a mistake which introduced errors of approximately one minute. The calculation of transit times, however, was (and remains) accurate to within one second.

NOON

The tabulated time for noon (solar transit) is the time when the sun is directly over the line of longitude specified in the page header. The listed time should be accurate to within a second.

RISING AND SETTING TIMES

The tabulated time should be close to the time of the first appearance of the sun's upper limb above the horizon at sunrise, and last appearance at sunset. However, the actual time of a careful observation will depend on temperature and humidity, on the observer's altitude and the rate at which the temperature and humidity change with altitude, the lay of the land, and such-like unpredictable factors.

The tabulated rising and setting time takes into account the observer's latitude and longitude, the date, and the sun's apparent coordinates, and an average value for refraction in the atmosphere, but not topology, temperature, humidity, elevation, etc.

Because of the unpredictable factors, the observed time for a sunrise or sunset may vary from the predicted time by a minute or more.

LENGTH OF DAY

The tabulated setting time, minus the tabulated rising time, may differ from the tabulated length of day because the arithmetic inside the computer is more precise than the tabulated values which are rounded to the nearest second. Observed values will also depend on the unpredictable terrestrial phenomena mentioned above for sunrise and sunset times.

TWILIGHT

The tabulated times represent the time when the center of the sun is geometrically 6 degrees (Civil Twilight), 12 degrees (Nautical Twilight), 15 degrees, or 18 degrees (Astronomical Twilight) below the horizon.

Civil twilight is conceived as the time when the sun is below the horizon, but there is enough light shining onto the ground to be useful (assuming that the sky is clear).

Nautical twilight is conceived to begin, or end, at the time when an observer at dawn has, or at nightfall no longer has, enough light to be able to distinguish the boundary (horizon) between sea (or land) and sky.

The times for twilight at 15 degrees below the horizon should correspond fairly well to the times when the horizon in the direction where the sun will rise, or has set, is completely dark as seen with unaided eyes.

Astronomical twilight is the period of time when the sun is not visible, but there is still enough light in the sky to interfere with astronomy.

All of the times mentioned above are tabulated in hours, minutes, and seconds with rounding of the calculated time to the nearest second.

EQUATION OF TIME

The equation of time is listed, in minutes, for each day at the time listed for noon. Because of the complicated geometry of the earth's orbit and orientation with respect to the sun, the time defined by the position of the sun in the sky (local solar time) will differ from the time defined by a fictitious sun moving through the sky at a uniform rate (local mean solar time). The difference between local solar time and local mean solar time is called the equation of time.

When the equation of time is less than zero, the standard time of actual noon is later than its average time, and when it is greater than zero the standard time of noon is earlier. The average value of the equation of time over a calendar year is close to zero. (It would be closer to zero if the length of a year were an exact multiple of 24 hours.)

Most locations are not on a standard time meridian (e.g. 75 degrees west for EST, 105 degrees west for MST) and so the time of local noon is earlier by 4 minutes of time for each degree of longitude you are east of your standard meridian, or 4 minutes later for each degree to the west you happen to be. For example, someone in Rapid City who might be at 103.171 degrees west of Greenwich is 1.829 degrees east of the standard meridian, and thus will, on average, see the sun transit 7.316 minutes before 12:00:00 Mountain Standard Time (i.e. at an average time of 11:52:41 MST). Note that the equation of time is a function of the date and time, but not latitude or longitude, and the time of local noon is a function of the date and longitude, but not the latitude. The actual time of noon, therefore, is influenced by the equation of time, and the observer's longitude.

SOLAR DECLINATION

In late June, the noontime sun is directly overhead for observers at approximately 23.4 degrees north of the equator, and, in late December, for observers that far south of the equator. The declination of the sun is the measure of how far north or south of the equator the sub-solar point is at any given time, and is needed to calculate all of the tabulated times other than the time of noon. This is tabulated in degrees of arc.

LUNAR ILLUMINATION

The percentage of the moon's disk illuminated by the sun, as seen from the earth, is given for 9 PM, Local Civil Time. When the moon is new this is zero. For about two weeks following the new moon the percentage increases to 50% (first quarter) and then over the next two weeks to

100% (full moon). In this period the moon appears in the evening sky setting later and later as the days go by.

After the full moon, day by day, the percentage of the moon's disk that appears to be illuminated shrinks back to zero. During this period, the moon rises only after sunset, and after a few more days, unless you are close to the North Pole or the South Pole, will not have risen by 9 PM. In the last few days before the moon is new it will appear as a thin crescent, and will rise only shortly before the sun rises.

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