Lunar Length of Day

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Definition

A lunar day is the time it takes for the Moon to complete one rotation on its axis with respect to the Sun. Due to tidal locking with the Earth, this lunar day is also the time it takes the Moon to complete one orbit around the Earth, returning to the same phase.

Orbit and Rotation

A “day” in simplest terms is a time frame in which a certain reference point returns to the same position. Relative to fixed stars on a celestial sphere, the Moon takes 27 Earth days, 7 hours, 43 minutes, and 12 seconds to complete one orbit (Lang 1992). Since the Earth-Moon system travels around the Sun at the same time, the Moon must travel further to return to the same phase.

There are three processes that were applied to provide standard time units on the Earth: (1) The Earth's rotation around the axis (mean solar time); (2) The Earth's revolution round the Sun (ephemeris time); and (3) Radiation (or absorption) of electromagnetic oscillations by atoms or molecules of some materials as a result of exchanging the energetic state (atomic time) (Habibullin et al. 1974). A scale of lunar time, similar to the terrestrial time-keeping, should be represented by an uniform-enough physical process and must be practically convenient.

However, the exact length of a lunar day or month varies over time because of the speed of the Earth-Moon system around the Sun. This complexity is due to the eccentricity of the Earth-Moon system’s elliptical orbit, variances in orbital velocity and lunar obliquity (Figure 1), and gravitational perturbations of the Sun (and other bodies in the Solar System) (Lang 2011).

While the Moon rotates on its own axis, the speed at which it rotates (sidereal rotation) is relatively slow. It takes the Moon 27.3 Earth days to complete a single rotation on its axis, the same amount of time it takes to complete a single orbit around the Earth (Gurevich 1965, 1967; Mietelski 1968).

According to Habibullin et al. (1974), the mean point of vernal equinox (similarly to terrestrial time keeping) is chosen to be the initial point, with respect to which the time is counted out, and convenient for the measurement of the right ascensions and selenographic longitudes (Habibullin et al. 1974).

Sidereal vs Synodic

While it takes 27.3 days for the Moon to orbit the Earth, we must keep in mind that the Earth-Moon system is also orbiting the Sun. Because of this, the Moon’s sidereal rotation is not the single value of a lunar day.

Similar to a terrestrial day, a sidereal lunar day is divided into 24 hours, an hour into 60 minutes, and so on. Thus, 1 hour of lunar sidereal time contains ~ 1/24 x 27.3216610 mean days = 27.396385 terrestrial sidereal hours. The sidereal time on an arbitrary meridian of the Moon is measured by the hour angle of

the vernal equinox point, the angle being transferred on to the lunar equator by an arc equal to the longitude of the ascending node of the lunar equator. According to Mietelski (1968) and Habibullin et al. (1974), the moment of the meridional passage of the vernal equinox transferred onto the lunar equator is taken as the beginning of a sidereal day on a given meridian of the Moon.

And while the amount of time the Moon takes to complete one turn on its axis with respect to the stars is 27.3 days, the amount of time it takes for the Sun to return to the same position in the sky is called a synodic day, which is 29.5 days. That extra 2.2 days is the extra angular distance that the Moon must travel to position itself in the same point in the sky (Figure 2). A synodic month (Table 1) can be taken as the beginning of a lunation (*Sky and Telescope* 1971), being taken to coincide with the moment of midnight on the prime lunar meridian, which corresponds within the magnitude of libration to the moment of new Moon with respect to the Earth. However, the angle and arbitrary longitude at the Moon can also arise other types of "months" as seen in Table 1.

So, indeed, for all precise astronomical calculations on the Moon, the usual terrestrial time can be used. But for calendar purposes, especially for future lunar explorations, it should be practical to evaluate to some local lunar scale of lunar chronology.

References

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Figures and Tables:

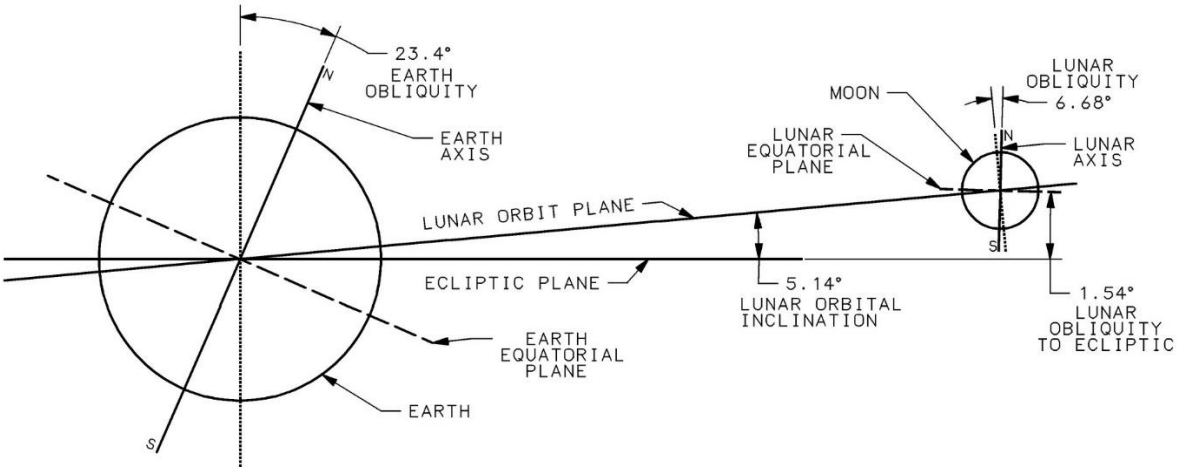

Figure 1: Diagram of the Moon's orbital plane and angular position with respect to the orbital plane of the Earth (ecliptic). Note that the Earth and Moon relative sizes, angles, and relative distance are not to scale. (Courtesy of Peter Sobchak who released this to the Public Domain).

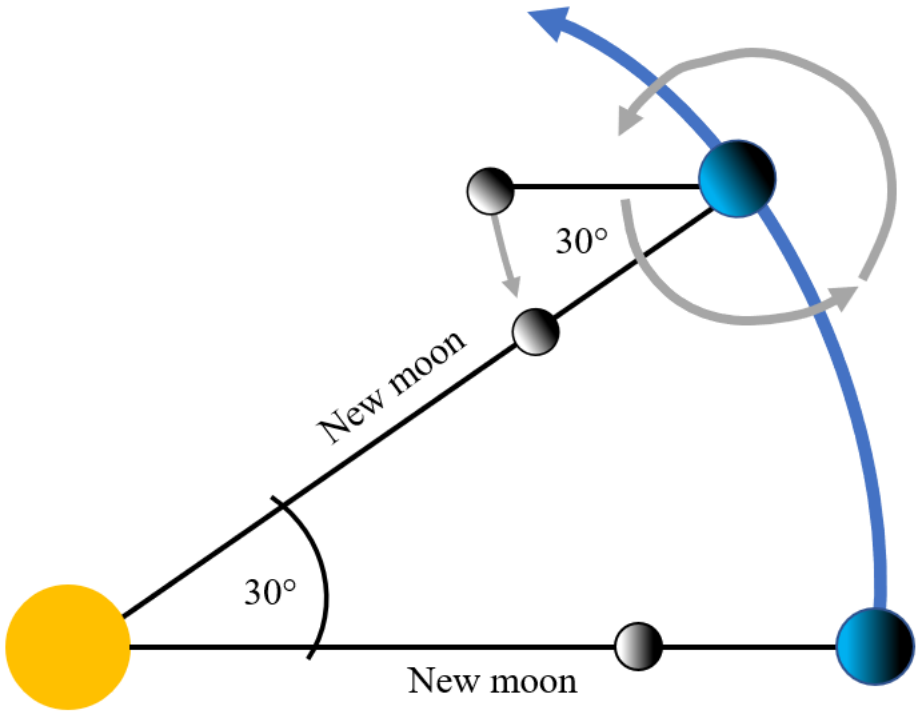

Figure 2: Synodic movement illustrating that the Earth travels about 30° per month in its orbit. A new moon must complete a full 360° orbit plus an extra 30° to be at the same position for the new moon phase.

Table 1: Length of mean months depending on the time frame and positioning used as a reference frame (from Lang 1992).

Length of Mean Months		
Month Name	Days	Time Frame
Sidereal	27.321661	Fixed star - fixed star
Synodic	29.530589	New moon - new moon
Anomalistic	27.554551	Perigee - perigee
Tropical	27.321582	Equinox - equinox
Draconic	27.21222	Node - node