

U.S. Naval Observatory

Astronomical Applications Department



Phases of the Moon and Percent of the Moon Illuminated

Note: For Moon phase information specific to a particular date, see

[Dates of Primary Phases of the Moon](#),
[Complete Sun and Moon Data for One Day](#),
[Fraction of the Moon Illuminated](#), or
[What the Moon Looks Like Today](#)
in Data Services.

From any location on the Earth, the Moon appears to be a circular disk which, at any specific time, is illuminated to some degree by direct sunlight. Like the Earth, the Moon is a sphere which is always half illuminated by the Sun, but as the Moon orbits the Earth we get to see more or less of the illuminated half. During each lunar orbit (a lunar month), we see the Moon's appearance change from not visibly illuminated through partially illuminated to fully illuminated, then back through partially illuminated to not illuminated again. Although this cycle is a continuous process, there are eight distinct, traditionally recognized stages, called phases. The phases designate both the degree to which the Moon is illuminated and the geometric appearance of the illuminated part. These phases of the Moon, in the sequence of their occurrence (starting from New Moon), are listed below.



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New Moon - The Moon's unilluminated side is facing the Earth. The Moon is not visible (except during a solar eclipse).

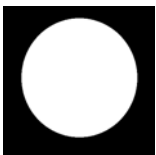
Waxing Crescent - The Moon appears to be partly but less than one-half illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is increasing.



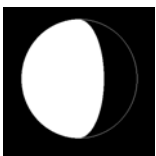
First Quarter - One-half of the Moon appears to be illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is increasing.



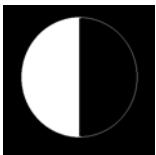
Waxing Gibbous - The Moon appears to be more than one-half but not fully illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is increasing.



Full Moon - The Moon's illuminated side is facing the Earth. The Moon appears to be completely illuminated by direct sunlight.



Waning Gibbous - The Moon appears to be more than one-half but not fully illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is decreasing.



Last Quarter - One-half of the Moon appears to be illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is decreasing.



Waning Crescent - The Moon appears to be partly but less than one-half illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is decreasing.

Following waning crescent is New Moon, beginning a repetition of the complete phase cycle of 29.5 days average duration. The time in days counted from the time of New Moon is called the Moon's "age". Each complete cycle of phases is called a "lunation".

Because the cycle of the phases is shorter than most calendar months, the phase of the Moon at the very beginning of the month usually repeats at the very end of the month. When there are two Full Moons in a month (which occurs, on average, every 2.7 years), the second one is called a "Blue Moon". See the article "Once in a Blue Moon" for the story of how the usage of this term has evolved (Ref: Philip Hiscock, [Sky & Telescope](#), March 1999, pp. 52-55.).

The first time that the thin waxing crescent Moon is visible after New Moon (low in the evening sky just after sunset) marks the beginning of a month in the Islamic Calendar - see the FAQ [Crescent Moon Visibility and the Islamic Calendar](#).

Although Full Moon occurs each month at a specific date and time, the Moon's disk may appear to

be full for several nights in a row if it is clear. This is because the percentage of the Moon's disk that appears illuminated changes very slowly around the time of Full Moon (also around New Moon, but the Moon is not visible at all then). The Moon may appear 100% illuminated only on the night closest to the time of exact Full Moon, but on the night before and night after will appear 97-99% illuminated; most people would not notice the difference. Even two days from Full Moon the Moon's disk is 93-97% illuminated.

New Moon, First Quarter, Full Moon, and Last Quarter phases are considered to be primary phases and their dates and times are published in almanacs and on calendars. (Click [here](#) for a list.) The two crescent and two gibbous phases are intermediate phases, each of which lasts for about a week between the primary phases, during which time the exact fraction of the Moon's disk that is illuminated gradually changes.

The phases of the Moon are related to (actually, caused by) the relative positions of the Moon and Sun in the sky. For example, New Moon occurs when the Sun and Moon are quite close together in the sky. Full Moon occurs when the Sun and Moon are at nearly opposite positions in the sky - which is why a Full Moon rises about the time of sunset, and sets about the time of sunrise, for most places on Earth. First and Last Quarters occur when the Sun and Moon are about 90 degrees apart in the sky. In fact, the two "half Moon" phases are called First Quarter and Last Quarter because they occur when the Moon is, respectively, one- and three-quarters of the way around the sky (i.e., along its orbit) from New Moon.

The relationship of the Moon's phase to its angular distance in the sky from the Sun allows us to establish very exact definitions of when the primary phases occur, independent of how they appear. Technically, the phases New Moon, First Quarter, Full Moon, and Last Quarter are defined to occur when the excess of the apparent ecliptic (celestial) longitude of the Moon over that of the Sun is 0, 90, 180, and 270 degrees, respectively. These definitions are used when the dates and times of the phases are computed for almanacs, calendars, etc. Because the difference between the ecliptic longitudes of the Moon and Sun is a monotonically and rapidly increasing quantity, the dates and times of the phases of the Moon computed this way are instantaneous and well defined.

The percent of the Moon's surface illuminated is a more refined, quantitative description of the Moon's appearance than is the phase. Considering the Moon as a circular disk, the ratio of the area illuminated by direct sunlight to its total area is the fraction of the Moon's surface illuminated; multiplied by 100, it is the percent illuminated. At New Moon the percent illuminated is 0; at First and Last Quarters it is 50%; and at Full Moon it is 100%. During the crescent phases the percent illuminated is between 0 and 50% and during gibbous phases it is between 50% and 100%.

For practical purposes, phases of the Moon and the percent of the Moon illuminated are independent of the location on the Earth from where the Moon is observed. That is, all the phases occur at the same time regardless of the observer's position.

Lunation Movie

If you click on either of the two images on the right, you will see a time-lapse movie of the

appearance of the Moon over one lunation. A lunation is a lunar month, during which time the Moon completely circles the Earth in its orbit. The complete cycle of phases is obvious. Two other effects can be easily seen. First, due to the elliptical shape of the Moon's orbit, the apparent size of the Moon's disk changes as its distance from Earth varies (the closest and farthest points do not always occur at the same phases, however). Second, although the Moon's near side directly faces the Earth on average, we get to view the Moon from slightly different angles as it orbits us. This effect, called libration, is caused partly by the tilt of the Moon's rotation axis with respect to its orbital plane and partly by the fact that the Moon's speed in its orbit varies but its rotation rate does not.

The movie is an animated GIF created by Antonio Cidadao from a sequence of still images taken during March and April 1998.

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(134k)



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