

## Lunar Phases - Introduction

The Moon, Earth's only natural satellite and one of the brightest objects in its sky, appears in the sky in many different shapes. It is also the only place in our solar system, other than Earth, where humans have visited. The Earth's Moon is the fifth largest in the whole solar system, and is bigger than Pluto. The Moon has a nearly circular orbit which is tilted about  $5^{\circ}$  to the plane of the Earth's orbit. Its average distance from the Earth is 238,855 miles (384,400 km). The combination of the Moon's size and its distance from the Earth causes the Moon to appear the same size in the sky as the Sun, which is one reason we can have total solar eclipses.

It takes the Moon 27.3 days to go around the Earth once. **Pick up Marker 2 -  to see this effect.** The Moon orbits the Earth in a counter-clockwise motion and during one calendar year it makes around 13.4 of these rotations. Because of this motion, the Moon appears to move about  $13^{\circ}$  against the stars each day, or about one-half degree per hour. If you watch the Moon over the course of several hours one night, you will notice that its position among the stars will change by a few degrees. The changing position of the Moon with respect to the Sun leads to lunar phases.

Because the Moon is spherical and the hemisphere that faces the Sun reflects sunlight, half of the Moon is always illuminated. Depending on the Moon's position relative to Earth, different portions of this illuminated hemisphere are visible to us.

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## Lunar Phases

The Moon travels around the Earth in an oval shaped orbit every 27.3 days. During this travel, the Moon goes through a cycle of phases or changes in its apparent shape as viewed from Earth. Because of the Earth's rotation, the Moon appears to rise in the east and set in the west each day. When viewed from Earth's North Pole, Earth and Moon rotate counter-clockwise about their axes; the Moon orbits Earth counter-clockwise and Earth orbits the Sun counter-clockwise (**Pick up Marker 2 to see this effect**).

Five designations that describe the Moon's apparent shape and sequence of phases are: new, crescent, quarter, gibbous, and full. Despite this division into five stages, the phases of the Moon are in fact part of a continuum. As the Moon orbits Earth, the portion of its illuminated hemisphere that is visible from Earth changes slightly every day.

### First Quarter

During the **New Moon** phase, the Moon is between the Sun and Earth. Because of this placement, the Moon's illuminated half is facing away from Earth. Therefore, the Moon is not visible from the Earth. **Pick up Marker 3 -  and line up observer on Earth's North Pole with the New Moon and the Sun to see this lunar phase.** Additionally, the moon is up throughout the day, and down throughout the night. For these reasons we cannot see the Moon during this phase. New Moon generally occurs once a month.

As the Moon continues its orbit, the illuminated side gradually becomes visible and is seen as a crescent as seen in **Marker 3**. This phase is also referred to as **Waxing Crescent**. This lunar sliver can be seen each evening for a few minutes just after sunset. We say that the Moon is "waxing" because each night a little bit more is visible for a little bit longer. During this phase, the Moon begins to look like letter "D." **Pick up Marker 3 and line up the observer on the North Pole with Waxing Crescent Moon to see this lunar phase.**

Over the next few days, the crescent appears to grow, or wax, showing a larger portion of the illuminated side of the Moon each successive day.

When half of its illuminated hemisphere becomes visible from Earth, the Moon appears as a half-disk, also known as the **First Quarter** Moon. **Pick up Marker 3 and line up the observer on the North Pole with the First Quarter Moon to see this lunar phase.** During first quarter, 1/2 of the Moon rises at noon and is high overhead at sunset (around 6pm). Thus it is visible for the first half of the evening, and then goes down around midnight, leaving the sky very dark.

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## **Second Quarter**

The Moon then continues to wax through gibbous phase, in which more than half of the illuminated side is visible from Earth. This phase is called **Waxing Gibbous**. Observers can see all but a little sliver of the moon. **Pick up Marker 4 -  and line up the observer on the North Pole with Waxing Gibbous Moon to see this lunar phase.**

During this phase, the Moon remains in the sky most of the night. The Moon has moved in its orbit so that it's now relatively far from the Sun in our sky. A waxing gibbous Moon rises during the hours between noon and sunset. It sets in the wee hours after midnight and it is most visible around 9pm.

When the Moon reaches the point of its orbit at which it is on the opposite side of Earth from the Sun, the entire lit hemisphere is visible and it appears as a **Full Moon** — a complete circular disk. **Pick up Marker 4 and line up the observer on the North Pole with Full Moon to see this lunar phase.**

A full Moon will rise just as the evening begins, and will set about the time morning is ushered in. The best time for viewing it is around midnight. In many ways, a full moon is the opposite of a new Moon. At both the new and full phases, the moon is on a line with the Earth and Sun. At **New Moon**, the Moon is in the middle position along the line. At **Full Moon**, Earth is in the middle, between the Moon and the Sun.

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## **Third Quarter**

As the Moon proceeds around the rest of its orbit, it wanes from full moon to **Waning Gibbous**. Like the Waxing Gibbous Moon, during this phase, we can see all but a sliver of the Moon. The difference is that instead of seeing more of the Moon each night, we begin to see less and less of the Moon each night. This is what the word "waning" means. During this phase the Moon begins to look like the letter "C." **Pick up Marker 5 -  and line up the observer on the North Pole with Waning Gibbous Moon to see this lunar phase**

After **Waning Gibbous**, the next waning stage is called the **Last Quarter**. During a Last Quarter Moon we can see exactly 1/2 of the Moon's lighted surface. **Pick up Marker 5 and line up the observer on the North Pole with Last Quarter Moon to see this lunar phase.** This phase rises around midnight, appears at its highest in the sky at dawn (around 6am), and sets around noon.

**Last Quarter Moon** comes about three weeks after **New Moon**. In **Marker 5** we can observe that the Moon in its orbit around Earth is at right angles to a line between the Earth and Sun. The moon is now three-quarters of the way around in its orbit of Earth, as measured from one new Moon to the next.

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## **Fourth Quarter**

Finally, during a **Waning Crescent**, or “**Old Moon**”, observers on Earth can only see a small sliver of the Moon, and only just before morning. Each night less of the Moon is visible for less time. Now the Moon has moved nearly entirely around in its orbit of Earth, as measured from one new Moon to the next. **Pick up Marker 6 -  and line up the observer on the North Pole with Waning Crescent Moon to see this lunar phase.**

Because the Moon is nearly on a line with the Earth and Sun again, the day hemisphere of the moon is facing mostly away from us once more. That is why we only see a slender fraction of the Moon’s day side (**Waning Crescent Moon**).

Over time, gravitational forces between the Moon and Earth have synchronized the Moon's rotation rate with its orbit, such that the Moon takes 27.3 days both to orbit Earth and to rotate on its axis. As a result, the **same side of the Moon** always faces Earth, and from Earth's surface people never see the far side.