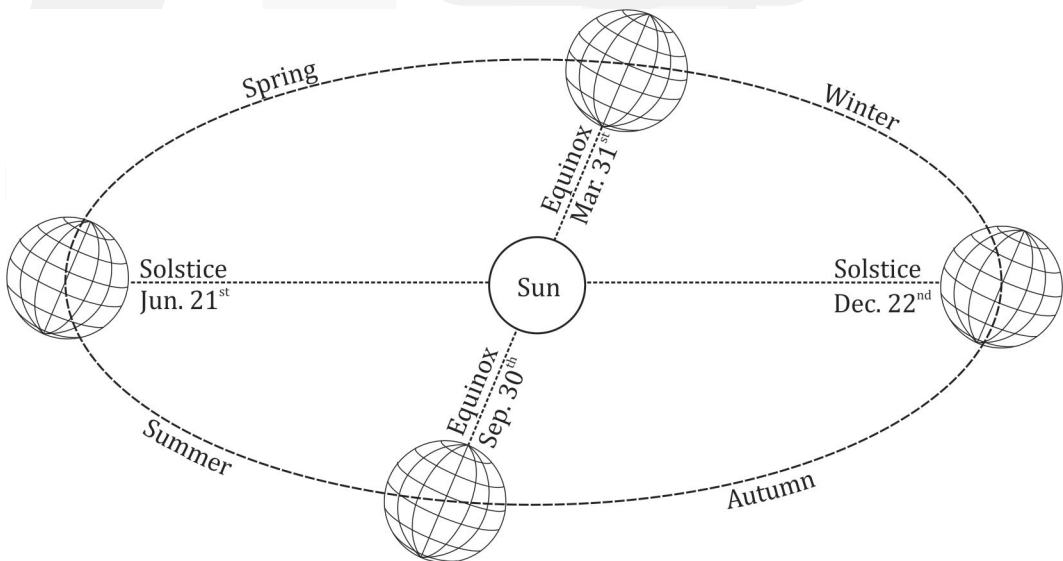


The Sun-Earth-Moon System

The earth is rotating counter-clockwise around its own axis while it travels around the sun in an elliptical orbit. It takes 23 hrs 56 min 04 sec (sidereal day) for the earth to complete one revolution of spinning around its own axis, and 365 days to complete one revolution around the sun.

The earth's equator is inclined to the elliptic by an angle of $23^{\circ}27'$, and the axis of the earth keeps pointing in a direction that almost coincides with *Polaris*. On June 21st, the sun reaches its maximum declination ($23^{\circ}27'N$) on the Northern Hemisphere, which is called the **Tropic of Cancer**. On September 30th, the earth is at **Libra**, the sun's declination is zero, it appears on the equator, and this is called the **Autumnal Equinox**. On December 22nd, the sun will be over **Tropic of Capricorn**, where it reaches a maximum declination ($23^{\circ}27'S$) in the Southern Hemisphere. On March 20th, the sun's declination is back to zero, it is at the **Vernal Equinox**, and this is called the **First Point of Aries**.



As the sun is a foci of the earth's orbit, so the sun will appear larger at **Perihelion**, which is approximately on January 01, and smaller at **Aphelion** on July 04.

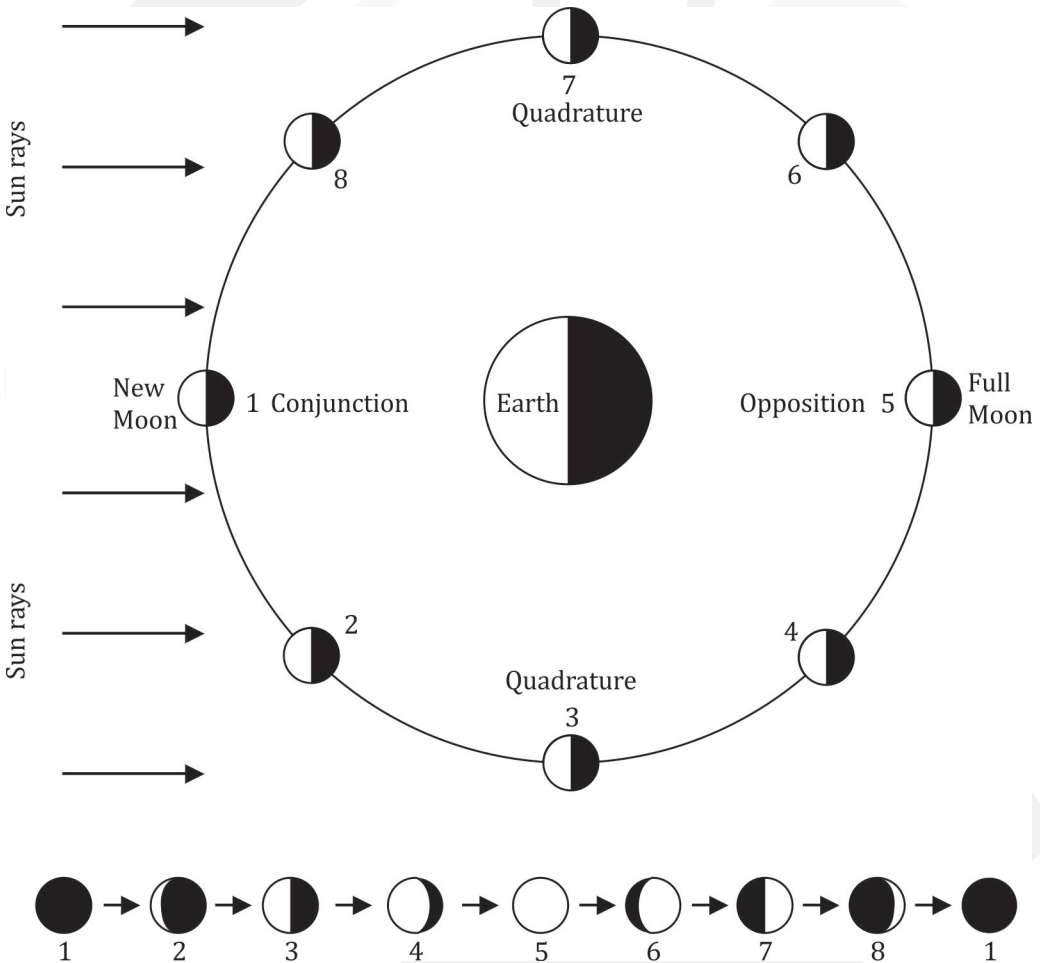
The moon travels around the earth on an elliptical orbit such that its plane is inclined at an angle at the orbit of about 5.25° , and it takes $27 \frac{1}{3}$ days for the moon to complete one revolution around the earth. The moon rotates only once on its own axis in the period of lunation, so it always shows its same side to the earth. Lunation is the moon's age, which is the period from the new moon to the next new moon; this period is not constant, but the average is about $29 \frac{1}{2}$ days.

The projection of the moon's orbit on the celestial sphere is a great circle, cutting the elliptic at two points called the Nodes.

- South to North: Ascending node;
- North to South: Descending node.

Conjunction, Opposition and Quadrature

The bellowed diagram shows the relationship between the sun, moon and earth. They are not necessarily on same plane. If they are on the same plane, then the Eclipse occurs at the new moon and the full moon.



Conjunction At position 1, the sun and the moon are on the same side of the earth. The sun and the moon cross the same meridian together at 1200 (midday); the period of lunation then begins. At this stage, the half side of the moon facing the earth is in shadow; from the earth, we see no moon. The moon is called *New Moon*, and the moon's age is 0 days 0 hours 0 minutes.

Opposition At position 5, the moon is opposite to the sun. The half side of the moon is facing the earth and is illuminated by the sun, so from the earth, we can see the shape of the moon as round. The moon is called *Full Moon*. The opposition occurs when the moon and sun cross the same meridian together at midnight, and the moon's age is about 15 days.

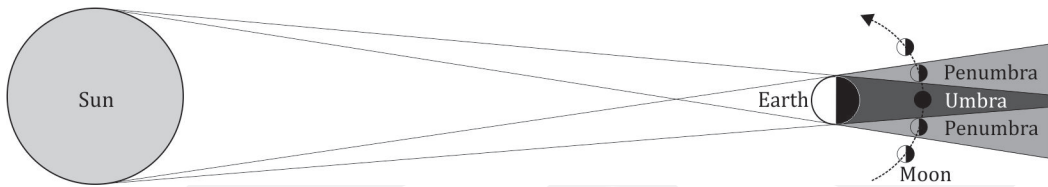
Quadrature At positions 3 and 7, the moon and the sun make an angle of 90° to the earth, which is a quarter of the circle, so it's called the **Quadrature** position. At these stages, half of the half side of the moon facing the earth is illuminated by the sun and the other half is in shadow, so from the earth, we can see the moon as half of the circle.

From the conjunction (position 1), the moon will take seven days to travel to the quadrature (position 3); the moon's visible disc gradually increases until it reaches half moon size, as in position 3, where we can see the half circled shape of the moon. The increasing of the visible disc of the moon is called **Wax** (getting bigger). From position 3, the moon continues to wax until it reaches position 5 (opposite), where we can see the whole shape of the moon.

From position 5, full moon, the visible disc of the moon starts diminishing. This is called **Wane**. The moon continues to wane, and when it reaches the next quadrature position (position 7), only half of its shape is visible from earth. As the waning continues, the moon will reach the conjunction position; the period of lunation is completed, and the new moon starts.

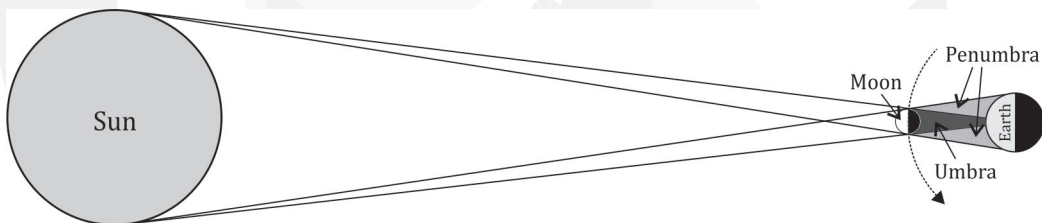
Apogee and Perigee The moon travels around the earth along a path that is not a circle but an ellipse, so the distance of the moon from the earth varies from 221 thousand miles to 252 thousand miles. The position where the moon is nearest to the earth is called **Apogee**; the position where the moon is furthest from earth is called **Perigee**.

Eclipse of the Moon Eclipse of the moon occurs when the moon, sun and earth are on same plane and the moon is at the opposite position. At this moment, the light that reflects from the sun is temporarily obscured by the earth.



Before entering the period of eclipse, the moon is usually full and bright. It then enters the Penumbra section, which is in the part of shadow that is still faintly visible. The moon then enters the Umbra section, or perfectly dark space; the moon is almost completely obscured by the earth's shadow. Leaving the Umbra, the moon enters the Penumbra section again before finally it is completely full and bright and the eclipse period is over.

Eclipse of the Sun The eclipse of the sun also occurs when the sun, moon and earth are on the same plane; however, in this case, the moon is in the conjunction position.



The phenomenon depends on the relative positions of the sun, moon and earth and the distances between them. As shown in the above diagram, the moon is smaller than the earth; the shadow of the moon just covers a small area of the earth's surface. When the shadow of the moon reaches the earth's surface, the area within the Umbra section will experience a *Total Eclipse*, and the areas that are within Penumbra sections will have a *Partial Eclipse*. An *Annular Eclipse* occurs when the Umbra section does not reach the earth's surface; the moon passes across the sun without obscuring the whole sun, thus leaving a ring of light around the moon while the central part, which is the shape of the moon, is dark.