

The Moon's Orbit

Lunar Phases and Eclipses

Reason for the Phases

- During the Moon's entire orbit, half of the Moon is illuminated by the Sun all the time.
- The different phases that we see result from our seeing the Moon from different angles.
- There are eight phases which are defined by the angle between a line connecting the Earth and the Moon and a line connecting the Earth and the Sun.

Names of the Phases

- The phases in chronological order

New Moon

Waxing Cycle:

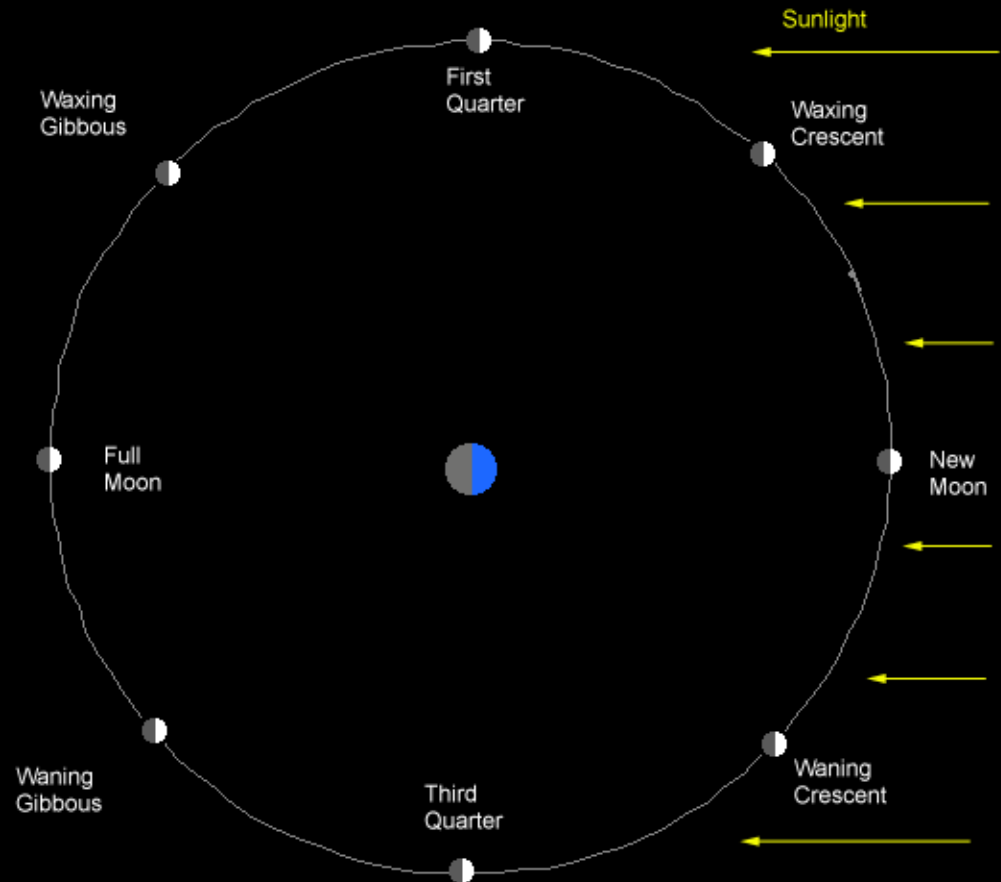
- Waxing Crescent
- First Quarter
- Waxing Gibbous

Full Moon

Waning Cycle:

- Waning Gibbous
- Third Quarter
- Waning Crescent

- The term 'waxing' means growing. During the waxing cycle, the portion of the illuminated face of the Moon seen from Earth increases.
- The term 'waning' means shrinking. During the waning cycle, the portion of the illuminated face of the Moon seen from Earth decreases.



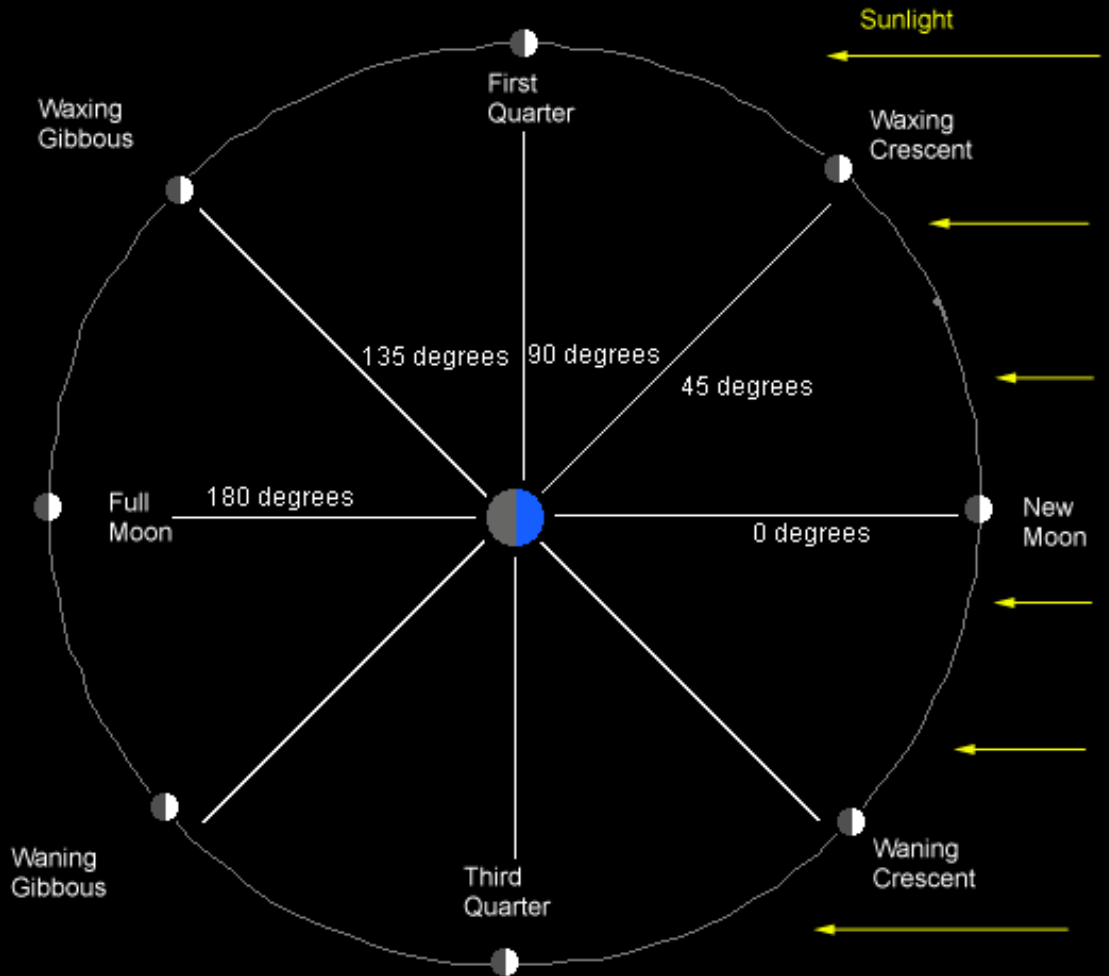
Angle of the Phases

- Each phase of the Moon can be defined by measuring the angular separation between the Moon and the Sun.
- If a line is drawn from the Earth to the Sun and another line is drawn from the Earth to the Moon, the angle between the two lines determine the phase of the Moon.
- Each phase of the Moon is separated by 45 degrees when defined in this fashion.

Angle of the Phases

Phase	Angle (degrees)
New Moon	0
Crescent	45
Quarter	90
Gibbous	135
Full	180

Here, the Sun is off screen to the right.



Angles of the Phases

- Both a waxing and a waning crescent are separated from the Sun in the sky by 45 degrees.
- However, a waning crescent will be west of the Sun and a waxing crescent will be east of the Sun.
- This relationship is true for all of the waxing and waning phases.

The Waxing Cycle of Phases



Waxing Crescent



First Quarter



Waxing Gibbous

The Waning Cycle of Phases



Waning Gibbous



Third Quarter

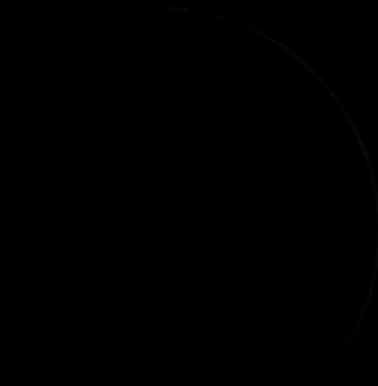


Waning Crescent

The Full and New Moon Phases



Full Moon



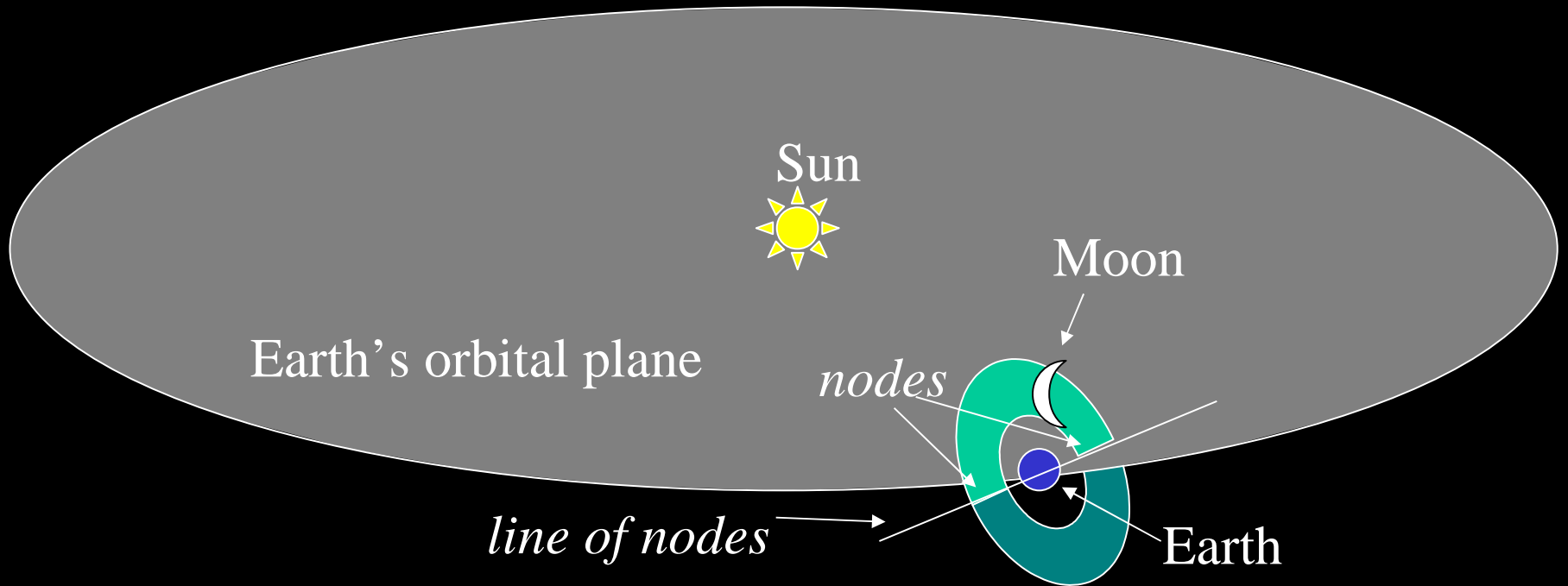
New Moon

The Moon's Orbit

- The Moon does not orbit in the same plane and the Earth.
- The Moon's orbit around the Earth is tilted by 5.2 degrees to the plane of Earth's orbit around the Sun.
- This means that eclipses don't happen with every New Moon and Full Moon.

Tilt of the Moon's Orbit

The points at which the Moon's orbit crosses Earth's orbital plane are called *nodes*. The line connecting these two points is called a *line of nodes*.



Requirements for an Eclipse

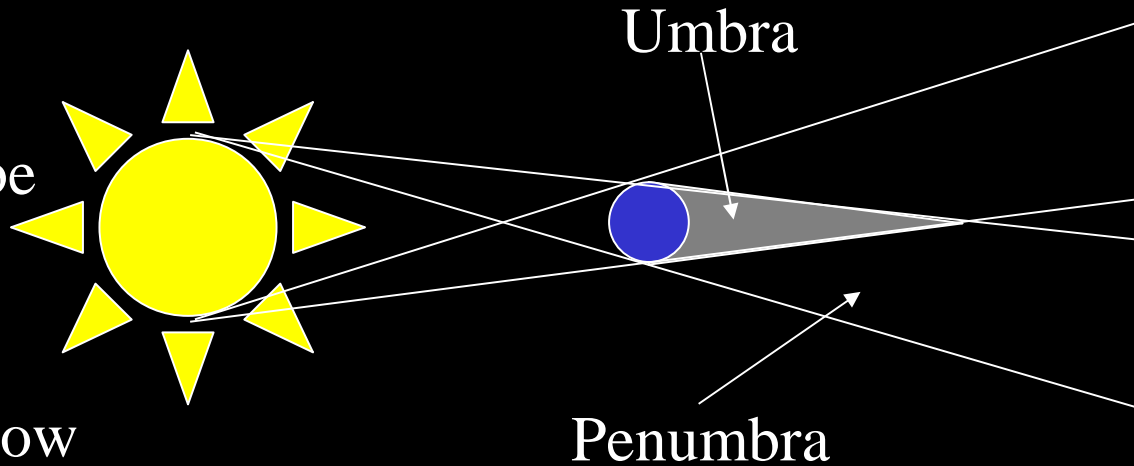
- In order for any type of eclipse to occur, the Moon must be at a node during either a new or full moon phase.
- If the Moon is at a node during a new moon phase, then a solar eclipse will occur.
- If the Moon is at a node during a full moon phase, then a lunar eclipse will occur.

Total and Partial Eclipses

- Sometimes the Moon will be very close to a node, but not exactly on a node during a new or full moon phase.
- When this happens, a partial eclipse may occur.
- Whether a total or partial eclipse will occur depends upon in what part of the Moon's shadow the Earth is in or in what part of Earth's shadow the Moon is in.

Anatomy of a Shadow

- Penumbra
 - Region of partial shadow
 - Partial eclipse will be seen
- Umbra
 - Region of total shadow
 - Total eclipse will be seen.



Lunar Eclipses

- If the Moon passes through the Earth's umbral shadow, a total lunar eclipse will be seen.
- If the Moon passes through the Earth's penumbral shadow, a partial lunar eclipse will be seen.
- This always occurs during a Full Moon.
- Your text refers to a special type of partial eclipse called a "Penumbral Eclipse" which is when the Moon grazes the Earth's penumbra. We will consider this to be a Partial Lunar Eclipse for this course.

Solar Eclipse

- If a point on the surface of the Earth passes through the Moon's umbral shadow, then a total solar eclipse will be seen.
- If a point of the surface of the Earth passes through the Moon's penumbral shadow, then a partial solar eclipse will be seen.
- This always occurs during a New Moon.