NASA
INTERNATIONAL
SPACE APPS
CHALLENGE

A TALE OF TWO ECLIPSES

BY

INTRODUCTION

“An eclipse in one phenomenon that is actually more impressive from the ground.”

~Leroy Chiao

An **eclipse** is an astronomical event that occurs when an astronomical object or spacecraft is temporarily obscured, by passing into the shadow of another body or by having another body passing between it and the viewer. The term eclipse is most often used to describe either a solar eclipse, when the Moon's shadow crosses the Earth's surface, or a lunar eclipse, when the Moon moves into the Earth's shadow. A solar eclipse happens when the Moon gets in the way of the Sun’s light and casts its shadow on Earth. That means during the day, the Moon moves over the Sun and it gets dark. During a lunar eclipse, Earth gets in the way of the Sun’s light hitting the Moon. That means that during the night, a full moon fades away as Earth’s shadow covers it up. As a tremendous natural phenomenon, solar eclipse holds great significance in many scientific approaches. Here through our project “A TALE OF TWO ECLIPSES” we are unveiling the mystery of eclipses and their mechanics.

ECLIPSES

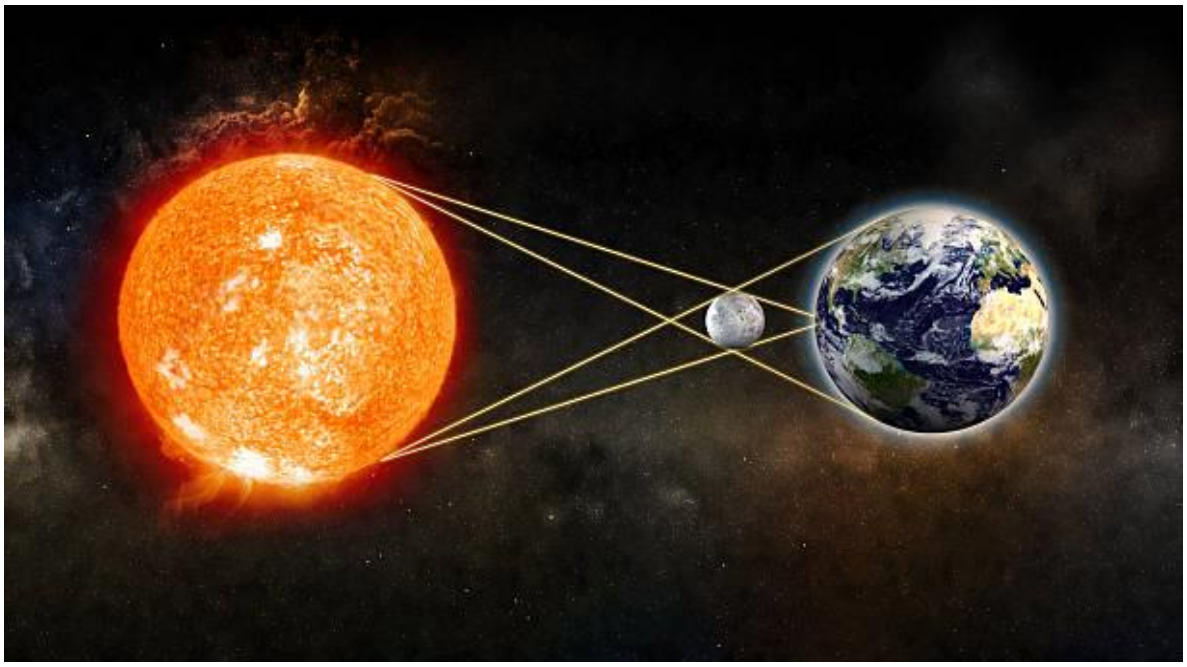
An eclipse occurs when one heavenly body such as a moon or planet moves into the shadow of another heavenly body. In astronomy, an eclipse is a complete or partial obscuring of a celestial body by another. An eclipse occurs when three celestial objects become aligned. An **eclipse** is an astronomical event that occurs when an astronomical object or spacecraft is temporarily obscured, by passing into the shadow of another body or by having another body pass between it and the viewer. This alignment of three celestial objects is known as a syzygy. There are two types of eclipses; the **Solar Eclipse** and **the Lunar Eclipse**. A solar eclipse happens when the Moon gets in the way of the Sun's light and casts its shadow on Earth. That means during the day, the Moon moves over the Sun and it gets dark. During a lunar eclipse, Earth gets in the way of the Sun's light hitting the Moon. That means that during the night, a full moon fades away as Earth's shadow covers it up.

Here we are going to discuss the various aspects of eclipses.

HOW DO ECLIPSES OCCUR?

SOLAR ECLIPSE

Due to all the interrelated motion happening between these three celestial bodies, the Sun, the Earth and the Moon, several physical phenomena occur. When the new moon, during its revolution around the Earth, moves between the sun and the Earth, it blocks out the sun's rays, which casts a shadow on parts of the planet. This is called an eclipse of the sun or a **solar eclipse**. In other words, a solar eclipse happens when the moon passes in a direct line between the sun and the Earth.



The moon is infinitesimally small compared to the sun, so why is it ever able to cover part of or sometimes even the entire sun? Although the moon is indeed about 400 times smaller than the sun, it also happens to be around 400 times closer to us than the sun. This is why both the moon and the sun appear to be the same size in our sky. The moon is very small compared to the sun and to Earth, which is why the moon's shadow isn't big enough to engulf our entire planet. Therefore, the moon's shadow is always limited to a certain area. This area changes even during an eclipse, as both the celestial bodies are in constant motion with respect to one another. When the moon eclipses the sun, it casts two types of shadows on Earth: the first is the umbra which is a small and very dark shadow.

If you're in a place on Earth where the umbra is cast, the entire central portion of the sun will be blocked out from your perspective.

The second type of shadow is known as the penumbra; it is a larger and relatively lighter shadow than the umbra. If the penumbra passes over you, then only a small part of the sun will be blocked out from your point of view.

Depending on the type of shadow the moon casts on Earth, solar eclipses are broadly classified into four types:

The first is a total solar eclipse. This is the most spectacular of all eclipses because, during a total solar eclipse, the entire sun is completely blocked out by the moon. This can only happen when the moon is near perigee, the point of the moon's orbit when it is closest to the Earth. It can only be seen within the umbral shadow, known as the path of totality.

Next up is a partial solar eclipse. This type of eclipse is observed when the moon covers only a part of the sun and casts a penumbra on Earth. Since it only covers a part of the sun, this phenomenon is known as a partial solar eclipse. People outside the path of totality see only a partial eclipse, where the moon passes in front of the sun off centre, never fully covering its surface.

When the moon passes through the centre of the sun, but its disk isn't big enough to cover the entire disk of the sun, then an annular solar eclipse occurs. When this happens, the sun's outer edges remain visible, making it look like a shiny, fiery ring in the sky. Unlike a total eclipse, during an annular eclipse, the moon doesn't completely block out the sun.

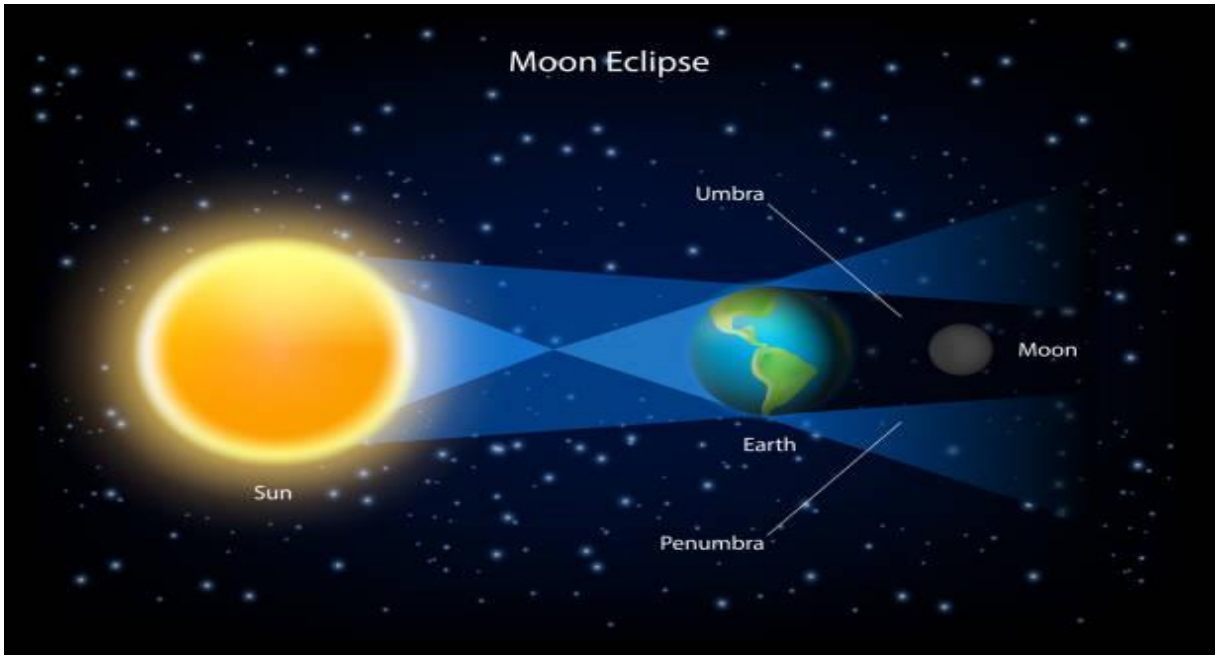
The fourth type of eclipse is the rarest of all; when the moon's position between the sun and the Earth is so delicately balanced that Earth's curvature plays a role, we call it a hybrid solar eclipse. During this type of eclipse, some parts of the Earth witness an annular solar eclipse, while other parts see a total solar eclipse. For that reason, this type of eclipse is also known as an annular total solar eclipse.

LUNAR ECLIPSE

Since the moon continuously revolves around the Earth, it's only natural that it sometimes comes between the sun and the Earth, while at other times it goes behind the Earth, so that the Earth comes between the moon and the sun. This is a **Lunar eclipse**. The moon completes one revolution around our planet in approximately 27 days and rotates at the same rate as it revolves around the Earth;

however, since the Earth rotates on its axis and also moves in its own orbit around the sun, from our perspective, the moon appears to orbit us every 29 days.

Earth casts two types of shadows on the moon - umbra and penumbra - when it is oriented between the sun and the moon.



Lunar eclipses can be divided into three types.

The first being a total lunar eclipse. The most picturesque and dramatic of all, a total lunar eclipse happens when the moon, Earth, and the sun are perfectly aligned so that the moon falls under the umbral shadow of our planet. During a total eclipse, Earth completely blocks any sunlight from reaching the moon. Due to this, the moon loses its characteristic whitish-grey colour and becomes a "sunset red". This happens due to refraction from the Earth's atmosphere. The shorter, blue wavelengths of sunlight are scattered outward by the atmosphere, while the longer red wavelengths are refracted inward toward the moon, giving it a reddish tinge during a total lunar eclipse.

Next is a partial lunar eclipse, which happens when the moon, Earth, and sun align in such a way that only part of the moon passes through the umbral shadow cast by the Earth. During a partial eclipse, you can see Earth's shadow covering a small part of the moon's surface. Then there's a penumbral lunar eclipse. As the name suggests, you can see this type of eclipse when the moon passes through Earth's penumbral shadow. This celestial event is so subtle that many of us don't even notice it visually, as the moon appears only slightly darker than its usual hue.

You can watch a lunar eclipse if you're on the nighttime side of Earth, and for those who were wondering, it's safe to watch a lunar eclipse with the naked eye. In contrast, it's highly dangerous to watch a solar eclipse with the naked eye. Observing a solar eclipse without appropriate precautions can potentially cause permanent eye injuries. The light from the sun that reaches the Earth consists of a broad range of radiation, from ultraviolet radiation at wavelengths longer than 290 nanometres all the way to radio waves existing in the meter range. The tissues in our eyes transmit a considerable portion of this radiation to the back of the eye - the light-sensitive retina. This can result in damage. When observing a solar or lunar eclipse, it is important to protect your eyes by wearing appropriate eye gear. These celestial events have the power to unite people and bring millions of stargazers out into the streets every year. In the past, such events were feared and considered bad omens, but humanity has made significant progress in understanding the forces of nature.

WHY DO ONLY SOME PEOPLE ON EARTH SEE AN ECLIPSE AT A GIVEN TIME?

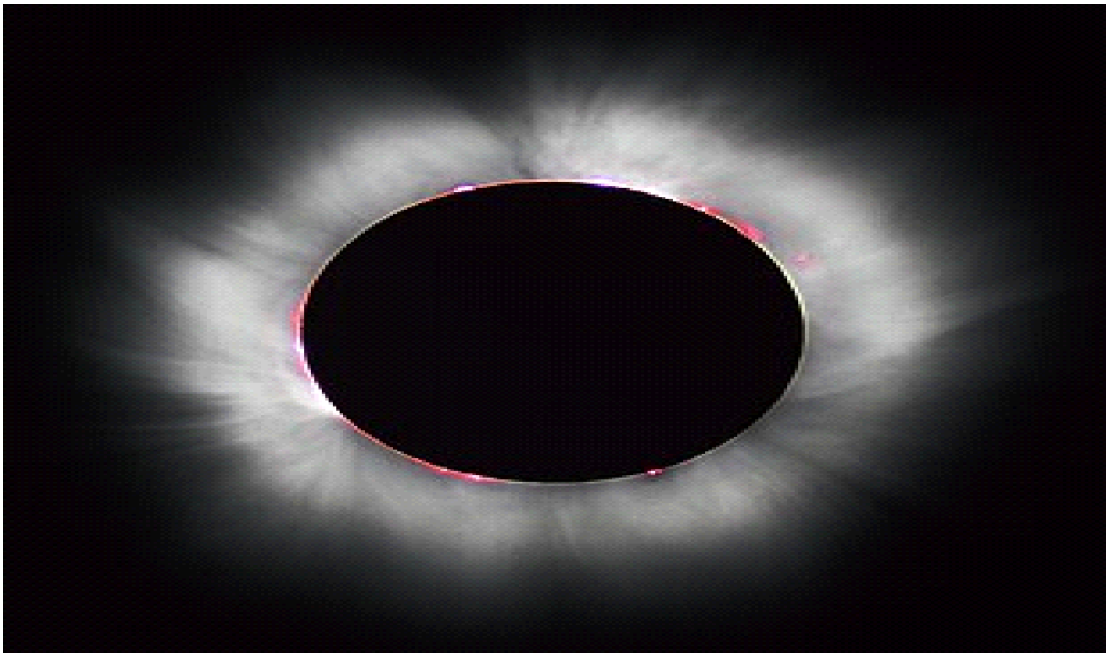
A solar eclipse occurs when the Moon comes between Earth and the Sun. In this process, the moon casts a shadow over Earth. The moon moves over the sun during the day and it becomes dark as the sunlight gets blocked. Astronomical events have always fascinated humans. Some occur every year, while others take place after a long time. One such celestial event is solar eclipse. The interesting part about this eclipse is that it is not visible everywhere on Earth. So, what is the reason behind this?

A solar eclipse occurs when the Moon comes between Earth and the Sun. In this process, the moon casts a shadow over Earth. The moon moves over the sun during the day and it becomes dark as the sunlight gets blocked.Since Moon is smaller as compared to the Sun and Earth, its shadow on Earth isn't very big. As a result, only some places on the planet get to witness the phenomenon. People who are on the sunny side of Earth and in the path of the moon's shadow can see the solar eclipse, while others miss it.

"On average, the same spot-on Earth only gets to see a solar eclipse for a few minutes about every 375 years," says the National Aeronautics and Space Administration (NASA).

Some parts of the planet will see the annular solar eclipse. However, this will be different from a total solar eclipse. During an annular solar eclipse, the moon does not completely cover up the sun, due to which a 'ring of fire' is left out. That's why this eclipse is also called the ring of fire eclipse.

Getting a chance to see a total solar eclipse is rare. The Moon's shadow on Earth isn't very big, so only a small portion of places on Earth will see it. You have to be on the sunny side of the planet when it happens. You also have to be in the path of the Moon's shadow.



A total solar eclipse occurs when the Moon completely covers the Sun's disk, as seen in this 1999 solar eclipse.

A total lunar eclipse occurs when the Sun, Earth and Moon are aligned such that the Moon is in the Earth's shadow. As the Earth is bigger than the Moon, the event is visible from the nighttime hemisphere of the Earth at the time of the eclipse.

A total solar eclipse occurs when the Sun, Moon and Earth are aligned and the Moon is close enough to the Earth that its disc completely covers the Sun's disc.

This doesn't tend to happen very often. Many total solar eclipses are only visible in uninhabited areas such as mid-ocean and near to the poles.

A partial eclipse can be seen in areas outside of the path of totality.

A total solar eclipse is a truly amazing sight. I am an eclipse chaser and I have seen ten. Getting to the right place at the right time takes some advance planning. Cruise ships will sometimes change their schedules to include the center line of a total solar eclipse. This is often the best way of seeing an eclipse.

You might be wondering why we don’t have a lunar eclipse every month as the Moon orbits Earth. It’s true that the Moon goes around Earth every month, but it doesn’t always get in Earth’s shadow. The Moon’s path around Earth is tilted compared to Earth’s orbit around the Sun. The Moon can be behind Earth but still get hit by light from the Sun. Because they don’t happen every month, a lunar eclipse is a special event. Unlike solar eclipses, lots of people get to see each lunar eclipse. If you live on the nighttime half of Earth when the eclipse happens, you’ll be able to see it.

WHAT CAUSES THE SUN, MOON & EARTH TO ALLIGN?

Solar and lunar eclipses take place when the Sun, Earth, and Moon are aligned. The alignment of the Sun, Moon, and Earth, known as a syzygy, occurs due to the gravitational interactions among these celestial bodies. Specifically:

1. Solar Eclipse: A solar eclipse happens when the Moon passes directly between the Earth and the Sun, blocking the Sun's light. This alignment occurs because of the Moon's orbit around Earth and its position relative to the Sun and Earth.

2. Lunar Eclipse: A lunar eclipse occurs when the Earth passes directly between the Sun and the Moon, casting a shadow on the Moon. Again, this alignment is due to the Moon's orbit around Earth and its position relative to the Sun and Earth.
3. Full Moon: During a full moon, the Sun, Earth, and Moon are approximately in a straight line, with Earth between the Sun and the Moon, causing the Moon to be fully illuminated.

These alignments are the result of the complex gravitational forces acting on these celestial bodies as they move in their respective orbits around one another.

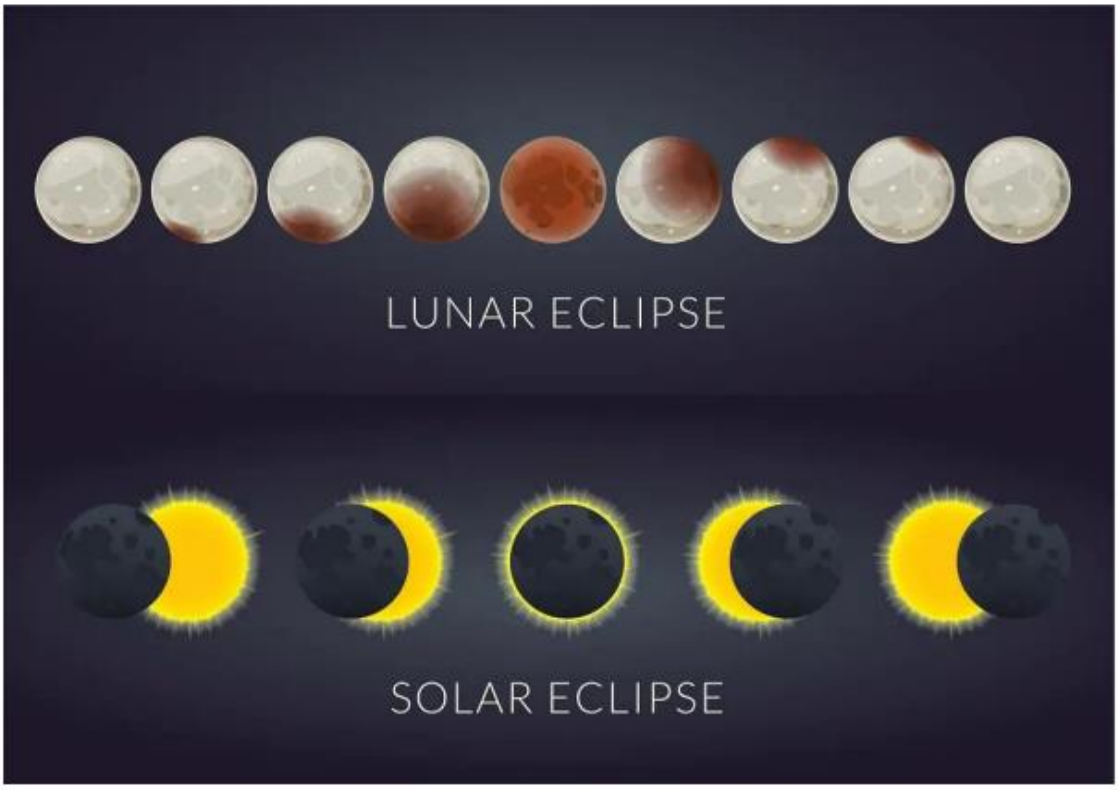
Eclipses, both lunar and solar, occur due to specific astronomical factors and alignments involving the Earth, Moon, and Sun. Here are the key factors that contribute to different types of eclipses:
1. Relative Positions: The relative positions of the Earth, Moon, and Sun are fundamental. Lunar eclipses occur when the Earth passes between the Sun and the Moon, casting its shadow on the Moon. Solar eclipses occur when the Moon passes between the Earth and the Sun, blocking out the Sun's light.
2. Earth's Shadow: The Earth's shadow consists of two parts: the outer penumbra (partial shadow) and the inner umbra (total shadow). The type of eclipse (partial or total) depends on whether the Moon passes through the umbra, penumbra, or both during its orbit.
3. Lunar Orbit: The Moon's elliptical orbit around the Earth plays a role in the frequency and type of eclipses. When the Moon is closer to the Earth (perigee), it appears larger in the sky, increasing the likelihood of total lunar eclipses.
4. Tilted Orbits: The Moon's orbit is tilted slightly relative to the Earth's orbit around the Sun. This tilt means that the Moon does not always align perfectly with the Sun and the Earth, making eclipses less frequent.

5. Eclipse Seasons: Eclipse seasons occur when the Sun, Earth, and Moon align closely, increasing the chances of eclipses. Eclipse seasons typically occur about twice a year and can result in both lunar and solar eclipses within a short timeframe.
6. Alignment Precision: For a total solar eclipse, the Moon must be positioned precisely to cover the entire solar disk. If the alignment is slightly off, it can result in a partial solar eclipse or an annular eclipse, where a ring of the Sun remains visible.
7. Earth's Rotation: The rotation of the Earth causes the path of solar eclipses to move across the planet's surface. Different regions of the Earth experience solar eclipses at different times, and the same location may not witness a solar eclipse for several years. 8. Observer's Location: Whether an eclipse is visible to an observer depends on their geographic location. Solar eclipses are visible only along a narrow path on the Earth's surface, while lunar eclipses are visible from the night side of the Earth.
These factors interact in complex ways, resulting in the various types of eclipses (total, partial, annular, penumbral) and their frequency. The study of celestial mechanics and orbital dynamics helps predict and understand these fascinating astronomical events.

HOW OFTEN DO ECLIPSE OCCUR?

Most years have four eclipses: the minimum number of eclipses in a year; 2 of these four eclipses are always solar eclipses. While rare, the maximum number of eclipses that can take place in a calendar year is seven. There are two or three eclipses during every eclipse season. At least one of these is always a solar eclipse, sometimes two. The same is true for lunar eclipses. Which order they come in depends on how each eclipse season coincides with the lunar (synodic) month. The lunar month is the period it takes the Moon to go through all the Moon Phases from a New Moon to the next, and it lasts, on average, 29.5 days. This is five days less than an eclipse season. Therefore, there will always be at least one New Moon, resulting in a solar eclipse, and at least one Full Moon, resulting in a lunar eclipse, during each eclipse season. This is also why solar and lunar eclipses come in pairs—a solar eclipse always takes place either about two weeks before or after a lunar eclipse, and vice versa. At most, there can be two New Moons and one Full Moon, or two Full Moons and one New Moon in the same eclipse season. Anywhere from four to seven times a year, our Earth, Moon and Sun line up just right to create the cosmic-scale shadow show known as an eclipse. The Moon's orbit around Earth is tilted relative to Earth's orbit around the Sun. This tilt is the reason why we have occasional eclipses instead of eclipses every month.

Eclipses occur regularly, but the frequency depends on the type of eclipse:



1. Solar eclipses:

On average, there are about 2 to 5 solar eclipses each year visible from different parts of the Earth and can be seen from the surface of the earth per three years. That is, we see it once every 18 months. However, any given location on Earth typically experiences a total solar eclipse only once every few centuries.

2. Lunar eclipses:

Lunar eclipses are more common. There can be anywhere from 2 to 4 lunar eclipses in a year. These are visible from the nighttime side of the Earth.

Why the lunar eclipses are more than solar eclipses?

Lunar eclipses are more common than solar eclipses because of the relative positions and sizes of the Earth, Moon, and Sun, as well as the geometry of their orbits. Here's why lunar eclipses occur more frequently:

1. Earth's Shadow Size: The Earth's shadow, which causes lunar eclipses, is significantly larger in diameter than the Moon itself. This means that the Moon can pass through Earth's shadow more easily and frequently.

2. Lunar Orbit: The Moon follows an elliptical orbit around the Earth. When the Moon is on the side of its orbit that brings it closer to Earth (perigee), it has

a higher chance of passing through Earth's shadow, increasing the frequency of lunar eclipses.

3. Solar Eclipses Require Alignment: Solar eclipses occur when the Moon passes precisely between the Earth and the Sun, blocking out the Sun's light. This alignment is less common because the Moon's orbit is tilted slightly relative to the Earth's orbit around the Sun. Thus, the Moon often passes either above or below the Sun when viewed from Earth, resulting in a miss for a solar eclipse.

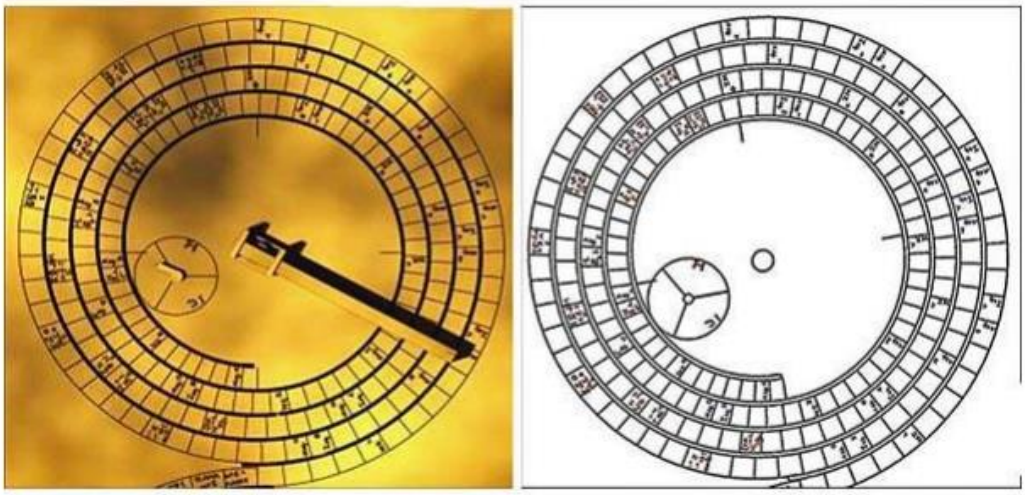
4. Narrow Eclipse Paths: Solar eclipses that do occur are often visible only along a narrow path on the Earth's surface, which further reduces their frequency in any given location.

In summary, lunar eclipses are more frequent because they occur when the Earth passes between the Sun and the Moon, casting a shadow that can cover a larger portion of the lunar surface. Solar eclipses, on the other hand, are rarer because they require a precise alignment of the Moon, Earth, and Sun, and they are often visible only from specific regions of the Earth’s surface.

HOW DO SCIENTISTS KNOW WHEN AND WHERE ECLIPSES WILL OCCUR?

IN ANCIENT WISDOM

The back dial of that Antikythera device told how to predict solar or lunar eclipses over an 18-year period called the "Saros cycle"



18 years = 223 lunar months = 38 possible times for eclipse

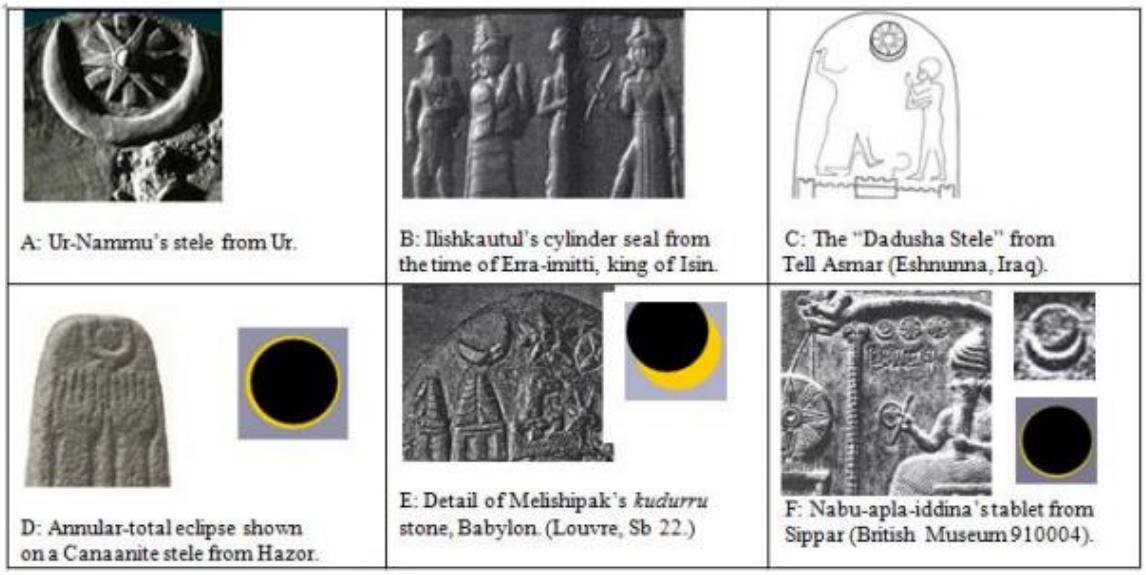
Ancient civilizations had limited scientific tools and knowledge compared to modern technology, but they still made observations and developed methods for predicting eclipses based on their understanding of celestial events. Here's how ancient cultures, with their "ancient wisdom," determined when and where eclipses might occur:

1. Empirical Observation: Ancient astronomers carefully observed the sky and kept records of celestial events. They noticed patterns and regularities in the motions of celestial bodies, including the Moon and the Sun. Over time, they identified certain conditions and sequences of events that often led to eclipses.

2. Lunar Calendar: Many ancient cultures used lunar calendars to track the phases of the Moon. Eclipses often occur when the Moon is in a specific phase relative to the Sun and Earth, such as the full moon phase for lunar eclipses or the new moon phase for solar eclipses. By studying lunar cycles, they could estimate when eclipses might occur.

3. Record Keeping: Babylonians, for example, were meticulous record keepers and developed cuneiform tablets with information on lunar and solar eclipses. These records helped them identify eclipse patterns and make predictions. 4. Mythology and Beliefs: Some ancient cultures associated eclipses with mythological stories or considered them as omens. They often had religious or cultural significance attached to eclipses, and this knowledge was passed down through generations. Priests or shamans with specialized knowledge might have been responsible for predicting eclipses based on their symbolic meaning. 5. Stone Monuments and Alignments: Some ancient structures, like Stonehenge in England or Newgrange in Ireland, were built with astronomical alignments that allowed for the prediction of certain celestial events, including eclipses. These structures served as primitive observatories**.**

6. Oral Traditions: In some cultures, eclipse prediction knowledge was transmitted orally from generation to generation. Elders and astronomers within the community would have specialized knowledge in predicting celestial events.



A: Ur-Nammu's stele from Ur.

B: Ilishkautul's cylinder seal from the time of Erra-imitti, king of Isin.

C: The "Dadusha Stele" from Tell Asmar (Eshnunna, Iraq).

D: Annular-total eclipse shown on a Canaanite stele from Hazor.

E: Detail of Melishipak's *kudurru* stone, Babylon. (Louvre, Sb 22.)

F: Nabu-apla-iddina's tablet from Sippar (British Museum 910004).

It's important to note that ancient eclipse predictions were often less precise and relied on empirical observations, patterns, and cultural beliefs. These methods were limited in their accuracy compared to modern scientific approaches, which involve advanced mathematical models, telescopes, and computer simulations. Nevertheless, the ancient wisdom and observations laid the foundation for our understanding of eclipses today.

IN MODERN TECHNOLOGY

Modern technology enables highly accurate predictions of when and where eclipses will occur. Here's how modern technology achieves this:

1. Orbital Mechanics and Ephemerides: Astronomers use precise mathematical models based on the principles of orbital mechanics to describe the orbits of celestial bodies, including the Earth, Moon, and Sun. These models provide extremely accurate predictions of the positions and movements of these bodies at any given time. The resulting data are known as ephemerides.

2. High-Powered Telescopes: Advanced observatories equipped with powerful telescopes and imaging equipment continuously monitor the positions of celestial objects. These observations help refine and verify the accuracy of the mathematical models used for eclipse prediction.

3. Computer Simulations: Complex computer simulations take into account the gravitational interactions between celestial bodies in our solar system. These simulations can calculate eclipse events precisely and forecast them years or even centuries into the future.

4. Lunar and Solar Coordinates: Astronomers use celestial coordinates, such as right ascension and declination, to precisely specify the positions of the Moon and Sun in the sky. These coordinates are continually updated to ensure accuracy.

5. Saros Cycles: Modern technology allows scientists to calculate and track Saros cycles with great precision. These cycles repeat every 18 years and 11 days and help predict when similar eclipses will occur in the future.

6. Global Coordination: International organizations like the International Astronomical Union (IAU) facilitate the exchange of eclipse prediction data and ensure consistency in predictions worldwide. This coordination helps provide accurate information to observers across different regions.

7. Space-Based Observations: Satellites, such as those operated by NASA and other space agencies, provide additional data and observations from space that contribute to eclipse predictions and help validate the models.

8. Online Resources and Software: Eclipse prediction data is widely accessible to the public through websites, apps, and software tools. These resources allow anyone interested in upcoming eclipses to find precise information about their timing and location.

Difference between ancient wisdom and modern technology know when and where eclipses occur?

The knowledge of when and where eclipses occur has evolved significantly from ancient wisdom to modern technology. Here are the key differences between the two approaches:

1. Methodology: -

Ancient Wisdom: Ancient civilizations relied on empirical observations, lunar calendars, mythological beliefs, and rudimentary instruments to predict eclipses. Their methods were often based on trial and error, cultural beliefs, and patterns they observed over time.

Modern Technology: Modern eclipse prediction relies on precise mathematical models, orbital mechanics, advanced telescopes, computer simulations, and space-based observations. These methods are grounded in scientific principles and data driven analysis.

2. Accuracy: -

Ancient Wisdom: Ancient predictions were often less accurate, with predictions based on patterns and observed phenomena. While they had some success, their predictions were less reliable and precise.

Modern Technology: Modern technology provides highly accurate predictions with a margin of error measured in seconds. Mathematical models and observations are continually refined, resulting in reliable predictions for years or even centuries into the future.

3. Global Coordination: -

Ancient Wisdom: Ancient eclipse predictions were often localized and specific to individual cultures or regions. There was limited coordination and sharing of prediction methods.

Modern Technology: Eclipse predictions today benefit from global coordination among astronomers and organizations like the International Astronomical Union (IAU). Predictions are standardized and available worldwide, ensuring consistency and accuracy.

4. Access to Information: -

Ancient Wisdom: Ancient eclipse predictions were often held by a select group of individuals, such as priests or astronomers, and were not widely accessible to the general population.

Modern Technology: Eclipse prediction data is widely accessible to the public through online resources, software, and apps. Anyone with an interest can easily access precise information about upcoming eclipses.

5. Scientific Foundation: -

Ancient Wisdom: Ancient eclipse predictions often incorporated cultural or mythological beliefs, and they lacked a scientific foundation as we understand it today.

Modern Technology: Modern eclipse prediction is based on the rigorous application of scientific principles, including physics, mathematics, and astronomy.

In summary, while ancient wisdom and observations were significant in laying the groundwork for eclipse prediction, modern technology has vastly improved the accuracy, reliability, and accessibility of eclipse predictions. Today, eclipse predictions are highly precise, globally coordinated, and firmly rooted in scientific knowledge and technology.

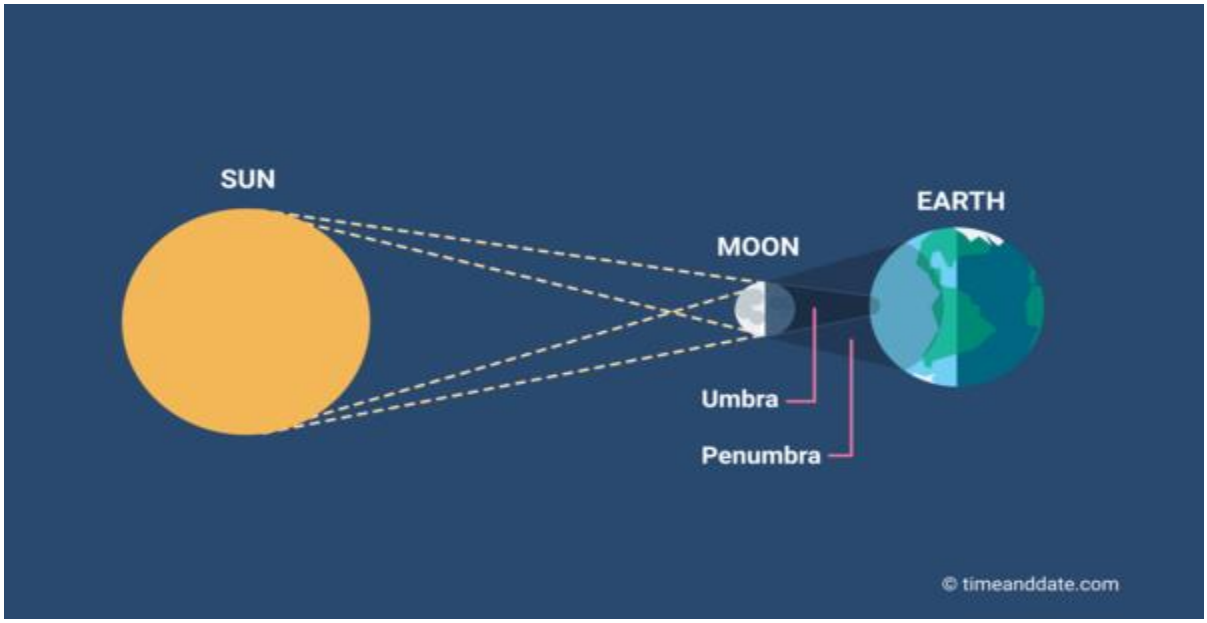
WHAT IS THE DIFFERENCE BETWEEN SOLAR ECLIPSE & LUNAR ECLIPSE?

SOLAR & LUNAR ECLIPSE

An eclipse happens when a planet or a moon gets in the way of the Sun's light. Here on Earth, we can experience two kinds of eclipses: solar eclipses and lunar eclipses.

SOLAR ECLIPSE

A solar eclipse happens when the Moon gets in the way of the Sun's light and casts its shadow on Earth. That means during the day, the Moon moves over the Sun and it gets dark. Isn't it strange that it gets dark in the middle of the day? This total eclipse happens about every year and a half somewhere on Earth. A partial eclipse, when the Moon doesn't completely cover the Sun, happens at least twice a year somewhere on Earth. But not everyone experiences every solar eclipse. Getting a chance to see a total solar eclipse is rare. The Moon's shadow on Earth isn't very big, so only a small portion of places on Earth will see it. You have to be on the sunny side of the planet when it happens. You also have to be in the path of the Moon's shadow. On average, the same spot on the Earth only gets to see a solar eclipse for a few minutes about every 375 years.



Also known as the eclipse of the sun, it occurs when the moon comes in between the sun and the earth. As a result, the moon blocks the light of the sun

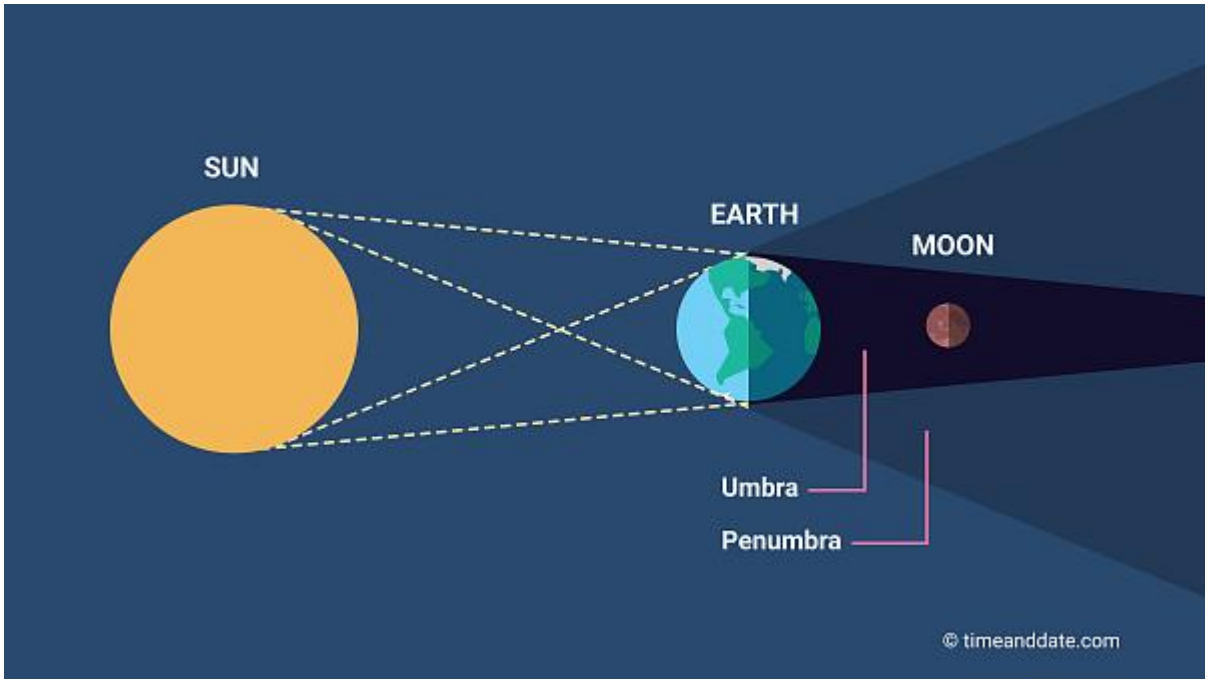
from reaching the earth’s surface and casts a shadow on it. This occurs in a new moon phase. We can observe up to 5 solar eclipses per year.

There are four types of solar eclipses:

- **TOTAL ECLIPSE:** A total eclipse occurs when the dark silhouette of the Moon completely obscures the intensely bright light of the Sun, allowing the much fainter solar corona to be visible. During any one eclipse, totality occurs at best only in a narrow track on the surface of Earth. This narrow track is called the path of totality.
- **ANNULAR ECLIPSE:** An annular eclipse occurs when the Sun and Moon are exactly in line with the Earth, but the apparent size of the Moon is smaller than that of the Sun. Hence the Sun appears as a very bright ring, or annulus, surrounding the dark disk of the Moon.
- **HYBRID ECLIPSE:** A hybrid eclipse (also called annular/total eclipse) shifts between a total and annular eclipse. At certain points on the surface of Earth, it appears as a total eclipse, whereas at other points it appears as annular. Hybrid eclipses are comparatively rare.
- **PARTIAL ECLIPSE:** A partial eclipse occurs when the Sun and Moon are not exactly in line with the Earth and the Moon only partially obscures the Sun. This phenomenon can usually be seen from a large part of the Earth outside of the track of an annular or total eclipse. However, some eclipses can be seen only as a partial eclipse, because the umbra passes above the Earth's polar regions and never intersects the Earth's surface

LUNAR ECLIPSE

During a lunar eclipse, Earth gets in the way of the Sun’s light hitting the Moon. That means that during the night, a full moon fades away as Earth’s shadow covers it up. The Moon can also look reddish because Earth’s atmosphere absorbs the other colours while it bends some sunlight toward the Moon. Sunlight bending through the atmosphere and absorbing other colours is also why sunsets are orange and red. During a total lunar eclipse, the Moon is shining from all the sunrises and sunsets occurring on Earth.



Also known as the eclipse of the moon, it occurs when the earth comes in between the sun and the moon. As a result, the earth blocks the light of the sun from reaching the moon's surface and casts its shadow on the moon. It occurs on a full moon day. We can observe up to 3 lunar eclipses per year.

There are three different types of lunar eclipses:
Total lunar eclipse: The Moon moves into the inner part of Earth's shadow, or the umbra.
Partial lunar eclipse: An imperfect alignment of Sun, Earth and Moon results in the Moon passing through only part of Earth's umbra.
Penumbral eclipse

LUNAR VERSUS SOLAR ECLIPSE

There is often confusion between a solar eclipse and a lunar eclipse. While both involve interactions between the Sun, Earth, and the Moon, they are very different in their interactions.

The Moon does not completely darken as it passes through the umbra because of the refraction of sunlight by Earth's atmosphere into the shadow cone; if Earth had no atmosphere, the Moon would be completely dark during the eclipse. The reddish coloration arises because sunlight reaching the Moon must pass through a long and dense layer of Earth's atmosphere, where it is scattered. Shorter wavelengths are more likely to be scattered by the air molecules and small particles; thus, the longer wavelengths predominate by the time the

light rays have penetrated the atmosphere. Human vision perceives this resulting light as red. This is the same effect that causes sunsets and sunrises to turn the sky a reddish colour. An alternative way of conceiving this scenario is to realize that, as viewed from the Moon, the Sun would appear to be setting (or rising) behind Earth.

The amount of refracted light depends on the amount of dust or clouds in the atmosphere; this also controls how much light is scattered. In general, the dustier the atmosphere, the more that other wavelengths of light will be removed (compared to red light), leaving the resulting light a deeper red colour. This causes the resulting coppery-red hue of the Moon to vary from one eclipse to the next. Volcanoes are notable for expelling large quantities of dust into the atmosphere, and a large eruption shortly before an eclipse can have a large effect on the resulting colour.

Solar Eclipse	**Lunar Eclipse**
Solar eclipse is the one in which the moon is in between the earth and the sun.	Lunar eclipse is the one in which the earth is in between the sun and the moon.
It occurs once in 18 months.	It occurs twice a year.
It lasts for about 5-7 minutes.	It lasts for an hour.
It is witnessed in a few places.	It is witnessed in many places.
It occurs during day time.	It occurs during night time.
The solar eclipse happens in the new moon phase.	When the moon is in its full moon phase, a lunar eclipse happens.
If you look directly, then there are high chances of losing vision as it damages the retina.	Witnessing a lunar eclipse with bare eyes is harmless as it does not cause any damage to the eyes.

WHAT IS AN ECLIPSE SEASON AND WHY DO THEY OCCUR APPROXIMATELY EVERY SIX MONTH?

ECLIPSE SEASONS

An eclipse season is a period of time, roughly lasting about 36 days, during which solar and lunar eclipses are more likely to occur. Eclipse seasons happen approximately twice a year due to the alignment of the Moon's orbit with the Earth's orbit around the Sun. the eclipse season (34 days long on average) is longer than the synodic month (one lunation, or the time for the Moon to return to a particular phase and about 29.5 days), the Moon will be new or full at least two, and up to three, times during the season. Eclipse seasons occur slightly shy of six months apart (successively occurring every 173.31 days - half of an eclipse year), the time it takes the Sun to travel from one node to the next along the ecliptic. If the last eclipse of an eclipse season occurs at the very beginning of a calendar year, a total of seven eclipses to occur since there is still time before the end of the calendar year for two full eclipse seasons, each having up to three eclipses.

The Moon's orbit is tilted by about 5.1 degrees relative to Earth's orbit (the ecliptic plane). This tilt means that most of the time, the Moon passes either above or below the Earth-Sun line during a new moon (solar eclipse) or a full moon (lunar eclipse). However, during an eclipse season, the nodes of the Moon's orbit align more closely with the position of the Sun.

The nodes are the points where the Moon's orbital path crosses the ecliptic plane. When a new moon or a full moon occurs near one of these nodes during an eclipse season, it increases the likelihood of an eclipse. This is why eclipse seasons are periods when we tend to observe solar and lunar eclipses more frequently.

TYPES OF SEASONS

There are typically two eclipse seasons per year, separated by about six months, during which eclipses become more probable. The specific dates and types of eclipses during each season can vary from year to year.

Solar Eclipse Season

During a solar eclipse season, the Moon is positioned between the Earth and the Sun, casting its shadow on Earth. This can result in either a total, partial, or annular solar eclipse, depending on the alignment and distances between the Earth, Moon, and Sun.

There are two types of solar eclipse seasons:

1. Spring Eclipse Season:

This occurs around the time of the vernal equinox when the Sun crosses the celestial equator from south to north. During the spring eclipse season, the Moon's orbit aligns in a way that allows for a series of eclipses. There's usually a partial solar eclipse followed by a total or annular solar eclipse, and occasionally another partial eclipse. Spring eclipse seasons provide opportunities for skywatchers to witness these celestial events, but the exact dates and types of eclipses during a particular season can vary from year to year.

2. Autumn Eclipse Season: This occurs around the time of the autumnal equinox when the Sun crosses the celestial equator from north to south. Similar to the spring eclipse season, the autumn eclipse season consists of a partial solar eclipse, a total or annular solar eclipse, and sometimes another partial eclipse.

Lunar Eclipse season

Lunar eclipse seasons occur approximately every six months and are periods when the conditions are right for lunar eclipses to happen. These seasons are separated by about 173.3 days, which is the time it takes for the Moon to return to the same position in its orbit with respect to the Sun. During a lunar eclipse season, there can be two to three lunar eclipses, which may include penumbral,

partial, or total lunar eclipses, depending on the alignment of the Earth, Moon, and Sun. The exact dates and types of lunar eclipses in a season can vary from year to year. Lunar eclipse seasons refer to periods when lunar eclipses are more likely to occur due to the alignment of the Earth, Moon, and Sun. There are two main types of lunar eclipse seasons:

1. Penumbral Lunar Eclipse Season:

During a penumbral lunar eclipse, the Moon passes through the Earth's penumbral shadow, causing a subtle shading on the Moon's surface. Penumbral lunar eclipse seasons are more frequent and less dramatic than partial or total lunar eclipses. These seasons can have multiple penumbral lunar eclipses in a short time frame.

2. Partial or Total Lunar Eclipse Season:

This type of lunar eclipse season is characterized by the occurrence of partial or total lunar eclipses. During a partial lunar eclipse, a portion of the Moon is in the Earth's umbral shadow, leading to a noticeable darkening of the lunar surface. A total lunar eclipse occurs when the entire Moon is in the Earth's umbral shadow, resulting in a striking reddish hue, often referred to as a "blood moon. "Partial or total lunar eclipse seasons are less frequent than penumbral seasons and can include one or more of these types of eclipses within a relatively short time frame. The exact dates and frequency of lunar eclipses within these seasons can vary from year to year due to the elliptical shape of the Moon's orbit and its inclination relative to Earth's orbit. Astronomers use complex calculations to predict when lunar eclipses will occur during these seasons.

WHY DO SOLAR ECLIPSES OCCUR APPROXIMATELY EVERY SIX MONTHS?

Solar eclipse seasons occur approximately every six months and are the periods when the alignment of the Sun, Moon, and Earth allows for the occurrence of solar eclipses. There are two types of solar eclipse seasons:

An eclipse season is a period of approximately 36 days when eclipses are more likely to occur. Eclipse seasons happen roughly every six months due to the inclination of the Moon's orbit relative to the Earth's orbit around the Sun. The Moon's orbit around the Earth is not perfectly aligned with Earth's orbit around the Sun; it's tilted by about 5.1 degrees. This tilt means that the Moon usually passes either above or below the Earth-Sun line during a new moon (solar eclipse) or a full moon (lunar eclipse). Eclipse seasons occur when the Moon's orbital nodes align with the position of the Sun. These nodes are the points where the Moon's orbit crosses the plane of Earth's orbit (the ecliptic). During an eclipse season, if a new moon or a full moon coincides with the Moon's crossing of one of these nodes, an eclipse can occur. This alignment occurs roughly every six months because it takes about 173.3 days for the nodes to return to the same position relative to the Earth-Sun line. So, there are typically two eclipse seasons per year, each about six months apart, during which solar and lunar eclipses become more likely. If the moon takes about a month to orbit the earth, we should get eclipses every two weeks - first a solar eclipse and then two weeks later, lunar eclipses back and forth. And occasionally, a total one of the heart. But we don't get them every month. In fact, it could take months and months between eclipses of any kind.

SUMMARY

Our project **"A TALE OF TWO ECLIPSES"** all about eclipses and their related aspects. As we all know there are two eclipses that we can experience on Earth; the solar eclipse and the lunar eclipse. So here in this project we, TEAM ORION has bought you a clear idea of both these eclipses and their mechanics. An eclipse occurs when one heavenly body such as a moon or planet moves into the shadow of another heavenly body. Hundreds of years ago, when people observed the Moon during an eclipse, they saw Earth's shadow on the Moon and discovered that the Earth is round. Even after all these years, scientists are still learning about the Moon from lunar eclipses. They also use solar eclipses as an opportunity to study the Sun's corona. Eclipses aren't just beautiful – they're great for science. In addition to inspiring artists and musicians, eclipses have driven numerous scientific discoveries. Here in this project, we had covered the whole concepts of eclipses; both solar and lunar eclipses.

We have discussed about various aspects of eclipses in this project. We could find out that eclipses can't be seen during every month. Solar eclipse occurs once in eighteen months and Lunar eclipses occur two times a year generally. We also have discussed about the different types of eclipses. Both solar and lunar eclipse can't be seen at the same time. Solar eclipse occurs during daytime and lunar eclipse occurs during nighttime. By going through this project, one will get a clear idea of both the eclipses.

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