

SUBJECT 6: LUNAR ECLIPSES

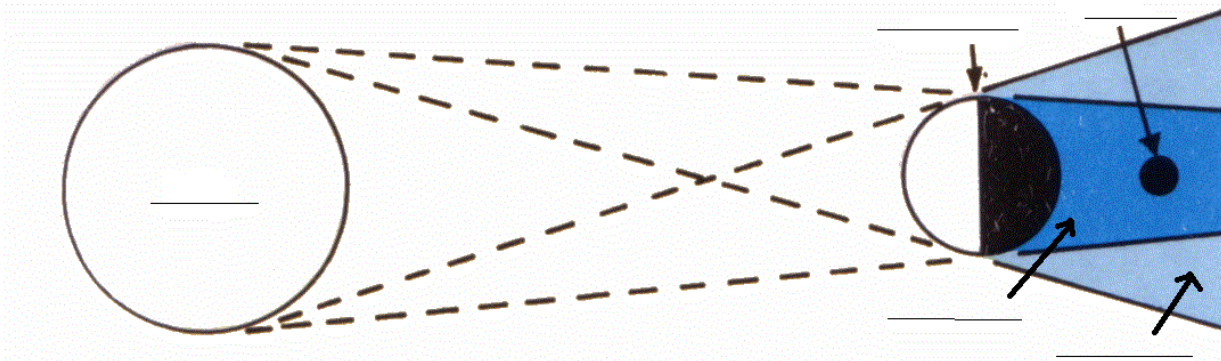
Task 1 : Principle of a lunar eclipse

Use the video to fill in the blanks:

A **lunar eclipse** occurs when the passes directly behind the..... into its(shadow). This can occur only when the Sun, Earth, and Moon are exactly, or very closely so, with the in the middle. Hence, a lunar eclipse can only occur the night of a moon.

The shadow of the Earth can be divided into two distinctive parts: theand.....

A occurs when the Moon passes through the Earth's penumbra. The penumbra causes a subtle darkening of the Moon's surface. A special type of penumbral eclipse is a **total penumbral eclipse**, during which the Moon lies exclusively within the Earth's penumbra.



Task 2: Diameter of the Moon & distance to Earth

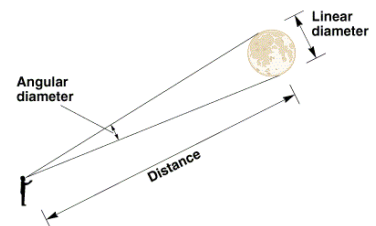


This photo shows the Moon penetrating the Earth's umbra, which we assume circular.

Let D_0 be the Earth's umbra diameter and D_M the Moon's diameter.

1. Work out the ratio $\frac{D_0}{D_M}$.

The **angular diameter** or **apparent size** of an object as seen from a given position is the "visual diameter" of the object measured as an angle.

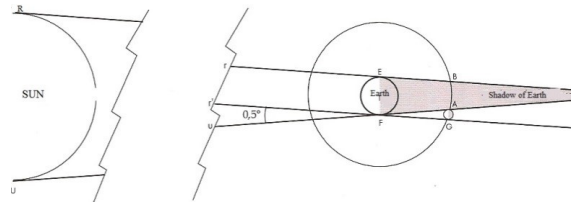


2. The Earth's radius is approximately 6,370 km and the angular diameter of the Moon is 0.5° .
 - a. We consider the Earth's umbra is a cylinder. Find the Moon's diameter
 - b. Deduce the distance from Earth to Moon.

3. Now we want more accuracy : in reality, the Earth's umbra is conic.

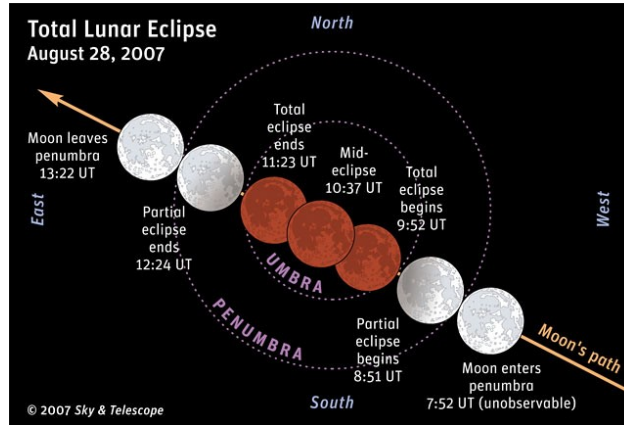
On the diagram besides, we assume the rays [Er) and (Er') are parallel since the sun is so far from the Earth.

- What is the value of $\widehat{uFr'}$?
- Compare the angles \widehat{AFG} and $\widehat{uFr'}$.
- Show that $D_E \approx D_0 + D_M$. Deduce D_M , compute the distance Moon-Earth.



then

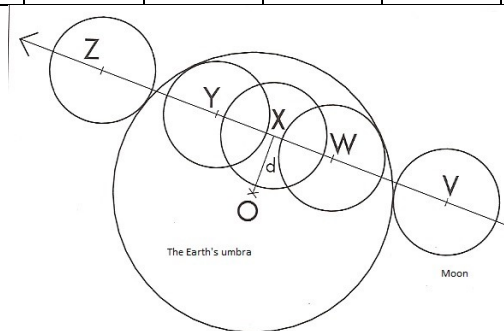
Task 3: 📖 Lunar eclipse times



1. Give the five stages in a total lunar eclipse.

The aim of this problem is to find the hours of each stage for each of the following eclipses:

| Date | 6/4/12 | 4/25/13 | 4/15/14 | 10/8/14 | 4/4/15 | 9/28/15 | 8/7/17 | 1/31/18 | 7/27/18 |
|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| d (km) | 5159 | 6352 | 1823 | 2338 | 2746 | 2000 | 5430 | 1821 | 643 |
| Earth-Sun (km) | 1.518×10^8 | 1.505×10^8 | 1.501×10^8 | 1.495×10^8 | 1.496×10^8 | 1.499×10^8 | 1.517×10^8 | 1.474×10^8 | 1.519×10^8 |
| Earth-Moon (km) | 3.59×10^5 | 3.65×10^5 | 3.85×10^5 | 3.66×10^5 | 4.03×10^5 | 3.57×10^5 | 3.95×10^5 | 3.6×10^5 | 4.06×10^5 |
| Time of mid-eclipse | 11:03 | 20:08 | 7:46 | 10:55 | 12:00 | 02:47 | 18:20 | 13:30 | 20:22 |
| Moon Speed (km/h) | 3680 | 3610 | 3400 | 3600 | 3220 | 3710 | 3310 | 3660 | 3200 |



- For each eclipse, work out:
 - the length of the Earth's umbra cone,
 - the radius AB of this cone at Moon distance,
 - the lengths VX and WX,
 - the times of 5 stages.