

How high the Moon.

by Bob Boucher

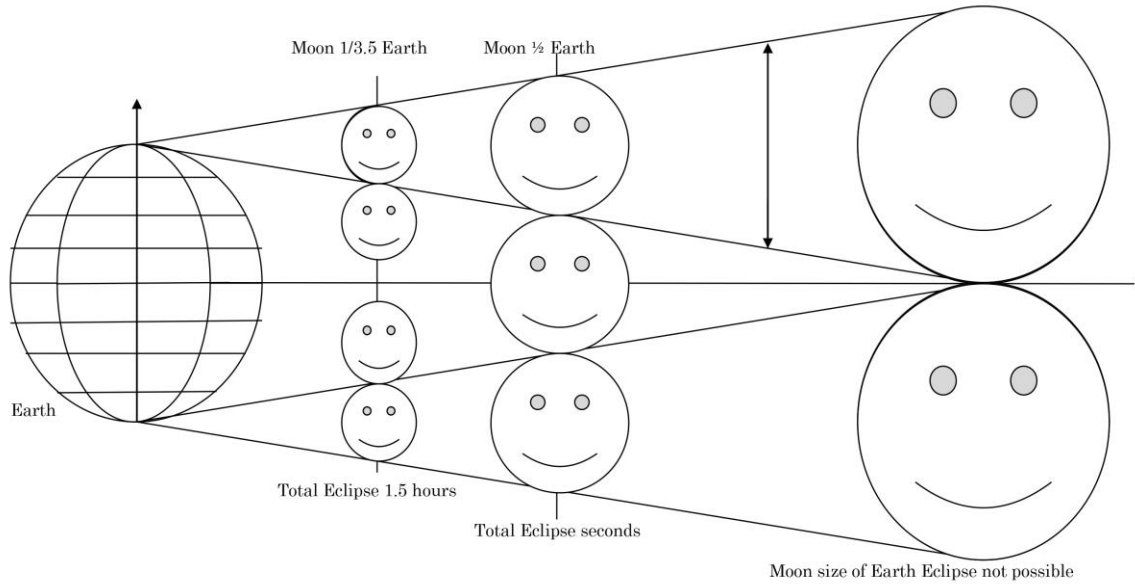
A reasonable estimate of the spherical earth's diameter was also done in the third century BC by Eratosthenes of Alexandria based on the information that at the summer solstice (June 21) the sun shone vertically overhead at Syene near to the present Aswan. Eratosthenes measured the sun's shadow on June 21 and found it to be 7.2 degrees from vertical. Eratosthenes hired trained pacers to measure the distance from Alexandria to Syene and found it to be 5000 Stades or 500 Roman Miles*. Since 7.2 degrees is $1/50$ of a full circle, the circumference of the earth must be 25,000 Roman Miles and the Diameter of the earth 8,000 Roman Miles.

The moon hits your eye like a big pizza pie. Oh that's a lie. At arm's length the moon's image at arms-length is smaller than a quarter, smaller than a nickel, smaller than a dime, about the size of a pea ($1/4$ in). The angle the moon subtends is $1/108$ radians or about 0.53 degrees. The angle the sun subtends is about the same. Observe the moon since during a solar eclipse, only a thin ring of fire is visible around the black moon shadow. The earth's converging conical umbra also extends 108 earth diameters at the identical 0.53 degrees and the expanding penumbra at twice the angle or 1.6 degrees. Using the method of shadows devised by Aristarchus of Samos of the third century B.C., we can compute the moon's size and distance in earth diameters.

The sun is much larger than the earth and its image subtends an angle of 0.53 degrees or $1/108$ radians. This means that the earth casts a shadow directly away from the sun that is conical and converges to a point at a distance of 108 earth diameters ($8000 \times 108 = 864,000$ Roman Miles.). At that distance and beyond there is no possibility of a lunar eclipse since there is no umbra. The moon's image subtends the very same $1/108$ radians so the actual diameter of the moon is related to its distance from the earth. At a distance of 108 earth diameters (864,000 Roman Miles) the moon would necessarily be the same size

at the earth (8000 Roman Miles). Such a moon would never see lunar eclipse. Suppose the moon were actually located at one half this distance or 54 earth diameters. Such a moon would necessarily be one half the size of the earth and the full lunar eclipse would only last for a moment. Suppose the moon were actually located at one third the maximum conical distance or 36 earth diameters. Such a moon would necessarily be one third the size of the earth and the conical shadow would contain two moon images and the full eclipse would last about one hour. Suppose the moon were located at one fourth the conical limit or 27 earth diameters. Such a moon would necessarily be one fourth the size of the earth and the conical shadow would contain three moon images and the full eclipse would last two hours. Aristarchus researched past recorded astronomical data and discovered that the full eclipse duration was about one and one half hours. He estimated the moons distance at 31 earth diameters (248,000 Roman Miles) and the Moon diameter 2300 Roam Miles. These estimates made in the third century B.C. are within 5% of today's modern measurements. Aristarchus also estimated the mass of the moon by the cube of the relative diameters. He assumed that the moon had the same mass density as the earth so calculated the mass as 43 times smaller than the earth. Modern methods indicate that mass ratio is closer to 81 times smaller because the moon has a much lower mass density the earth.

Note . A Roman Mile is 1000 two-step paces of five feet each so a Roman Mile is 5000 feet. This remained the standard mile in the British Empire until Queen Elizabeth 1st decreed the British mile to be 8 furlongs or 5280 feet.



- 1 Earth Diameter estimated by Eratosthenes 8000 Roman Miles
2. Earth Umbra extends 108 Earth Diameters, equals 864,000 Roman Miles
2. Moon distance estimated by Aristarchus $864,000 / 3.5$ equals 247,000 Roman Miles
3. Moon Diameter estimated by Aristarchus $8000 / 3.5$ equals 2280 Roman Miles
4. Mass of the Moon estimated by Aristarchus by the cubing the diameter was 43 times smaller than the earth
5. The Greeks “Knew” that the Earth, Moon, Sun and planets were spheres.



Figure 1 Solar Eclipse of the sun when moon is near perigee (largest moon). (Nasa Photo)



Figure 2 Solar Eclipse when moon is at perigee (largest moon). Notice sun corona.

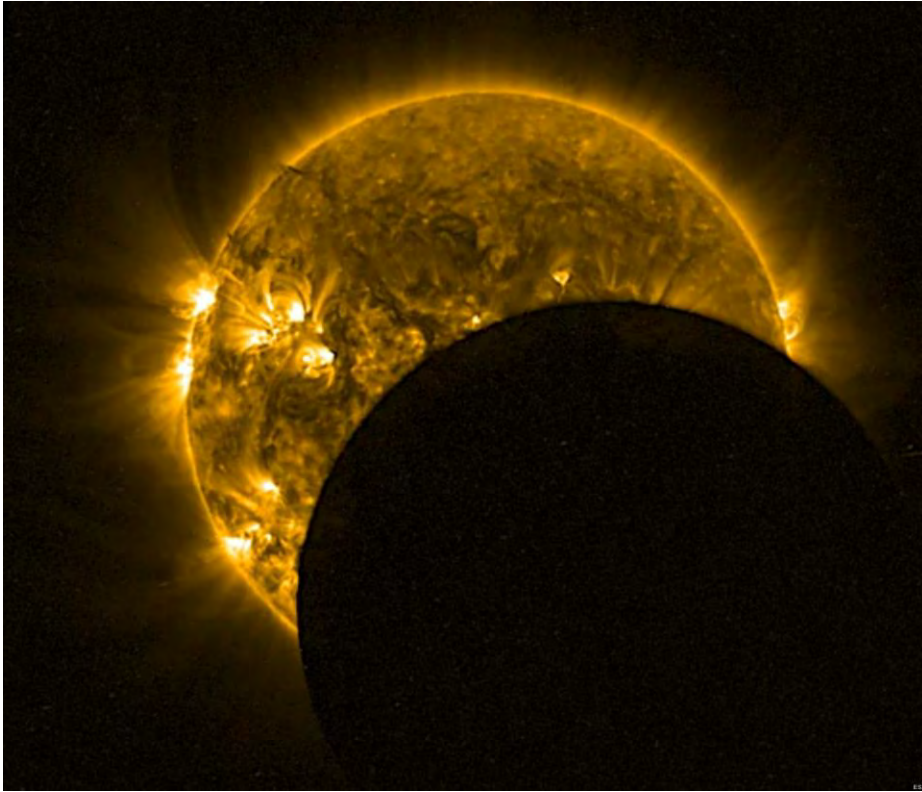


Figure 3 Solar Eclipse notice sun spots.



Figure 4 Solar Eclipse spectacular corona.



Figure 5 Annular Solar Eclipse when moon is at apogee (smallest moon). Note bright ring of fire.

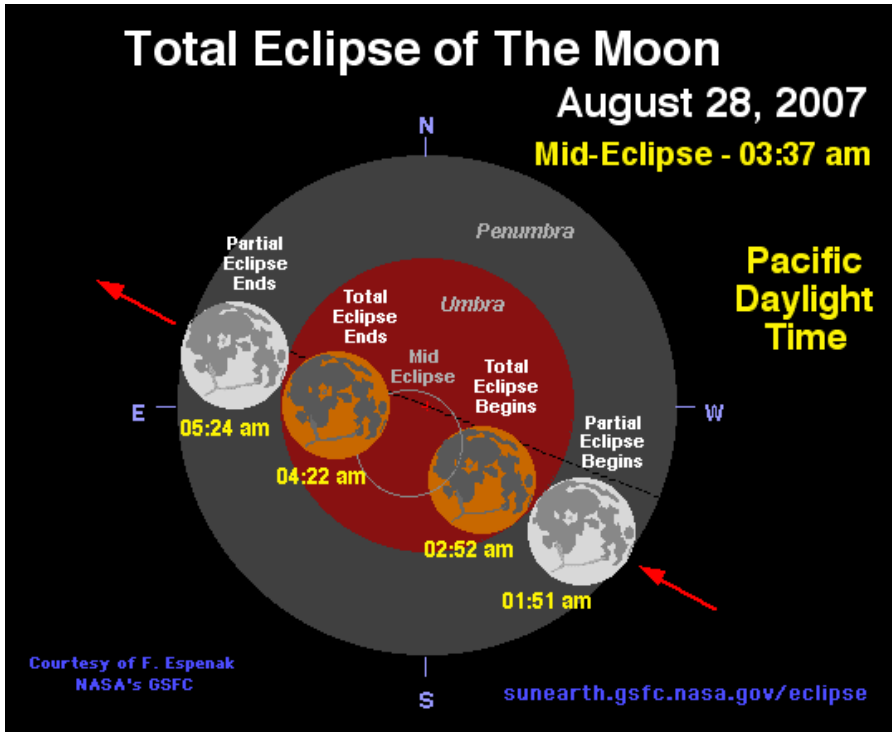


Figure 6 This is the kind of eclipse that Aristarchus saw.
Total eclipse duration 1.5 hours, partial eclipse duration 3.5 hours

