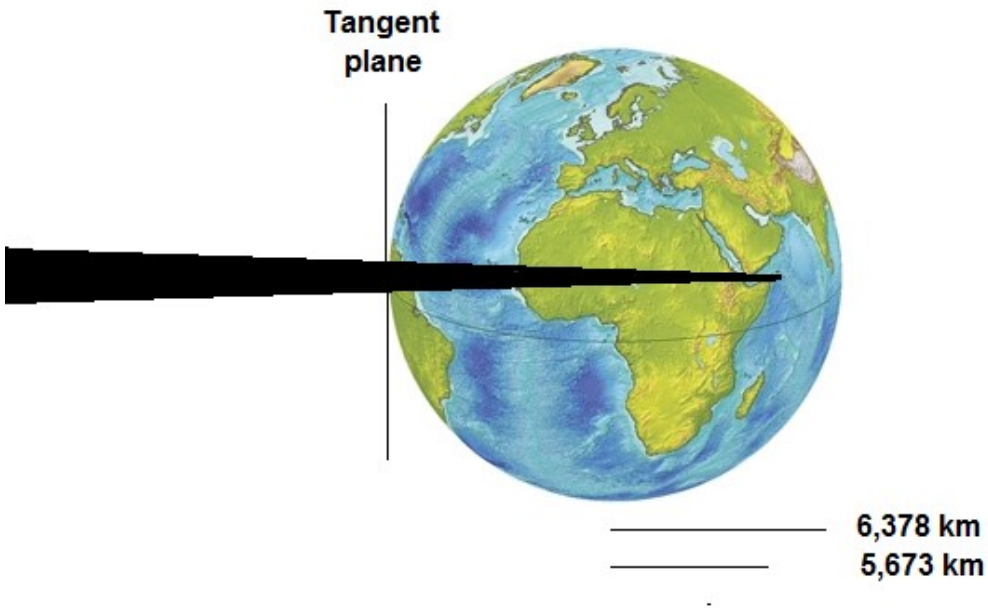
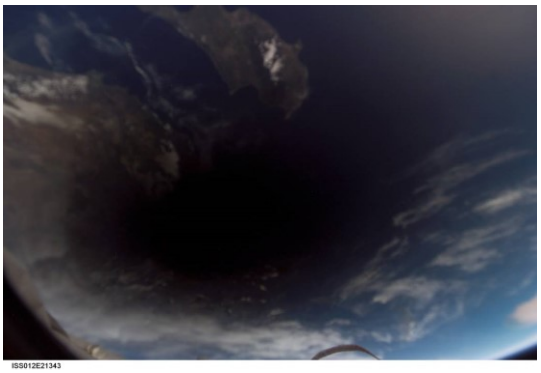
Lunar Shadow Size on Earth's Surface

The center-to-center distance between Earth and moon is 372,027 kilometers, and the distance of the vertex of the shadow cone from the center of the moon is 377,700 km. That means that the vertex lies below the daytime surface of Earth and stretches 377,700 – 372,027 = 5673 km beyond the center of Earth. It is also 705 km below the surface of Earth diametrically opposite the daytime position of totality.





What this means is that the shadow of the moon on Earth's daytime surface is a disk of darkness, and not a mathematical point, that traverses the path of totality. This has been seen in many photos taken from space of total solar eclipses such as this one obtained from the International Space Station on March 29, 2006 by the Expedition 12 crew.

We can calculate the radius of moon shadow on the Earth's surface over North America from the radius of the moon (1737 km) and by invoking a simple proportion:

$$\frac{\text{Lunar radius}}{\text{Shadow cone length}} = \frac{H}{(\text{cone length} - \text{earthmoon distance}) + \text{earth radius}}$$

$$H = \frac{(5673+6378)\ 1737}{377{,}700} = 55 \text{ km radius or } 110 \text{ km diameter}$$

A detailed calculation at the Greatest Eclipse location near Carbondale, Illinois gives a diameter of about 114 km diameter.

Problem 1 – For the August 21, 2017 total solar eclipse, the average speed of the moon's shadow across Earth's surface is about 2,600 km/hr. How long will 'totality' last if you are standing on the center of the path of the lunar shadow?

Problem 2 - The Martian Moon Phobos has a diameter of 25 km, orbits Mars at a distance of 9,300 km from its center, and has a shadow cone length of 8,186 km. What is the diameter of its shadow on the surface of Mars if the radius of Mars is 3,396 km?