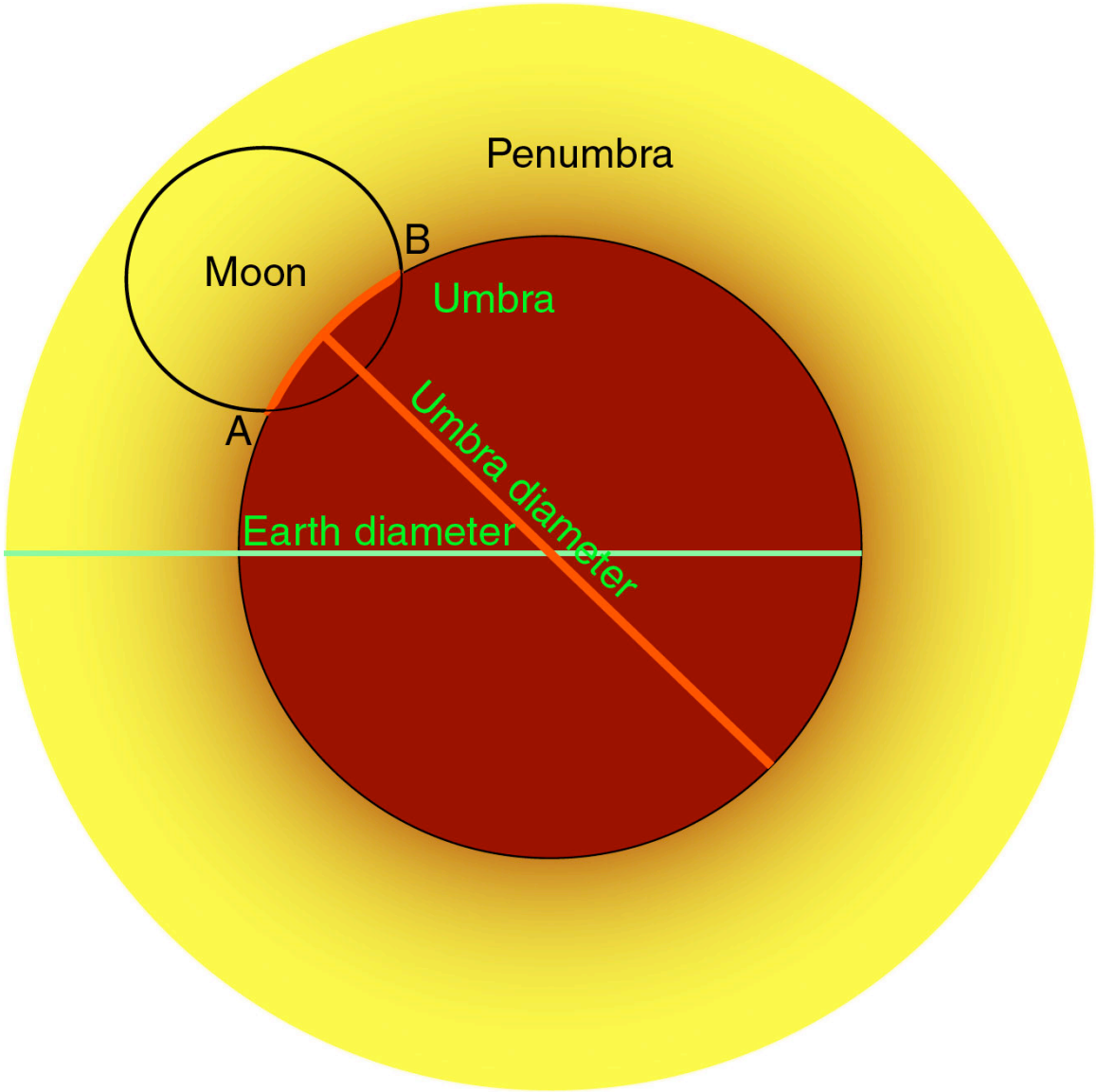
Do it yourself: The distance to the Moon
October 27 in 2004

Motivation: Getting the distance to the Moon and its size is a first step to getting at the vastness of space. The geometry is particularly convenient during a partial ellipse of the Moon. The ancients did an adequate job here. We will follow a convenient form of their methods. We will use the diameter of the Earth as our "yardstick." The ancients had adequate, but imprecise estimates of this quantity. One is stuck with observing on the night of an ellipse. We give the exercise for the nice Oct 2004 eclipse.

Project: There was an eclipse of the Moon on October 27. It was total between 7:23 and 8:45 PM. The partial eclipse between 20:45 and 21:54 allowed estimation the distance to the Moon. You will probably as well as the ancients with equipment available to them. Remember you can only see the shadows where they hit the Moon's surface.


Penumbra
Moon
B
Umbra
A
Umbra diameter
Earth diameter

During the partial eclipse, the Moon is partly in the Earth's inner shadow, the umbra, and partly in the shadow, the penumbra. Sketch the Umbra shadow (dark edge line) on the Moon and estimate its diameter in Moon diameters. An easy way to do this is to use cardboard circles, coins, or small balls. This will work better in practice if one person holds the disks further way and the other observes. Then you can use a golf or tennis ball for the disk and get far enough away that the diameter of the pupil of your eye is small compared with your disks and balls.

Record the disk or ball diameter. D =_____.

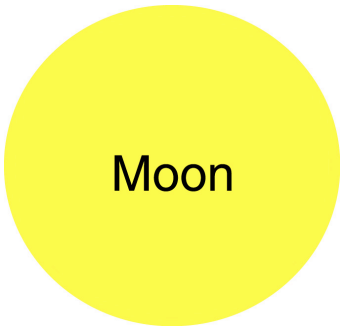
Hold the disk out so that is just covers the disk of the moon. Record how far you held it out.

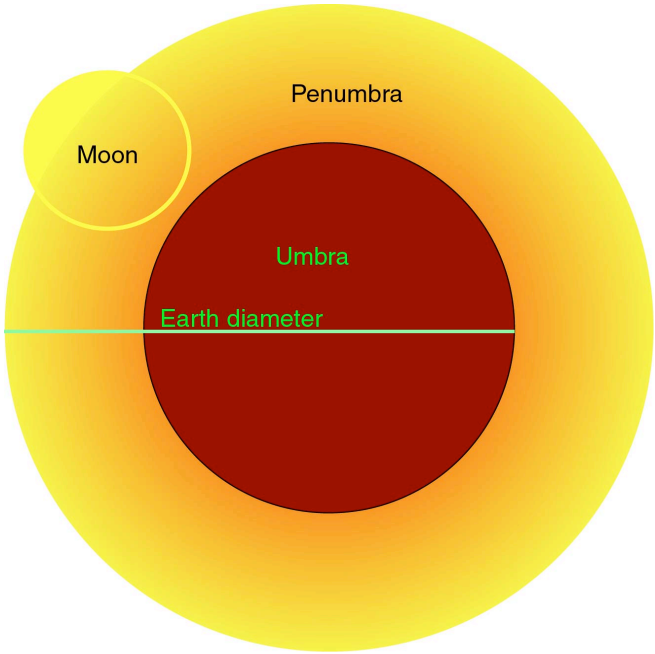
Y = _____.

Now hold the disk closer so the it covers the edge of the Umbra (between A and B on the last page). Record how far you help it from your eye.

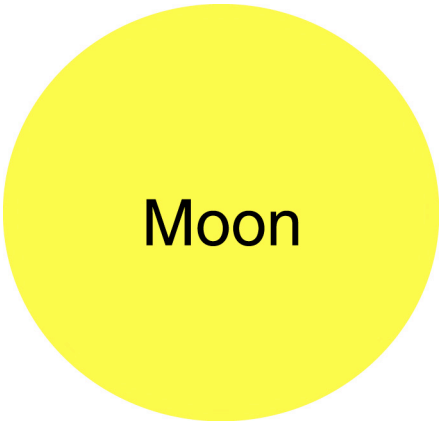
X = _____

The umbra diameter in Moon diameters is U = X/Y _____ / _____ = _____.





The partial 2004 eclipse ended at 9:54. You need to be alert right after that. In a few minutes, the Penumbra shadow edge will then cross the disk of the Moon. It will be on the opposite side that you last saw the edge of the umbra. It is not possible to spot the actual outer edge of the penumbra but you will see a gradient in brightness across the face of the Moon. The Moon exited penumbra shadow edge at 11:02 PM. Try to extrapolate the gradient and make a good guess a few minutes after the partial eclipse ends. Sketch gradient. If it is somewhat cloudy this will be futile but you may still see a gradient of brightness across the face of the Moon.



You will not get a reliable estimate of P since you will not see the edge. We use P=U+2 which takes advantage of the fact that the disk diameters of the Sun and the Moon are

both ABOUT 0.5°. One could measure disk angle of the Sun and Moon and use geometry to make the estimate more precise. The former can be safely done with a pinhole.

The Earth's diameter in Moon diameters is with a little geometry and algebra
E=(U+P)/2 = U+1 _____

So the Moon's diameter in Earth diameters is 1/E = M _____
The distance from the Moon to the Earth in Earth diameters is (using again that the Moon's disk angle is 0.5° which you can obtain from the ratio D/Y) with a little more geometry is

M*114.6 = _____

You now have a reasonable naked-eye distance to the Moon in Earth diameters.