

What did Greek cosmologists study (200BC-200AD)—8 Sep

- Cosmology is the study of the universe at the largest scales.
- Erathosthenes measured the size of the earth.
- Hipparchus measured the distance to the moon.
- Tools used by Greek astronomers
 - Telescopes?
 - Geometry

Erathosthenes measures size of Earth ~200 BC

- A correspondent in Syene reports that at noon on the summer solstice, the sun illuminates the bottom of a well. In Alexandria (where Erathosthenes lived), a stick makes a 7° shadow.
- It takes a camel 50 days to travel from Syene to Alexandria. A camel can travel 100 stadia/day.
- What is the distance between Alexandria & Syene in km?

Erathosthenes ~200 BC

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- It takes a camel 50 days to travel from Syene to Alexandria. A camel can travel 100 stadia/day.
- 1. What is the distance between Alexandria & Syene in km?
What is the length of a stadium?
- Guess that a stadium is 100m.
- What is the distance between Alexandria & Syene in km?
 - $100\text{m/stadium} \times 100\text{stadia/day} \times 50\text{days} = 500,000\text{m} = 500\text{km}$

Erathosthenes ~200 BC

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- It takes a camel 50 days to travel from Syene to Alexandria. A camel can travel 100 stadia/day.
- 1. The distance between Alexandria & Syene is 500 km?
- 2. Draw a picture to show the relationship between the sun, the well, the stick, and the two locations. "A clear picture is 90% of clear thinking."
- Picture shows Alexandria & Syene are 7° apart in latitude.
- The circumference is 360° around Earth
 - $500\text{km} \times 360^\circ/7^\circ = 25,000\text{km}$
- Actual circumference is 40,000km.

Hipparchus measures the moon's distance ~200BC

- At the Hellespont, the solar eclipse of 189BC was total. (Sparta defeated Athens there in 405 BC.)
- In Alexandria, the moon covered $\frac{3}{4}$ of the sun.
- Alexandria is 1000km from the Hellespont.
- Did Hipparchus need a telescope to make this observation?



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Observations of an eclipse



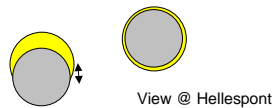
- Photo taken by my brother Eddie
1. Why are there many images of the sun? My explanation is correct. The moon is exactly in front of the sun.
 - A. YY
 - B. YN
 - C. NN
 - D. NY

Hipparchus measures the moon's distance ~200BC

- At the Hellespont, the solar eclipse of 189BC was total. (Sparta defeated Athens there in 405 BC.)
- In Alexandria, the moon covered $\frac{3}{4}$ of the sun. Alexandria is 1000km from the Hellespont.
- The diameter of the sun is $\frac{1}{2}$ degree. In Alexandria, the angle between the sun and moon is $\frac{1}{4} * \frac{1}{2} = \frac{1}{8}$ degree.
- "A clear picture is 90% of clear thinking."
- Draw a picture to show the relationship between the sun, the moon, the two locations, and the angle between the sun and moon in Alexandria.



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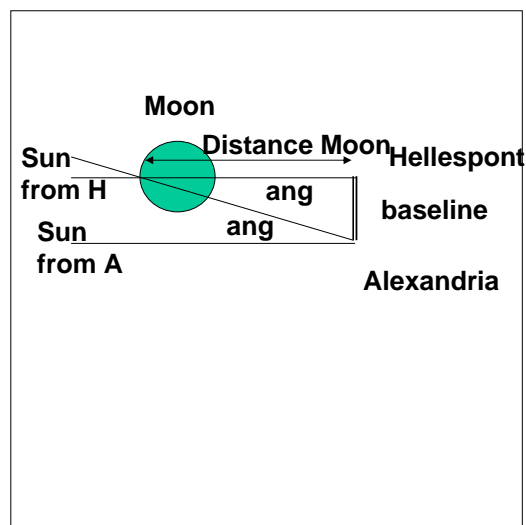


View in Alexandria.
Moon is offset by 1/4 diameter of sun

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- Parts of triangle
 - Angle is due to parallax: moon in foreground shifts with respect to sun in the background.
 - One leg of triangle is the baseline.
 - Other leg is distance to moon.
- Small-angle approximation
 - Angle = Baseline/Distance
 - Angle must be in radians
 - 180° in π rad
 - $57^\circ/\text{rad}$
- Find distance
 - Distance = Baseline/Angle

What triangle did Hipparchus use?

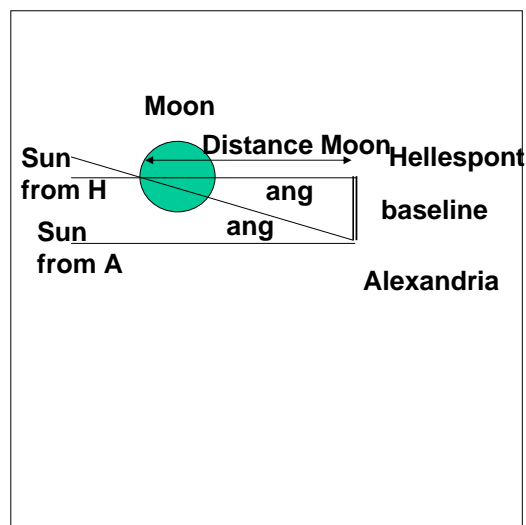


Small-angle approximation

- Small-angle approximation
 $\text{Angle} = \text{Baseline}/\text{Distance}$
 - Angle must be in radians
 - 180° in π rad
 - $57^\circ/\text{rad}$
1. From Alexandria to the Hellespont, the angle between the sun and moon shifts by $1/8^\circ$. What is the shift in radians? Explain how to do this without remembering a formula.
- A. $1/8$ rad
 B. $57/8 = 6$ rad
 C. $1/8/57=1/440$ rad

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- Small-angle approximation
 $\text{Angle} = \text{Baseline}/\text{Distance}$
 - Angle must be in radians
 - 180° in π rad
 - $57^\circ/\text{rad}$
- Find distance
 $\text{Distance} = \text{Baseline}/\text{Angle}$
 $\text{angle} = 1/440$ rad
 $D = 1000\text{km} \cdot 440 = 440,000\text{km}$

What triangle did Hipparchus use?



- Identify the big ideas for this class.