TEACHER'S GUIDE

HOW BIG IS THE EARTH?

Overview

Age range: 12 - 16 years

Prep. time: 15 minutes + the time to find a partner school

Lesson time: 30 minutes

Cost per activity: 0

Includes the use of: calculator

Outline

In this exercise, we will measure the circumference of the Earth using the same procedure as Eratosthenes did 240 BC. To do this, we need to measure the height of the sun in two locations directly north-south of each other. Are you able to get answers close to the result we have today?

Pupils will learn

- Basic mathematics (multiplication and division)
- Measurement techniques
- Geometry

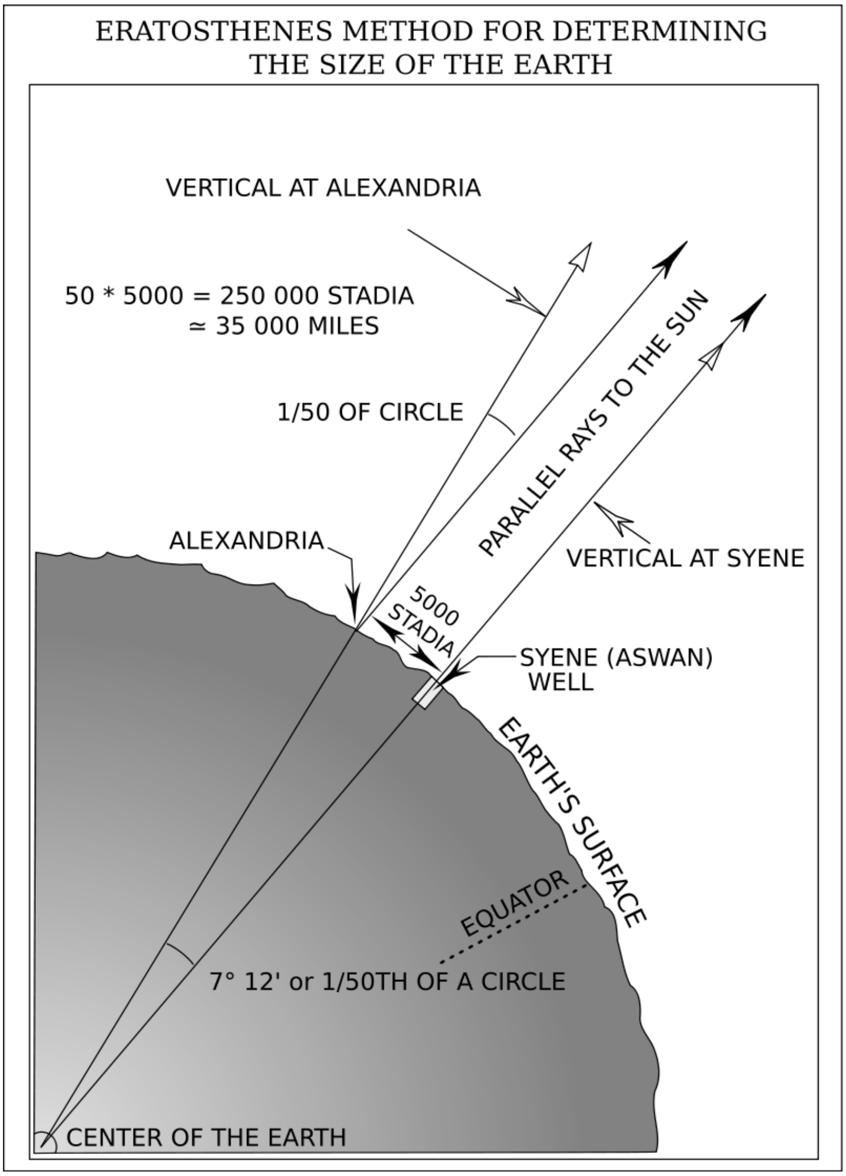
Lesson plan

1. Find the solar height at noon measured from your school
2. Find the solar height at noon measured at some other school, far north of south
3. Compare angles and use a map to find the distance between the schools
4. Calculate the Earth's circumference
5. Discussions

Introduction to the subject

Measurement of Earth's circumference has been important to navigation since ancient times. The first known scientific measurement and calculation was first calculated by Eratosthenes, which he did by comparing altitudes of the mid-day sun at two places a known north–south distance apart.

In modern times, Earth's circumference has been used to define fundamental units of measurement of length: the nautical mile in the seventeenth century and the metre in the eighteenth. Earth's polar circumference is very near to 21,600 nautical miles because the nautical mile was intended to express 1/60th of a degree of latitude (i.e. 60 × 360), which is 21,600 partitions of the polar circumference. The polar circumference is even closer to 40,000 kilometres because the metre was originally defined to be one 10-millionth of the circumferential distance from pole to equator. [1]



Eratosthenes' method for determining the circumference of the Earth, with sunbeams shown as two rays hitting the ground at two locations in Egypt – Syene (Aswan) and Alexandria. Source: Wikipedia.

Eratosthenes got his idea from the observation that on one particular date, the sun would shine all the way to the bottom of the well at noon in Syene. He noticed one year later that this did not occur in Alexandria on the same date, suggesting the position of the sun was not equal seen from Syene and Alexandria. He estimated the distance between Syene and Alexandria from the time travelled to be *5000 stadia* (approx. 800 km). He also found the difference in solar height was 7^{o}.

The angle he measured corresponded to the difference in latitude between Syene and Alexandria, since the rays of light from the Sun are parallel to each other. From this fact, he could set up the equality:

$$\frac{distance\ between\ Alexandria\ and\ Syene}{Earth\ circumerence} = \frac{7^0}{360^0}$$

and solving this for Earth circumference, he found that the circumference should be 250 000 stadion or approx. 40 000 *km*. The circumference measured today using satellites gives 40 075 *km*.

Is the world flat?

Interestingly enough, there are several young students today who have asked their teacher's for proof that the world is round, after having found videos by the flat earth society on youtube convincing. Although most people will accept the fact that the Earth is round, it might be challenging to find convincing arguments based on observations students have done or can do themselves.

There are in fact several simple observations you can perform:

1. If your school is close to the sea, you can observe the curved horizon using a long ruler. Hold the ruler horizontally in front of you with your arms stretched out. Aim so that the ruler is exactly at the horizon in both ends. The curvature should then show as the horizon rises above the ruler in the middle. This effect should, hopefully, convince those in doubt.
2. If students have experience from observing the constellations at night time when travelling, ask if they noticed any difference when travelling north-south or east-west. Use a well known constellation, e.g. Ursa Major / Big Dipper, and ask if they noticed the constellation's height above the horizon compared to home. Students travelling east or west will not notice any difference, while students travelling north-south will. This observation can also be done with the sun. This effect is not possible to describe with a flat earth model.

[1] https://en.wikipedia.org/wiki/Earth%27s_circumference

Preparations

Find a partner school situated some distance away (preferably in another country) north or south of your school. If you do not know which school to ask, ask any of the partners in the Online Observatory project to suggest a school in their country:

- Norway: Harestua Solar Observatory, post@solobservatoriet.no
- Denmark: Brorfelde Observatory, micli@holb.dk
- Latvia: Baldone Observatory, ilgmars.eglitis@lu.lv
- UK: Faulkes Telescope Project, info@faulkes-telescope.com
- Finland: Helsinki Observatory, observatorio@helsinki.fi