ACTIVITY "BONS RAIOS TE MEÇAM"

21, March, 2014

INSTRUCTIONS

Material:

- cardboard or butcher paper;
- equipment with internet access;
- plumb line and/or level;
- gnomon (stick, pencil, post, …);
- ruler or tape measure, set square (triangle), compass;
- watch.

Before the measurements ...

1st Get the exact coordinates of the location where it will perform the activity.

You can do this using a GPS device and / or device with internet access (Google Earth or internet website to obtain geographic coordinates).

At noon of March 21, the Sun will focus almost perpendicularly above the equator, as it will be the Spring Equinox (in the Northern Hemisphere). The distance can be obtained using a map and calculating the actual distance given by its scale. You cam make this measure by using Google Earth or by using an online distance measure.

2nd Verifying the time of solar noon on the day of the activity in your location.

At the time of time of solar noon the shadow of the objects is minimal.

You can use an online solar noon calculator to realize what will be the time of solar noon at your location. We recommend to synchronize your personal watch with the legal time.

Solar noon moment in diferent locations in March, 21st, 2014										
Coimbr	Porto	Lisboa	Guard	Braganç	Tavira	Funcha	Ponta Delgad	Príncip	Luanda	Maput
12h42	12h42	12h45	12h37	12h35	12h39	13h16	13h51	11h38	11h15	9h58m

3rd Choose the object that will serve as the gnomon.

Unleash creativity and adapt an object that serves for this purpose, preferably cylindrical in shape. Seek simple materials, low cost and easy to obtain. For example, a new pencil serves as a gnomon. However it is recommended to use a gnomon with a height of at least 1 meter.

4th Choosing a flat and horizontal place exposed to the Sun.

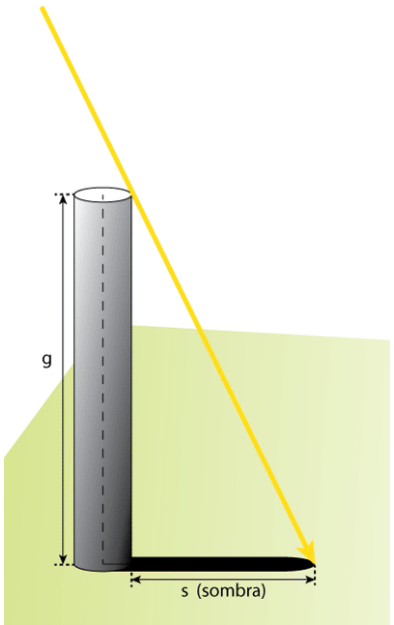
Ensure that the floor plan selected (floor, table, board, etc..) which underlies the gnomon (and drop shadow) is completely horizontal. Use a ruler with bubble level to make sure the horizontality. Typically, the existing sports fields in schools provide a good basis for achieving horizontal experience. Nevertheless, we recommend using a level to check that feature floor.

5th Prepare the space for activity.

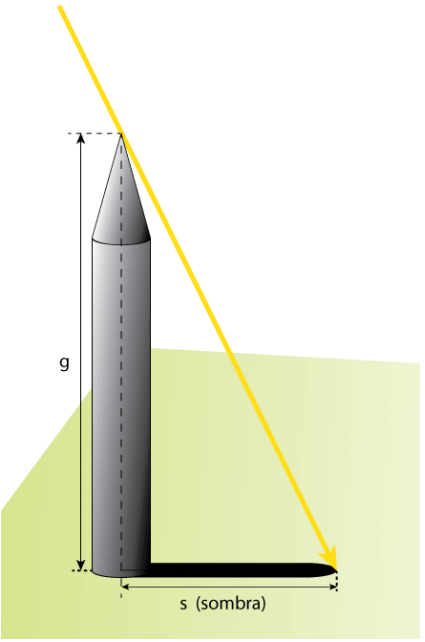
Just before solar noon, you should fix the cardboard or sheet of butcher paper with adhesive tape at the local level chosen for the measurements. Remember to choose a location where there is no shadow of buildings or trees. Then shall erect the gnomon chosen so as to allow the recording of shadows on the paper and use the plumb line or a ruler with bubble level to make sure that it is perfectly vertical relative to the ground.

Taking measurements ...

Approximately half an hour before the scheduled time for solar noon, start recording from the end of the shadow of the gnomon on the paper (or butcher paper) and the respective time of registration. Repeat this process five minutes. During these notes will realize that the shadow size decreases until it reaches a minimum at a given moment, and then returns to the shadow increase in size. This instant is the solar noon and is precisely this tag that interests for the activity.



At the end of the records should remove the gnomon and measure the distance between the minimum shadow and the spot where the base of the gnomon was. See the following images to decide whether to use as reference the outer surface of the gnomon (if left) or the position of its center (if right).



If you cannot find the right position which is the minimum shadow, you can construct the perpendicular bisector of the segment defined by two identical records (prior to and after the solar noon) and take the minimum shade for measuring the distance from the point where it was erected the gnomon to the point of interception between the bisector and the arc described by the edge of the shadow.

After obtaining the minimum length of the shadow and the height of the gnomon (previously measured), you already have all the data necessary to estimate the radius of the Earth value!

Fix the value of the shadow: At minimum value obtained for the shadow you need to remove half value of the diameter of the gnomon (radius).

At this time you can submit the data collected at the site of the Mathematics of Planet Earth project using the form provided for that purpose.

However you can continue the activity by calculating your estimate for the radius of the Earth, given the fact that at noon on 21 March (Spring Equinox) the Sun passes vertically through Ecuador at noon, at these locations, the extent of the shadow of a vertical rod is zero.

Now the Mathematics...

Consider:

- g the measure of the gnomon's length;
- d the distance from your location to the Equador (in km);
- s the measure of the shadow's length (after correction));
- α the magnitude of the angle defined by the sun and the gnomon;
- P the estimated value for the circumference of the planet Earth;
- r the estimated value for the radius of the Earth.

Start by determining the value of the angle defined by the sun and gnomon using trigonometry, as follows:

$$\alpha = \tan^{-1}\left(\frac{s}{g}\right)$$

Having the values of α and d it is estimated calculating the circumference of Earth, using the expression

$$P = \frac{360 \times d}{\alpha}$$

and, finally, to determine the approximate value for the radius of the Earth

$$r = \frac{P}{2\pi}$$

Compare o seu resultado com o valor do raio equatorial terrestre: 6378,14 km.

Document translated by José Gonçalves, in 15-03-2014

Scientific Advisers

Filipe Pires (Centro de Astrofísica da Universidade do Porto)

João Fernandes (Observatório Astronómico da Universidade de Coimbra)

Máximo Ferreira (Centro Ciência Viva de Constância)

Rui Agostinho (Observatório Astronómico de Lisboa)

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Photograph records

Activity "Bons Raios Te Meçam" – June, 21st of 2013 (1st Edition)
Portugal
Noutros locais do planeta

Activity "Bons Raios Te Meçam" – September, 23 of 2013 (2nd Edition)
Portugal

Activity "Bons Raios Te Meçam" – December, 23 of 2013 (3rd Edition)
Portugal

Photographic records of similar activities previously performed:

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Playlist about this topic in Youtube channel MPT2013:

http://tinyurl.com/pnlghe4

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Oficial webpage of the activity

Thank you for your participation and cooperation …

Matemática do Planeta Terra