

Eratostrhenes

project

indian



इण्डियन

2015, July 27th



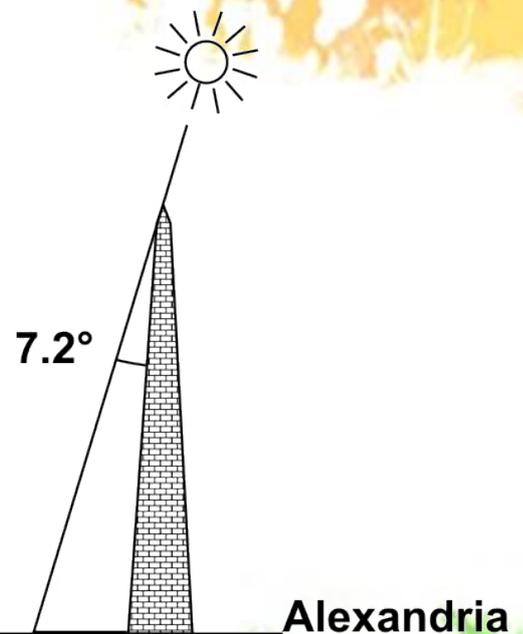
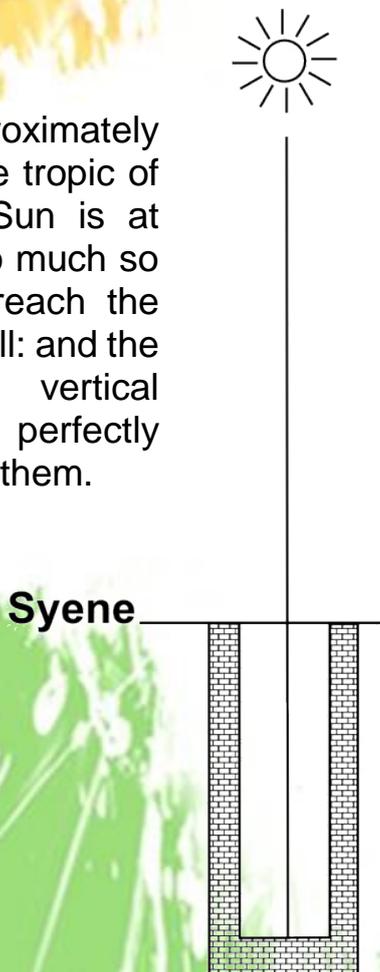
# The Historical Experiment

In 205 B.C., the Greek astronomer Eratosthenes, at the time Director of the Great Library of Alexandria in Egypt, proposed a purely geometrical method to measure the length of the Earth's meridian (circle passing through the poles).

He started by using the observation of shadows made at two different places, Alexandria and Syene (now Aswan) distanced approximately 800 km apart (distance estimated in relation to the time taken by a caravan of camels to connect the two towns !) at the time of the Summer solstice and at noon local solar time.

On that date and at that precise time in the northern hemisphere, the Sun reaches its highest position in the year above the horizon. However, Eratosthenes noticed differences from one place to another.

In Syene (approximately situated on the tropic of Cancer) the Sun is at the vertical, so much so that its rays reach the bottom of a well: and the shadows of vertical objects are perfectly centred round them.

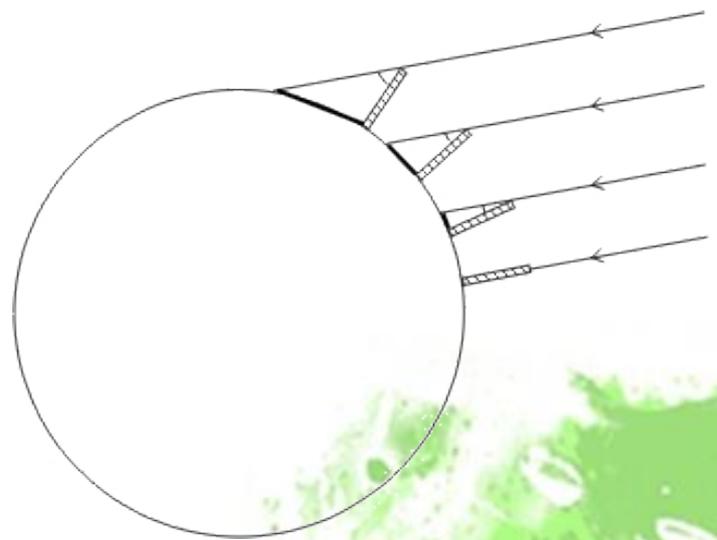
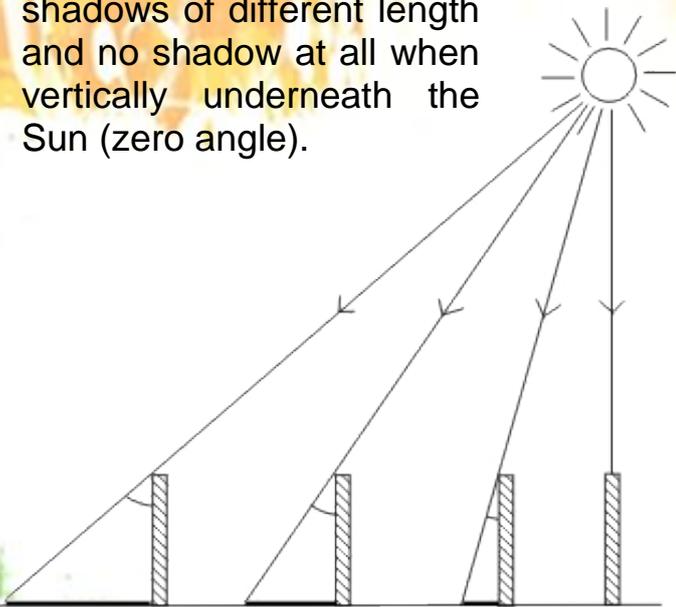


In Alexandria, on the other hand, the Sun is no longer at the vertical, and these same objects have a very shallow offset shadow. Eratosthenes set about measuring the shadow of an obelisk whose height he knew, and used this information to deduce the angle of the sun's rays from the vertical: he found 7.2°

On the basis of these observations, two hypotheses lay before him:

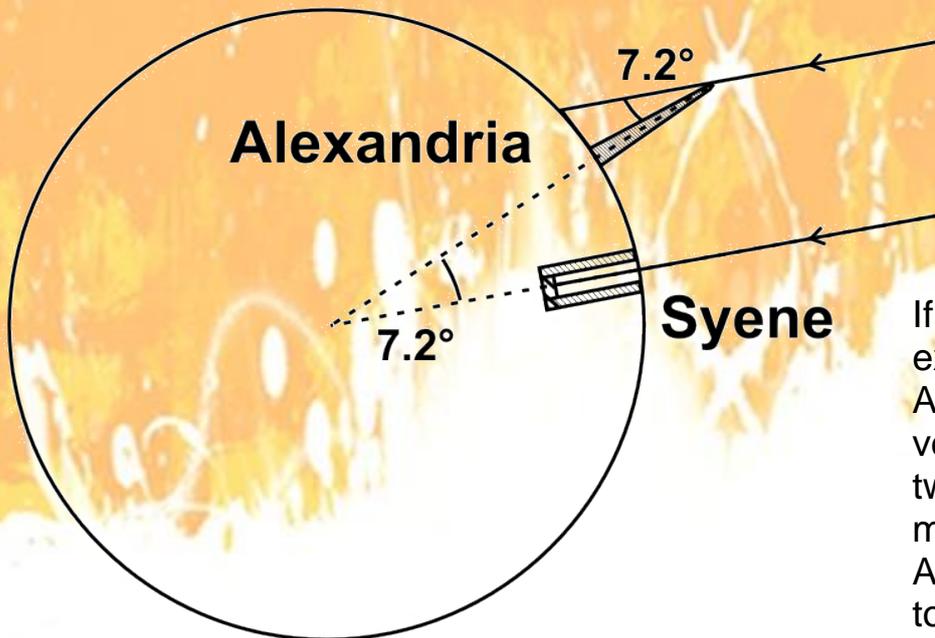
The Earth is flat, but in this case the Sun would be sufficiently close for there to be a significant divergence in its rays reaching distant objects: since objects of identical length have shadows of different length and no shadow at all when vertically underneath the Sun (zero angle).

The Earth is not flat, but has a curved, and perhaps even a round surface. Only, the same results can be obtained with sun rays which are all parallel: this implies that the Sun is sufficiently far away, very, very far away...



Eratosthenes opted for the second hypothesis. Indeed, the Ancients had already suspected that the Earth was not flat, on the basis of various observations seemingly providing evidence that its surface was somewhat curved: navigators perched on the top of their main mast are the first to perceive the distant coastline; observers on top of a cliff have a longer view of ships moving towards the horizon than observers on the beach; the pole star is not at the same height above the horizon in Greece as in Egypt; finally during eclipses of the Moon, the shadow of the Earth projected onto the Moon shows a circular section.

Convinced that the Earth is round, our genius Eratosthenes set about tracing his famous "amazingly simple" geometrical figure, which he used to calculate with ease the length of the Earth's meridian! Look for yourselves:



If the Earth is round, by extending the vertical in Alexandria (the obelisk) and the vertical in Syene (the well), these two verticals should by definition meet at the centre of the Earth. Also, Eratosthenes knew that the town of Syene being situated directly South in relation to Alexandria, the two cities were situated on approximately the same meridian. Since the sun's rays are indeed parallel, the angle formed by the two verticals at the centre of the Earth must therefore be identical to the angle he measured with the shadow of the obelisk (7.2°).

The proportion of this angle in relation to the 360° of a circle is the same as the proportion of the distance separating the two cities (approximately 800 km) relative to the circumference of a circle (in this case the Earth's meridian). The rest you can guess: 360° divided by 7.2° gives 50, and 800 km multiplied by 50 indeed gives 40000 km (a length which was found again later but using other methods).

Angle (°)	Distance (km)
7.2	800
360	circumference



$$\text{Circumference} = 360 \times 800 / 7.2 = 40\,000$$

On July 27<sup>th</sup>, the conditions were the same in **Mumbai** as in Syene 205 BC: The Sun is at the vertical at noon. The experiment took place in Marwari Vidyalaya High School, conducted by *Vishal Sawant*.

For this date a special measuring spot was built in **Baghpat**, Shri Vinayak College Of Education, during the science fair organized by *Yogesh Kumar*, co-ordinator VIPNET club: Science Innovation & Humanist Sansthan.

In **Allahabad**, 2 schools participated to this event: Vashisth Vatsalya Public School, and St Marys Convent School Ghoorpur, under guidance of science communicators *Swapnil Kumar Sharma*, *Ritanshu Gupta*, and *Rishi Pandey Rishabh* from iCREATORZ.

**Yamunanagar** measure was planned by *Darshan Baweja* co-ordinator VIPNET club: C.V. Raman Science Club.

The measure in **Dholpur** was conducted by *A.K. Srivastava*.

13 European teachers were involved in this experiment (from their holiday place):

*Stavroula Lada*, Primary School DDMN, Greece (**Chania**)

*Olga Keramida*, 1st Kindergarten of Pylos, Greece (**Pylos**)

*Katerina Atmatzidoys*, Lykeio Sximatariou, Greece (**Chalkida**)

*Maria Kontoula*, Junior High School of Krokos, Greece (**Kozani**)

*Petros Efstathiou*, 3rd Junior High School of Ilion, Greece (**Selianitika**)

*Aspasia Dilalou*, 1st Junior High School of Aigio, Greece (**Cephalonia**)

*Eleni Chartzavalou*, Experimental College of Ioannina, Greece (**Ioannina**)

*Bill Kostopoulos*, Experimental College Agion Anargyron, Greece (**Athens**)

*Fotini Petridou*, Lardos Elementary school, Greece (**Lardos beach & Serres**)

*Athanasia Zafeiropoulou*, 4th Junior High School of Petroupolis, Greece (**Methoni**)

*Daniela Ruzic Mrak*, OŠ kneza Branimira, Croatia, **Donji Muc**

*José María Díaz Fuentes*, Colegio Salesiano Santo Domingo Savio, Spain, **Ubeda**

*Costantino Soudaz*, Istituzione Scolastica Monte Rosa A, Italy **Pont Saint Martin**

*Cindea Hung* coordinated measures in Taiwan at Chia Hwa Senior High School, **Chiayi City** and 鳳西國中FXM, **Kaohsiung**, and in China **Shenzhen** with *Jia Huang*

*Jeane de Fatima*, Centro Educacional Nosso Mundo, Brazil, **Rio de Janeiro** and, *Dr Jose Luis Cabrera*, Fundación Caminos de **Anisacate**, Argentina were our 2 south American partners



The circumference of the Earth  
has been calculated after experiments of  
25 spots of measurements  
from 9 countries

Argentina  
Brazil  
China  
Croatia  
India  
Italy  
Greece  
Spain  
Taiwan

For the videoconference, all the calculations of the circumference were made with the measure in Mumbai as reference

City	Country	School	Latitude (+N/-S) decimal(°)	Longitude	Date	Gnomon height [cm]	Shadow length [cm]	Angle (°)
Pont St Martin	Italy	Istituzione Scolastica Monte Rosa A	45.601	7.795	27/07/2015	100.0	48.5	25.9
Donji Muć	Croatia	Oš kneza Branimira	43.694	16.462	27/07/2015	100.0	43.5	23.5
Serres	Greece	Teacher	41.089	23.553	27/07/2015	100.0	39.4	21.5
Kozani	Greece	Teacher	40.290	21.815	30/07/2015	130.0	48.2	20.3
Ioannina	Greece	Teacher	39.683	20.825	27/07/2015	100.0	36.4	20.0
Chalkida	Greece	Teacher	38.465	23.592	27/07/2015	60.0	21.0	19.3
Selianitika	Greece	Teacher	38.282	22.028	27/07/2015	143.0	47.7	18.4
Athens	Greece	Teacher	38.130	23.849	27/07/2015	40.0	13.3	18.4
Cephalonia	Greece	Teacher	38.102	20.575	27/07/2015	40.5	13.8	18.8
Ubeba	Spain	Colegio Salesiano Santo Domingo Sawo	38.017	-3.367	27/07/2015	109.4	37.3	18.8
Methoni Castle	Greece	Teacher	36.812	21.705	27/07/2015	100.0	30.0	16.7
Pylos	Greece	Teacher	36.544	21.413	27/07/2015	58.0	19.2	18.3
Lardos	Greece	Teacher	36.042	28.004	27/07/2015	163.0	49.8	17.0
Chania	Greece	Teacher	35.514	24.015	26/07/2015	121.0	35.0	16.1
Yamuna nagar	India	Mukand Lal PS Sarojini Colony	30.133	77.283	27/07/2015	20.0	3.6	10.2
Baghpat	India	Shri Vinayak College Of Education	28.881	77.249	27/07/2015	114.6	19.0	9.4
Tagiwali Dholpur	India	GSSS Tagawali	26.708	77.908	3/8/2015	159.0	24.0	8.6
Allahabad VVPS	India	Vashisth Vatsalya Public School	25.452	81.841	27/07/2015	100.0	12.5	7.1
Allahabad Ghoorj	India	St Marys Convent School Ghoorpur	25.327	81.823	27/07/2015	100.0	12.5	7.1
Chiayi City	Taiwan	Chia Hwa Senior High School	23.483	120.477	30/07/2015	50.0	3.2	3.7
Kaohsiung	Taiwan	鳳西國中 FXM	22.621	120.354	27/07/2015	50.0	2.9	3.3
Shenzhen	China	Futian	22.524	114.061	27/07/2015	50.0	5.5	6.3
Mumbai	India	Marwari Vidyalaya High School	18.957	72.818	27/07/2015	81.0	0.0	0.0
Rio de Janeiro	Brazil	Centro Educacional Nosso Mundo	-22.890	-43.317	27/07/2015	30.0	-29.0	-44.0
Anisacate	Argentina	Fundación Caminos de Anisacate	-31.717	-64.400	27/07/2015	96.0	-117.0	-50.6

The average circumference is:

# 40 027 km

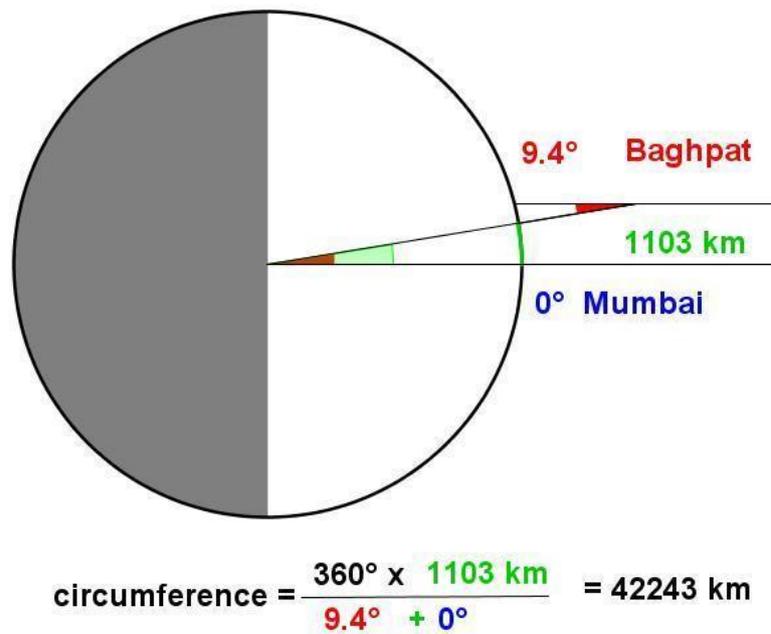
# Marwari Vidyalaya High School Mumbai, India (18.957N - 72.818E)



# Shri Vinayak College Of Education Baghpat, India (28.881N - 77.249E)



27 July 2015 (Baghpat-INDIA) Latitude: 28.88°  
27 July 2015 (Mumbai-INDIA) Latitude: 18.96°

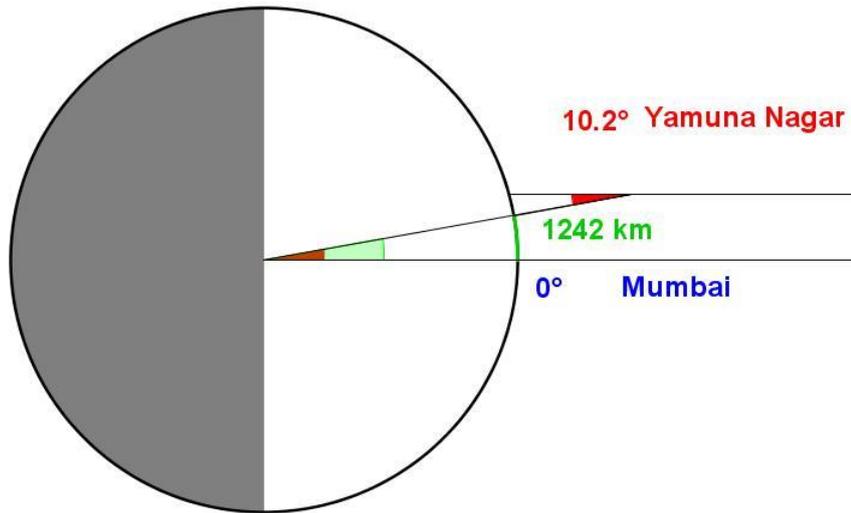


# C V Raman Science Club Sarojini Colony Yamunanagar India (30.133N - 77.283E)



27 July 2015 (Yamuna Nagar-INDIA) Latitude: 30.13°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



$$\text{circumference} = \frac{360^\circ \times 1242 \text{ km}}{10.2^\circ + 0^\circ} = 43835 \text{ km}$$

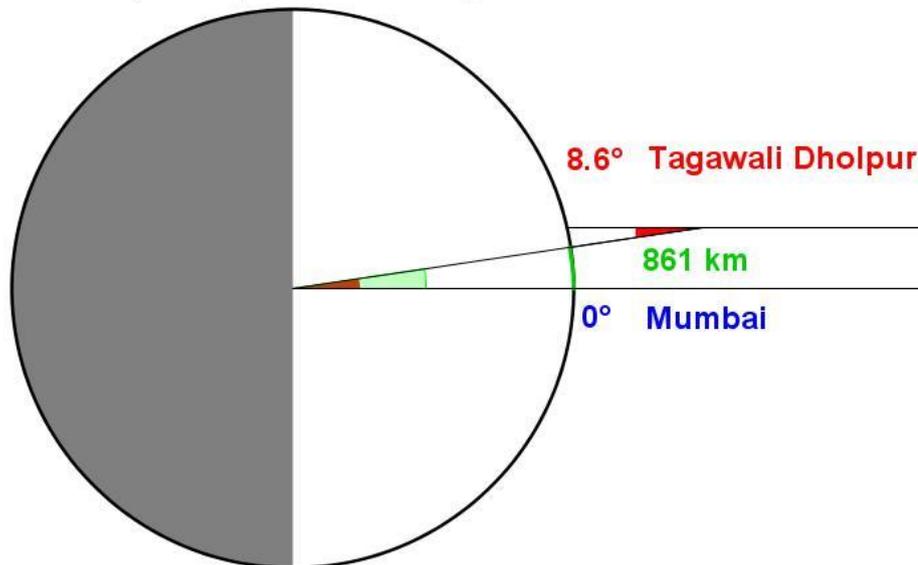


# GSSS Tagawali

## Tagawali Dholpur, India (26.708N - 77.908E)



3 August (Tagawali Dholpur-INDIA) Latitude: 26.71°  
 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



$$\text{circumference} = \frac{360^\circ \times 861 \text{ km}}{8.6^\circ + 0^\circ} = 36042 \text{ km}$$

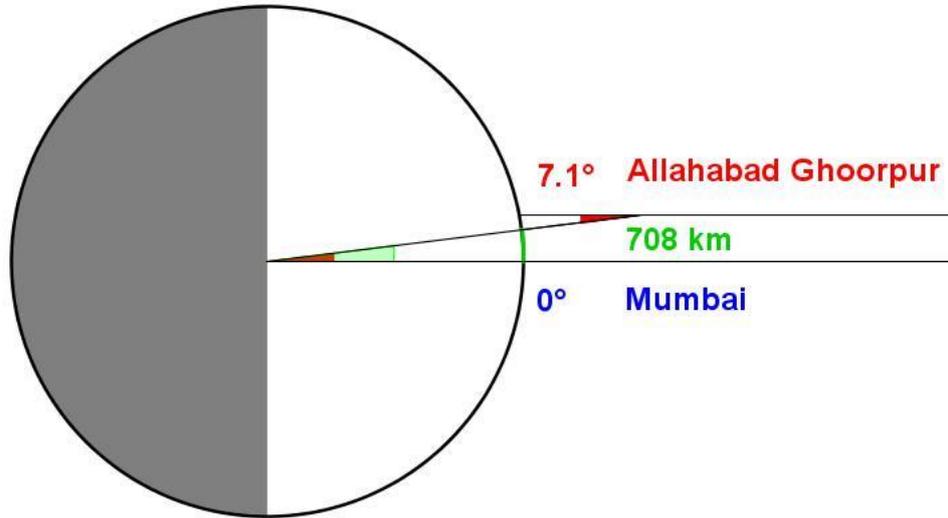


# St Marys Convent School Ghoorpur Allahabad Ghoorpur, India (25.327N - 81.823S)



27 July 2015 (Allahabad Ghoorpur-INDIA) Latitude: 25.33°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



$$\text{circumference} = \frac{360^\circ \times 708 \text{ km}}{7.1^\circ + 0^\circ} = 35899 \text{ km}$$

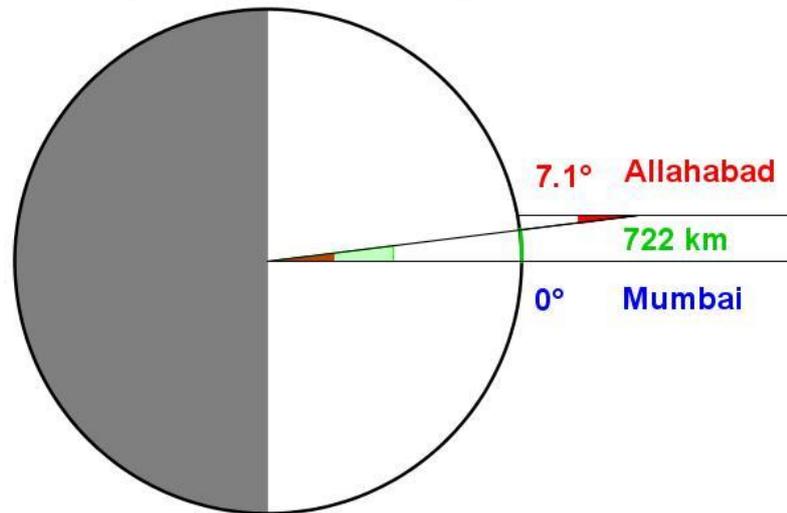


# Vashisth Vatsalya Public School Allahabad, India (25.452N- 81.841S)



27 July 2015 (Allahabad-INDIA) Latitude: 25.45°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



$$\text{circumference} = \frac{360^\circ \times 722 \text{ km}}{7.1^\circ + 0^\circ} = 36608 \text{ km}$$

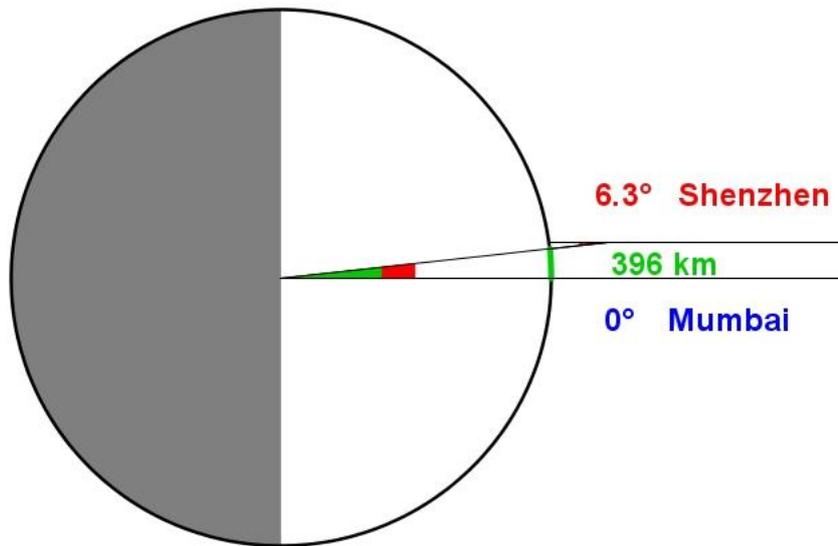


# Futian

## Shenzhen, China (22.524N - 114.061E)



27 July 2015 (Shenzhen-CHINA) Latitude: 22.52°  
 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°

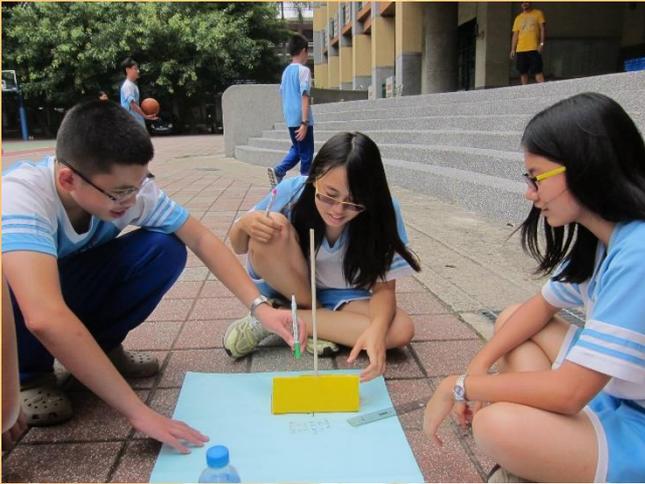


$$\text{circumference} = \frac{360^\circ \times 396 \text{ km}}{6.3^\circ - 0^\circ} = 22629 \text{ km}$$



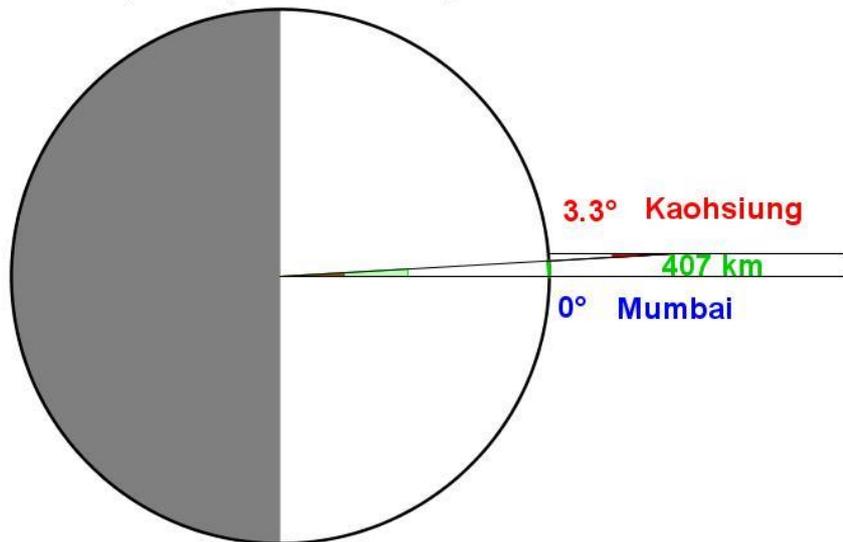
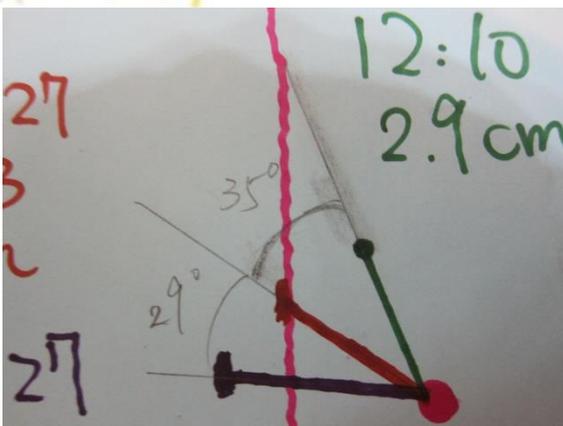
# 鳳西國中 FXM

Kaohsiung, Taiwan (22.621N - 120.354E)



27 July 2015 (Kaohsiung-TAIWAN) Latitude: 22.62°

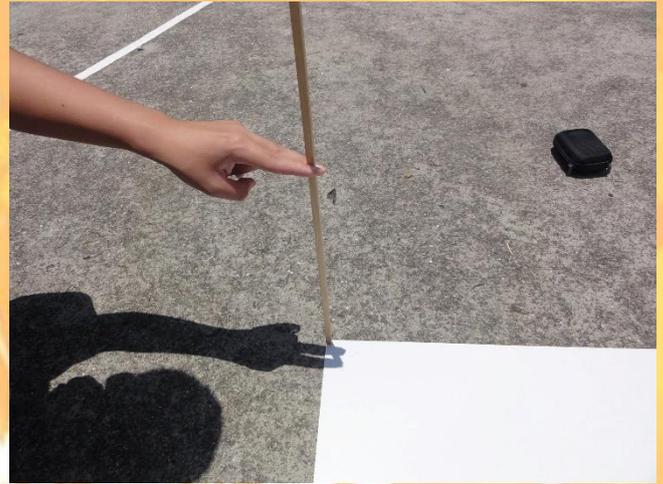
27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



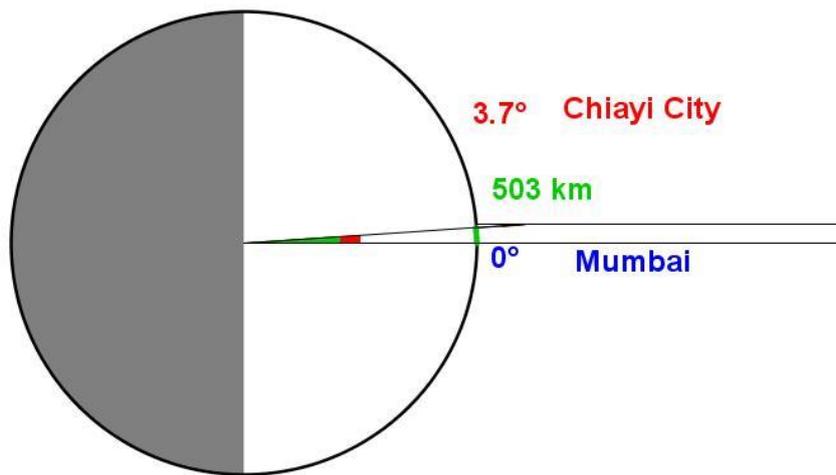
$$\text{circumference} = \frac{360^\circ \times 407 \text{ km}}{3.3^\circ + 0^\circ} = 44400 \text{ km}$$



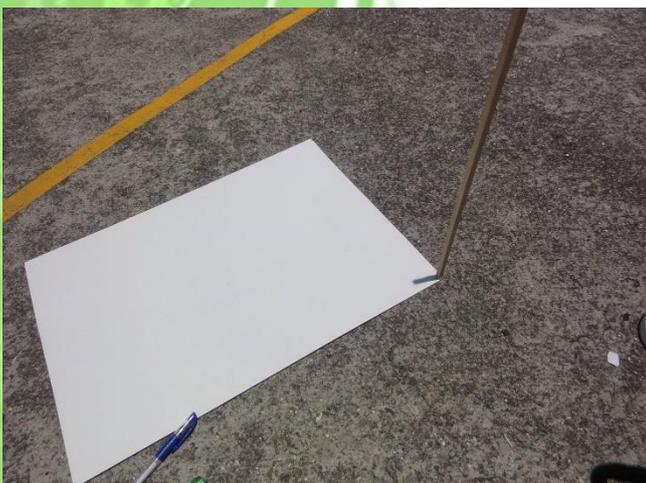
# Chia Hwa Senior High School Chiayi City, Taiwan (23.483N - 120.477E)



30 July 2015 (Chiayi City -TAIWAN 23.48)  
27 July 2015 (Mumbai-INDIA 18.96)



$$\text{circumference} = \frac{360^\circ \times 503 \text{ km}}{3.7^\circ - 0^\circ} = 48941 \text{ km}$$

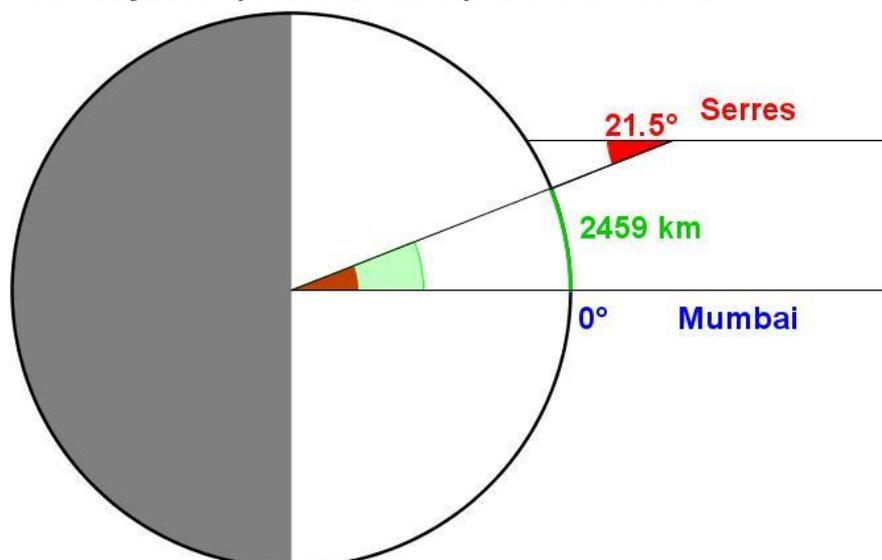


# Serres, Greece (41.089N - 23.553E)

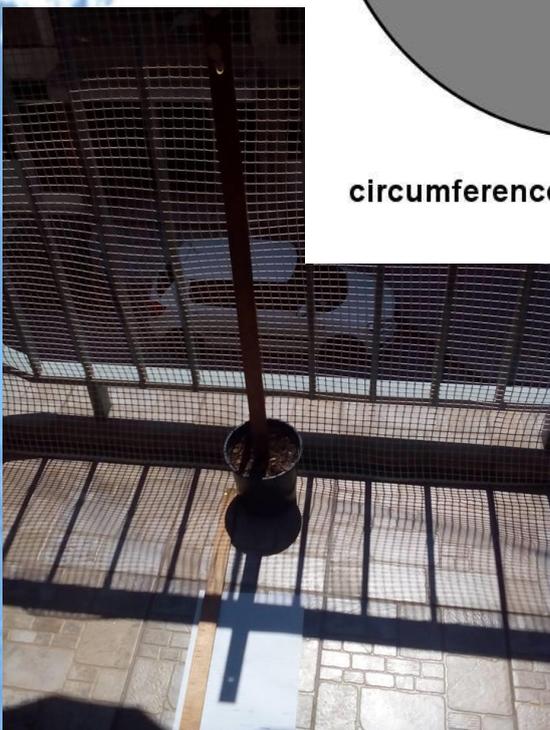


27 July 2015 (Serres-GREECE) Latitude: 41.09°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



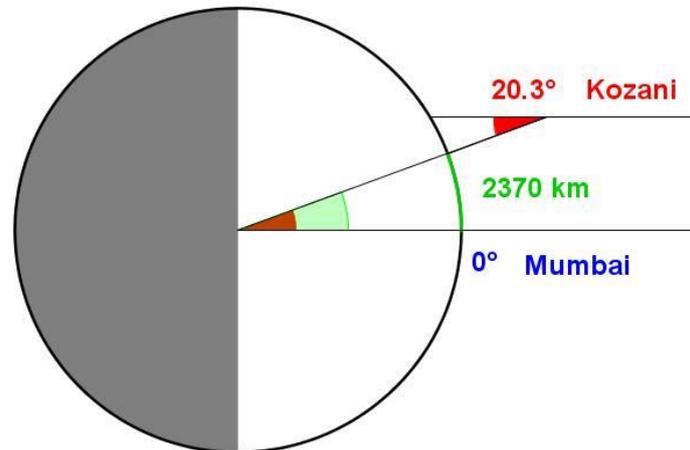
$$\text{circumference} = \frac{360^\circ \times 2459 \text{ km}}{21.5^\circ + 0^\circ} = 41174 \text{ km}$$



# Chalkida, Greece (38.465N - 23.592E)



30 July 2015 (Kozani-GREECE) Latitude: 40.29°  
 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°

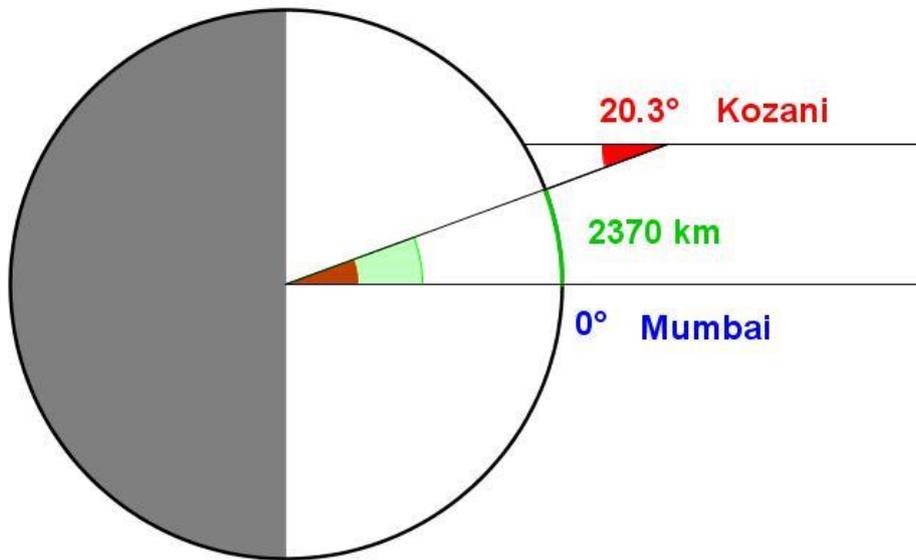


$$\text{circumference} = \frac{360^\circ \times 2370 \text{ km}}{20.3^\circ + 0^\circ} = 42030 \text{ km}$$



# Kozani, Greece (40.290N - 21.815E)

30 July 2015 (Kozani-GREECE) Latitude: 40.29°  
27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



$$\text{circumference} = \frac{360^\circ \times 2370 \text{ km}}{20.3^\circ + 0^\circ} = 42030 \text{ km}$$

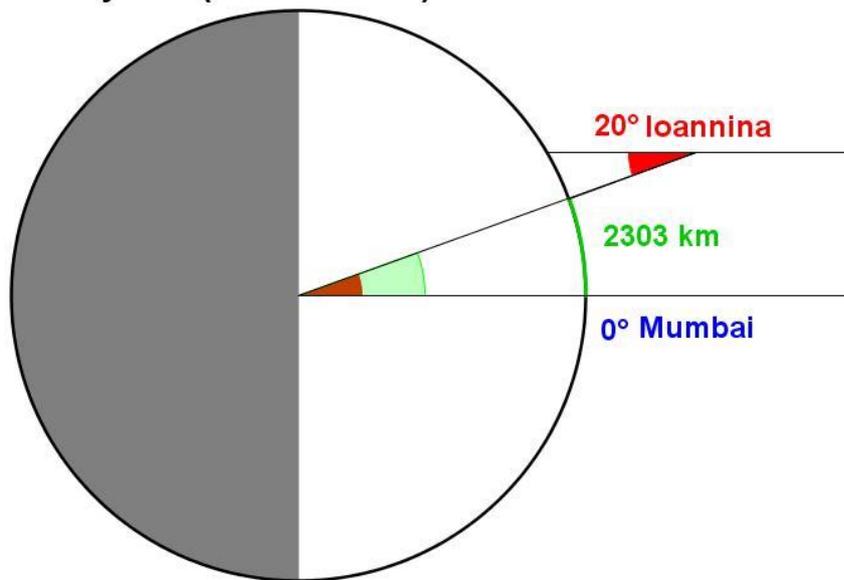


# Ioannina, Greece (39.683N - 20.825E)



27 July 2015 (Ioannina-GREECE) Latitude: 39.68°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



$$\text{circumference} = \frac{360^\circ \times 2303 \text{ km}}{20^\circ + 0^\circ} = 41454 \text{ km}$$

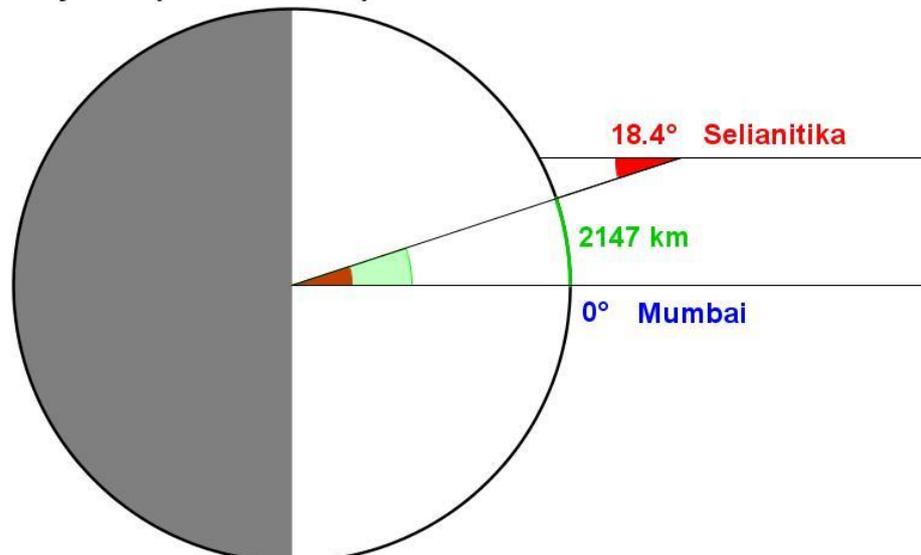


# Selianitika, Greece (38.282N – 22.028E)



27 July 2015 (Selianitika-GREECE) Latitude: 38.28°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



$$\text{circumference} = \frac{360^\circ \times 2147 \text{ km}}{18.4^\circ + 0^\circ} = 42007 \text{ km}$$

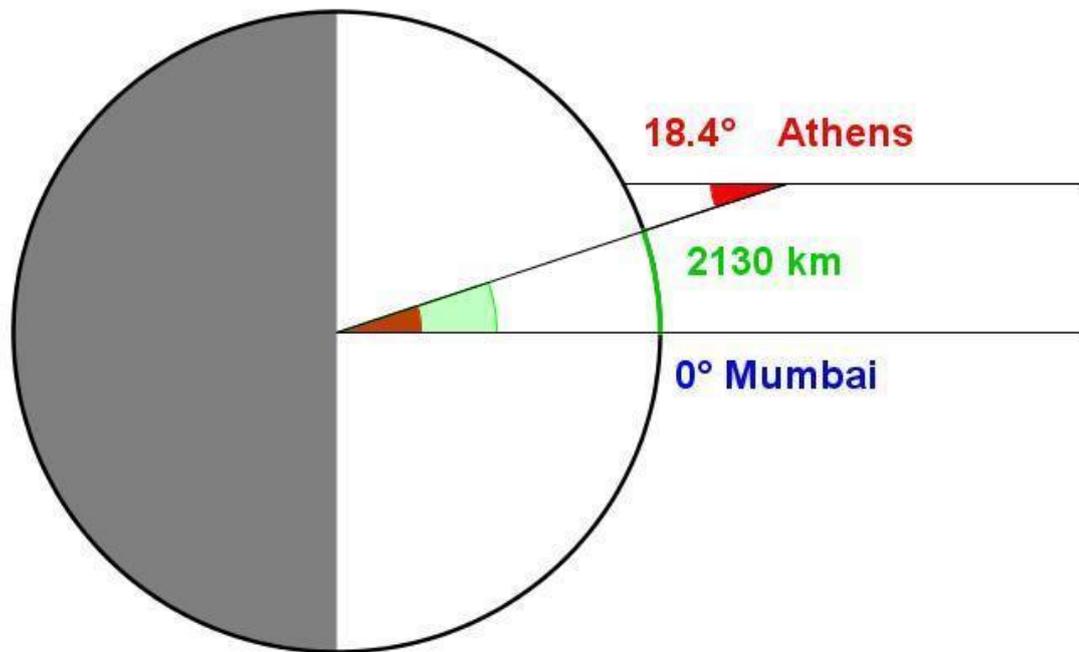


# Athens, Greece (38.130N - 23.849E)



27 July 2015 (Athens-GREECE) Latitude: 38.13°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



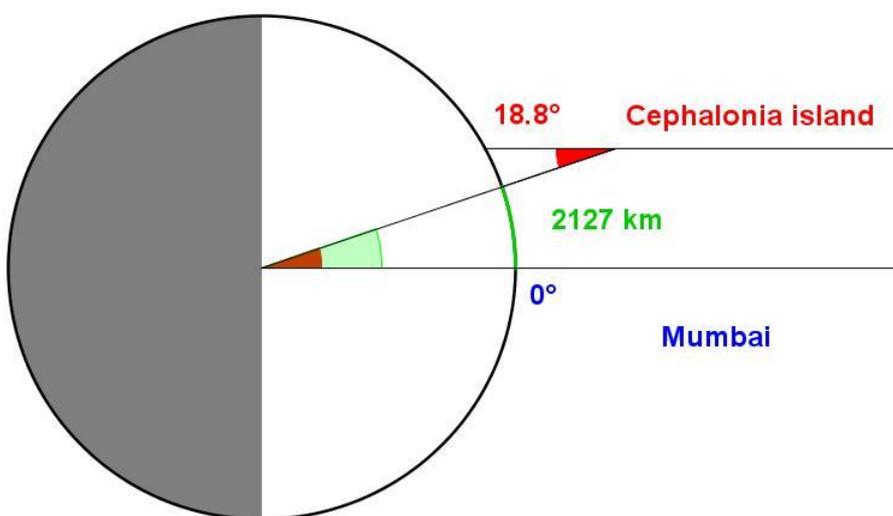
$$\text{circumference} = \frac{360^\circ \times 2130 \text{ km}}{18.4^\circ + 0^\circ} = 41674 \text{ km}$$



# Cephalonia, Greece (38.102N - 20.575E)



27 July 2015 (Cephalonia island-GREECE) Latitude: 38.1°  
27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



$$\text{circumference} = \frac{360^\circ \times 2127 \text{ km}}{18.8^\circ + 0^\circ} = 40730 \text{ km}$$

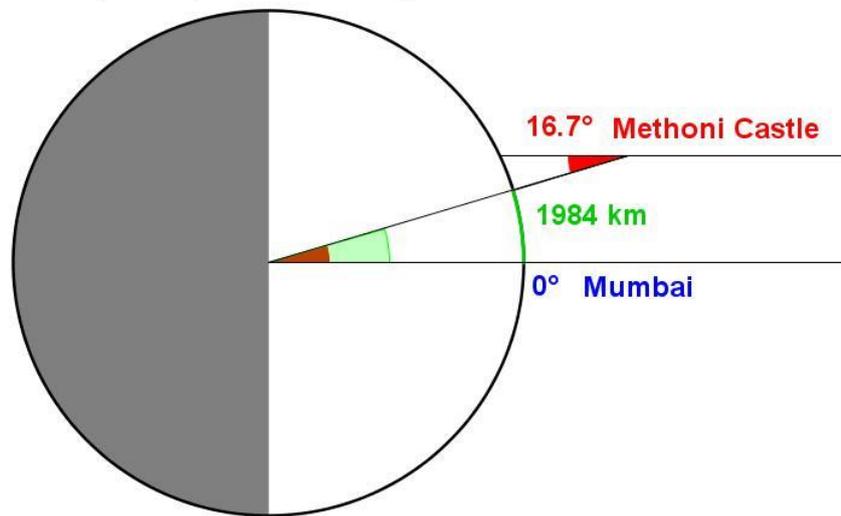


# Methoni Castle, Greece (36.812N - 21.705E)



27 July 2015 (Methoni Castle-GREECE) Latitude: 36.81°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



$$\text{circumference} = \frac{360^\circ \times 1984 \text{ km}}{16.7^\circ + 0^\circ} = 42769 \text{ km}$$

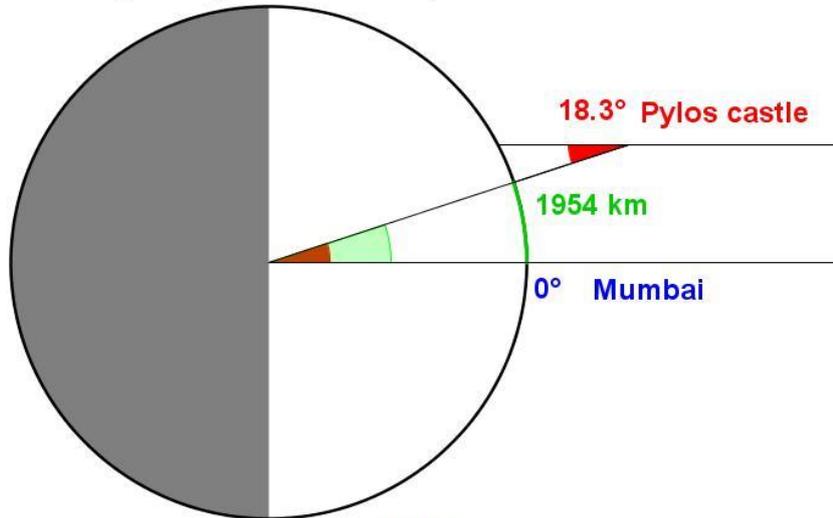


# Pylos, Greece (36.544N - 21.413E)



27 July 2015 (Pylos castle-GREECE) Latitude: 36.54°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



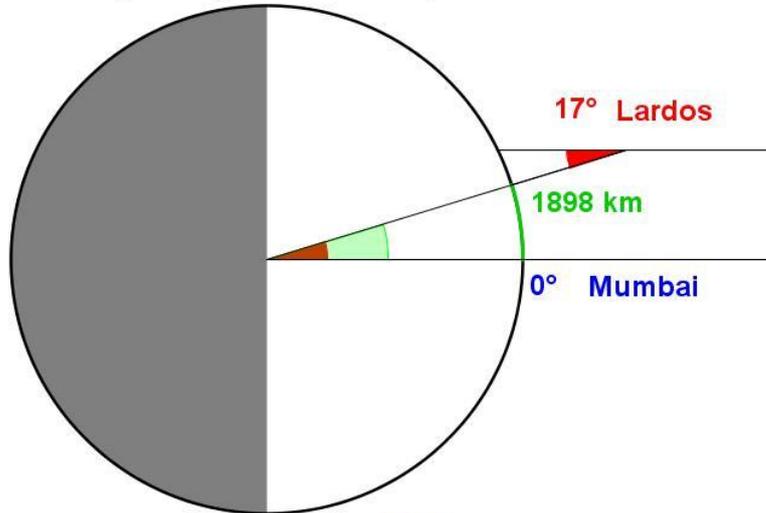
$$\text{circumference} = \frac{360^\circ \times 1954 \text{ km}}{18.3^\circ + 0^\circ} = 38439 \text{ km}$$



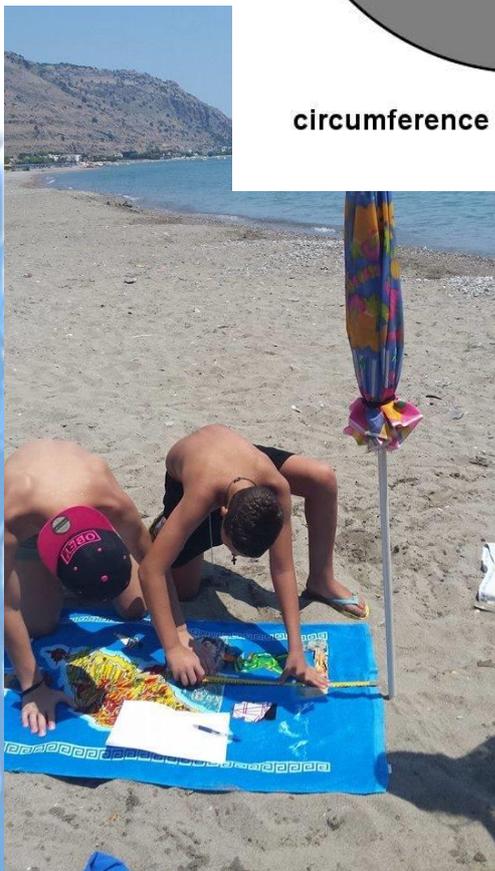
# Lardos, Greece (36.042N - 28.004E)



27 July 2015 (Lardos-GREECE) Latitude: 36.04°  
27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



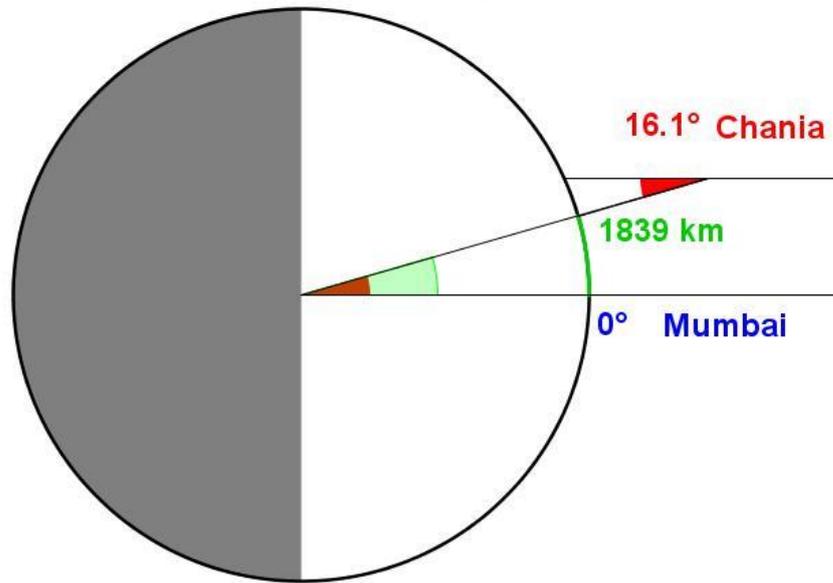
$$\text{circumference} = \frac{360^\circ \times 1898 \text{ km}}{17^\circ + 0^\circ} = 40193 \text{ km}$$



# Chania, Greece (35.514N - 24.015E)

26 July 2015 (Chania-GREECE) Latitude: 35.51°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



$$\text{circumference} = \frac{360^\circ \times 1839 \text{ km}}{16.1^\circ + 0^\circ} = 41120 \text{ km}$$

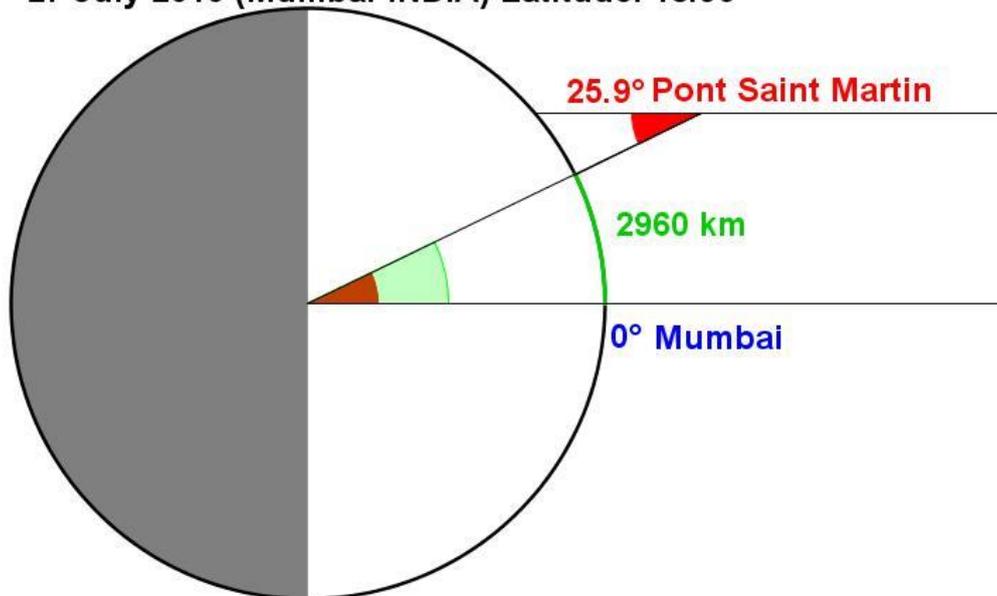


# Istituzione Scolastica Monte Rosa A Pont St Martin, Italy (45.601N - 7.795E)



27 July 2015 (Pont Saint Martin-ITALY) Latitude: 45.6°

27 July 2015 (Mumbai-INDIA) Latitude: 18.96°

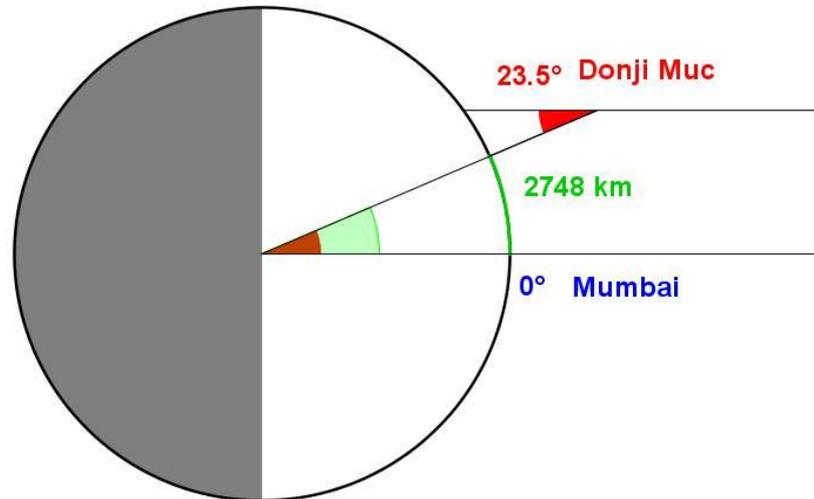


$$\text{circumference} = \frac{360^\circ \times 2960 \text{ km}}{25.9^\circ + 0^\circ} = 41143 \text{ km}$$

# Oš kneza Branimira Donji Muć, Croatia (43.694N - 16.462E)



27 July 2015 (Donji Muc-CROATIA) Latitude: 43.69°  
27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



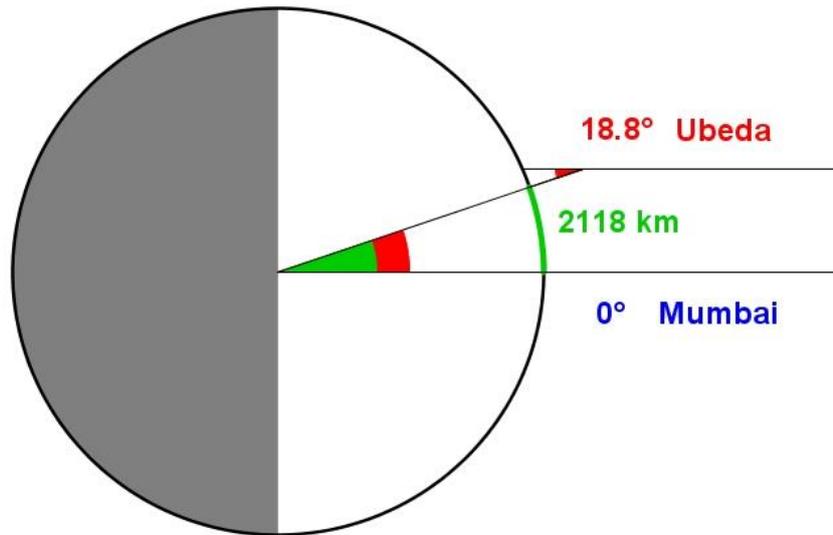
$$\text{circumference} = \frac{360^\circ \times 2748 \text{ km}}{23.5^\circ + 0^\circ} = 42097 \text{ km}$$



# Colegio Salesiano Santo Domingo Savio Ubeba, Spain (38.017N - 3.367W)



27 July 2015 (Ubeda-SPAIN) Latitude: 38.02°  
27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



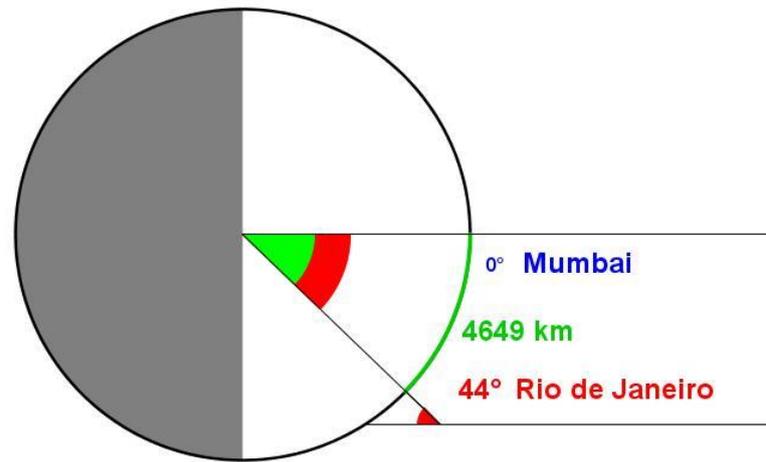
$$\text{circumference} = \frac{360^\circ \times 2118 \text{ km}}{18.8^\circ - 0^\circ} = 40557 \text{ km}$$



# Centro Educacional Nosso Mundo Rio de Janeiro, Brazil (22.890S - 43.317W)



27 July 2015 (Rio de Janeiro-BRASIL) Latitude: -22.89°  
 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°N

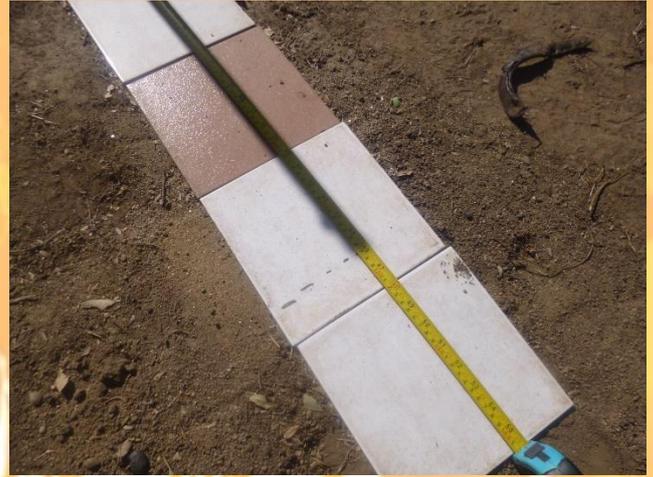


$$\text{circumference} = \frac{360^\circ \times 4649 \text{ km}}{44^\circ - 0^\circ} = 38037 \text{ km}$$

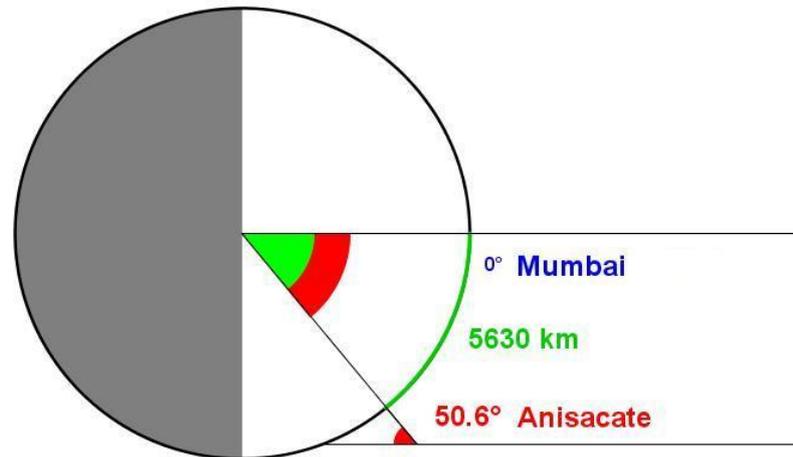


# Fundación Caminos de Anisacate

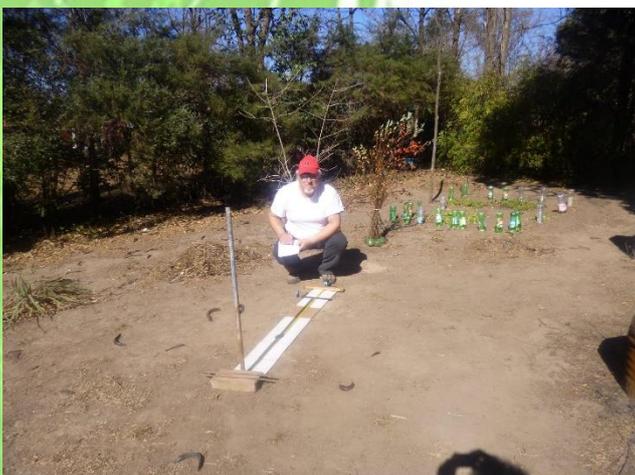
## Anisacate, Argentina (31.717S - 64.400W)



27 July 2015 (Anisacate-ARGENTINA) Latitude: -31.72°S  
27 July 2015 (Mumbai-INDIA) Latitude: 18.96°N



$$\text{circumference} = \frac{360^\circ \times 5630 \text{ km}}{50.6^\circ - 0^\circ} = 40055 \text{ km}$$



The best partnership is calculated for all the measuring spots.

<b>Best Partnership Table</b>		
<b>Partner #1</b>	<b>Partner #2</b>	<b>Circumference (km)</b>
Pont St Martin	Ioannina	40 088
Donji Muć	Methoni Castle	40 500
Rio de Janeiro	Donji Muć	39 451
Baghpat	Serres	40 344
Yamunanagar	Kozani	40 206
Selianitika	Yamunanagar	39 732
Chalkida	Anisacate	40 156
Chiayi City	Athens	39 845
Cephalonia	Kaohsiung	39 948
Ubeba	Anisacate	40 186
Pylos	Dholpur	40 565
Pylos	Allahabad Ghoorpur	40 050
Lardos	Anisacate	40 090
Anisacate	Chania	40 312
Allahabad VVPS	Anisacate	39 625
Shenzhen	Anisacate	38 126
Mumbai	Anisacate	40 055

The average circumference is:

**39 958 km**



# Videoconference



<https://youtu.be/fZ-ljfkTE8w>



## दरारुतुथेनेडु

indian इपुललएर उठरड

Mumbai (Maharashtra)  
Allahabad (Uttar Pradesh)  
Yamunanagar (Haryana)  
Baghpat (Uttar Pradesh)  
Dholpur (Rajasthan)

Argentina  
Brazil  
China  
Croatia  
Greece  
Italy  
Spain  
Taiwan

## रुतुररुतु इतुवुठु

रु वुलुलहलड

20:24 / 20:24





<http://twinspace.etwinning.net/5691/>

<http://etwinning.net>

# eTwinning



**VIGYAN PRASAR**  
विज्ञान प्रसार

<http://www.vigyanprasar.gov.in/>

<http://www.fondation-lamap.org/eratos>

<http://www.fondation-lamap.org/>



*la main  
à la pâte*