



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.

Syene_

7.2°

Alexandria

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:

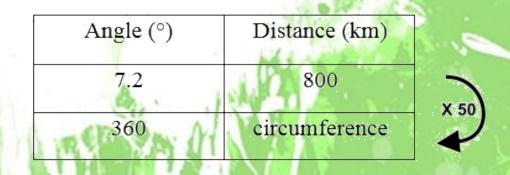
Syene

7.2°

Alexandria

lf the Earth is round, by vertical extending the 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).



Circumference=360 x 800 / 7.2 = 40 000

On July 27th, 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

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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 Savio	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	
Pγlos	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 WPS	India	Vashisth Vatsalya Public School	25.452	81.841	27/07/2015	100.0	12.5	7.1	
Allahabad Ghoor	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	nisacate Argentina Fundación Caminos		-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)





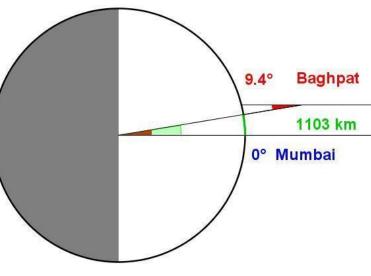
Shri Vinayak College Of Education Baghpat, India (28.881N - 77.249E)





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





circumference = $\frac{360^{\circ} \times 1103 \text{ km}}{9.4^{\circ} + 0^{\circ}}$ = 42243 km





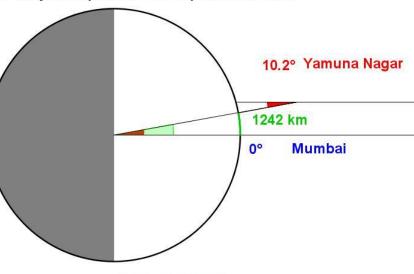
C V Raman Science Club Sarojini Colony Yamunanagar India (30.133N - 77.283E)







27 July 2015 (Yamuna Nagar-INDIA) Latitude: 30.13° 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°









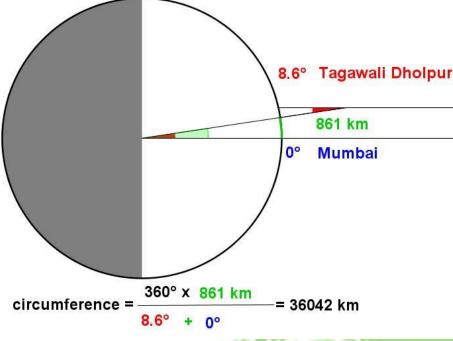
GSSS Tagawali Tagawali Dholpur, India (26.708N - 77.908E)







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









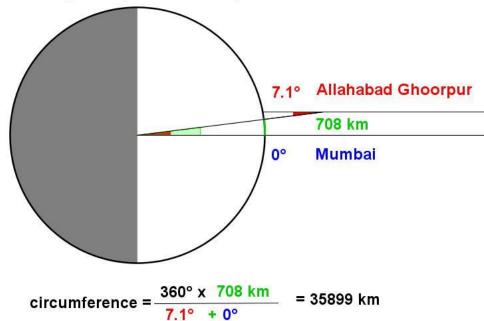
St Marys Convent School Ghoorpur Allahabad Ghoorpur, India (25.327N - 81.823S)





27 July 2015 (Allahabad Ghoorpur-INDIA) Latitude: 25.33° 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°











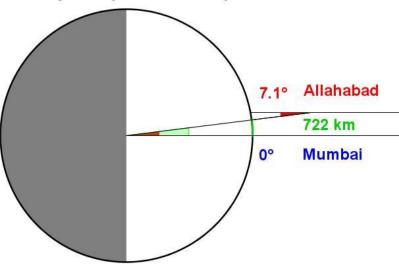
Vashisth Vatsalya Public School Allahabad, India (25.452N- 81.841S)





27 July 2015 (Allahabad-INDIA) Latitude: 25.45° 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°





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





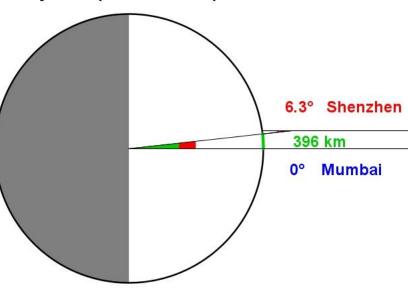
Futian Shenzhen, China (22.524N - 114.061E)







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



360° x 396 km

6.3° - 0°

= 22629 km

circumference =

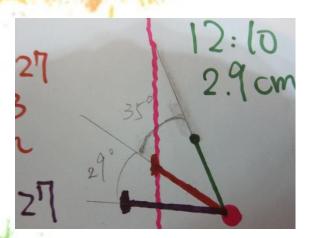


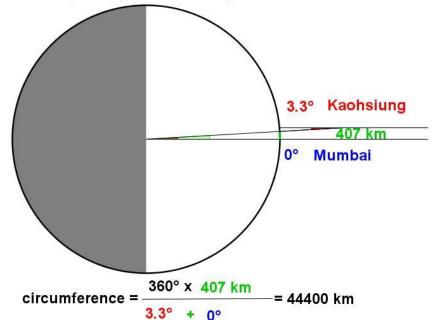
鳳西國 中 FXM Kaohsiung, Taiwan (22.621N - 120.354E)





27 July 2015 (Kaohsiung-TAIWAN) Latitude: 22.62° 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°





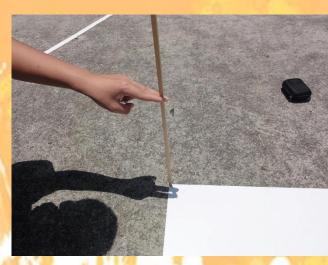
0°



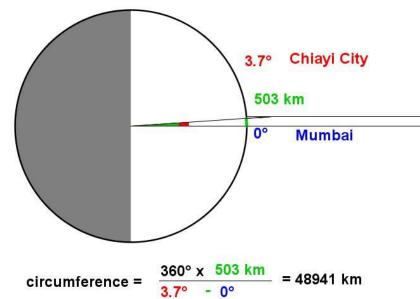


Chia Hwa Senior High School Chiayi City, Taiwan (23.483N - 120.477E)





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



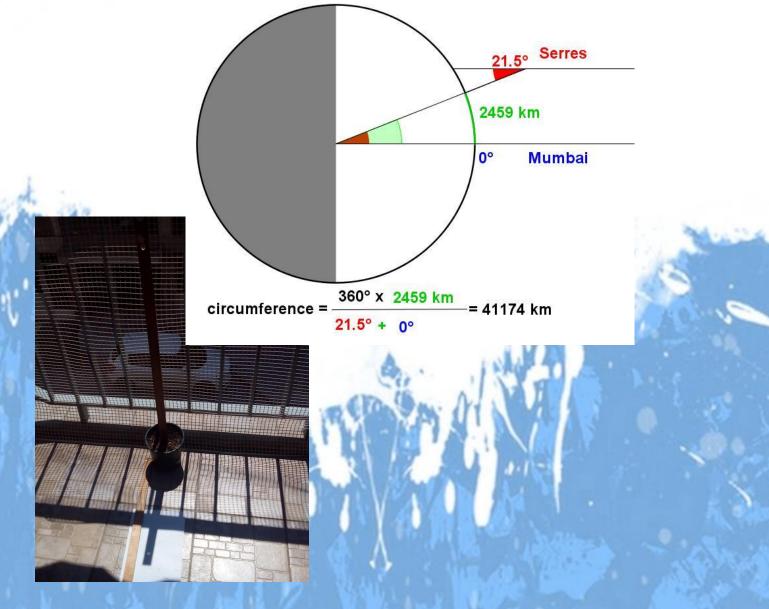




Serres, Greece (41.089N - 23.553E)



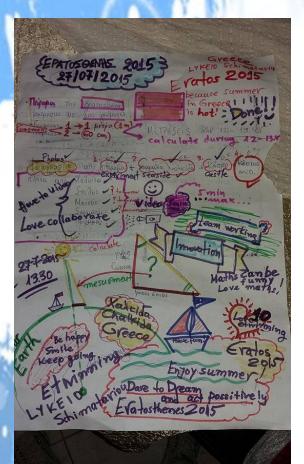
27 July 2015 (Serres-GREECE) Latitude: 41.09° 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



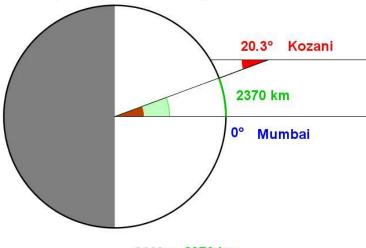
Chalkida, Greece (38.465N - 23.592E)







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



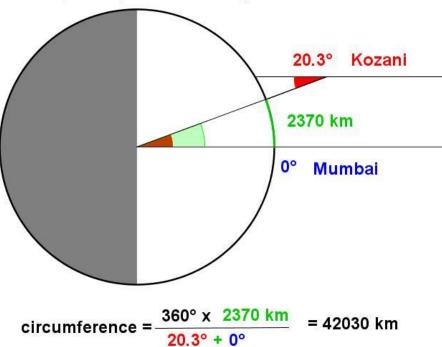
circumference = $\frac{360^{\circ} \times 2370 \text{ km}}{20.3^{\circ} + 0^{\circ}}$ = 42030 km

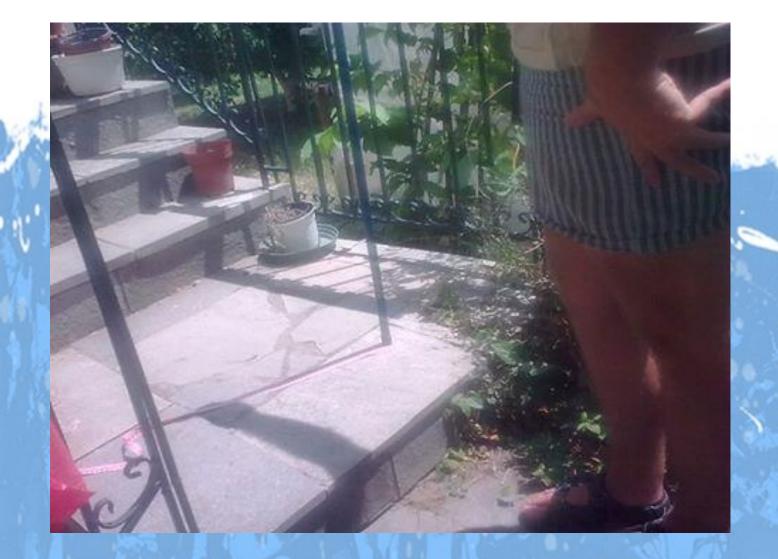




Kozani, Greece (40.290N - 21.815E)

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

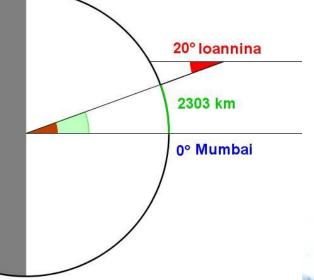




Ioannina, Greece (39.683N - 20.825E)



27 July 2015 (Ioannina-GREECE) Latitude: 39.68° 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



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

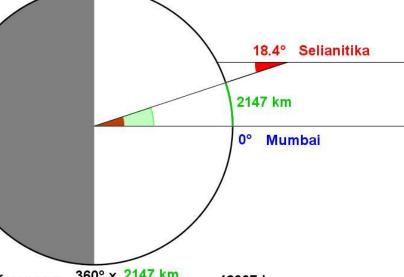


Selianitika, Greece (38.282N – 22.028E)





27 July 2015 (Selianitika-GREECE) Latitude: 38.28° 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



circumference = <u>360° x 2147 km</u> = 42007 km 18.4° + 0°

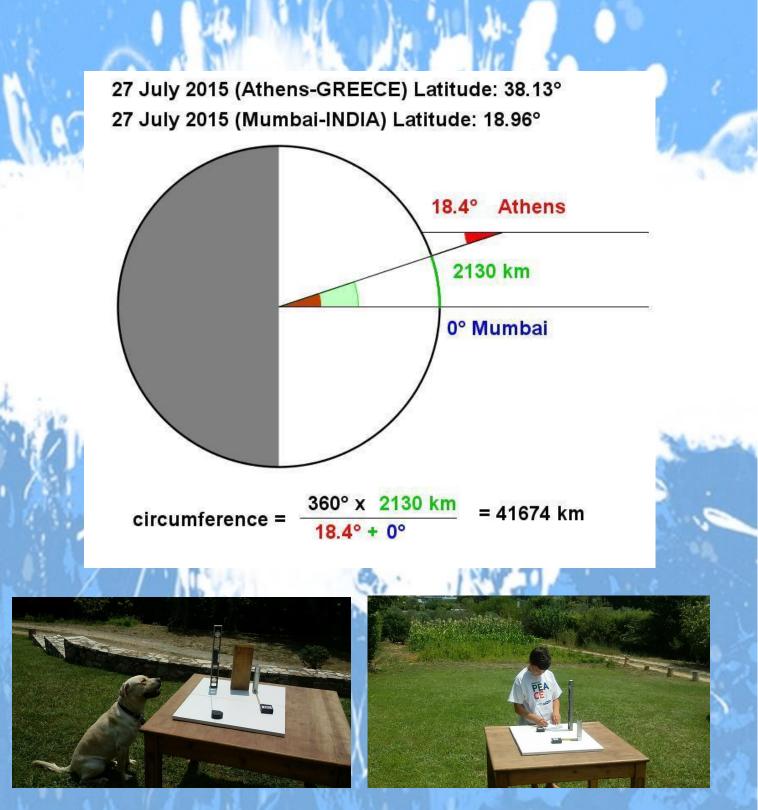




Athens, Greece (38.130N - 23.849E)



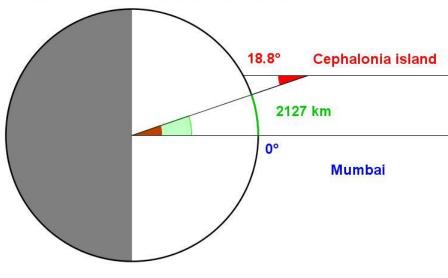




Cephalonia, Greece (38.102N - 20.575E)



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







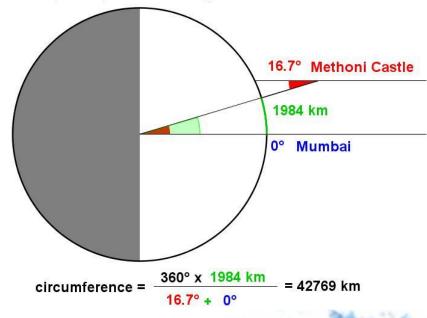
Methoni Castle, Greece (36.812N - 21.705E)





27 July 2015 (Methoni Castle-GREECE) Latitude: 36.81° 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°







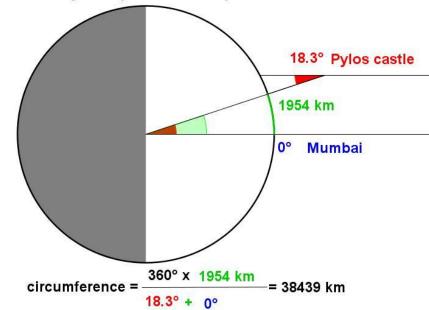
Pylos, Greece (36.544N - 21.413E)







27 July 2015 (Pylos castle-GREECE) Latitude: 36.54° 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°







Lardos, Greece (36.042N - 28.004E)

R

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

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





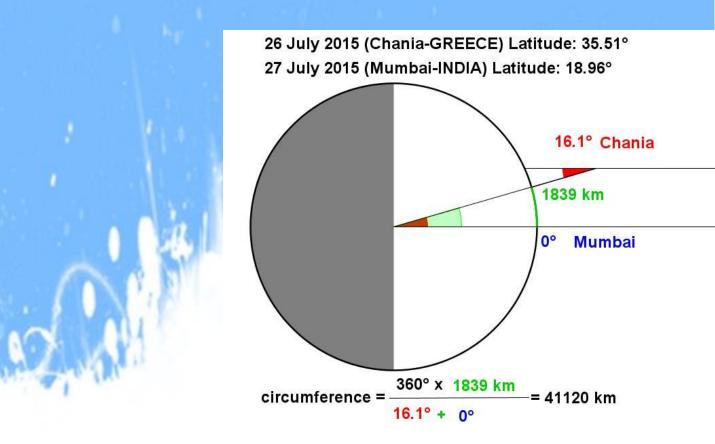
17° Lardos

1898 km

0° Mumbai

G

Chania, Greece (35.514N - 24.015E)

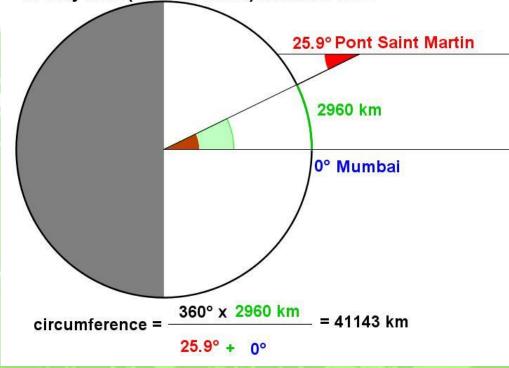




Istituzione Scolastica Monte Rosa A Pont St Martin, Italy (45.601N - 7.795E)



27 July 2015 (Pont Saint Martin-ITALY) Latitude: 45.6° 27 July 2015 (Mumbai-INDIA) Latitude: 18.96°



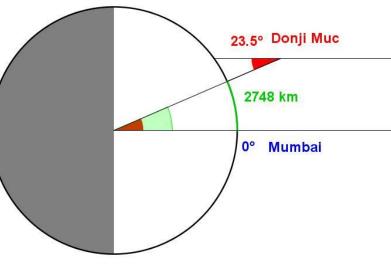
Oš kneza Branimira Donji Muć, Croatia (43.694N - 16.462E)





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





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

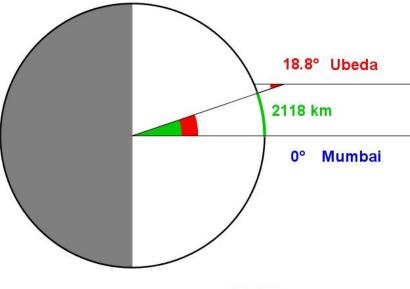




Colegio Salesiano Santo Domingo Savio Ubeba, Spain (38.017N - 3.367W)



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



circumference =

360° x 2118 km 18.8° - 0°

= 40557 km

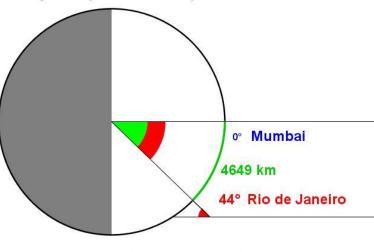


Centro Educacional Nosso Mundo Rio de Janeiro, Brazil (22.890S - 43.317W)





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



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



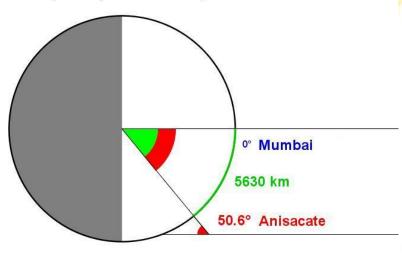
Fundación Caminos de Anisacate Anisacate, Argentina (31.717S - 64.400W)





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











The best parternship is calculated for all the measuring spots.

Best Partnership Table											
Partner #1	Partner #2	Circumference (km)									
Pont St Martin	Ioannina	40 088									
Donji Muć	Methoni Castle	40 500									
Rio de Janeiro	Donji Muć	39 4 51									
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

ate	-50.6		24 C	- 8	80 R	21 C	52 U	56 M	76 F	87 E	н 88	86 E	29 N	26 C	90 E	12	8	92	72	25	44	5	21	26	55	90		
Rio de Shenzhen Mumbai Janeiro Anisacate			8 40424	1 40703	7 40389	8 40621	5 40452	0 40156	8 40576	0 40487	3 40238	2 40186	9 40729	5 39626	8 40090	9 40312	8 40689	8 40392	1 39472	9 39625	0 39544	3 40661	1 40321	7 38126	7 40055	53509	-	
Rio de Janeiro	0.0 -44.0		3 39188	7 39451	4 39067	0 39298	4 39105	1 38770	17 39208	4 39110	0 38843	7 38792	62262 63	9 38155	38638	0 38869	6 39128	3 38778	2 37711	8 37839	9 37740	1 38883	0 38481	9 36107	38037	0	0 981	
en Mumk	6.3 0		94 41143	28 42097	51 41174	50 42030	35 41454	13 40421	96 42007	90 41674	53 40730	35 40557	35 42769	10 38439	35 40193	38 41120	00 43835	37 42243	33 36042	50 36608	50 35899	15 48941	20 44400	22629	396	15 4649	26 5630	
			7 47094	49228	9 48861	9 50760	2 50085	0 49043	3 52096	51590	49853	6 49565	54935	8 46740	0 50535	5 53008	5 78000	81987	8 72783	2 146250	5 139950	0 -14815	-1320	_		5045	6026	
Kaohsiung	3.3		40667	41721	40589	41569	40872	39600	41483	41078	39948	39716	42367	37128	39180	40275	43565	41016	30838	29842	28516	86400		11	407	5056	6037	
Chiayi City	3.7		39843	40818	39560	40489	39755	38423	40261	39845	38718	38503	41012	35778	37759	38816	40929	37895	26302	23188	21706		8	107	503	5152	6133	
Allahabad Ghoorpur	7.1		43123	44802	43775	45327	44512	43082	45844	45303	43662	43385	47850	40050	43273	45280	62013	61826	23948	2191		205	8	311	708	5357	6338	
ad	7.1		42874	44495	43425	44973	44121	42669	45398	44888	43231	42954	47325	39600	42800	44720	60387	59635	33600	Received	14	219	315	325	722	5371	6351	
Tagiwali Allahat Baghpat Dholpur VVPS	8.6		43679	45592	44595	46431	45537	43940	47241	46616	44682	44329	49911	40565	4443	46944	85725	108450		140	153	358	454	465	861	5510	6491	
] Jaghpat [9.4		40538	42026	40344	41879	40755	387.27	41760	41120	39217	38872	43447	34422	37705	39600	3108	÷	241	381	395	600	695	706	1103	5752	6732	
g	10.2		39394	40791	38772	40206	38976	36633	39732	38985	37047	36670	41095	31644	34729	36488		139	381	520	534	739	835	845	1242	5891	6872	
Yamur Lardos Chania nagar	16.1		41180	44222	41267	45514	42738	36900	48209	45548	38400	37067	86400	18655	23600		598	737	978	1118	1132	1337	1432	1443	1839	6489	7469	
Lardos (17.0		42957	47077	44880	51491	48600	42104	64029	59657	45800	43800	-10320(15508		8	656	796	1037	1177	1190	1395	1491	1502	1898	6547	7528	
Pylos	18.3		47653	54969	56813	74880	73906	76680	34518 694800	30918633600	24514 124560	22971 118080	-6750 -		95	114	712	851	1093	1232	1246	1451	1547	1558	1954	6603	7584	
Methoni Castle	16.7		38191	40500	35625	38600	34800	25477	34518(30918	24514	22971		8	88	144	742	881	1123	1262	1276	1481	1577	1587	1984	6633	7614	
ba	18.8		42744	48332	45467	60720	55500	36000	-26100	-2700 -11700	i0//IC#		134	164	219	278	876	1015	1256	1396	1410	1615	1710	1721	2118	6767	7747	
Cephalonia	18.8		42237	47566	44267	58320	52800	28800	-18000 -26100	-2700	17520	0	143	173	229	288	885	1024	1266	1405	1419	1624	1720	1731	2127	67.76	7757	
Athens (18.4		39840	43624	38206	45474	38925	14800	#DIV/ID#		m	13	146	176	232	291	888	1028	1269	1409	1422	1627	1723	1734	2130	6779	7760	
Selianitika.	18.4		39024	42424	36232	42253	35100	8000	Ŧ	17	20	8	153	193	249	308	905	1044	1286	1425	1439	1644	1740	1751	2147	6796	1777	DISTANCE
Serres Kozani Ioannina Chalkida Selianitika Athens cephalonia Ube	19.3		43255	49800	47782	73080	69429		8	37	40	6	184	213	269	328	926	1065	1306	1446	1460	1665	1760	1771	2167	6817	797	
oannina	20.0		40088	45874	37440	80400	11. T	135	156	173	176	185	319	349	405	463	1061	1200	1442	1581	1595	1800	1896	1906	2303	6952	7933	
Kozani	20.3		37929	42525	26700		67	203	223	240	243	253	386	416	472	531	1128	1268	1509	1649	1662	1867	1963	1974	2370	7019	8000	
Serres	21.5		40991	52020		8	156	292	312	329	332	341	475	505	561	619	1217	1356	1598	1737	1751	1956	2052	2063	2459	7108	8089	
Donji Muć	23.5		31800		289	378	446	581	601	618	621	631	765	794	850	606	1507	1646	1887	2027	2041	2245	2341	2352	2748	7397	8378	
Pont St Donji Martin Muć	25.9			212	501	590	657	793	813	830	833	843	976	1006	1062	1121	1718	1858	2099	2239	2252	2457	2553	2564	2960	7609	8590	
	Angle >	Latitude V	45.601	43.694	41.089	40.290	39.683	38.465	38.282	38.130	38.102	38.017	36.812	36.544	36.042	35.514	30.133	28.881	26.708	25.452	25.327	23.483	22.621	22.524	18.957	-22.890	-31.717	
27/07/2015			Pont St Martin	Donji Muć	Serres	Kozani	loannina	Chalkida	Selianitika	Athens	Cephalonia	Ubeba	Methoni Castle	Pylos	Lardos	Chania	Yamuna nagar	Baghpat	Tagiwali Dholpur	Allahabad VVPS	Alahabad Ghoorpur	Chiayi City	Kaohsiung	Shenzhen	Mumbai	Rio de Janeiro	Anisacate	

Videoconference



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