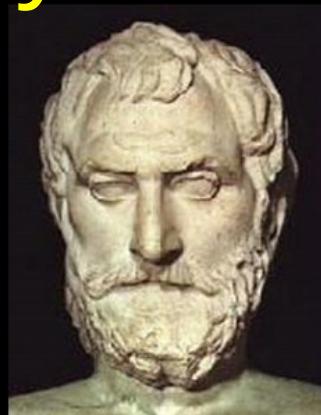


பண்டை நாகரிகங்களின்  
வானியலும் கணிதமும்

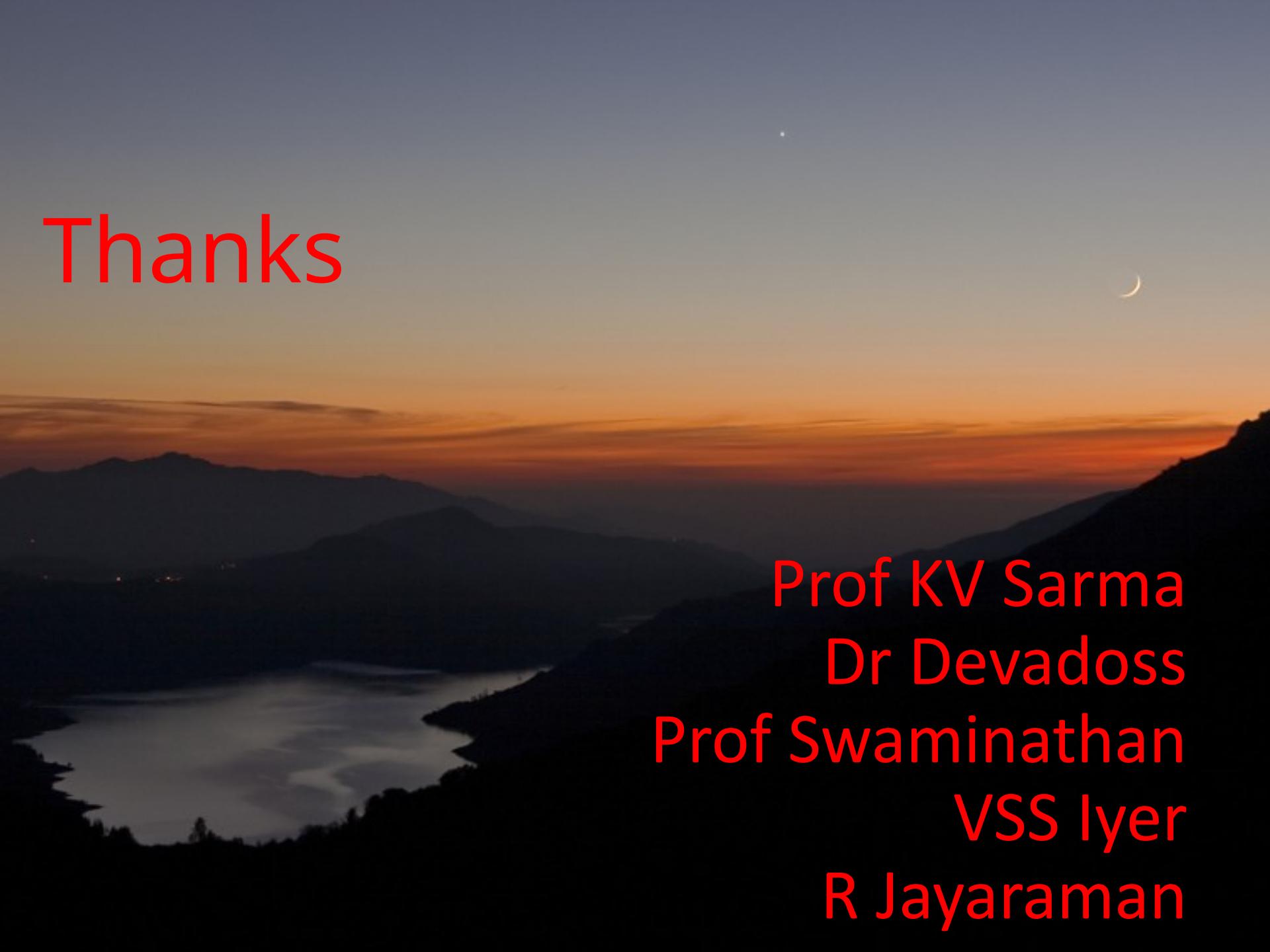
## Astronomy of Ancient Cultures



ர. கோபு

R. Gopu

[VarhaMihiraGopu.BlogSpot.com](http://VarhaMihiraGopu.BlogSpot.com)

A scenic sunset or sunrise over a range of mountains. The sky is a gradient from deep blue at the top to warm orange and yellow near the horizon. A small, thin crescent moon is visible in the upper right quadrant. In the foreground, the dark silhouettes of mountain peaks and a winding river or lake are visible.

Thanks

Prof KV Sarma

Dr Devadoss

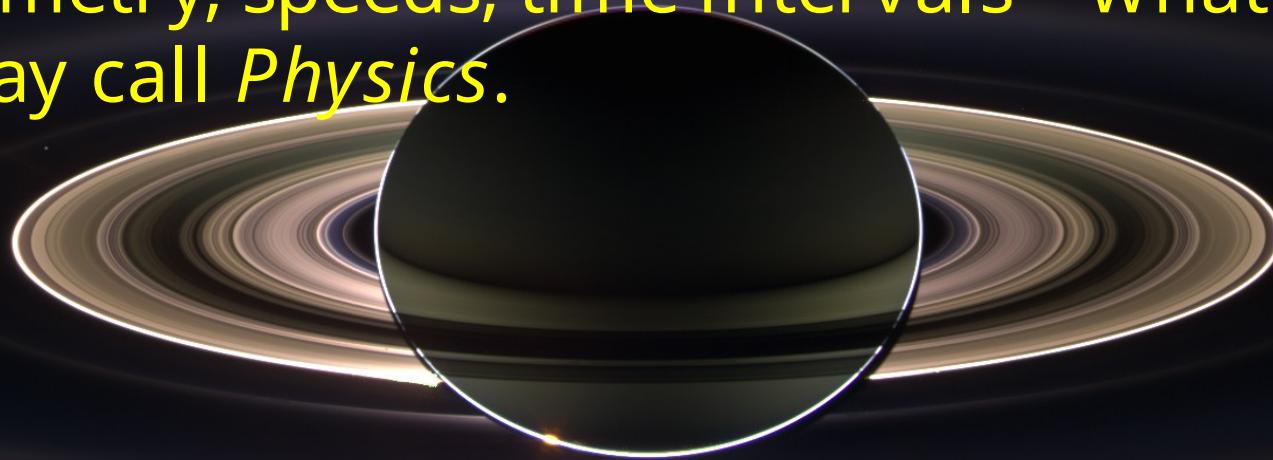
Prof Swaminathan

VSS Iyer

R Jayaraman

AstroLOGY deals with predicting effects of planets stars etc. on humans – e.g. horoscopes.

AstroNOMY is the study of orbits, motions, geometry, speeds, time intervals – what we today call *Physics*.



Until the 18<sup>th</sup> century they were often treated as the same subject.

Religion

Calendars

Astronomy

Astrology

Instrument  
s

Number  
System

Mathemati  
cs

All human cultures – even nomads - have language, fire, tools, weapons, hunting, cooking, clothing

All have religion, politics, war and art

But only FOUR civilizations invented *agriculture*

Only FOUR civilizations invented *writing*

# Only seven developed astronomy



The sun, the moon and the stars  
form natural **clocks** in the sky.

They give regular, precise,  
predictable measures of  
time.

Phases of the moon,  
the transit of the sun,  
stars and constellations,  
even eclipses,  
all follow definite cycles

No celestial period is a whole number multiple of another.

So the mathematics is subtle, complex, tricky.



சுமேரியா

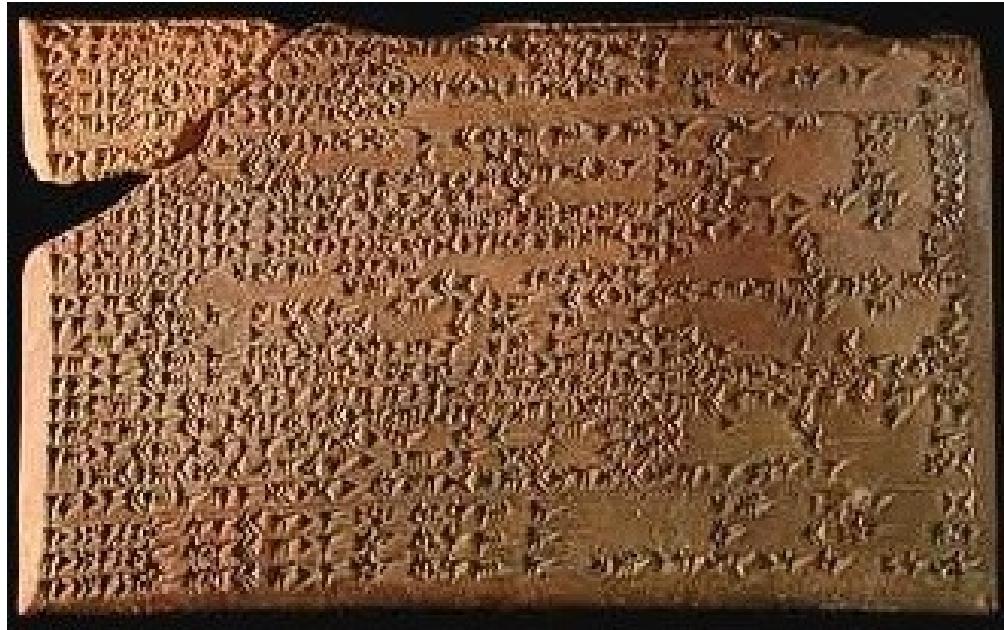
**SUMERIA**

# Sumerian Astronomy

சுமேரியா

- Sexagesimal Number System – Base 60
- 60 minutes, 60 seconds!!
- Oldest Zero (digit not number)
- Recordings of Observations on Clay Tablets for 700 years
- Invention of Zodiac with 12 constellations
- Invention of Water Clock

# Cuneiform Clay Tablets



**Enuma Anu Enlil**

# Water Clocks

The oldest water clock was found in Sumeria

A water clock measures time by how long it takes for the water to drain

A full pot always takes the same time to drain



# The 7 Day Week

Day	Norse God	Roman God	Greek God	Tamil
Sunday	Sun	Solis	Helios	குாயிறு
Monday	Moon	Luna	Selenes	திங்கள்
Tuesday	Tiu	Mars	Ares	செவ்வாய்
Wednesday	Odin	Mercury	Hermes	புதன்
Thursday	Thor	Jupiter	Zeus	வியாழன்
Friday	Freya	Venus	Aphrodite	வெள்ளி
Saturday	Saturn	Saturn	Cronus	சனி

# Odin and Thor

## Odin's Day and Thor's Day



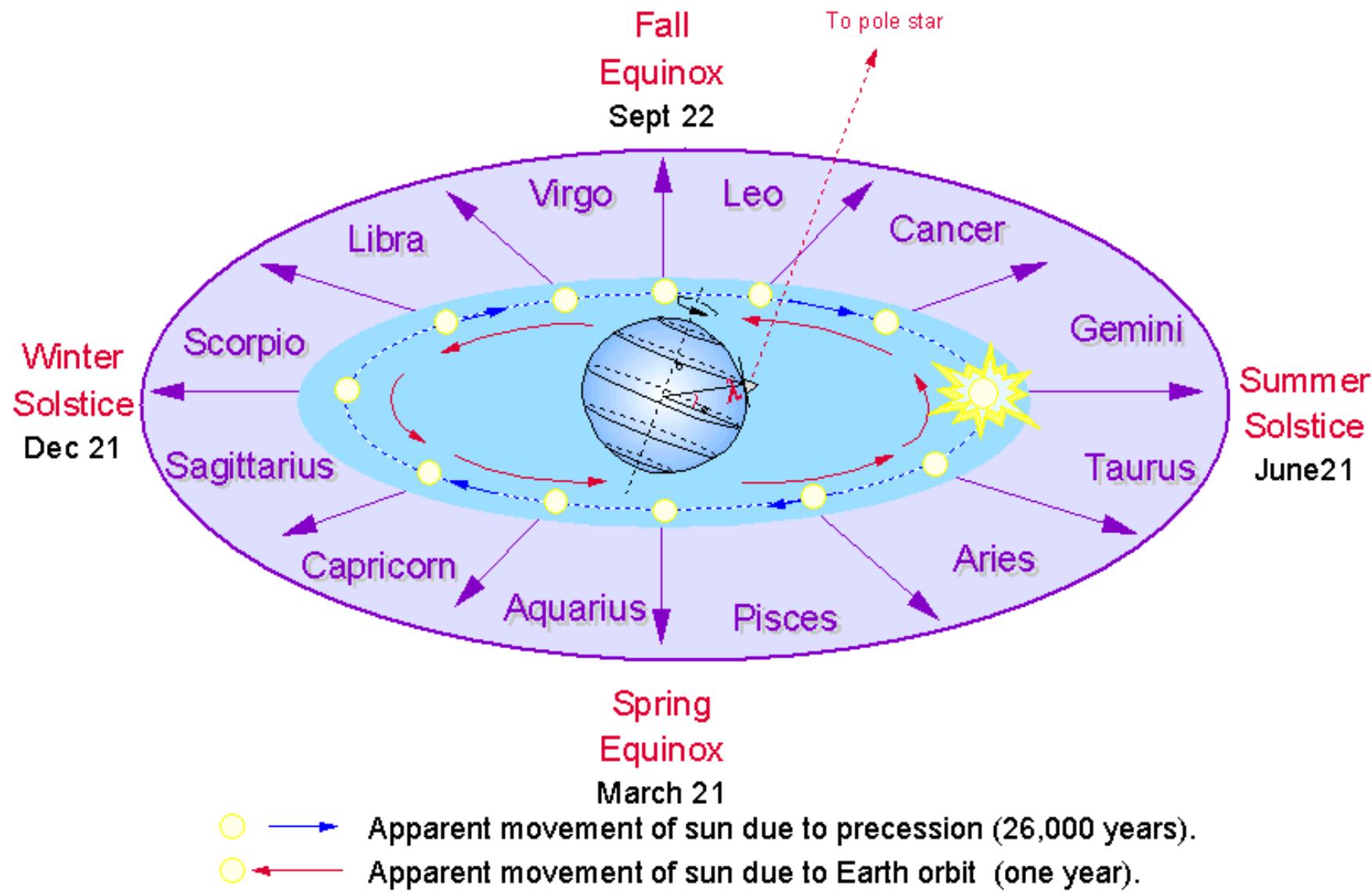
# The Zodiac

Identified constellations on the Sun's path

Recognized by observing pre-dawn sky just before sunrise

12 “houses” dividing sky into 12 equal parts

# The birth of the Zodiac



The Zodiac in the year 2000 A.D.

	Symbol	Longitude	Latin name	English name	Greek name	Sanskrit Name	Sumero Bayblonian Name
1	♈	0°	<a href="#">Aries</a>	The Ram	Κριός	Meṣa (मेष)	MUL LU HUN.GA "The Agrarian Worker"
2	♉	30°	<a href="#">Taurus</a>	The Bull	Ταῦρος	Vṛṣabha (वृषभ)	MUL GU <sub>4</sub> .AN.NA "The Steer of Heaven"
3	♊	60°	<a href="#">Gemini</a>	The Twins	Δίδυμοι	Mithuna (मिथुन)	ULMAŠ.TAB.BA.GAL.GAL "The Great Twins"(Lugalirra and Meslamta-ea)
4	♋	90°	<a href="#">Cancer</a>	The Crab	Καρκīνος	Karkaṭa (कर्कट)	MUL AL.LUL "The Crayfish"
5	♌	120°	<a href="#">Leo</a>	The Lion	Λέων	Siṁha (सिंह)	MUL UR.GU.LA "The Lion"
6	♍	150°	<a href="#">Virgo</a>	The Virgin	Παρθένος	Kanyā (कन्या)	MUL AB.SIN "The Furrow"; "The Furrow, the goddess S hala's ear of corn"

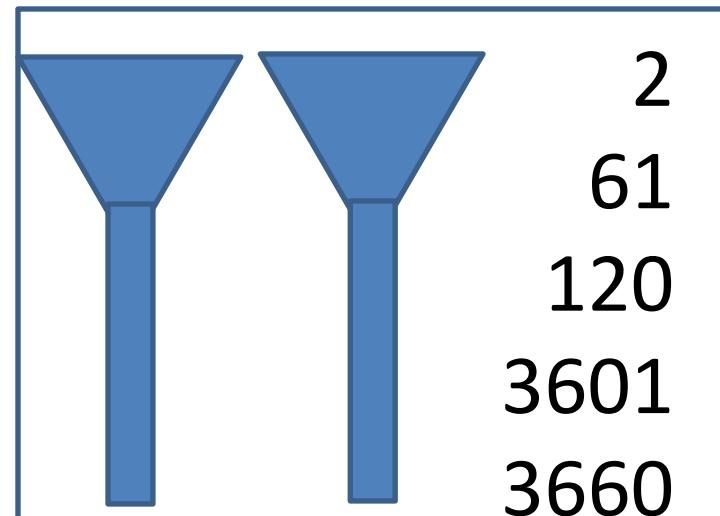
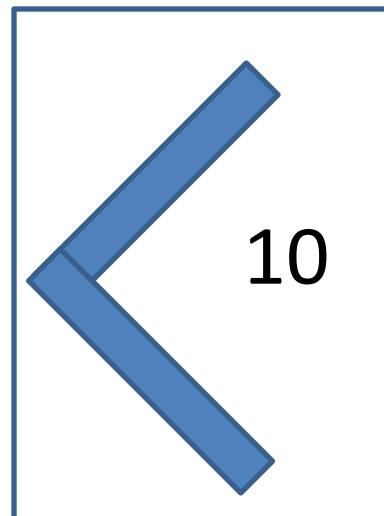
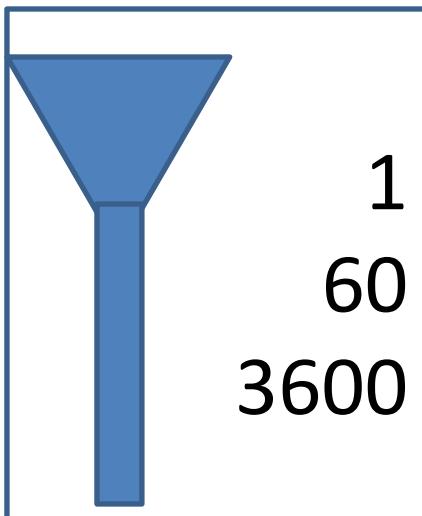
	Symbol	Longitude	Latin name	English name	Greek name	Sanskrit Name	Sumero Bayblonian Name
7	♎	180	<a href="#">Libra</a>	The Scales	Zugός	Tula (তুলা)	<sup>MUL</sup> <i>zibaniṭum</i> "The Scales"
8	♏	210	<a href="#">Scorpio</a>	The Scorpion	Σκορπιός	Vṛścika (বৃশিক)	<sup>MUL</sup> <i>GIR.TAB</i> "The Scorpion"
9	♐	240	<a href="#">Sagittarius</a>	Centaur The Archer	Τοξότης	Dhanus (ধনুষ)	<sup>MUL</sup> <a href="#"><u>PA.BIL.SAG</u></a> , <i>Nedu</i> "soldier"
10	♑	270	<a href="#">Capricorn</a>	"Goat-horned" (The Sea-Goat)	Αίγόκερως	Makara (মকর)	<sup>MUL</sup> <i>SUHUR.MAŠ</i> "The Goat-Fish"
11	♒	300	<a href="#">Aquarius</a>	The Water Bearer	Ὑδροχόος	Kumbha (কুম্ভ)	<sup>MUL</sup> <i>GU.LA</i> "The Great One", later <i>qâ</i> "pitcher"
12	♓	330	<a href="#">Pisces</a>	Fish	Ίχθεῖς	Mīna (মীন)	<sup>MUL</sup> <i>SIM.MAH</i> "The Tail of the Swallow", later <i>DU.NU.NU</i> "fish-cord"

# Sumerian Numerals

1		11		21		31		41		51	
2		12		22		32		42		52	
3		13		23		33		43		53	
4		14		24		34		44		54	
5		15		25		35		45		55	
6		16		26		36		46		56	
7		17		27		37		47		57	
8		18		28		38		48		58	
9		19		29		39		49			
10		20		30		40		50		59	

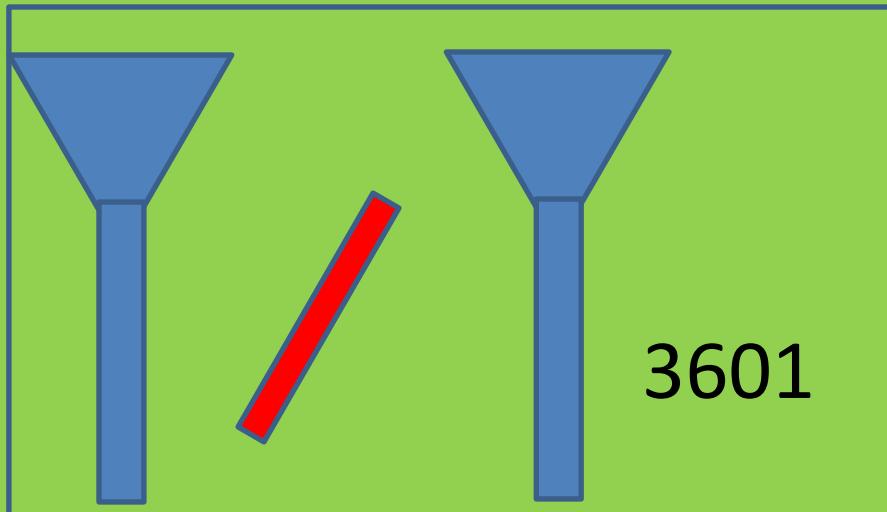
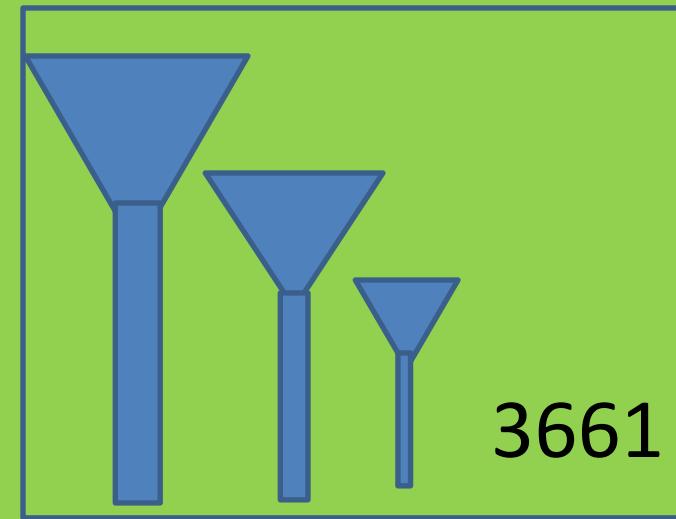
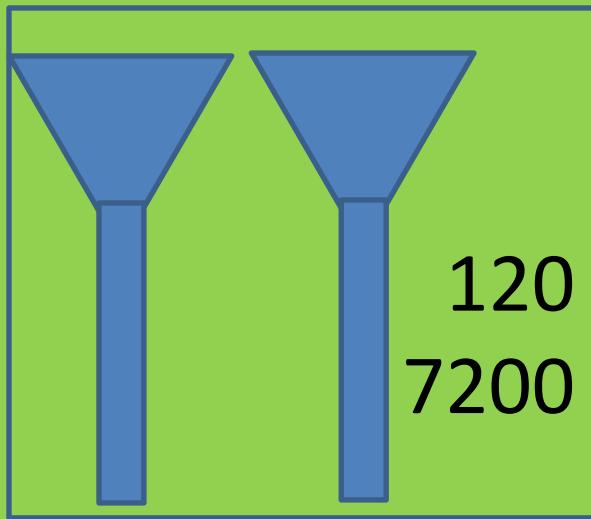
Symbol Repetition and Counting, like most numeral systems. Only partly based on place value.

# Sumerian Numerals



1	𒂵	11	𒌋	21	𒌋𒌋	31	𒌋𒌋	41	𒌋	51	𒌋
2	𒂵	12	𒌋	22	𒌋𒌋	32	𒌋	42	𒌋	52	𒌋
3	𒂵	13	𒌋	23	𒌋	33	𒌋	43	𒌋	53	𒌋
4	𒂵	14	𒌋	24	𒌋	34	𒌋	44	𒌋	54	𒌋
5	𒂵	15	𒌋	25	𒌋	35	𒌋	45	𒌋	55	𒌋
6	𒂵	16	𒌋	26	𒌋	36	𒌋	46	𒌋	56	𒌋
7	𒂵	17	𒌋	27	𒌋	37	𒌋	47	𒌋	57	𒌋
8	𒂵	18	𒌋	28	𒌋	38	𒌋	48	𒌋	58	𒌋
9	𒂵	19	𒌋	29	𒌋	39	𒌋	49	𒌋	59	𒌋
10	𒌋	20	𒌋	30	𒌋	40	𒌋	50	𒌋		

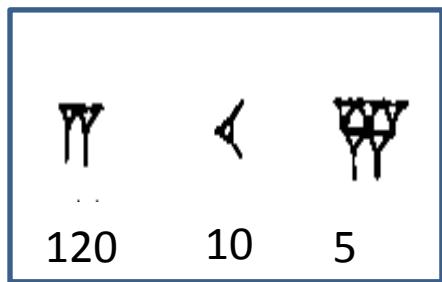
# Sumerian Numerals



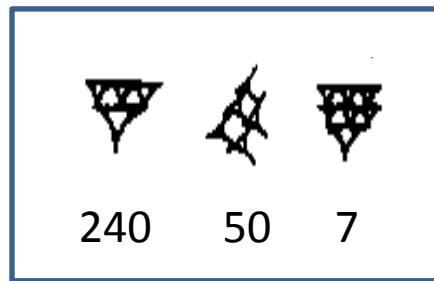
Babylonian Zero

## Sumerian Numbers

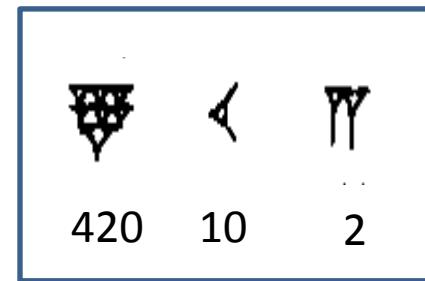
$$135 + 297 = 432$$



135



297



432

## Sumerian Numbers

$$245 + 357 = 602$$



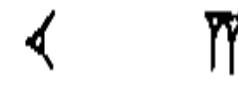
240      5

245



300      50      7

357



600      2

602

# Sumerian Arithmetic

- Numbers recorded in Cuneiform
- But arithmetic mostly done with counting pebbles
- Six types of pebbles found
  - Small cone, small sphere, Large cone, Large sphere, Perforated cone, perforated sphere
  - Representing 1, 10, 60, 600, 3600, 36000

# Sumerian counting pebbles

oooooooooooo



10

oooooo



60

oooooooooooo



600

oooooooooooo



3600

oooooooooooo



36,000

# ஐந்தாம் வாய்பாடு

## Multiplication Table



Pythagoras  
triplets?  
Sine tables?



# Mathematical Clay tablets கணித ஓடுகள்

Hundreds of multiplication tables

And reciprocal tables  $1/81, 1/250, 1/1000$

20 lakh tablets; one lakh read and published



எகிப்து  
**EGYPT**

# Northern Pyramids



# Southern Egypt Temple of Hatshepsut



# Southern Egypt Temple of Rameses



# Nut and Geb Sky Goddess, Earth God



# Egyptian Mythology

# எகிப்து

- Sun god was called Ra
- Sun dies, each night, swallowed by Nut
- Reborn each morning from Nut
- Belief in human cycles of birth/death
  - Pyramids considered womb (garba griha) of goddess Nut

# Egyptian Calendar

- Originally Lunar calendar
  - 12 lunar months of 30 days each
- Annual Flooding of the Nile
  - Coincides with appearance of star Sirius just before dawn
- The first 365 day calendar ( 3000 BC?? )
  - 5 additional days of festivities (adhika days!)
  - To resolve Lunar vs Solar year difference
- The Decans (36 Stars , 10 degrees each !)
- The 12 hour day and 24 hour day

# Egyptian Astronomy

- Pyramids in the North
  - Alignment based on Equinox
- Temples in the South
  - Alignment based on Solstice
- Absence of Celestial Omens (no astrology!)

2150 BC

Oldest Pharaonic Astronomy Book

1500 BC

Sundial & Water Clock

1460 BC

Ceiling of Senmut {Q Hatchepsut}

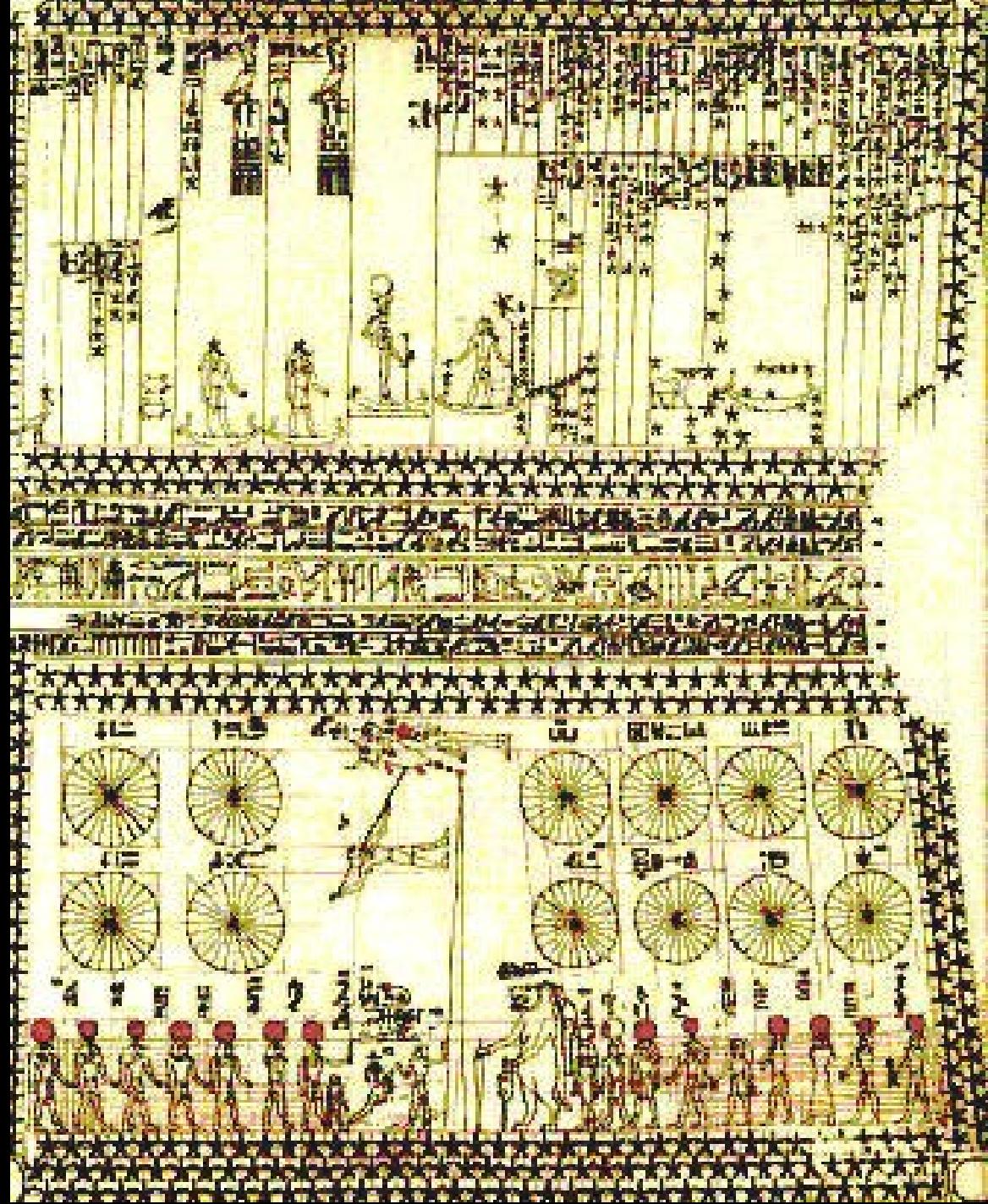
1220 BC

Almanac {Rameses}

1100 BC

Catalog of Universe {Amenhope}  
- Strange absence of Sirius

# The ceiling of Senmut



# Egyptian Numerals



1    10     $10^2$      $10^3$      $10^4$      $10^5$      $10^6$

# Egyptian Numbers



2,387



2,00,130



# Egyptian Numbers

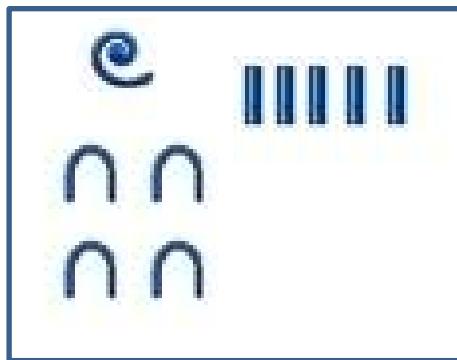
324

+

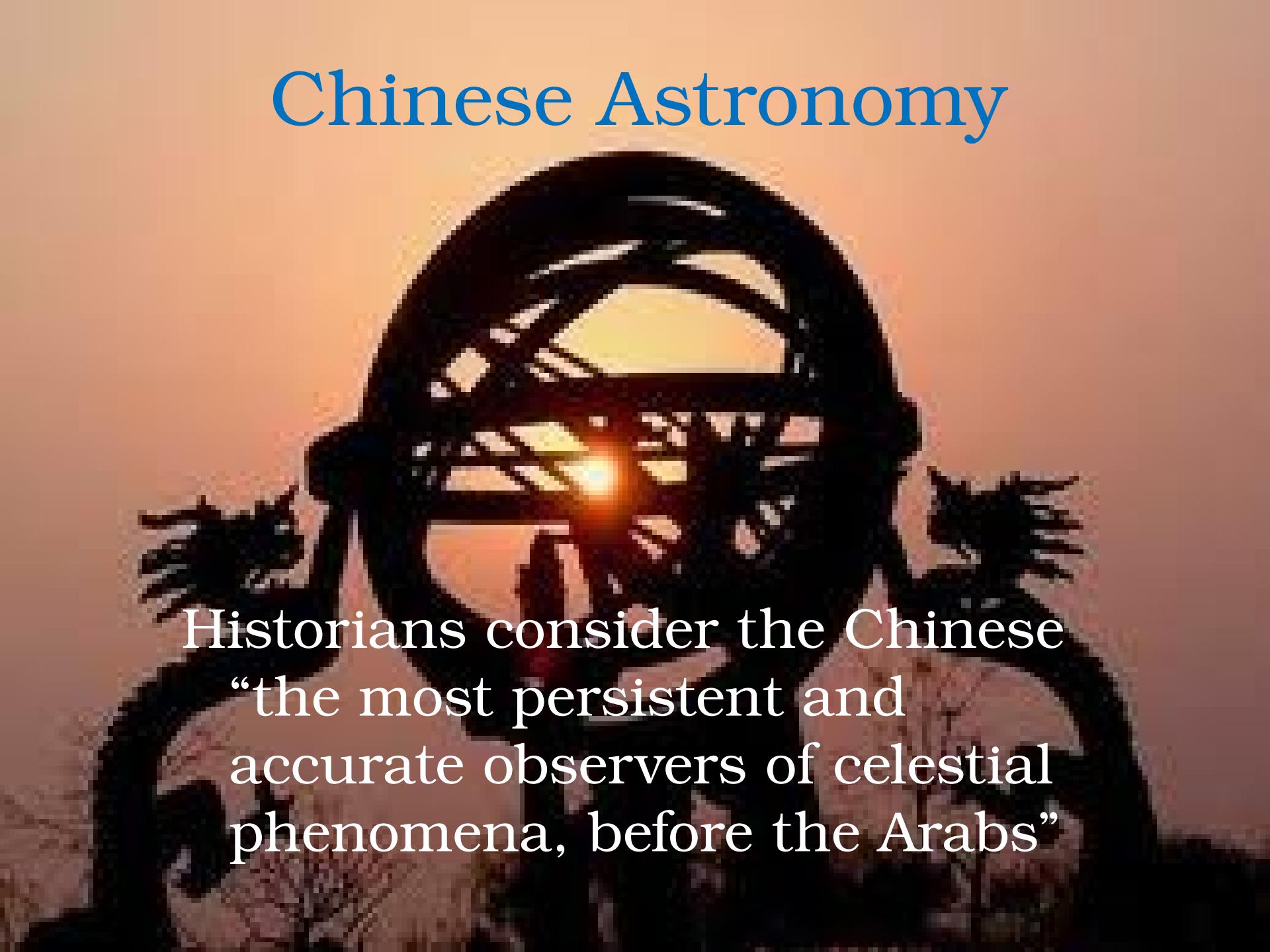
145

=

439



# Chinese Astronomy



Historians consider the Chinese  
“the most persistent and  
accurate observers of celestial  
phenomena, before the Arabs”

# Zhongguo

Celestial Kingdom

Heaven

Middle Kingdom

China

Other Earthly Kingdoms

# Chinese Mathematics

8<sup>th</sup> century BC: Nine-nines Rhyme

Counting downwards from  $9 \times 9 = 81$  to  $2 \times 2 = 4$

Order reversed in 13<sup>th</sup>-14<sup>th</sup> century

5<sup>th</sup> – 3rd century BC (Warring States period)

A Treatise on Law: Basic operators + - x

Book of Crafts: Construction techniques for horse carriages,  
boats, bows, arrows. Angles, Lengths, fractions

Zhou Rites (Six Gentlemanly Arts)

Wu Li - Five Rites

Liu Yue - Six modes of Music

Wu She - Five methods of Archery

Wu Yu - Five ways of Horsemanship

Liu Shu - Six ways of calligraphy (artistic writing)

Jiu Shu - Nine calculations of Mathematics

Zhoubi Suanjing (Arithmetical Book of Gnomon and Circular  
Paths of Heaven)

# Gougo Theorem (right triangles)

Gou Vertical guage

Gu Shadow of guage

Xian string of bow

Right angle triangle called Gougo

# Chinese Astronomy

Recorded Solar Eclipse in 2137 BC

28 Lunar Mansions in Four Quadrants (1200BC)

Gan De and Shi Shen – 4<sup>th</sup> cent BC Astronomers

Government Departments for Astronomy

Invention of Paper – 1<sup>st</sup> cent AD?

Invention of Printing – 8<sup>th</sup> cent AD

Compass – Use in Navigation 10<sup>th</sup> century

Shen Kuo – Astronomer (1031 -1095)

Star Maps of 1092

Recorded Supernova of 1054 (also by Arabs)

# Black Tortoise

White  
Tiger

Azure  
Dragon

Vermilion Bird



# Chinese Zodiac

Lunar year  
354 days

New Year moves  
backward every year



# Chinese Numerals (decimal, without zero)

||

one

||

two

|||||

five

T

six

||||

nine

—

ten

= T

twenty-six

====

fifty

上

sixty

|| ||

seventy-two

||

||

T

—

=

T

one hundred two hundred six hundred one thousand two thousand seven

# Chinese Numerals

## Poem by Master Soon

How are the counting rod forms arranged to accord with the decimal number system? The method is: for the units use the vertical form, for the tens use the horizontal form, for the hundreds use the vertical form, for the thousands use the horizontal form, for the ten thousands again use the vertical form and so on. A blank space is used for zero. Hence a number can be represented by digits arranged in vertical and horizontal forms alternatively, working from right to left in the usual order units, tens, hundreds, thousands, ten thousands, etc. For example, 378 can be represented as 𢚔 𢚕 𢚖 , 6 708 as 𢚕 𢚖 𢚔 . This method of recording numbers is explained in *Master Sūn's Mathematical Manual* (孫子算經; *Sūnzi Suànjing*, about the fifth century AD) and in *Xiāhóu Yáng's Mathematical Manual* (夏侯陽算經; *Xiāhóu Yáng Suànjing*, about the eighth century AD). Master Sūn says:

‘Units are vertical, tens are horizontal,  
Hundreds stand, thousands lie down;  
Thus thousands and tens look the same,  
Ten thousands and hundreds look alike’.

# Chinese Numerals

## Addition

$$\begin{array}{r} \boxed{\text{一} \equiv \text{二}} \\ + \left\{ \begin{array}{rrr} 7 & 8 & 9 \\ 4 & 5 & 6 \end{array} \right. + \left\{ \begin{array}{rrr} 7 \\ 4 & 5 & 6 \end{array} \right. \\ \boxed{\text{三} \equiv \text{一}} \quad \boxed{- \text{一} \equiv \text{一}} \\ \hline 1 & 1 & 5 & 6 \end{array}$$

**Addition** using intermediate steps

One digit at a time

# Chinese Numerals

## Subtraction

Subtraction is similar. For instance,  $1234 - 789$ . First lay down 1245 and subtract 7 from the hundreds' position. Second, subtract the numbers from the tens' and then the units' positions. Again this is carried out from left to right as below:

$$\begin{array}{r}
 - \left\{ \begin{array}{ccccc} 1 & 2 & 4 & 5 \\ 7 & 8 & 9 \end{array} \right\} - \left\{ \begin{array}{ccccc} 1 & 2 & 4 & 5 \\ 7 & & & \end{array} \right\} \\
 \boxed{- \text{ II } \equiv \text{ III}} \qquad \qquad \boxed{\text{III} \equiv \text{III}} \\
 . \\
 \boxed{\text{II} \equiv \text{III}}
 \end{array}$$

**Subtraction** Also using intermediate steps

# One digit at a time

# Chinese Numbers

176 + 253 = 429

| || T

|| === | |

||| == T T



МОШНОТ

**MAYAN**

# American Cultures before 1500

Olmec

Maya

Aztec



Pyramid at Chichen Itza

# **Maya Astronomy**

- Extraordinary Importance of Venus
  - More central than Sun or Moon
- Two Calendars
  1. Religious
  2. Solar
- The Long Count

# Observatory at El Caracol



- Buildings aligned for Summer and Winter Solstices
- Fully followed Venus cycles – synodic period of 584 days
- First appearance of Morning Star – Evil One!

# Maya Mathematics

- Vigesimal System (Base 20)
- Invented True Zero
- Infinity
- No Geometry or Trigonometry?

# Maya Multi Calendar System

- Solar Calendar – 18 months of 20 Days : 360 Days
- Tzolkin Calendar – 13 months of 20 days : 260 Days
  - Called Tonalamatl calendar in Aztec's Nahuatl language
- 365 day haab (vague) calendar! 360 days + 5 Days for Feasting

$$360 * 52 = 18720 = 260 * 72$$

Human Sacrifice on Start of 52 year cycle

# Aztec Calendar Stone



# Mayan Long Count

- Long Count
  - August 13, 3112 BC : Day 0.0.0.0
- Mayan Calendar
  - 52 year cycle
  - 400 year cycle
  - 5200 year cycle
  - 26000 year cycle also
- December 2012
  - Day 12.19.19.17.19 turned to Day 13.0.0.0.0
  - Start of 5200 year cycle

# Maya Codices



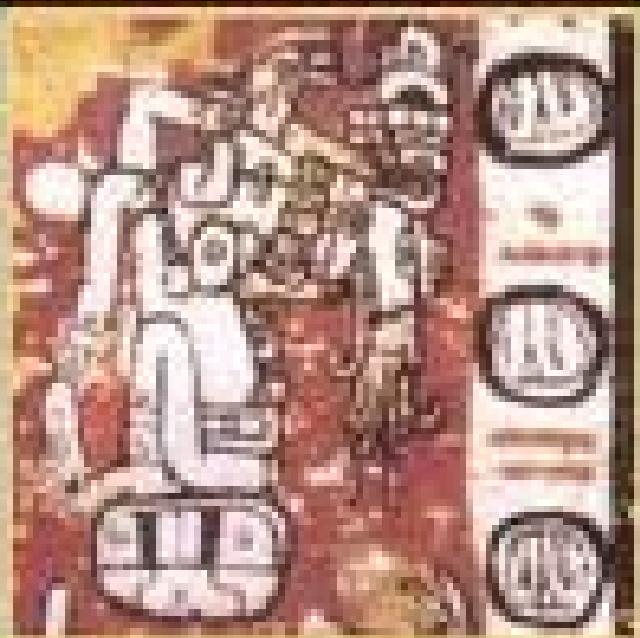
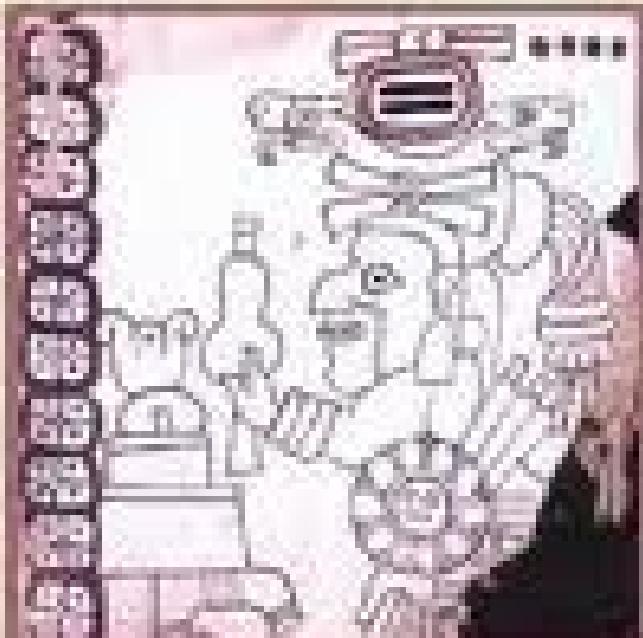
# Maya Codices



# Maya Codices

Dresden

Grolier



Madrid

Paris

# **Maya Names**

<b>English Name</b>	<b>Maya Name</b>		
Venus	Chak Ek	Ah Chikum Ek (Morning Star)	Lamat (Evening Star)
Sun	K'inich		
Moon	Ix Chel		
Milky Way	Wakah Chan		
Libra	Xoc	Shark	
Taurus	Kuh	Owl	
Gemini	Ak Ek	Turtle	
Capricorn	Balam	Jaguar	
Pisces	Zotz	Bat	

# Maya Numbers



one



two



five



six



nine



ten



thirteen



fifteen



nineteen



twenty



twenty-one



twenty-three



twenty-five



forty



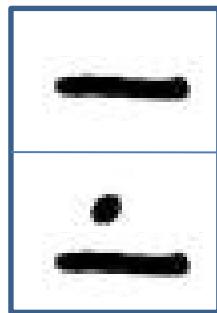
one hundred

# Maya Numbers – sample

$$106 + 334 = 440$$

$$5 * 20^1 = 100$$

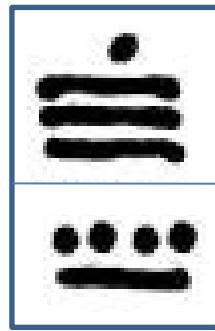
$$6 * 20^0 = 6$$



106

$$16 * 20^1 = 320$$

14

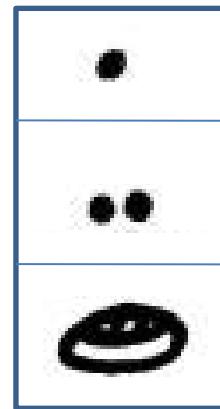


334

$$1 * 20^2 = 400$$

$$2 * 20^1 = 40$$

0



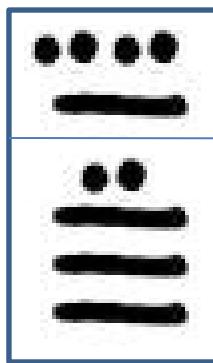
440

## Maya Numbers

$$197 + 354 = 551$$

$$9 * 20^1 = 180$$

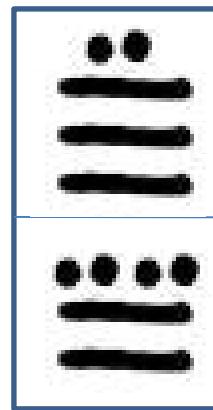
17



197

$$17 * 20^1 = 340$$

14

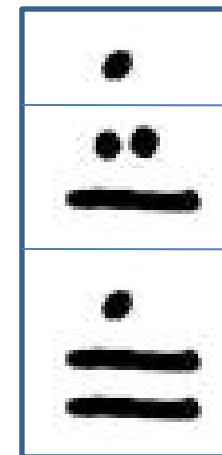


354

$$1 * 20^2 = 400$$

$$7 * 20^1 = 140$$

11



551

# Maya Vigesimal Number System

Hun	$20^0$	1
Kal	$20^1$	20
Bak	$20^2$	400
Pic	$20^3$	8,000
Calab	$20^4$	160,000
Kinchel	$20^5$	3,200,000
Alce	$20^6$	64,000,000

# **Maya Infinity**

*Hun tso'dz'ceh*, the hairs that a deer has.

*Maxocbin*, infinite in number.

*Hunhablat*, countless

*Picdzaac*, long number, countless

*Ox'lahun D'zakab*, eternal thing.

*Hunac*, countless times.

# Maya Codex with Astronomical Data



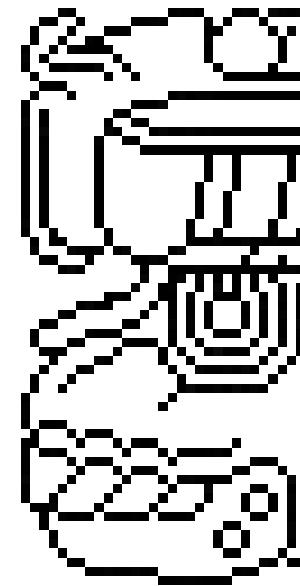
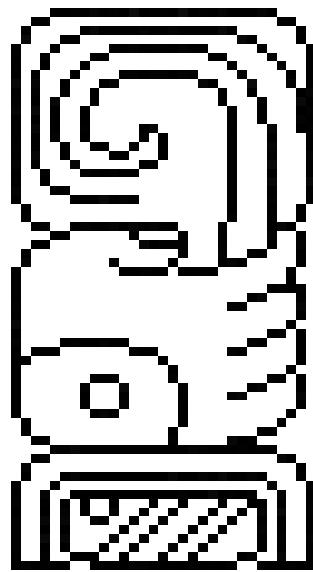
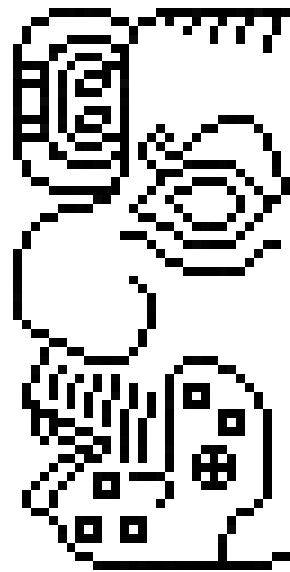
Figure 3: Mayan numbers



# **Maya Glyph Numerals**

**Zero  
to  
Nineteen**

# Maya Portrait Glyph Numerals



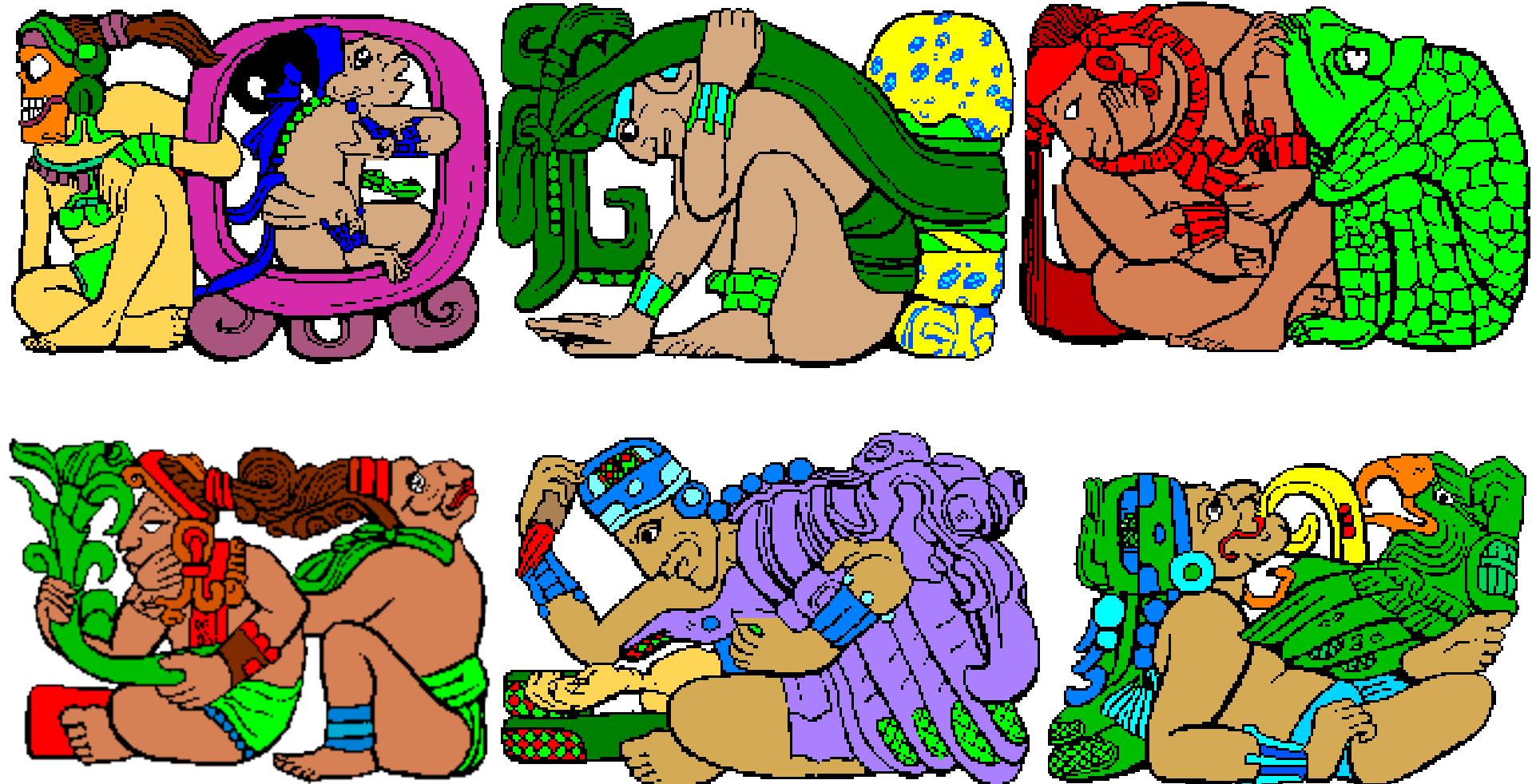
# **Maya Full Figure Glyph Numerals**



# Maya Full Figure Glyph Numerals



# Maya Full Figure Glyph Numerals



# Tamil Numerals

୦	-	୦	୦
କ	-	କ	୧
୨	-	୨	୨
ର୍ତ୍ତ	-	ର୍ତ୍ତ	୩
ସ	-	ସ	୪
ଟ୍ର୍ମ	-	ଟ୍ର୍ମ	୫
ସ୍ରୀ	-	ସ୍ରୀ	୬
ଶ	-	ଶ	୭
ସ୍ରୀ	-	ସ୍ରୀ	୮
ଟ୍ର୍ମେ	-	ଟ୍ର୍ମେ	୯

A decimal system

With Tamil letters as numerals

Special letter markers for 1000<sup>th</sup>, 100<sup>th</sup>, 10<sup>th</sup> place



Magic Square in Tamil Numerals  
Madambakkam Dhenupurishvarar temple

8	1	6
3	5	7
4	9	2

# Vellore Vrincipuram inscription

ஏ இராஜாதிராஜபரமேஸ்வரன்

ஸ்ரீ[வி]ரபுரதாபதேவராய-

அருளானின்ற

சகாஸ்து

தநாசமிளழின்

மெல்

இராஜாதிராஜபரமேஷ்வரான ஸ்ரீவீரப்ரதாபதேவராய-  
அருளானின்ற சகாப்தம் 1347ழின் மெல்

தநாசமிள

= 1347

சத - 1000

நு - 3

ளா - 100

ச - 4

ய - 10

எ - 7

# கிரேக்கம் GREECE



The difference between  
Greek civilization  
and Roman Republic

# Greek Astronomy

- Borrowed from Egypt, Babylon
- Decimal System (Base 10)
- Greek Names for Zodiac, Weekdays
- Trigonometry with Greek numerals
- Instruments
  - Astrolabe, armillary sphere

# Greek Numerals

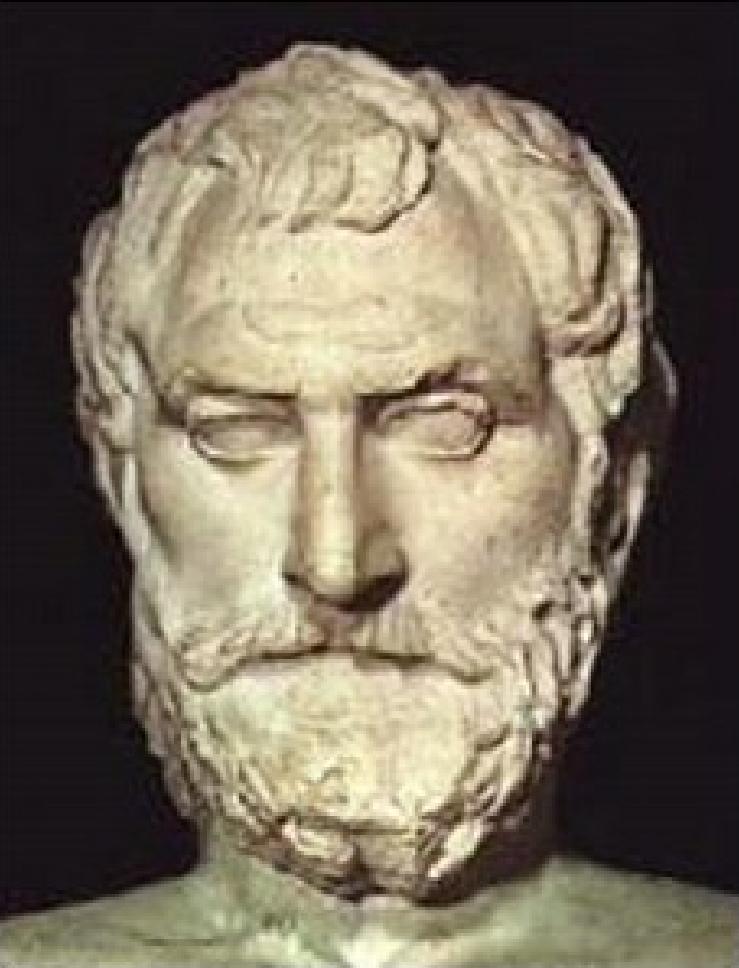
Decimal system, without zero

1	$\alpha$	alpha	10	$\iota$	iota	100	$\rho$	rho
2	$\beta$	beta	20	$\kappa$	kappa	200	$\sigma$	sigma
3	$\gamma$	gamma	30	$\lambda$	lambda	300	$\tau$	tau
4	$\delta$	delta	40	$\mu$	mu	400	$\upsilon$	upsilon
5	$\epsilon$	epsilon	50	$\nu$	nu	500	$\phi$	phi
6	$\varsigma$	vau*	60	$\xi$	xi	600	$\chi$	chi
7	$\zeta$	zeta	70	$\circ$	omicron	700	$\psi$	psi
8	$\eta$	eta	80	$\pi$	pi	800	$\omega$	omega
9	$\theta$	theta	90	$\vartheta$	koppa†	900	$\sphericalangle$	sampi

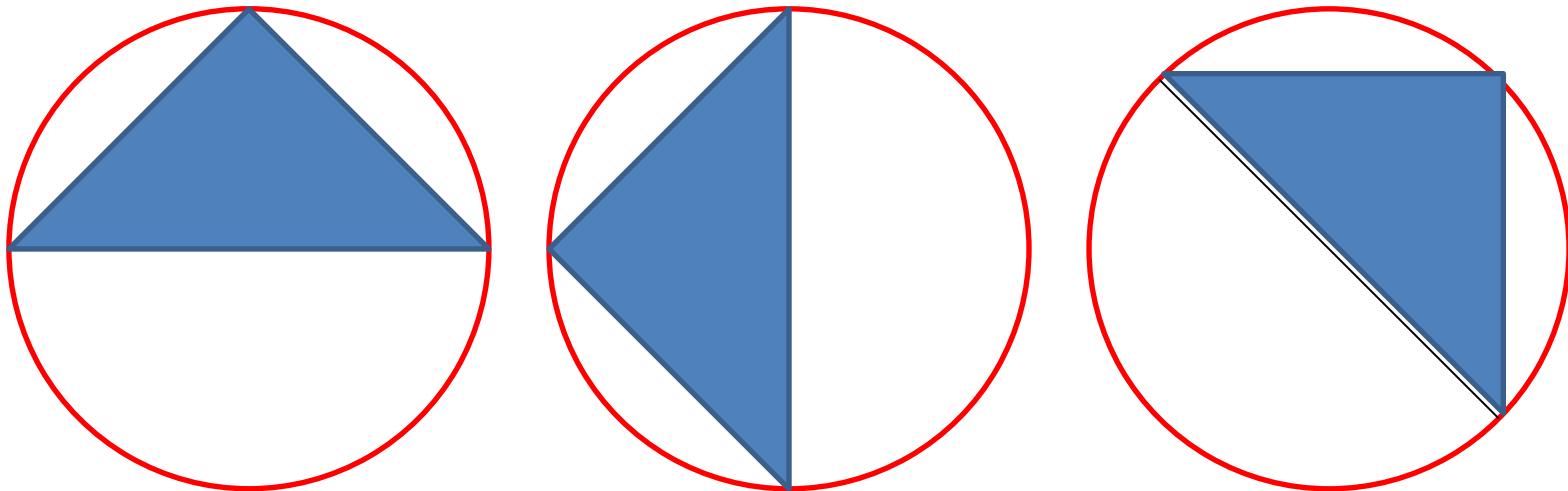
\*vau, koppa, and sampi are obsolete characters

# Thales 624 BC

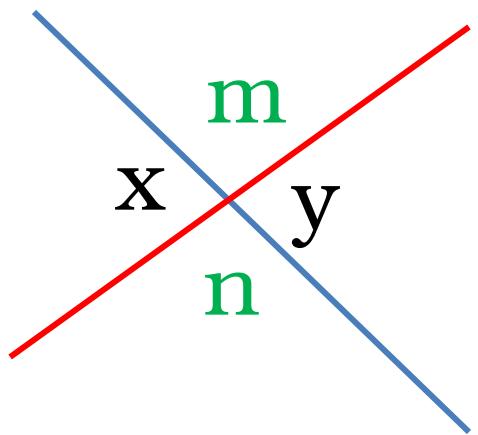
## தேலீஸ்

- 
- One of Seven Wise Men
  - Predicted 585BC solar eclipse
    - Halted Lydia-Medea war
  - Variation of seasons
  - Distance of ships
  - Height of pyramids

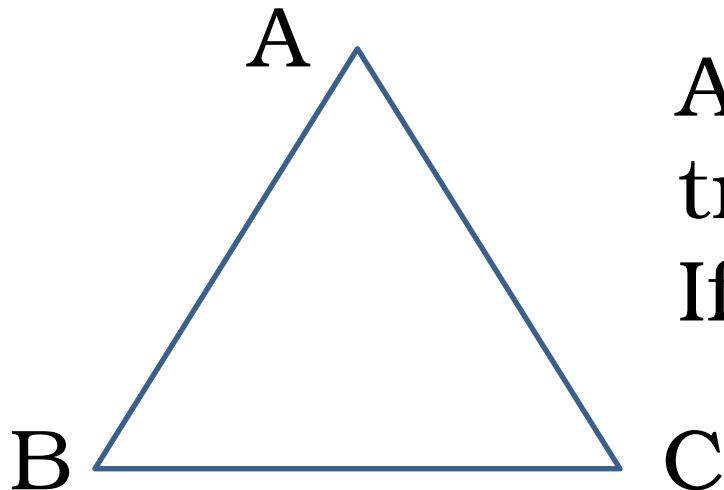
A circle is bisected by any diameter



The angle in a semi circle is a right angle



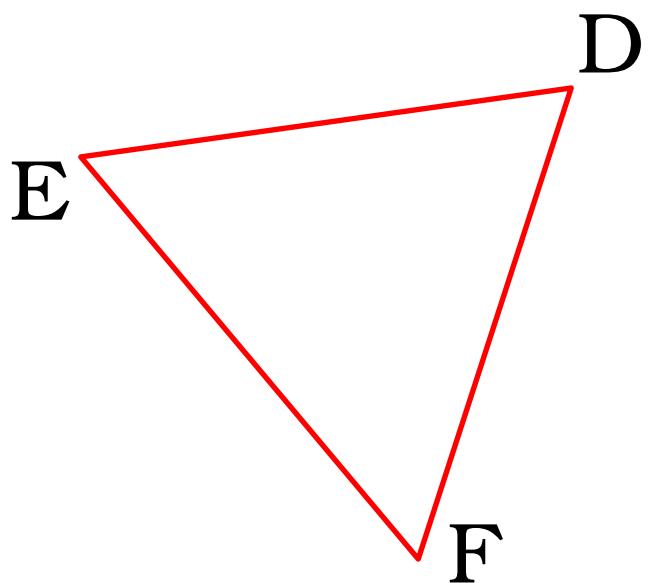
If two straight lines cut,  
vertically opposite angles  
are equal



Angles at base of isosceles triangle are equal  
If  $AB = AC$ , then  $\angle B = \angle C$

If two triangles have two angles,  
and one side equal,  
The triangles are equal

If  $\angle B = \angle E$  and  $\angle C = \angle F$   
and  $BC = EF$   
then  $\triangle ABC \cong \triangle DEF$

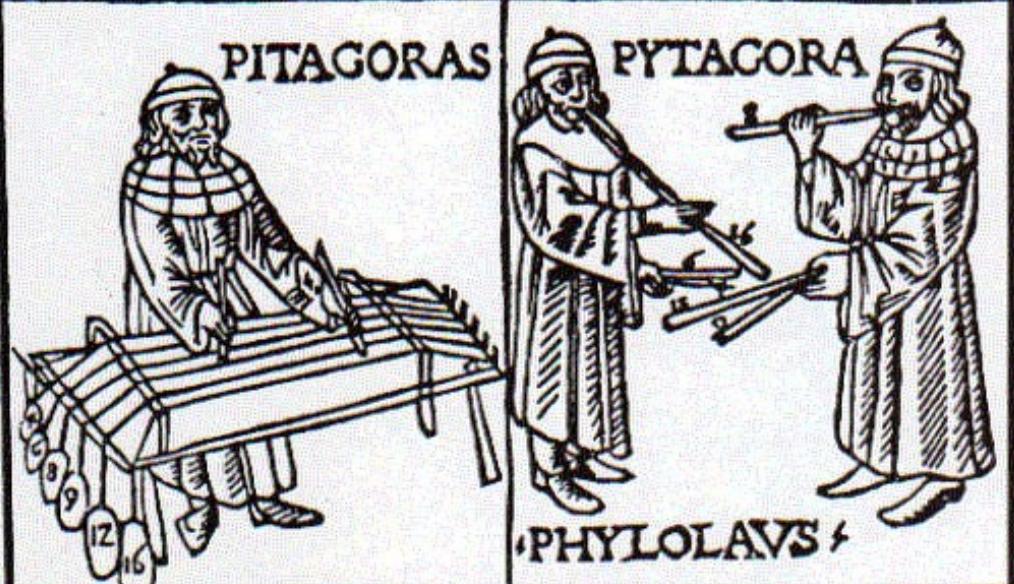


# Pythagoras 47<sup>th</sup> theorem

## Observations on Music

Hammers on anvil

Lyre - string length

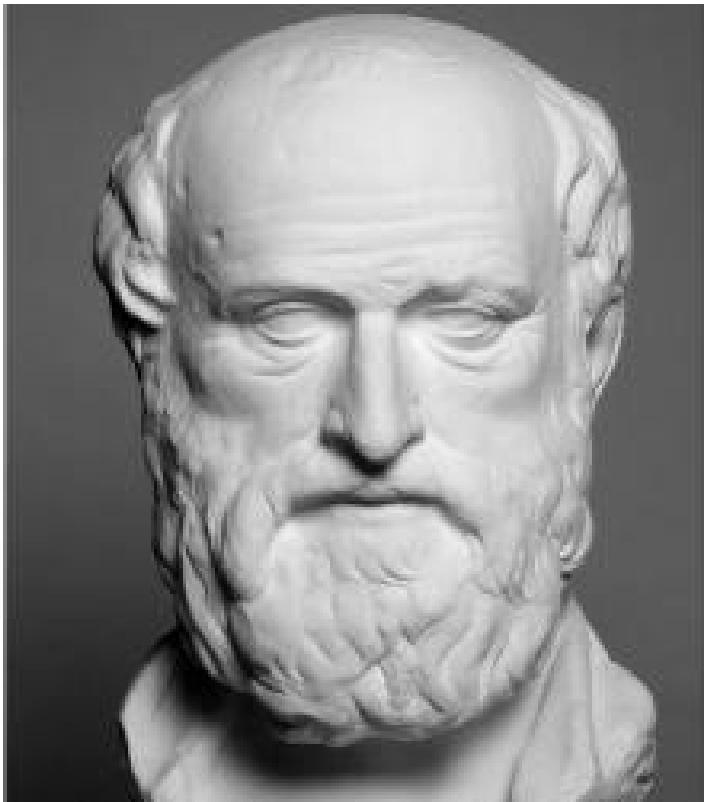


# Pythagorean School

- Concept of proof
- Frightened of Zero, Infinity!!!
- Discovered Irrational Numbers
- Death Sentence for Square Root of Two!
- Euclid : Geometry

# Eratosthenes (276 BC)

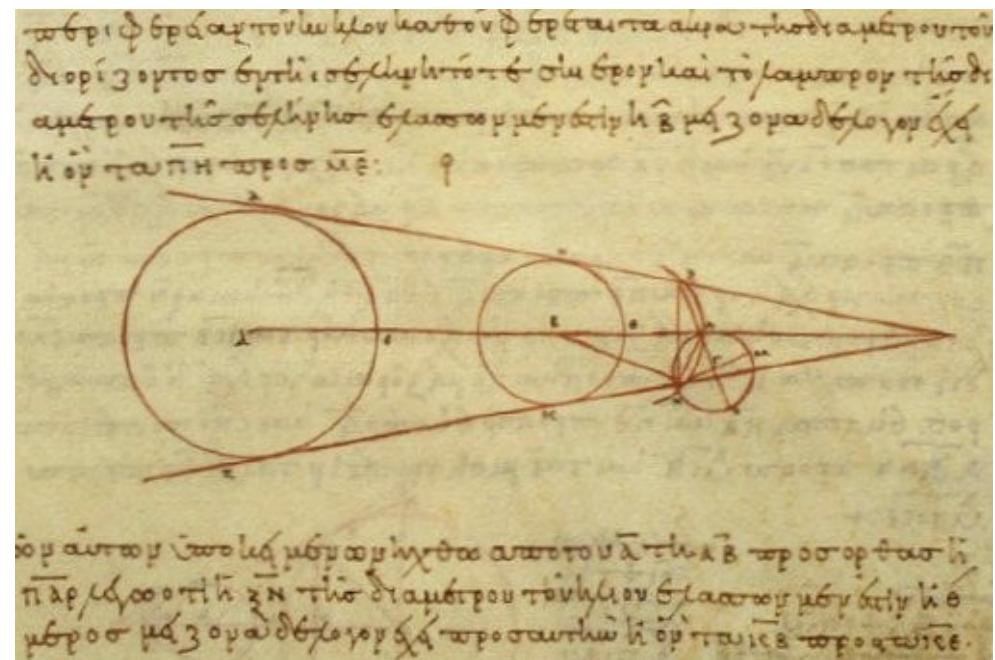
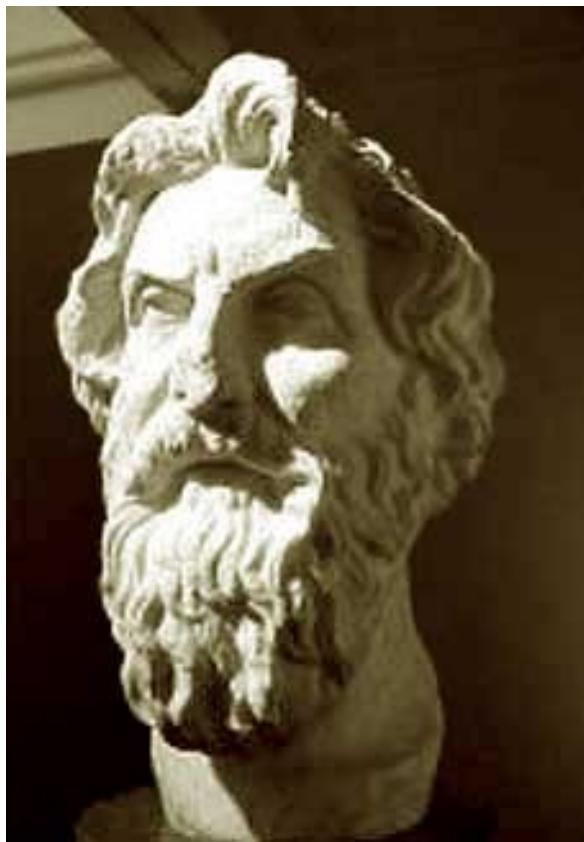
## எராடோஸ்தெனீஸ்



- Librarian - Alexandria
- Father of Geography
- Geography using astronomy
  - Calculated circumference of earth
  - Longitude, Latitude
- Invented Armillary sphere

# Aristarchus

- Proposed Heliocentric theory
- But not accepted by others



# Euclid

- Euclid's book the Elements (Numbers) was the standard book of Greek/European geometry for 1900 years (300BC-1600AD)
- Includes Definitions, axioms, theorems, proofs
- Compilation of 300 years of mathematics
- Pharaoh Ptolemy I asked him to teach geometry quickly
- “There is no royal road (shortcut) to Geometry” – Euclid's response

# Claudius Ptolemaeus

- Ptolemy : The Almagest (al kitabu il mijisti), originally called *He Megale Syntaxis*, Great Synthesis
- Its geocentric theory was accepted as correct in Islamic and European countries until Copernicus.



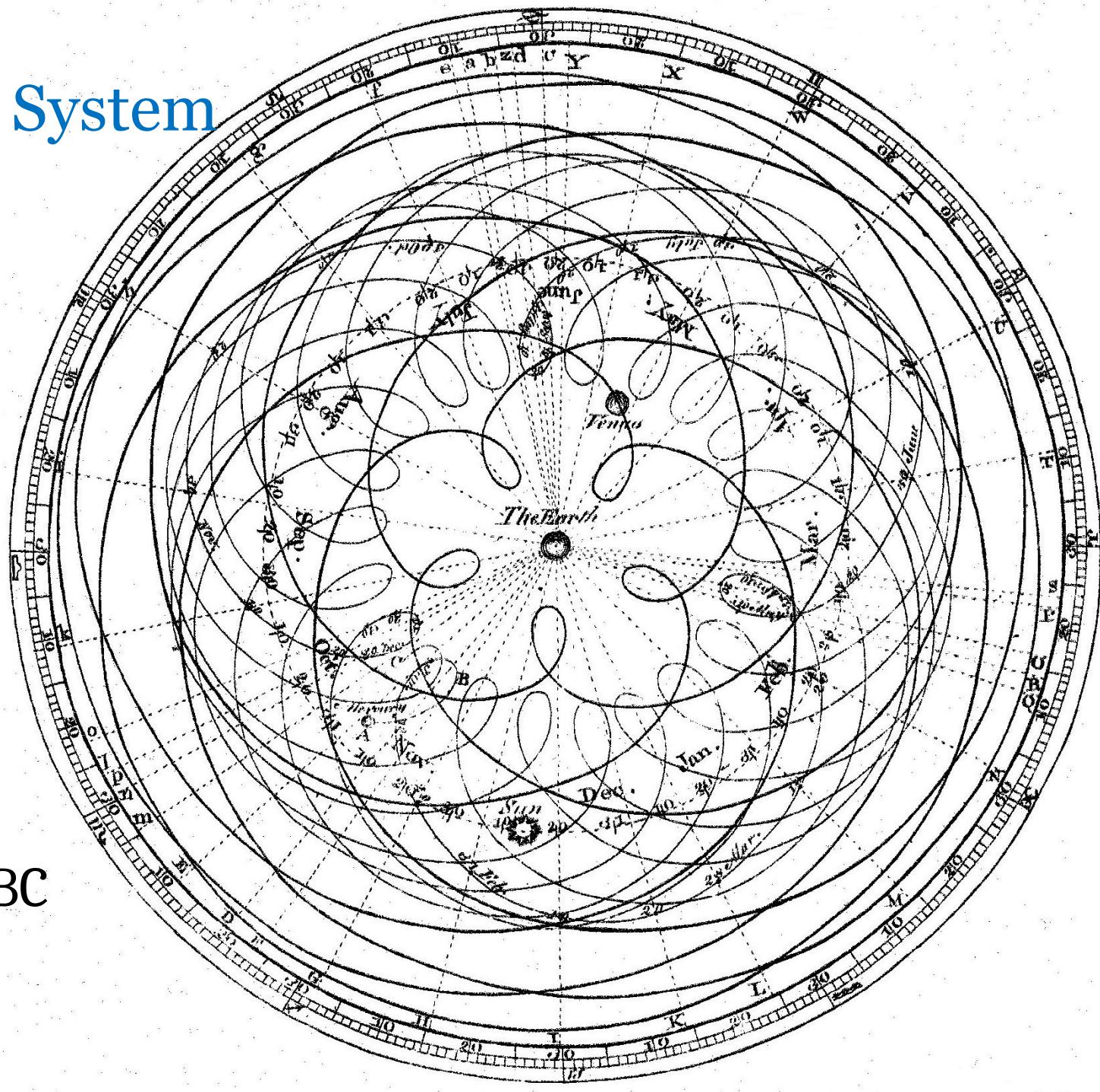
Schema huius praemissæ divisionis Sphærarum.

# Sky map



# Geo centric System

## Epicycles



- Eudoxus
- 4<sup>th</sup> century BC

# Hipparchus

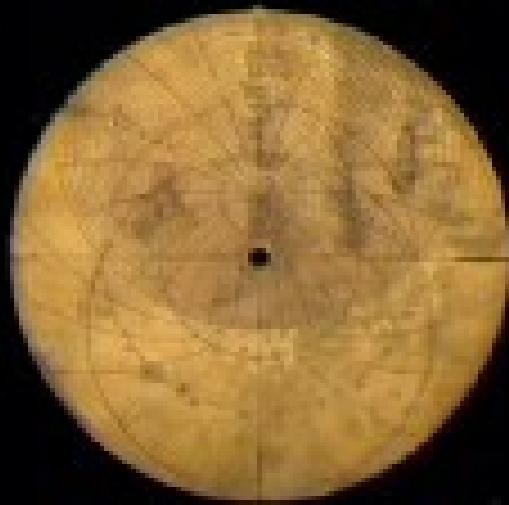
- Precession of Equinoxes
- Invented Astrolabe
- Founded Trigonometry



# Astrolabes



Rete



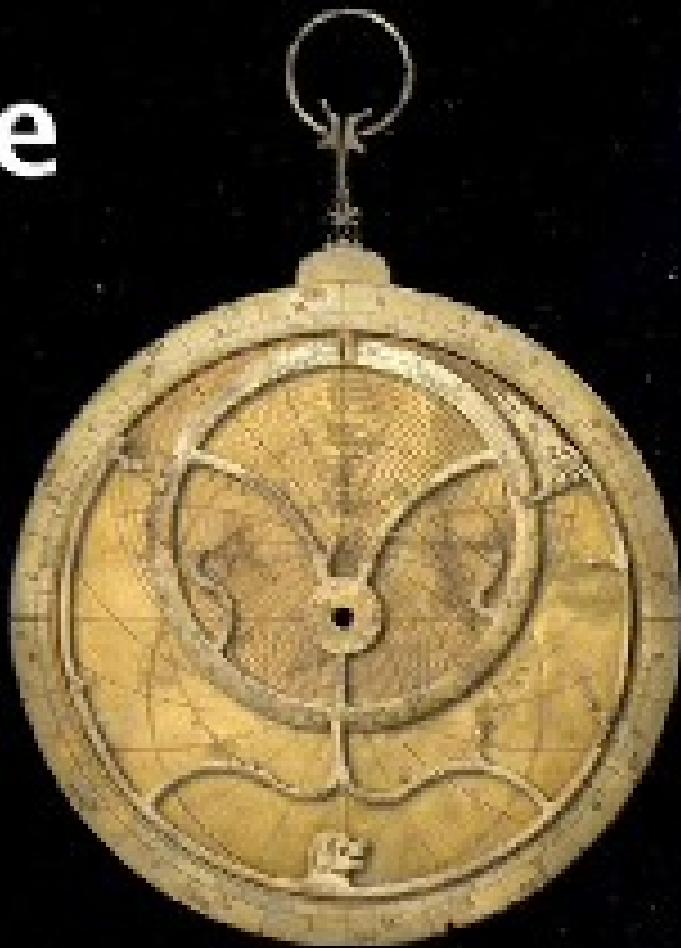
Plate



Mater

# Astrolabes

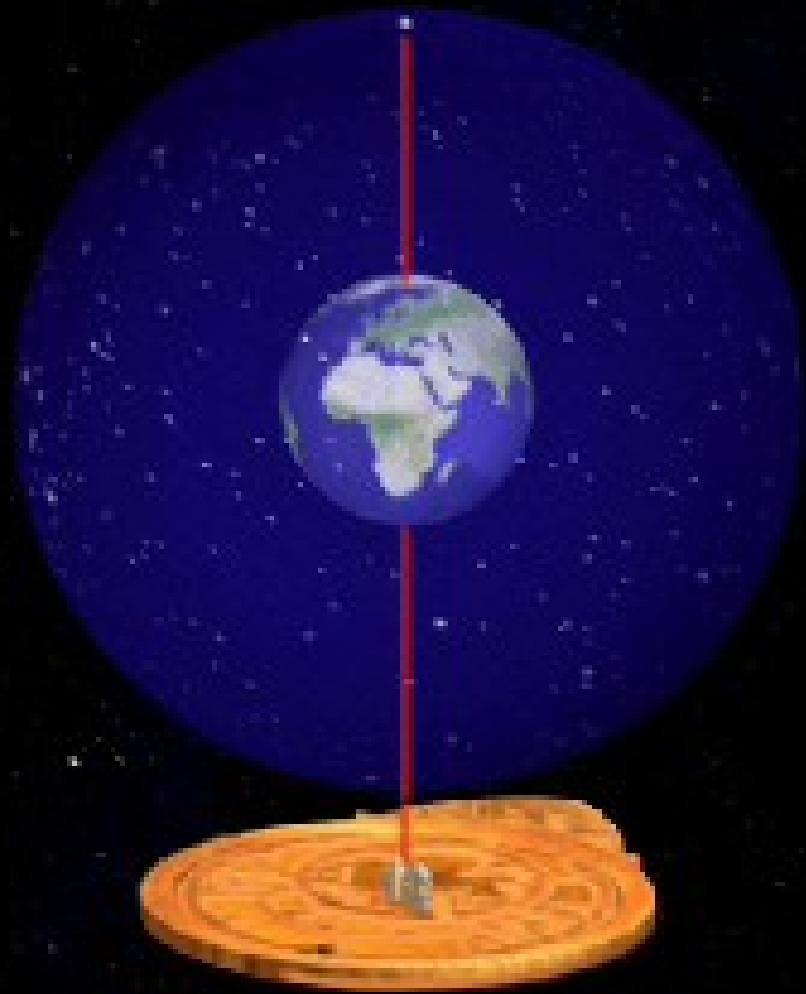
The  
Astrolabe



# Astrolabes

## Stereographic Projection

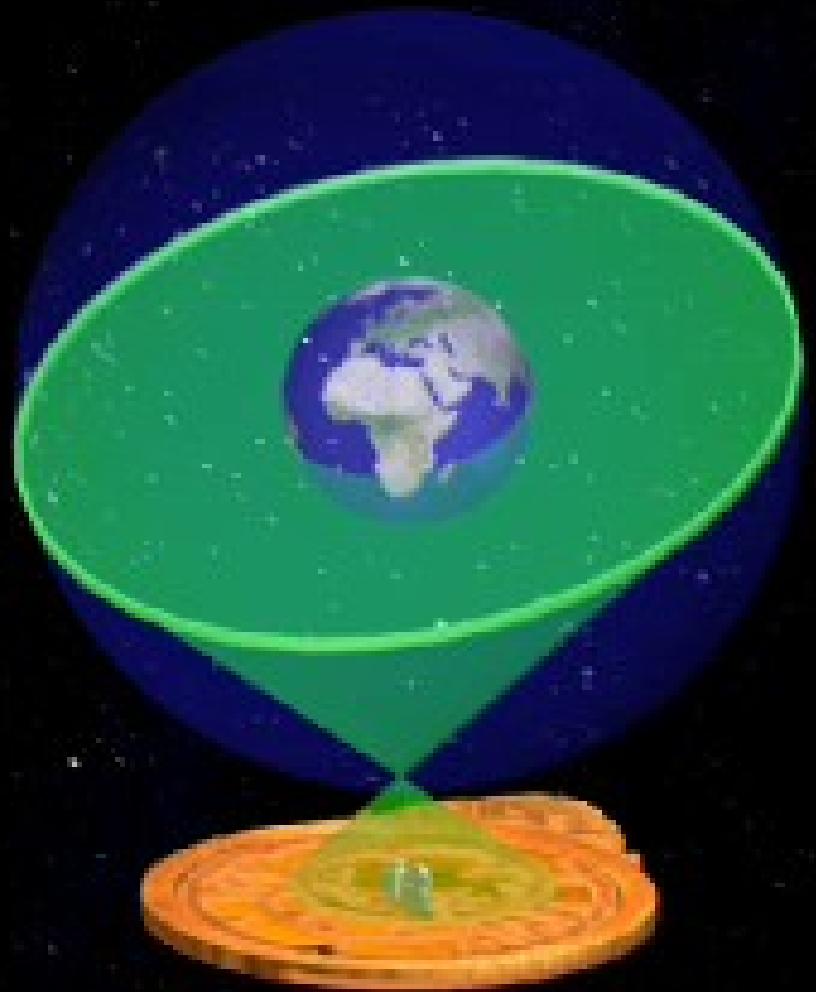
North Star



# Astrolabes

Stereographic  
Projection

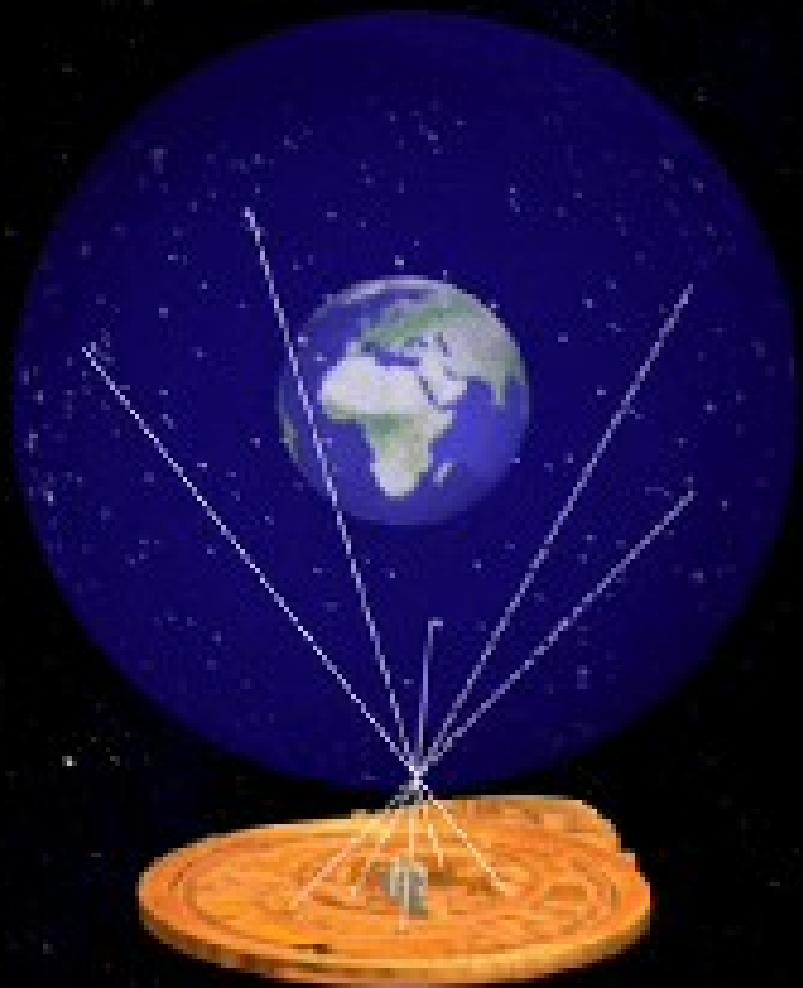
Ecliptic



# Astrolabes

Stereographic  
Projection

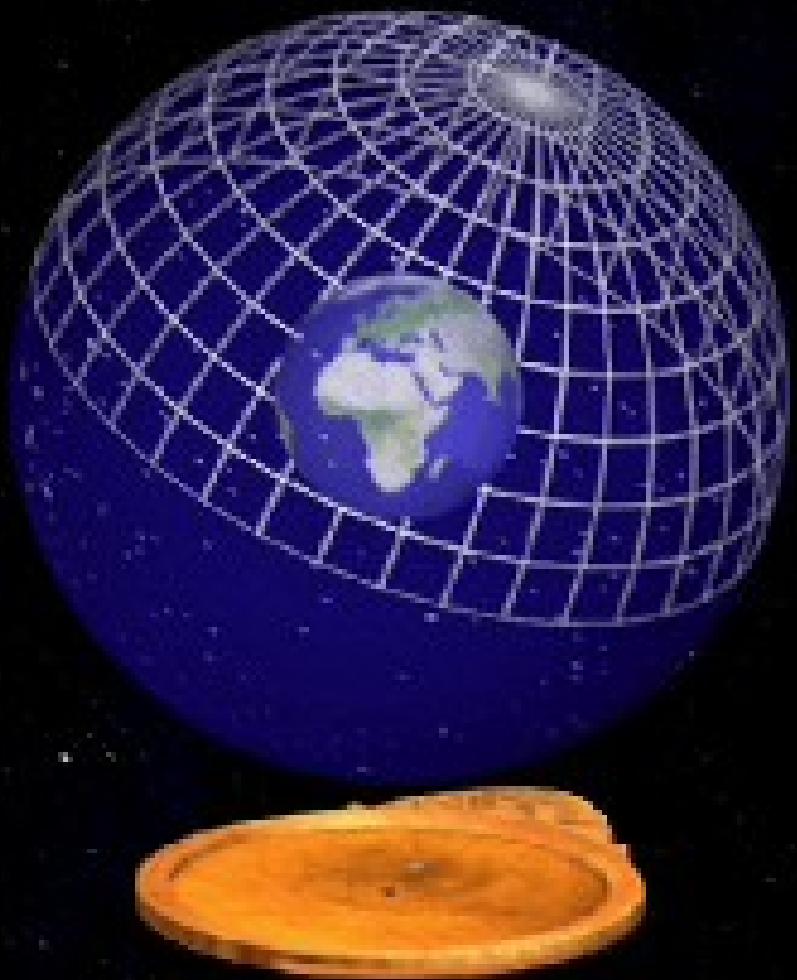
Bright Stars



# Astrolabes

Stereographic  
Projection

Altitude



# Astrolabes

## Astrolabe Functions

Time

Calculate Distances

Date

Building Height

Surveying

Latitude

Prayer Times

Meridian

Rising Time

Longitude

Horoscope

Eclipses

Object's Altitude

Cardinal Directions

Calculate Sines

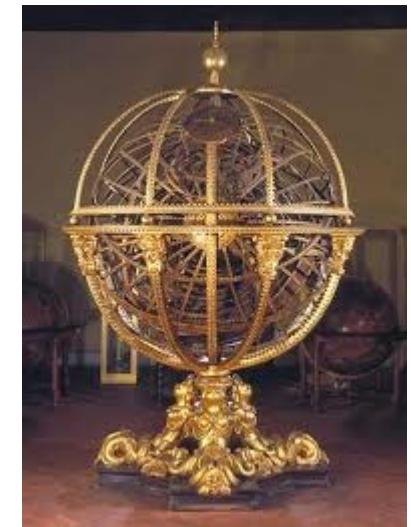
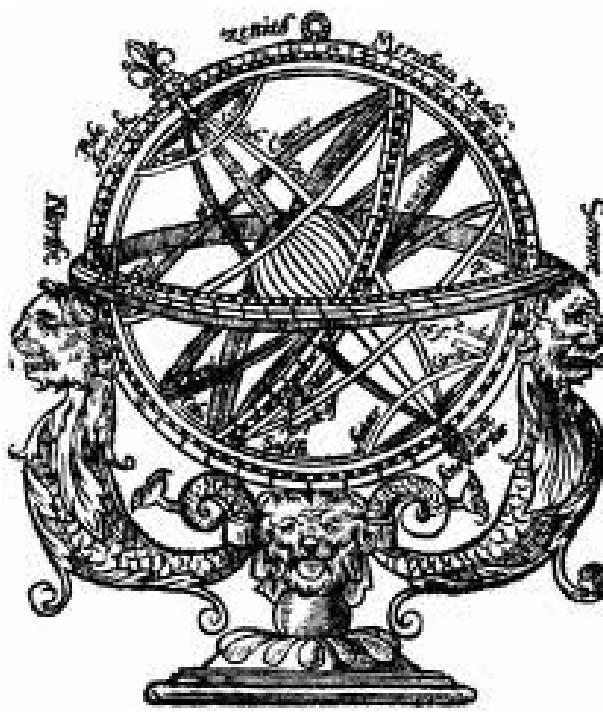
Time Calculation

Planets Position

Occultations

Direction to Mecca

# Armillary Spheres



# Armillary Sphere Sculptures



# Armillary Sphere Sculptures



# Harappan Mathematics

- Brick wall, Lothal
- Recangular bricks
- Wall or channel way

- A well in Mohenjadaro
- Trapezoidal bricks, not recangular
- Forms two circles
- Stable structure



# A well in Nalanda

- Bihar – 7<sup>th</sup> century
- 2000 + years after Harappa
- Remarkable continuity



# A water regulator in Srivilliputhur

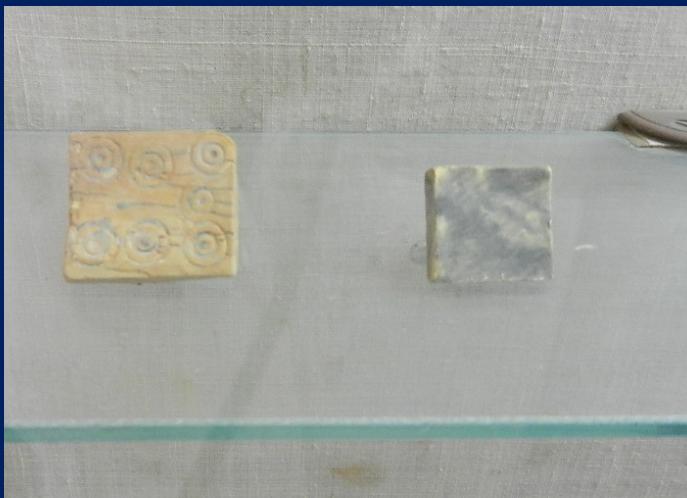
9<sup>th</sup> century  
Trapezoidal stones  
Inlet channel  
Seven sluice gates  
ஏழு கண் மடை



“Repaired” or “renovated”  
by 21<sup>st</sup> century masons,  
with cement in gaps

# Harappan Weights

- Cubical weights, in increasing sizes
- Binary multiples : 1,2,4,8,16,32...
- No script or number markings
- Indicates business, trade, taxes



Pictures from Dholavira museum

# Harappan Weights

multiples of the smallest unit	1	2	4	8	16		32	64
multiples of 13.65 g unit	1/16	1/8	1/4	1/2	1		2	4
Idealized Weight	0.85g	1.75g	3.45g	6.85g	13.65g		27.35g	54.65g
Larger by Factor of 10					160	200	320	640
					136.5g	170.6g	273.5g	546.5g

Table from [https://sizes.com/units/harappan\\_weights.htm](https://sizes.com/units/harappan_weights.htm)

Simon Pierre Laplace: “This is a profound and important idea which appears **so simple** to us now that **we ignore its true merit**. But its very simplicity and the great ease which it has lent to all computations put our **arithmetic in the first rank of useful inventions.**”

The usefulness of Place Value system can be understood when we realize that it has replaced ALL other pre-existing number systems : Chinese, Egyptian, Sumerian, Greek and Roman - **in every country which uses mathematics.**

Procedures for multiplication, division, square and cube roots, and several algebraic methods, become very simple compared to the other ancient systems. Some of these algorithms are not even possible with other number systems; in other cases, complicated tables need to be created as in Sumerian system, or cumbersome procedures as in other number systems.

The utility of the place value system is not just in science and technology, but also in **commerce, administration and everyday life.**

# Burnt Libraries and Lost Books

- Alexander's Invasions
- Library of Alexandria
  - Julius Caesar's Invasion ~50 BC
  - Christian Invasion ~400 AD
  - Muslim Invasion ~700 AD
- Crusaders of Europe
- Mayan Manuscripts – destroyed on the orders of Bishop Diego de Landa to save Mayans from the sins of paganism and idol worship
- Sanskrit and Tamil Manuscripts (offered to rivers)

# Preservation and Study

- Alexander's Soldier – Philosophers
- Muslim Scholars
- Genghis Khan!!
- European Orientalists
  - Asiatic Society of Bengal
- Napoleon's Army of Scholars

# Varahamihira Science Forum

## நன்றி Thank you

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