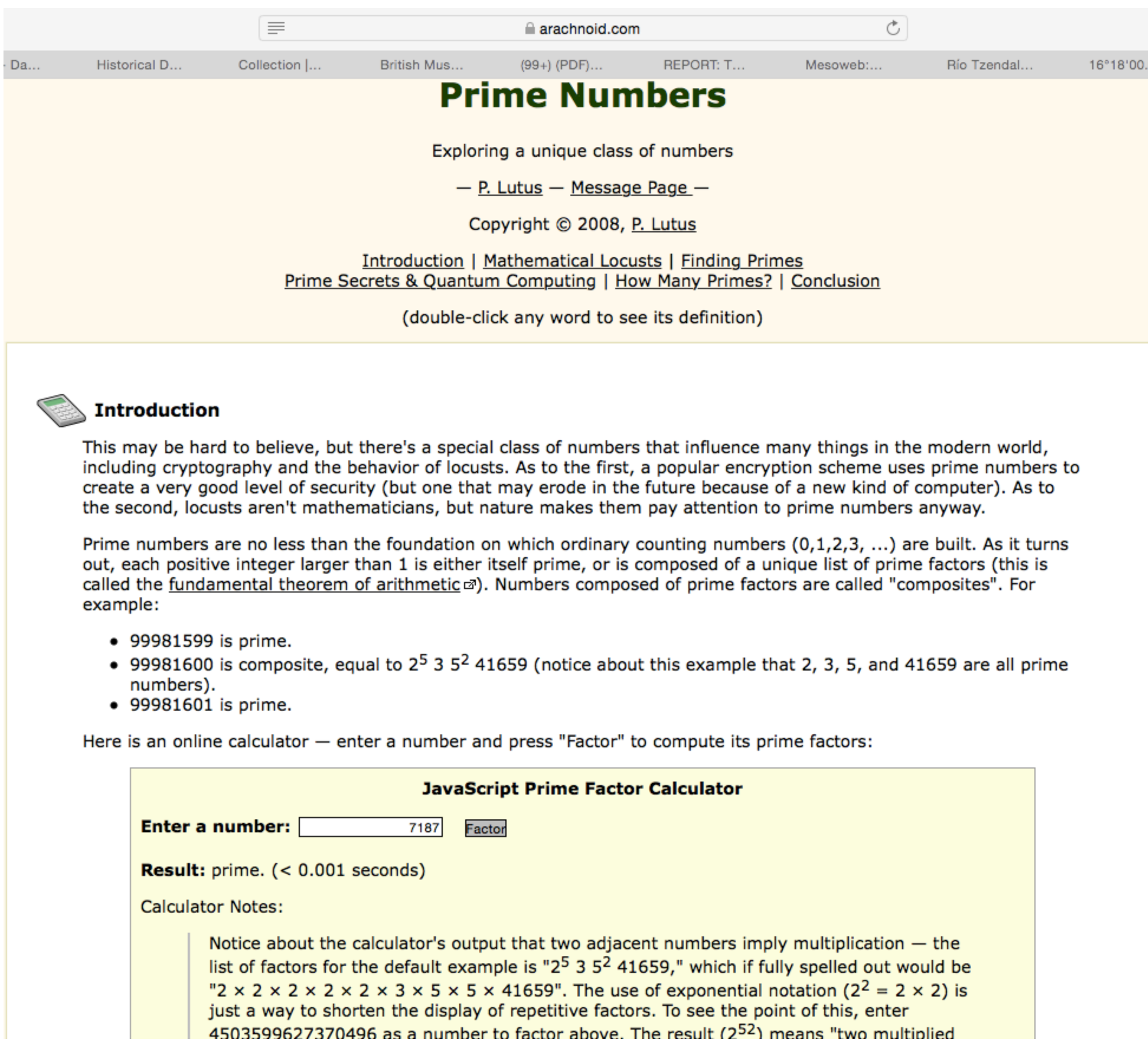
Workbook for Workshop, 10 April 2021
Philadelphia PCS, University of Pennsylvania Museum of Archaeology and Anthropology

Finding solar longitudes for dates in the Maya Classic Period and calculating sidereal year lengths by hand -- using Maya enumeration (by Hutch Kinsman)

1. A good website to find prime factors of any number.


arachnoid.com

Da… Historical D… Collection |… British Mus… (99+) (PDF)… REPORT: T… Mesoweb:… Río Tzendal… 16°18'00.0

Prime Numbers

Exploring a unique class of numbers

— P. Lutus — Message Page —

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Introduction | Mathematical Locusts | Finding Primes
Prime Secrets & Quantum Computing | How Many Primes? | Conclusion

(double-click any word to see its definition)

Introduction

This may be hard to believe, but there's a special class of numbers that influence many things in the modern world, including cryptography and the behavior of locusts. As to the first, a popular encryption scheme uses prime numbers to create a very good level of security (but one that may erode in the future because of a new kind of computer). As to the second, locusts aren't mathematicians, but nature makes them pay attention to prime numbers anyway.

Prime numbers are no less than the foundation on which ordinary counting numbers (0,1,2,3, ...) are built. As it turns out, each positive integer larger than 1 is either itself prime, or is composed of a unique list of prime factors (this is called the fundamental theorem of arithmetic). Numbers composed of prime factors are called "composites". For example:

- 99981599 is prime.
- 99981600 is composite, equal to 2^5 3 5^2 41659 (notice about this example that 2, 3, 5, and 41659 are all prime numbers).
- 99981601 is prime.

Here is an online calculator — enter a number and press "Factor" to compute its prime factors:

JavaScript Prime Factor Calculator

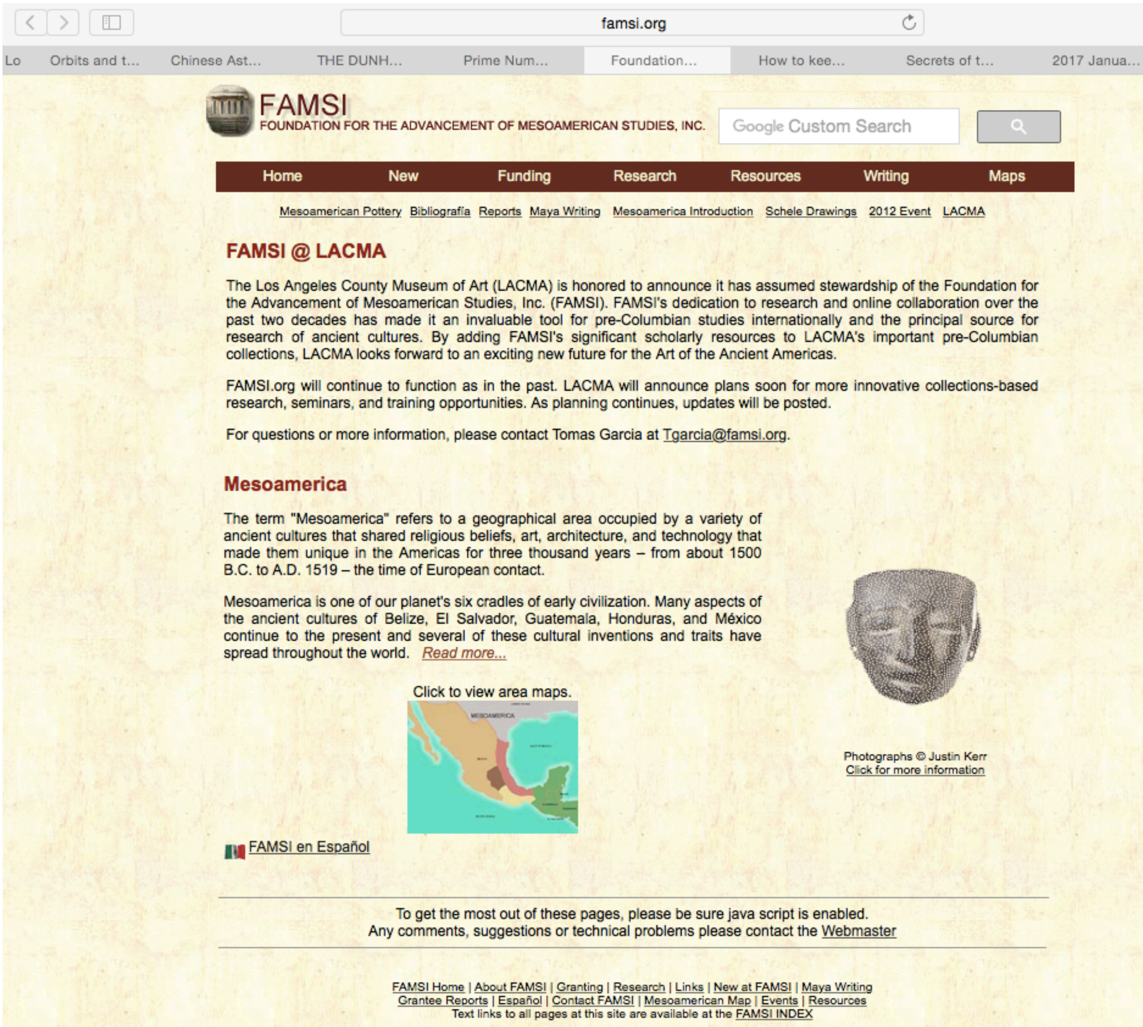
Enter a number: 7187 Factor

Result: prime. (< 0.001 seconds)

Calculator Notes:

Notice about the calculator's output that two adjacent numbers imply multiplication — the list of factors for the default example is "2^5 3 5^2 41659," which if fully spelled out would be "2 × 2 × 2 × 2 × 2 × 3 × 5 × 5 × 41659". The use of exponential notation (2^2 = 2 × 2) is just a way to shorten the display of repetitive factors. To see the point of this, enter 4503599627370496 as a number to factor above. The result (2^{52}) means "two multiplied

2. Converting Maya dates to Julian Calendar dates.



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FAMSI @ LACMA

The Los Angeles County Museum of Art (LACMA) is honored to announce it has assumed stewardship of the Foundation for the Advancement of Mesoamerican Studies, Inc. (FAMSI). FAMSI's dedication to research and online collaboration over the past two decades has made it an invaluable tool for pre-Columbian studies internationally and the principal source for research of ancient cultures. By adding FAMSI's significant scholarly resources to LACMA's important pre-Columbian collections, LACMA looks forward to an exciting new future for the Art of the Ancient Americas.

FAMSI.org will continue to function as in the past. LACMA will announce plans soon for more innovative collections-based research, seminars, and training opportunities. As planning continues, updates will be posted.

For questions or more information, please contact Tomas Garcia at Tgarcia@famsi.org.

Mesoamerica

The term "Mesoamerica" refers to a geographical area occupied by a variety of ancient cultures that shared religious beliefs, art, architecture, and technology that made them unique in the Americas for three thousand years – from about 1500 B.C. to A.D. 1519 – the time of European contact.

Mesoamerica is one of our planet's six cradles of early civilization. Many aspects of the ancient cultures of Belize, El Salvador, Guatemala, Honduras, and México continue to the present and several of these cultural inventions and traits have spread throughout the world. *Read more...*

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Photographs © Justin Kerr
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FAMSI en Español

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DATE CONVERSION

To find a date, choose the appropriate correlation constant (default is 584283) and enter the known Long Count or Gregorian date. Other conversion options are listed at the bottom of the page.

Correlation Constant: 584286 - Martin-Skidmore   Clear Form   Today's Date

Enter Long Count: . . . .   OR   Enter Date (mm-dd-yyyy): 1 0 2 CE Convert

Thursday, December 5, 2019 CE is
Long Count: 13.0.7.0.17
0Julian Date: November 22, 2019 CE
Calendar Round: 6 Kab'an 5 Mak
Year Bearer: 8 Eb'
Lord of Night: G8

13 Bak'tun	0 K'atun
7 Tun	0 Winal
17 K'in	6 Kab'an
G8	5 Mak

Direction: Lak'in - East (Oriente)
Color: Chak - Red (Rojo)

819 day count: 0.0.1.15.8 (668) 1 Muluk 7 Pax

Julian Day #: 2,458,823
Maya Day #: 1,874,537
Lunar Age: 8.37 day(s)
Aztec Calendar Round: 6 Ollin 5 Tozoztontli
Mixtec Calendar Round: 6 Qhi (Earthquake) 5 Reed

Find Missing Parts of a Date
Date Conversions
Print Current Month Calendar

3. Finding Solar Longitudes for Julian Calendar dates.

ssd.jpl.nasa.gov

ww.meso… Kerr Portfol… IMO | Intern… Ptolemy al… Monumenta… pallas.astro… Brief O

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Solar System Dynamics

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JPL Solar System Dynamics

Welcome to the JPL solar system dynamics web site. This site provides information related to the orbits, physical characteristics, and discovery circumstances for most known natural bodies in orbit around our sun.

Features

Ephemerides
High-precision ephemerides with custom selected observing parameters are available using our HORIZONS system.

Orbits
Orbit diagrams for most solar system bodies as well as tables of orbital elements for the planets, planetary satellites, asteroids and comets are available.

Physical Characteristics
Selected physical characteristics of the planets, planetary satellites, and some small-bodies are available.

Discovery Circumstances
For many solar system bodies, discovery circumstances such as date, location, and discoverers are available.

On-Line Tools
We provide a number of on-line tools in addition to our HORIZONS system, including a date/time converter and small-body identification from astrometry.

Where to Find More

If you can't find what you're looking for on our site, be sure to check our site map before giving up.

HORIZONS System

The JPL HORIZONS *on-line* solar system data and ephemeris computation service provides access to key solar system data and flexible production of highly accurate ephemerides for solar system objects (1055407 asteroids, 3711 comets, 209 planetary satellites, 8 planets, the Sun, L1, L2, select spacecraft, and system barycenters). HORIZONS is provided by the Solar System Dynamics Group of the Jet Propulsion Laboratory.

The HORIZONS system can be accessed using any of the following methods:

- **telnet** (instructions)
- **email** (instructions)
- **web-interface** (see note below)

NOTE: Although the web-interface to HORIZONS provides *nearly* all capabilities of the primary telnet interface (and email interface), it does not provide the following:

- Small-body PARAMETER-MATCHING population searches (use the small-body search engine as an alternative)
- Integration of USER-INPUT ORBITS
- SPK BINARY FILE production
- CLOSE-APPROACH TABLES

HORIZONS Documentation - (updated 2019-Dec-10)

Complete documentation is available in the following formats:

- HTML document
- PDF document (temporarily unavailable)
- PostScript document (temporarily unavailable)

Documentation is also available *on-line* using the telnet interface to HORIZONS (simply type `'?'` from any prompt). New users of the web-interface to HORIZONS may want to consult this tutorial first. HORIZONS system news is also available describing recent changes and improvements.

Using the `telnet` Interface

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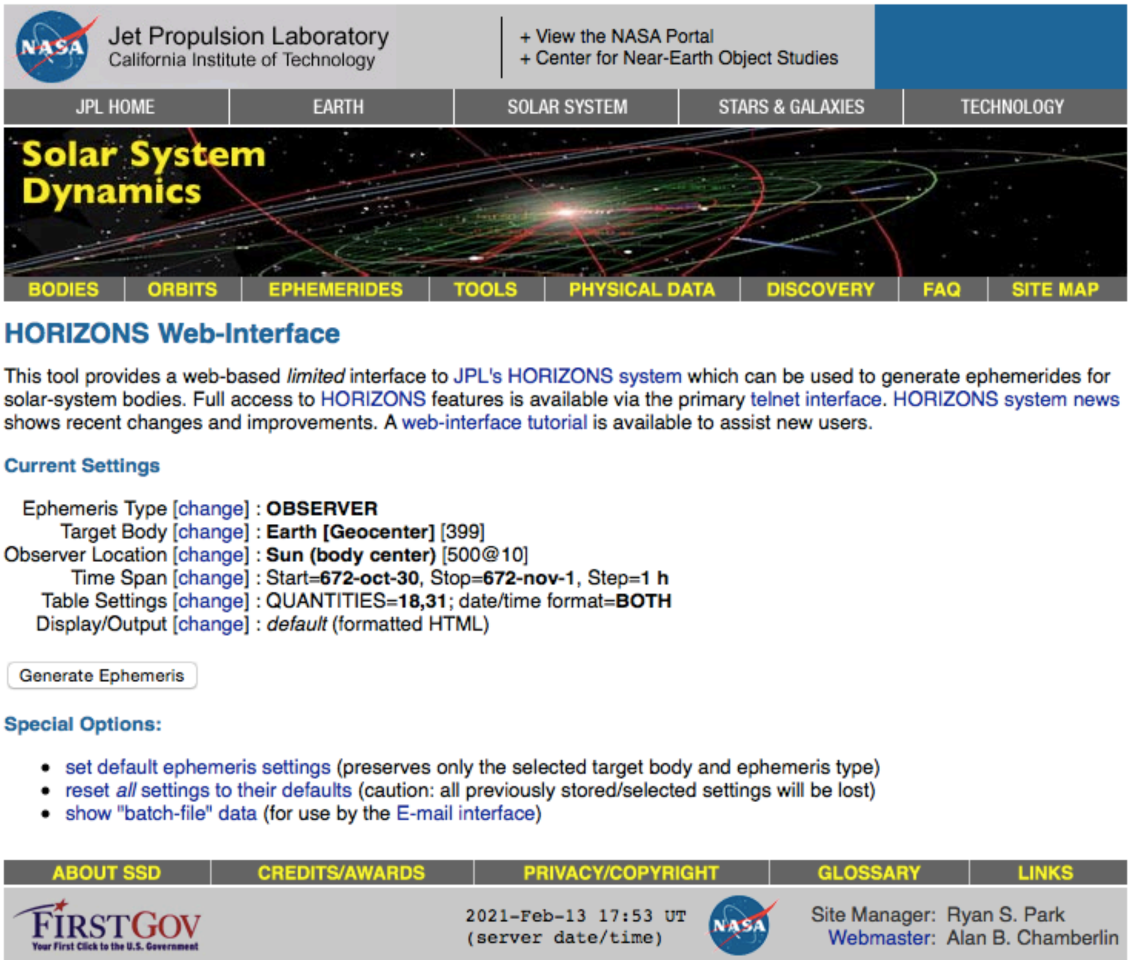
Using the `telnet` Interface



Sidereal Year – Horizons web-interface
ssd.jpl.nasa.gov/horizons
Ephemeris Type [change]: **OBSERVER**
Target Body [change] : **Earth [Geocenter**] [399]
Observer Location [change]: **Sun (body center)** [500@10]
Time Span [change]: Start=**570-jul-22**, Stop=**570-jul-23**, Step=1 **m** [minute]
Table Settings [change]: QUANTITIES= **31**; date/time format=**BOTH** (so the output has both the Julian Day Number and the Julian date).
Display/Output [change]: default (formatted HTML)
We are taking inverse of result, to agree with definition of solar longitude. (add 2, subtract 2, or add 180º to get actual solar longitude.

4. Development of and using a table to determine sidereal year intervals the way that the Maya might have done (devised by the author in 2017 for the workshop at Maya at the Playa conference).

After checking nearly 60 different dates, where many had the same solar longitude, I found that the number 39 years or its multiple showed up 7 or 8 times as the difference between two or more of these dates.

Using sidereal values 20 years or less

25 (13 of these were exactly 4 years off) more were within 1-4 years of those values (i.e. 114, 121, 152, 386 (390 – 4, etc.)—4.1.1 ~ 4 sidereal years; 25 others were single year numbers that required slightly more manipulation using sidereal values for
365 days = 1.0.5 (2)(365) = 2.0.10 (3)(365) = 3.0.15
(4)(365) = 4.1.0

Calculations for less than 39 sidereal years:

A sidereal year is really slightly more than 365 and ¼ days, so add 1 day for every 4 years to get approximately 4 sidereal years.
4 sid years ~ (4.1.0) + (0.1) = 4.1.1
8 sid years ~ (8.2.0) + (0.2) = 8.2.2
12 sy ~ (12.3.0) + (0.3) = 12.3.3
16 sy ~ (16.4.0) + (0.4) = 16.4.4
20 sy ~ (1.0.5.0) + (0.5) = 1.0.5.5

39-78-117-10-20-30 Formula

Add 10 days to each 39 haab to arrive at 39 sidereal years = 365.256410 days/yr

(current accepted value = 365.256363)

(39)(haabs) = (39)(365)

```
(39)(1.0.5) = 1.19.9.15      39 haabs

                    +    .10      10 days

                 -------------

                 1.19.10.5 = 39 sidereal years
```

Add 20 days to 78 haabs = 78 sidereal years of 365.256410 days/year

```
(78)(1.0.5) = 3.19.1.10       78 haabs

                   +   1.00       20 days

                --------------

                 3.19.2.10  = 78 sidereal years
```

Add 30 days to 117 haabs = 117 sidereal years of 365.256410 days/year

```
(117)(1.0.5) = 5.18.11.05      117 haabs

                     +    1.10        30 days

                  ---------------

                    5.18.12.15 = 117 sidereal years
```

When checking the Xultun numbers, I realized that all 4 haab' factors of Xultun A, B, C and D were divisible by 39 which meant that each number could be useful in determining a sidereal year value of 365.256410.

Since for every 39 Haab's adding 10 days computes to 39 sidereal years, the additives to calculate sidereal years are easy to figure for each Xultun interval.

Xultun

	Number of Haab's	Additive Decimal	Additive Maya
A 8.6.1.9.0 1,195,740 = (365)(3276)	3276 = (39)(84)	840 days	2.6.0
B 2.7.9.0.0 341,640 = (365)(936)	936 = (39)(24)	240 days	12.0
(1/2)(2.7.9.0.0) = 1.3.14.9.0 170,820 = (365)(468)	468 = (39)(12)	120 days	6.0
A + (1/2)(B) = 8.6.1.9.0 + 1.3.14.9.0 = 9.9.16.0.0			
Lounsbury. 9.9.16.0.0 1,366,560 = (365)(3744)	3744 = (39)(96)	960 days	2.12.0
C 17.0.1.3.0 2,448,420 = (365)(6708)	6708 = (39)(172)	1720 days	4.14.0
D 12.5.3.3.0 1,765,140 = (365)(4836)	4836 = (39)(124)	1240 days	3.8.0

Xultun	Haab's (365 days)		Additive		Sidereal Years	
	Maya	Decimal	Decimal	Maya	Deci.	Maya
	1.19.09.15	39= (39)(1)	10 days	0.10	39	1.19.10.05
	3.19.01.10	78=(39)(2)	20 days	1.00	78	3.19.02.10
	5.18.11.05	117=(39)(3)	30 days	1.10	117	5.18.12.15
	7.18.03.00	156=(39)(4)	40 days	2.00	156	7.18.05.00
	9.17.12.15	195=(39)(5)	50 days	2.10	195	9.17.15.05
	11.17.04.10	234=(39)(6)	60 days	3.00	234	11.17.07.10
	13.16.14.05	273=(39)(7)	70 days	3.10	273	13.16.17.15
	15.16.06.00	312=(39)(8)	80 days	4.00	312	15.16.10.00
	17.15.15.15	351=(39)(9)	90 days	4.10	351	17.16.02.05
	19.15.07.10	390=(39)(10)	100 days	5.00	390	19.15.12.10
(0.5)(B)	1.03.14.09.00	468=(39)(12)	120 days	6.00	468	1.03.14.15.00
A	8.06.01.09.00	3276=(39)(84)	840 days	02.06.00	3276	8.06.03.15.00
B	2.07.09.00.00	936=(39)(24)	240 days	12.00	936	2.07.09.12.00
(1.5)(B)	3.11.03.09.00	1404=(39)(36)	360 days	01.00.00	1404	3.11.04.09.00
(2)(B)	4.14.18.00.00	1872=(39)(48)	480 days	01.06.00	1872	4.14.19.06.00
(3)(B)	7.02.07.00.00	2808=(39)(72)	720 days	02.00.00	2808	7.02.09.00.00
A+0.5(B)	9.09.16.00.00	3744=(39)(96)	960 days	02.12.00	3744	9.09.18.12.00
C	17.00.01.03.00	6708=(39)(172)	1720 days	04.14.00	6708	17.00.05.17.00
D	12.05.03.03.00	4836=(39)(124)	1240 days	03.08.00	4836	12.05.06.11.00
(4)(C)	3.08.00.04.12.00	26832=(39)(688)	6880 days	19.02.00	26832	3.08.01.03.14.00

Table 1. 39-10-Xultun table for calculating sidereal years (365.256410 days/year) (by Hutch Kinsman, 2017).

Small adjustments can be made with a “leap year” additive/subtractive, i.e.,

One year, 365 days = 1.05. Four years = 4.1.0. Adding a quarter of a day for each year means adding 1 day for every four, thus 4.1.1 is an acceptable additive of 4 sidereal years (365.25 ~ 365.25636).

4 sidereal years ~ 4.1.1 8 sidereal years ~ 8.2.2

12 sidereal years ~ 12.3.3 16 sidereal years ~ 16.4.4

20 sidereal years ~ 1.0.5.5

Calculating sidereal distances between different dates using 39-10 Xultun table
Many events are related by integral values of sidereal years –closest possible value to 365.256410 days (or close to this value)

61.576º 562 Apr 30.75, 9.6.8.4.2, Tikal falls in **Star War** to CRC?

+ **117**

61.574º 679 May 1.75, 9.12.6.16.17, Tikal **falls** to Dos Pilas.

9.12.6.16.17
- 9. 6. 8. 4. 2

AD 484 April 9 outburst SL = 42.045º April 13.75 accession SL = 46.181º

9.2.9.0.16 10 Kib 4 Pop Yajaw Te' K'inich I, Caracol.

+ 47

AD 531 April 10 outburst SL = 41.915º April 14.75 **accession** SL = 46.129º

9.4.16.13.3 4 Ak'bal 16 Pop K'an I, Caracol.

47 years difference 17,167 days/47 years = 365.255319 days/yr

9.4.16.13. 3
- 9.2. 9. 0.16

Knowing what the sidereal additives are for large numbers such as the Xultun numbers means that sidereal years can be calculated forwards or backwards into time for large numbers.

For example, to show the calculations for the crocodile decapitation in 3298 BC, start from the axe event in 556 on April 10, possibly involving an execution (G&M, 2004:II)

The solar longitude is 42.835º, the average of the top 10 outbursts is 42.657º, and the solar longitude of the crocodile decapitation in 3298 BC (T. XIX, PAL) is 43.299º.

9.6.2.1.11, 42.835º 6 Chuwen 19 Pohp, 556 Apr 10.75 (noon local time).

Find the ring number for 12.10.12.14.18 by subtracting from 13.0.0.0.0. Add the **ring number to the date in question.**

13.00.00.00.00	9.6.2.1.11
- 12.10.12.14.18	+ **9. 7.3. 2**
RING: 9.7.3.2	**9.15.9.4.13**

9.15.9.4.13 is a companion number, which is a distance number that overlaps era day (13.0.0.0.0). Lounsbury (A Rationale for the Initial Date of the Temple of the Cross at Palenque) uses the term companion number (CN) and notes that Satterthwaite (1964) used this term in association with the ring numbers. Now determine sidereal values from the table that will add up to the companion number.

Find sidereal years between axe event (possibly involving an execution) on 9.6.2.1.11, 556 April 10.75 and crocodile decapitation event on pre-era (before 13.0.0.0.0). Start by determining the ring number and then add to the date to get a companion number.

9.6.2.1.11 axe event CRC

\+ 9.7.3.2 Ring number (13.0.0.0.0 – 12.10.12.14.18 = 9.7.3.2)

9.15.9.4.13 This is a companion number (or a distance number)

Look for a large sidereal number from the table

close to (but less than) 9.15.9.4.12.

Subtract from the companion number

```
  9.15. 9. 4.12
- 9.9.18.12. 0      3744 sidereal years (table)

    5.10.10.12      (Distance number. Go to table to find a value less than
                     this to subtract)

    5.10.10.12      (DN)

-   3.19.2.10       78 sidereal years (table)
    1.11.8. 2       (DN)

    1. 0. 5. 5      (~20 sid yrs)

      11.2.17       (DN)

       8.2. 2       (~8 sid yrs)

       3.0.15       (~3 sid yrs)
```

Now add up the sidereal yrs: 3744 + 78 + 20 + 8 + 3 = 3853 sid years.

501 Jun 4.75 (jdn: 1904203.250)

(A8B8—T.XVII)

9.3.6.7.17 5 Kaban 0 Sotz’ (J12I13)

— 1.7.11 DN (not rec) (T. Cross)

9.3.5.0.6 (not recorded) (Prev 819)

|

(“Distance number of 819 cycles”)

(9.3.5.0.6)

+ (10.0.3.15) (ring number)

9.13.5.4.1 (1,391,481) (dn)

(1,391,481) = (1699)(819)

1699 cycles of 819 (**prime**)

|

12.9.19.14.5 T.XIX D1C2 (819 ct)

1 Chikchan 18 Ch’en (3311 BC May 11.75)

(jdn: 512211.25)

Decimal sidereal calc: 1904203 – 512211

= **1,391,992**.

(1,391,992)/(3811) = 365.256363

Shrine dedication (Cross group)
692 Jan 8.75 (jdn: 1973818.25) (309.672º)
(A1A2—TFC Sanc Jambs)
9.12.19.14.12 5 Eb' 5 K'ayab (TFC S. Jambs)
- 1. 7.11 DN (A5B5, TFC S. Jambs)
9.12.18. 7. 1 1 Imix 19 Ch'en (B6A7a)
(Prev 819, on TFC S. Jambs)
|
("Distance number of 819 cycles") (9.12.18.7.1)
+ (6.15.0) (ring number)
9.13.5.4.1 (1,391,481)(dn of 819 cycles)
(1,391,481) = (1699)(819)
1699 cycles of 819 (**prime**)
|
12.19.13.3.0 (T. Cross, main A16B16)(819 ct)
1 Ajaw 18 Sotz' (3121 BC Dec 14.75)
(jdn: 581826.25)
Sidereal calc: (1973818 – 581826) = **1,391,992**
(1,391,992)/(3811) = 365.256363

39-10 Calculations to test for sidereal years between dedication date and myth date
Find ring number:
13. 0. 0. 0. 0
- 12.19.13.3. 0
6.15.0
Add ring number to
dedication date to get
distance number
(companion number)
6.15. 0 ring
+ 9.12.19.14.12 5 Eb' 5 K'ayab
9.13. 6.11.12 distance no.
Use 39-10 table to find
sidereal years

9.13. 6.11.12 distance number
- 9. 9.18.12. 0 (3744 sy)(table: A + 0.5B)
3. 7.17.12 (remainder)
- 1.19.10. 5 (39 sy)(table)
1. 8. 7. 7 (remainder)
1. 0. 5. 5 (~20 sy)
8. 2. 2 (remainder)
- 8.2. 2 (~8 sy)
Total sy = 3744 + 39 + 20 + 8 = 3,811 sy

Therefore, 3,811 sidereal years between the
5 Eb' 5 K'ayab', 692 Jan 8, dedication date and the 819 day cycle on the Temple of the Cross of 12.19.13.3.0, 1 Ajaw 18 Sotz', 3121 BC Dec 14)
1.7.11 days is the distance number additive to add to 1699 cycles of 819 days to arrive at 3811 sidereal years.
This example likely falls on a meteor shower solar longitude, ~309º

8.18. 0.13.6 Birth of K'uk' B'alam
\- 5. 7.11. 8.4 Birth of U Kokan Chan
3.10.9. 5.2 (507,342d, DN not rec.)

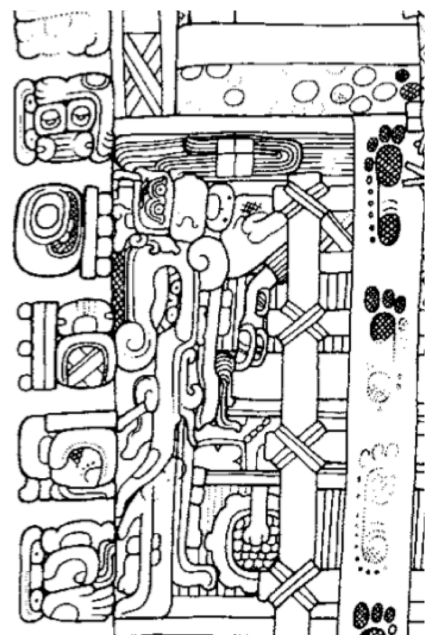
3.11.4.9.0 (1404 sy)(table)
\- 3.10.9.5.2 distance number
15.3.18 (remainder)
\- 12.3. 3 (~12 sy)
3.0.15 (= [3][1.0.5]
Total = 1404 – 12 - 3 = 1389 sy birth-birth
3.10.9.5. 2
\+ 1.2.5.14 additive (recorded G6-H6)
3.11.11.10.16 Total distance interval

8.19. 3. 1. 0 5 Ajaw 18 K'ayab'
\- 5. 7. 11. 8. 4 birth U Kokan Chan
3.11.11.10.16 total distance interval
\- 3.11. 4. 9. 0 (1404 sy)(Table)
7. 1.16 (remainder)
\- 4. 1. 1 (~4 sy)
3. 0.15 ([3]x[1.0.5])
Total: 1404 + 4 + 3 = 1411 sy
1411 sy = (83)(17)(365.256)
(83)(17)(Earth sy)
= (7)(17)(4330.9)
(7)(17)(Jupiter sy)
@ 4330.9 d/jup sy

Example: from 9.12.15.0.0 we want to calculate the number of sidereal years back to **12.10.12.14.18,** the date of the crocodile decapitation event found on Pal. T. XIX. First find the ring number by subtracting the pre-era date from 13.0.0.0.0.
Add this number to the original date to get a distance number (“companion number).
Use 39-10 table to calculate sidereal years (sy)

13. 0. 0. 0. 0
\- 12.10.12.14.18
9. 7. 3. 2

43.225º Eta Aquariid
Piedras Negras Stela 6
9.12.15.0.0
687 April 12.75



9.12.15.0.0
\+ 9. 7.3.2
10. 2. 2.3.2

10.2. 2. 3. 2
\- 9.9.18.12.0 (3744 sy)
12.3.9.2
12. 3.9. 2 (DN)
\- 11.17.7.10 (234 sy)
6.1.12
6.1.12
\- 4.1.1 (~4 sy)
2.0.11 (~2 sy)

Total:
3744
+ 234
+ 4
+ 2
3984 sy

Use Aveni's number to calculate the number of (7 Jupiter sidereal years) in this number (10.2.2.3.2). Aveni's number (nicknamed by the author)

4.4.3.16 = 30,316 days. Add one day for every 4 times used.

Calculations to test for sidereal year intervals in 1.2.5.14 distance number example (add 1.2.14.5 to birth of K'uk' Balam to get 8.19.3.1.0)

8.19. 3. 1. 0 5 Ajaw 18 K'ayab'
\- 5. 7. 11. 8. 4 birth U Kokan Chan
3.11.11.10.16 total distance interval
\- 3.11. 4. 9. 0 (1404 sy)(Table)
7. 1.16 (remainder)
\- 4. 1. 1 (~4 sy)
3. 0.15 ([3]x[1.0.5])
Total: 1404 + 4 + 3 = 1411 sy
1411 sy = (83)(17)(365.256)
(83)(17)(Earth sy)
= (7)(17)(4330.9)
(7)(17)(Jupiter sy)
@ 4330.9 d/jup sy

Use Aveni's number to calculate the number of (7 Jupiter sidereal years) in this number (3.11.11.10.16) Aveni's number (nicknamed by the author)

4.4.3.16 = 30,316 days. Add one day for every 4 times used.