

Mayan Calendar Mystique

Why would studying the Mayan Calendar be of any interest to a computer scientist?

Actually, there are numerous reasons beyond just sheer fascination with an ancient culture that evolved separately away from the influences of the cultures in the Eastern Hemisphere.

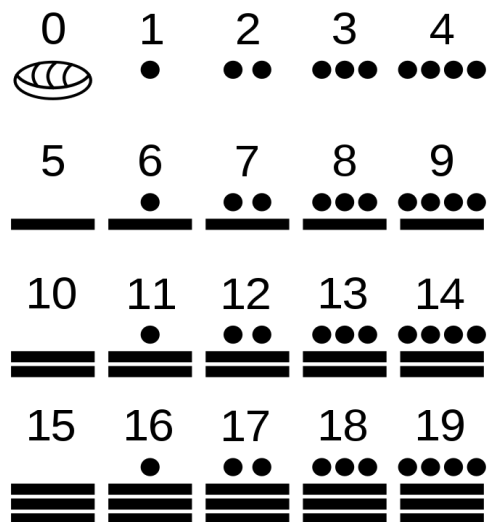
For instance, let's look at their numbering system. On the other side of the world, most numbering systems were based on the decimal system. The logic behind this system seems to be derived from the fact that most people have ten fingers: perfectly-designed tools for counting. However, the ancient Mayans (and most other ancient cultures in Mesoamerica) used the vigesimal (base 20) system probably because most people also have ten toes.

Another fascinating fact about their system is that counting quite often began with zero rather than with one. Sound familiar? Certainly those of us who need to justify the use of hexadecimal and octal systems (and counting that begins with zero) to naysayers can see the beauty of this.

Note: For most of this document, the words Mayan and Mesoamerican will be used interchangeably. For the most part, the vigesimal (and in one case, octodecimal) were used by almost all cultures in the region. In fact, the Long Count Calendar was used universally by all of the peoples in Mesoamerica, even though some of their other calendar systems differed. Similarly, every attempt will be made to use the most popular and most widely-accepted practices and nomenclatures used by modern archeologists and Mesoamerican scholars today. Some of these practices persist into the present day and are still in use by the modern Mayan peoples of primarily the Yucatan peninsula in Mexico and the highlands of Guatemala. For this reason, some of the words used may be from different Mayan dialects. The people of Mexico most often use *Yucatec* Mayan as their chosen dialect to describe the names of almost everything Mayan. However, the *Academia de Lenguas Mayas de Guatemala* (or ALMG) has become a much-trusted source of information as well, and they most often use words from the *Quichean-Mamean* group of Mayan dialects. This battle is waged mostly because of the high numbers of native speakers of these dialects. And this controversy will probably not end any time soon. Add to this confusion the number of archeological purists who would prefer to stick to the ancient Mayan language dialects, that are most often unpronounceable and only obscurely known, and you soon have a fine mess on your hands. For this reason, attempting to study this subject can sometimes be both challenging and confusing, to say the least.

Vigemimal? Octodecimal? Would you please continue and avoid any tangential discussions?

Yes, of course. The Mesoamerican numeral system consists of what is sometimes called a series of "sticks and stones" to signify the nineteen numerical digits, combined with a "clamshell" that signifies zero. Each of the "stones" represented "one" and each of the "sticks" represented "five" and they were arranged by a counting sequence that will be described next.

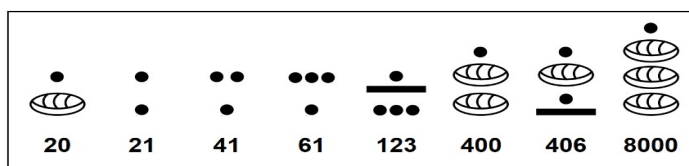


Counting generally started with zero (but not always). And then, numerals one through four (1-4) were represented by “stones” arranged in a row until we reached the number five (5), which was represented by a “stick.” Then, for numerals six through nine (6-9), we arranged one to four “stones” on top of one “stick” until we reached the number ten (10), which was represented by two “sticks”. Then, for numerals eleven through fourteen (11-14), we arranged one to four “stones” on top of two “sticks” until we reached the number ten (15), which was represented three “sticks”. Then, for numerals sixteen through nineteen (16-19), we arranged one to four “stones” on top of three “sticks” until we reached the number twenty (20).

At this point, the “ones place” was exceeded, so we put one “stone” in the “twenties place” to represent 1×20^1 and we put a “clamshell” in the “ones place” to represent 0×20^0 . Hopefully, the illustration on the left and the one below will help to clarify this.

Now let us examine the characteristics that make this a vigesimal numbering system. In the vigesimal system, after the “ones place” (20^0), and the “twenties place” (20^1), comes the “four-hundreds place” (20^2), the “eight-thousands place” (20^3), the “one-hundred-sixty-thousands place” (20^4), etc. The magnitude of the number grows exponentially when counting in vigesimal, just like in any other numbering systems. This next illustration should help to clarify this.

Notice that the number 20 can be expressed with only two place-holders, but 400 requires three, and 8,000 requires four.



OK, thanks for math lesson. Are you going to talk about the Mayan Calendar or not?

We thought you’d never ask. Yes, without further ado, let’s jump right into it, shall we?

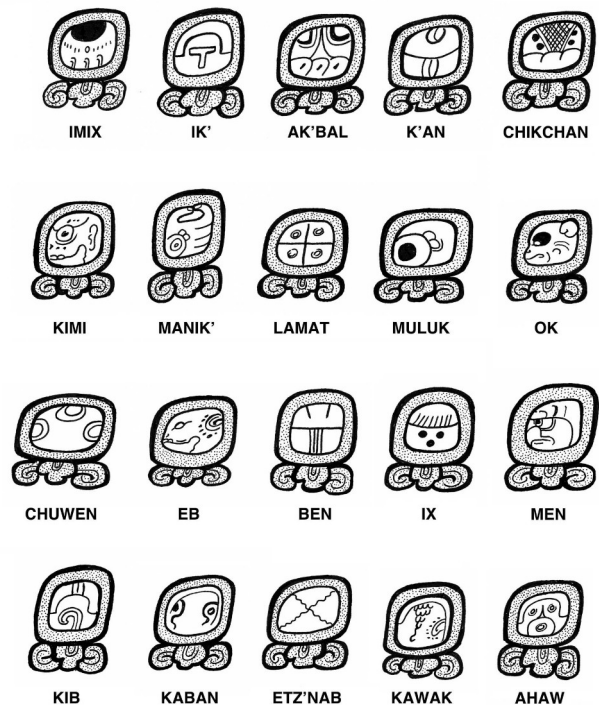
We often hear about how advanced the Mayan culture was, since its astronomers used a 365-day calendar. However, they actually used two different calendars: the *Tzolk’in* calendar and the *Haab’* calendar.

The *Tzolk’in* calendar uses a system that will seem very strange to us. It consisted of 20 “weeks” that were 13 days in length. Thus, one complete cycle of the *Tzolk’in* calendar was only 260 days. The *Tzolk’in* calendar was used primarily for religious and ceremonial purposes since it did not coincide with the annual change of seasons. Also, we should note how the *Tzolk’in* calendar works. Each “week” had a name and the days in the week were numbered 1 through 13.

Wait! You said that the Mayans usually counted starting with zeroes, right?

Yes, but this is a case where they did not. In this case, the first day of the “week” began with a one.

So the first day in the first named “week” in the *Tzolk'in* calendar is called *1 Imix'* and the second day is called *2 Imix'* and the third day is called *3 Imix'* and that continues until you reach *13 Imix'* which is the last day in the *Imix'* “week” (or “month”, depending on how you want to classify it). Please note that some sources call these 13-day cycles “weeks” while others refer to them as “months.” This seems odd to those of us who think of a week as being about half of that 13-day length, and we often think of a month as being over twice the length of that 13-day cycle.



Yes, yes. Please continue!

So after *13 Imix'* comes the 14th day, or the first day of the second “week”, and it is called *1 Ik'* which is followed by *2 Ik'* on through *13 Ik'* which is followed by *1 Ak'b'al* and *2 Ak'b'al*. And eventually, the 13th day of the 20th “week” (or 260th day) is called *13 Ajaw* and the calendar ends, only to start all over again with *1 Imix'*. That is essentially how the *Tzolk'in* calendar works.

But it is the *Haab'* calendar that is the 365-day Mayan calendar that is the most accurate and more closely follows the changing seasons.

Most early solar calendars were based on some number of days that was as close to an actual solar year as their astronomers could possibly approximate. The discussion of the accuracy of solar calendars is a very lengthy one indeed, but in an attempt to quickly boil it all down, let's just say that scientists today believe that a mean tropical solar year is approximately 365.242198781 days in length, so a calendar that is anywhere near 365 days in length is actually considered to be rather accurate. Early Roman calendars were actually somewhat of a huge mess, but when the Julian calendar was adopted in 46 BC, the concept of leap years adding an extra day every 4 years improved calendar accuracy to 365.25 days per year. Even then, the Julian calendar was still off by 1 day every 128 years, so the Gregorian calendar was adopted in 1582 with a new set of leap year rules that actually improved calendar accuracy to 365.2425 days per year, which is only off by 1 day every 3,300 years. It is the Gregorian calendar that is in use by much of the modern world today. And there is still room for improvement. If you were to add one additional leap year rule that years evenly divisible by 4000 are *not* leap years, then you would obtain an average solar year of 365.24225 days per year which, compared to the actual mean tropical year of 365.242198781, is equivalent to an error of one day over a period of about 19,500 years. However, we are presently correcting calendar errors by adjusting our clocks with “leap seconds” every so often. In reality, the most accurate calendar system in the world today is the Solar Hijri algorithmic calendar, which has a complex system of leap year rules that makes the calendar accurate to 365.242198520 days per year, which reduces the error to one day every 3,831,418 years!

Gee, that's fascinating, but you promised no more tangents. Um, the Haab' calendar?



A very good point! Let's get back on track. As mentioned earlier, the *Haab'* calendar is a 365-day calendar that is divided into eighteen months that are 20 days in duration, with a nineteenth month (called *Wayeb'*) that is only five days in duration, giving us a calendar that is exactly 365 days. And when using the *Haab'* calendar, we actually start counting with the number zero. So the first day of the *Haab'* calendar is called *0 Pop*, followed by *1 Pop*, *2 Pop*, and so on until we reach *19 Pop*. On the 20th day of the *Haab'* year, we start the second month with *0 Wo'* followed by *1 Wo'* until we get to *19 Wo'* and the day

following that is *0 Sip*. This pattern of counting continues until we reach the 360th day of the *Haab'* year which is *19 Kumk'u*. Then, the 361st day is the first day of the 19th month and it is called *0 Wayeb'* followed by *1 Wayeb'* ... until we reach the 365th day of the year which is *4 Wayeb'*. The next day restarts the *Haab'* calendar with the first day of the *Haab'* year, also known as *0 Pop*.

It needs to be said that both of these calendars run concurrently. Therefore, each day is identified by both a *Tzolk'in* calendar date combined with a *Haab'* calendar date. One such example would be *3 K'an 17 Xul* which combines the *Tzolk'in* calendar date of *3 K'an* with the *Haab'* calendar date of *17 Xul*.

By combining the *Tzolk'in* and *Haab'* calendar dates we get a unique pattern of dates that only repeats every 52 years called a Calendar Round, which is 18,980 days in length. Each Calendar Round can then be broken down into either 52 *Haab'* years of 365 days each, or 73 *Tzolk'in* "years" of 260 days each. Again, keep in mind that both of these Mayan calendars actually run concurrently.

That brings us to a discussion of our third calendar type, the Mesoamerican Long Count Calendar.

Wait! A *third* calendar type? As if keeping track of *two* wasn't complicated enough!

Ah, but this is the most interesting and exciting calendar of them all! While the *Tzolk'in* and *Haab'* calendars are truly Mayan, the Mesoamerican Long Count Calendar is a 360-day calendar that was used by all the people in Mesoamerica, not just the Mayans. And yet, it was the Mayans who got blamed when the so-called apocalyptic "end of the Mayan calendar" event happened on December 21, 2012.

Yes I remember that happening. Or *not* happening! What was the deal with that?

Oh good! I've finally piqued your interest with all my rambling.

The story goes that according to the ancient Mesoamericans, the mythical creation date occurred on a date that coincides with the Proleptic Gregorian calendar date of August 11, 3114 BCE. That date can also be measured in a number of other ways. This date is also Julian Date 584257 and that date also correlates to the Mesoamerican Long Count Date of 13.0.0.0.0. Another thing that is interesting

about the Mayans is that – just completely opposite of Eastern Hemisphere ways of thinking – the number 13 was always considered to a sacred and “lucky” number. In the case of Long Count Date of 13.0.0.0.0, the mythical legend tells us that the old world was ending and a new world was beginning. In doing so, the calendar would need to be restarted all start over again at Long Count Calendar Date 0.0.0.0.0. And that was the reason for all the panic on December 21, 2012, a Gregorian calendar date that just happened to coincide with what else? Long Count Date 13.0.0.0.0. That was also the reason why so many non-Mayans believed that the world might end on that date.

But since we are still here and the world did not come to an end on that date, the Long Count Calendar continues to count along into its 13th *B'ak'tun*.

The table on the right is here to help explain the Long Count Calendar Dates. Each day is counted as one *K'in* in this calendar system. And just as each *Haab'* month consists of 20 days, so does the unit of time measurement here called the *Winal*. And, since there are 18 months of 20 days in each year (not counting the 5 days called the month of *Wayeb'* in the *Haab'* calendar), each *Tun* is counted as 18 *Winal* of 20 *K'in* each. In addition, each *K'atun* is roughly 20 years in length (or exactly 20 *Tun*). And lastly, each *B'ak'tun* lasts roughly 400 years (or exactly 20 *K'atun* of 20 *Tun* each). Of course, this table also shows us that the Mayans had other measurements of time that were theorized but never really used. For example, if the dinosaurs went extinct 65 million years ago, that was just over one short *Alautun* ago. In another example, the Gregorian calendar date of October 12, 4772 will be that last day of the 19th *B'ak'tun* and the last day of the 0th *Piktun* (19.19.19.17.19). On October 13, 4772, the 1st *Piktun* will begin and all the date fields in the current Long Count Calendar will then need to be reset to zeroes (0.0.0.0.0). And if that's not the end of the world, then the Long Count Calendar will need to add another placeholder for the *Piktun*.

Units of Time	Conversion Units	Total Solar Days Per Each	Approximate Solar Years
K'in		1	
Winal	20 K'in	20	
Tun	18 Winal	360	0.986
K'atun	20 Tun	7,200	19.7
B'ak'tun	20 K'atun	144,000	394.3
Piktun	20 B'ak'tun	2,880,000	7,885
Kalabtun	20 Piktun	57,600,000	157,704
K'inchiitun	20 Kalabtun	1,152,000,000	3,154,071
Alautun	20 K'inchiitun	23,040,000,000	63,081,429

So, the five placeholders in the Long Count Calendar Date are the number of *B'ak'tun*, *K'atun*, *Tun*, *Winal*, and *K'in* separated by periods. These Long Count Calendar Dates are found all over Mesoamerica. Just as we inscribe dates on our monuments, the Mayans and other Mesoamericans did the very same thing.

Um, one of the dates you used above has a 17 rather than a 19. What's up with that?

Very observant! Yes, the date 19.19.19.17.19 is at full count because all of its digital placeholders are vigesimal except for the *Winal* placeholder is octodecimal (base 18) due to the fact that there are only 18 *Winal* of 20 *K'in* in each 360-day *Tun*. That might sound complicated, but it really is not that complicated if you think about it in terms of Mayan measurements for days, months, and years.

OK, but the system you are explaining doesn't use Arabic decimal numerals separated by periods! This is some kind of code devised by non-Mayans to explain it!

Once again, nothing gets by you! Yes this is a type of coded shorthand used to explain the real Long Count Calendar dates, and *Tzolk'in* and *Haab'* calendar dates, as they exist in reality, which exist as chiseled inscriptions on monuments of stone called steles which can be found all over the ancient Mayan world. Let's look at one now.

Friday, August 27, 0709

9 . 13 . 17 . 12 . 10
8 Ok 13 Yax



Although this stele might look cartoonish, it is nevertheless a representation of a real Long Count Calendar date stele as found in Lintel 16 from Yaxchilan, Chiapas, Mexico. This date is the actual birthdate of the great Yaxchilan king, Yaxun Balam IV, who was the fourth king by that name in the royal dynasty of Yaxchilan.

Notice that the stele on the left has eight rows of glyphs. The glyph at the top simply tells us that this is a calendar date. The next five rows tell us the Long Count Calendar date. The second row tells us the number of the *B'ak'tun* (9). The third row tells us the number of the *K'atun* (13). The fourth row tells us the number of the *Tun* (17). The fifth row tells us the number of the *Winal* (12). And the sixth row tells us the number of the *K'in* (10). The seventh row tells us the *Tzolk'in* calendar date (8 Ok) and the eighth row tells us the *Haab'* calendar date (13 Yax). Mostly what we are trying to learn

here is *not* how to read Mayan glyphs! What we are trying to learn here is how other cultures, especially the Mayans and other Mesoamerican peoples, used different numerals and numbering systems from those being used by people in the Eastern Hemisphere at the same period in time. Something else we could learn here is how to decode a Long Count Calendar date from a stele into real numbers that we can easily understand. And we can learn how to convert those numbers to a Gregorian or Julian date given the table shown on the previous page compared against a known date such as 13.0.0.0.0 which is the Gregorian date of December 21, 2012. After all, it's just a simple game of converting different based numbering systems and counting the number of days between dates. Would it be fun to calculate the Long Count Date of the signing of the U.S. Declaration of Independence? Or maybe the Long Count Date of your own birthday? How about the reverse of that? What if you were given a Long Count Date? Would you be able to do the math and to convert it to a Gregorian calendar date? And lastly, would it pique your interest any if you were told that a program was just recently written that could draw these steles automatically from the dates you just entered? Ponder that last question carefully.

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