Project Services Pty Ltd

The origins of the Coordinated Universal Time (UTC) calendar

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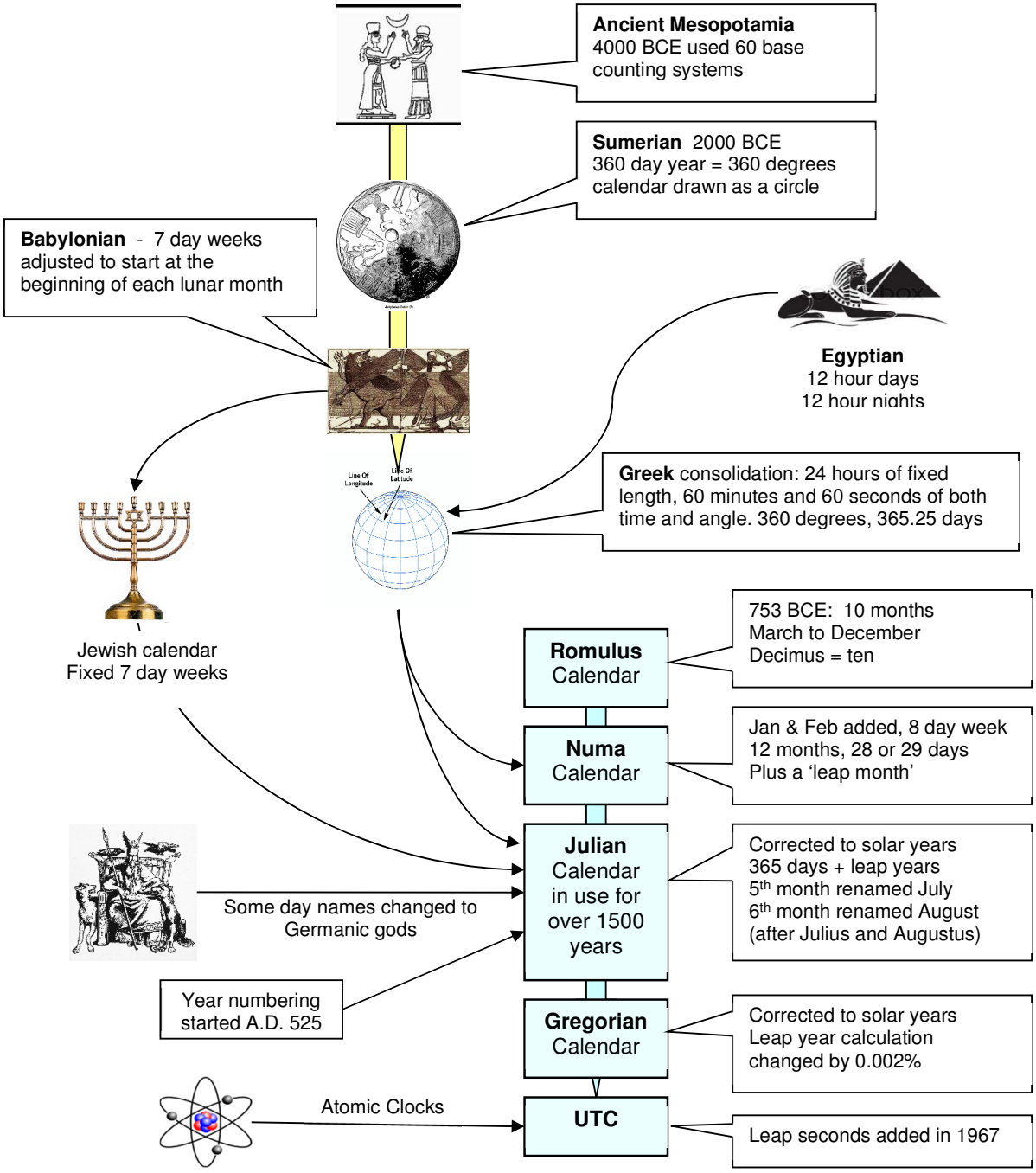
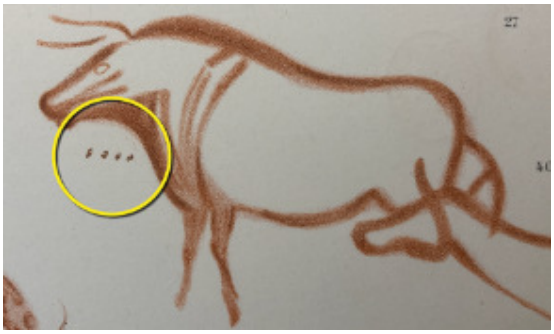
Introduction

Next time you are setting up your calendars in favorite scheduling tool, stop for a minute and consider the odd collection of numbers that make up the standard UTC calendar, 60 seconds in a minute, 60 minutes in an hour, 24 hours in a day and varying numbers of days in the months and years. The origins of these numbers and the basis of the modern calendar go back a very long way.



The first proto-calendar



In at least 400 European caves such as Lascaux, Chauvet and Altamira, from at least 37,000 BP, Stone Age people drew, painted and engraved figurative images (notably animals). As well as the animal, there are often non-figurative signs which may have conveyed meaning.

It is now thought that three of the most frequently occurring signs: the line <|>, the dot <•>, and the <Y>, when found in close association with an image of an animal create a simple lunar calendar beginning in the spring. The line <|> and dot <•> constitute numbers denoting lunar months and recording time from the start of spring. The <Y> sign has the meaning <To Give Birth>. The position of the <Y> within a sequence of marks denotes month of birth, an ordinal representation of number in contrast to the cardinal representation used in tallies. It is believed that the purpose of this system of associating animals with calendar information was to record and convey seasonal information about specific prey behaviour in the local geographical region[1].

Origins of the 24-Hour day[2]

It appears that the Ancient Egyptians were responsible for the 24-hour day.

One of the world's earliest sundials excavated from the Kings' Valley, Upper Egypt

[1] See: https://www.cambridge.org/core/journals/cambridge-archaeological-journal/article/an-upper-palaeolithic-protowriting-system-and-phenological-calendar/6F2AD8A705888F2226FE857840B4FE19

[2] To see the events discussed in this paper in a comprehensive historical timeline covering the last 1000 years download ***Project Management - A Historical Timeline***: https://mosaicprojects.com.au/PDF_Papers/P212_Historical_Timeline.pdf

The Egyptians were fond of counting in base twelve (instead of base 10 which is commonly used today). This is thought to be because they counted finger joints instead of fingers. Each of your fingers has three joints, so if you count by pointing to finger joints with your thumb you can count to twelve on each hand[3].

They divided their day into 10 hours of daytime with 1 hour of twilight at each end of the day (making 12 hours in total) and 12 hours of night-time. This is known from various sundials dating from the period and various tables defining the stars visible during the 12 hours of night[4].

In the Egyptian system, the lengths of the day-time and night-time hours were unequal and varied with the seasons. Ordinary people continued to use these seasonally varying hours until the advent of mechanical clocks in Europe in the 14th Century, made the more precise system we use today common place.

The origin of AM and PM. The variability in the length of each hour throughout the year created challenges measuring the time difference between days using a sundial. There is only one point on a sundial that is constant throughout the year, and that's noon. Noon doesn't change, but sunrise and sunset will. And, noon is easy to find, the sun is directly overhead (or at its highest point). Over time noon became the "starting point" of numerical hours - the "meridian". AM and PM come from this starting point, they're abbreviations of the Latin for "Ante Meridiem" (before noon) and "Post Meridiem" (after noon).

Mechanical clocks retained these conventions, they kept the 12-hour face (it was obvious when it was day or night), and were made it go "clockwise" to mimic the direction of the shadow on a sundial in the Norther hemisphere. The devices used to measure of time within each day and how the measurement of time improved over the centuries is covered in our article: ***Measuring time***[5].

Origins of the 60 minute Hour and other odd numbers

The counting systems that would later become the classical standard for the Babylonian empire were developed during the 'Uruk Period' in Mesopotamia, (the Early Bronze Age c 4000 BCE – c3500 BCE[6]). Studies of protocuneiform clay tablets indicate counting systems based on 60 were used. It is believed the sexagesimal (60) base was used because it is convenient for both counting large numbers and expressing the fractions which were essential for trade, business and astronomical calculations; the subdivision of hours and minutes into 60 comes from this source (but only after a few thousand years). The Sumerians inherited the Mesopotamian sexagesimal (base 60) numbering system and used place-value numbering in the same way we do[7].

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[3] 12 also has a larger number of integers (than 10) allowing precise divisions into quarters, thirds, etc.

[4] The Egyptians had a system of 36 star-groups called 'decans'; chosen so that on any night one decan rose 40 minutes after the previous one.

[5] Download ***Measuring time*** from: https://mosaicprojects.com.au/Mag_Articles/AA031_Measuring_time.pdf

[6] Whilst 4000 BCE is incredibly ancient, Neolithic settlements in nearby Southern Turkey date back 10,000 years; the settlement of Çatalhöyük is dated to about 7500 BCE; Aşıklı Höyük to about 8000 BCE. These settlements (small towns) relied on agriculture and there is some evidence of them trading with communities in Cyprus and Syria. Agriculture and trade need an understanding of calendars and numbers, and 4000 years of development provides ample opportunity for a society to start developing the sophisticated religious and counting systems that were used in Mesopotamia - what's missing is written records.

[7] The Sumerians also created one of the first standards of measurement in 2150 BCE during the Akkadian Empire under the reign of Naram-Sin when competing systems were unified by a single official standard, the royal gur-cube. This standard continued to be used through the Babylonian, Assyrian, and Persian Empires.

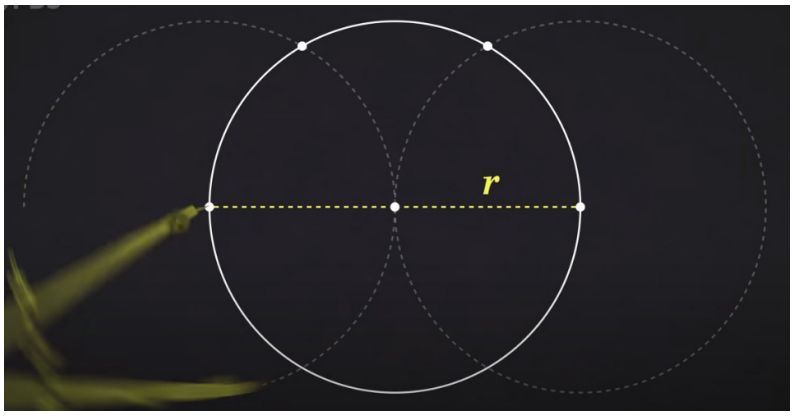
The origins of the Coordinated Universal Time (UTC) calendar

The recorded history of astronomy in Mesopotamia, and the world[8], also begins with the Sumerians around 3500–3200 BCE. Astronomy, astrology, religion and the development of calendars were closely intertwined in Sumerian culture. They used a 360-day year and began the modern practice of dividing a circle into 360 degrees to represent the cycle of the seasons through the year and the movements of the stars and planets, their calendar!

[9]

By around 3200 BCE or possibly earlier, the Sumerians also appear to have identified at least 4 constellations that are included in the modern Zodiac: Torus, Scorpius, Leo, and Aquarius; along with other astrological concepts. By 1100 BCE, the Mesopotamians had expanded on this work in the 'Three Stars Each' list, and all 12 of the Zodiac constellations were known to the Mesopotamians by 1000 BCE (9 in the classic form), but these were simply part of a long list of constellations.

The 12 signs of the Zodiac, arranged as a 'Zodiac', dates from around 420 BCE (the term Zodiac is Greek and means 'circle of animals'), this knowledge was taken by the Greeks following the conquest of Mesopotamia by Alexander The Great in 331 BCE, who used other influences to settle on the current Zodiac; and this knowledge was in turn passed onto the Romans and into modern usage. Why 12 signs? Probably because you only need a scriber and a piece of string to first draw the circle, and then using the radius divide the circle into 6 and then 12 parts:



[8] Aboriginal Australians may be the world's oldest known astronomers (but their 30,000 year old culture is based on oral storytelling). In indigenous culture everything that happened on earth is recorded in the sky; they studied the movement of, and named, celestial objects; understood the moon governs the tides and worked out the causes of eclipses. This information informed the people about navigation, seasonal changes and food economics including hunter-gathering, fishing and even agriculture in some locations.

[9] The clay disc on the right tells how an astronomer on June 29, 3123 BCE. watched a massive asteroid approaching Earth that finally entered our planet's atmosphere and reached the surface. This 5,100-year-old clay tablet was discovered in the 19th century in King Ashurbanipal's underground library in Nineveh, but its significance as an astronomical treasure has only recently been understood.

The 12 signs of the Zodiac align with the concept of 12 months, and is consistent with the Egyptian 'civil calendar's' 12 months divided into 3 seasons. However, while the concept of 12 months in a year is ancient and probably influenced first the Greeks and through them the Romans, the calendar months we are familiar with is a Roman construct (discussed below).

The sexagesimal (base 60) system and astronomy were in turn inherited by the Babylonians from the Sumerians. The Babylonians were the first to recognize that astronomical phenomena are periodic and apply mathematics to their predictions. The earliest Babylonian star catalogues dating from about 1200 BCE contain many star names in Sumerian suggesting this continuity reaching back to the Early Bronze Age and forward into the Persian Empire.

Consolidation by the Greeks

The conquests of Egypt and the Persian Empire by Alexander the Great brought these two strands of knowledge together and combined their systems into the modern form[10].

In the last couple of centuries of the BC era, Greek astronomers normalised the lines of latitude and longitude to encompass the full 360 degrees of the globe and divided the day into 24 hours of equal length[11].

In his treatise *Almagest* (circa A.D. 150), Claudius Ptolemy explained and expanded on this work by subdividing each of the 360 degrees of latitude and longitude into smaller segments. Each degree was divided into 60 parts, each of which was again subdivided into 60 smaller parts. The first division, *partes minutae primae*, or first minute, became known simply as the *minute*[12]. The second segmentation, *partes minutae secundae*, or "second minute," became known as the *second*.

So although it is no longer used for general computation, thanks to the Greeks, the sexagesimal system is still used to measure angles, geographic coordinates and time[13]. But as we all know a year is not 360 days……..

Much of this work was done in the Great Library of Alexandria, the foremost research centre of the ancient world[14].

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[10] The Ancient Egyptians had three calendars, two lunar calendars, and a 'civil calendar'. The 'civil calendar' was based on a 365-day year with three seasons of 120 days each based on the annual Nile flood cycle, plus an intercalary month of five days. Each season was divided into 4 months of 30 days, consisting of 3 10-day periods known as decans.

The 'old' lunar calendar appears to be very ancient. The 'civil calendar' based on a solar year seems to have been developed in or before the Old Kingdom (some 2500 years BCE). The 'new' lunar calendar was developed later to reconcile the differences between lunar and solar calendars for religious purposes. While there is the probability of the exchange of ideas between Egypt and Mesopotamia, the Greek developments of the calendar seem to be based on Babylonian and Persian traditions rather the Egyptian, with the exception of the 12 hours of day and night.

[11] The development of latitude, longitude and calculating the size of the earth was the work of Greek astronomers and mathematicians. These developments are covered in ***Knowing (exactly) where you are is not that simple!***, see: https://mosaicprojects.com.au/Mag_Articles/AA032_Knowing_where_you_are.pdf

[12] It appears having the same word for very small (minute) and 60 seconds of time or angle (minute) is no accident.

[13] The Antikythera Mechanism, the world's oldest analogue computer, was created by the Ancient Greeks around 250 BCE to provide a 'ready reckoner' showing the Greek zodiac and an Egyptian calendar, information about lunar cycles and eclipses, and the movement of the five known planets. The device appears to combine Babylonian mathematics with Greek geometry: https://en.wikipedia.org/wiki/Antikythera_mechanism

[14] For more on the Great Library of Alexandria see ***The Great Library of Alexandria – The first Google?***: https://mosaicprojects.wordpress.com/2023/01/30/the-great-library-of-alexandria-the-first-google/

The Roman Calendars

The basis of the UTC calendar with 12 months of varying duration is Roman. The original Roman calendar is believed to have been a lunar calendar, which may have been based on one of the Greek lunar calendars, or possibly Egyptian. The Egyptians formalise a civil calendar of 12 months of 30 days (with an extra five days added for the solar year) some 3000 years BCE[15].

Calendar of Romulus

Roman writers attributed the original Roman calendar to Romulus, the founder of Rome around 753 BC. The Romulus calendar had ten months with the regular calendar year consisted of 304 days, and the winter days after the end of December and before the beginning of the following March not being assigned to any month.

The names of the first four months were named in honour of Roman gods: *Martius* in honour of Mars; *Aprilis* in honour of Fortuna Virilis *Maius* in honour of Maia[16]; and *Iunius* in honour of Juno; The names of the months from the fifth month on were based on their position in the calendar: *Quintilis* comes from Latin quinque meaning five; *Sextilis* from sex meaning six; *September* from septem meaning seven; *October* from octo meaning eight; *November* from novem meaning nine; and *December* from decem meaning ten.

Numa Pompilius, the second of the seven traditional kings of Rome, reformed the calendar of Romulus around 713 BC. He added January and February and created a standard year of 355 days. To keep the calendar year roughly aligned with the solar year, a leap month was added in the middle of February every couple of years[17] but this process lacked predictability.

Julian calendar

Julius Caesar, as *Pontifex Maximus*, reformed the calendar in 46 BC by increasing the number of days in most months to 30 or 31 to create a year of 365 days. The Julian months have the modern form and an extra day is added to February every fourth year to keep the calendar aligned with the earth's rotation around the sun. The Julian year is, therefore, on average 365.25 days long[18]. His new calendar took effect in 45 BC after a year of 445 days[19] (in 46 BC) needed to realign the calendar with the seasons.

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[15] The Egyptians appear to have used a purely lunar calendar prior to the establishment of the solar civil calendar in which each month began on the morning when the waning crescent moon could no longer be seen, this continued in use for religious purposes in parallel with the civil calendar. The civil calendar was a solar calendar with a 365-day year. The year consisted of three seasons of 120 days each, plus an intercalary month of five days treated as being outside of the year proper. Each season was divided into four months of 30 days. These twelve months. Each month was divided into three 10-day periods known as decans. It has been suggested that during the Nineteenth Dynasty and the Twentieth Dynasty the last two days of each decan were usually treated as a kind of weekend for the royal craftsmen, with royal artisans free from work. The concept of a 'leap year' was not introduced until the Roman Empire ruled Egypt. See: https://en.wikipedia.org/wiki/Egyptian_calendar

[16] In ancient Roman religion and myth, Maia embodied the concept of growth and may have been associated with the Greek goddess Maia, the daughter of Atlas, mother of Hermes, and is the eldest of the seven Pleiades.

[17] To keep the Numa calendar year roughly aligned with the solar year, a leap month, called the *Mensis Intercalaris*, was added in the middle of February every couple of years. The *Pontifex Maximus* determined when this intercalary month was to be inserted. On average, it should have happened every two to three years but was subject to political interference. None were added during the five Roman years before 46 BC.

[18] The Julian calendar was based on the knowledge of Egyptian/Greek astronomer Sosigenes of Alexandria, and combined the old Roman months, the fixed length of 365 days of the Egyptian calendar, and the 365 1/4 day of the Greek astronomy.

[19] This was the longest 'year' in human history.

The reforms to the Julian calendar were completed during the reign of his successors; Augustus renamed Quintilis as Iulius (July) in honour of Julius Caesar in 44 BC and Sextilis was renamed Augustus (August) in honour of Augustus in 8 BC.

This calendar became the predominant calendar in most of Europe, and in European settlements in the Americas and elsewhere, until it was refined and superseded by the Gregorian calendar more than 1500 year later.

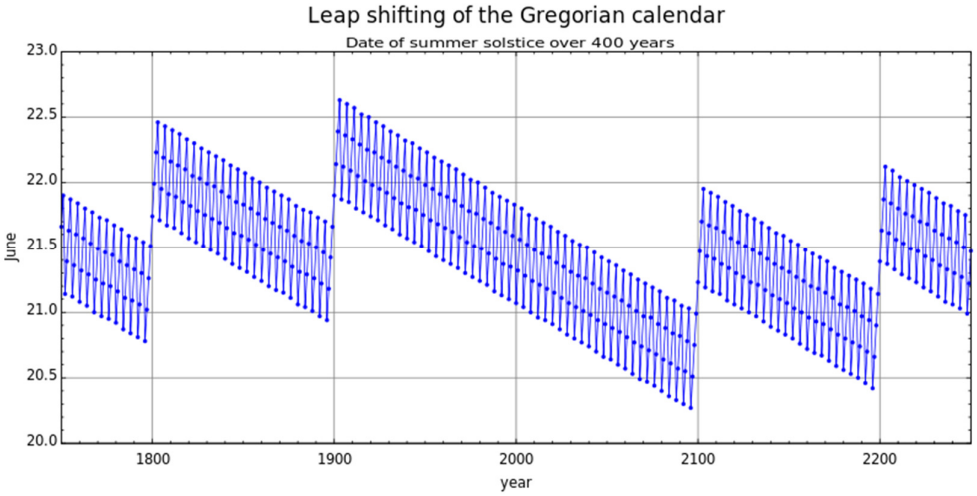
Gregorian calendar

Greek astronomers had known, for at least a century before the Julian reform that the tropical year was a few minutes shorter than 365.25 days, and the Julian calendar did not compensate for this difference. As a result, the calendar year gained about three days every four centuries compared to observed equinox times and the seasons. This discrepancy was corrected by the Gregorian reform of 1582.

The Gregorian calendar has the same months and month lengths as the Julian calendar, but inserts leap days according to a slightly different rule. The Gregorian reform modified the Julian calendar's scheme of a leap year every fourth year as follows:

> ***Every year that is exactly divisible by four is a leap year, except for years that are exactly divisible by 100, but these centurial years are leap years if they are exactly divisible by 400. For example, the years 1700, 1800, and 1900 were not leap years, but the year 2000 was.***

This alteration changed in the mean length of the calendar year from 365.25 days (365 days 6 hours) to 365.2425 days (365 days 5 hours 49 minutes 12 seconds), a reduction of 10 minutes 48 seconds per year; a difference of 0.002%; resulting in a remarkably accurate tracking of the summer solstice over centuries[20].



The Gregorian calendar reforms also dealt with the accumulated difference between the Julian calendar and the solar year. To correct the difference, the Gregorian calendar began by skipping 10 calendar days, to restore the 21st March as the date of the vernal equinox.

[20] As accurate as it is, on a time scale of thousands of years, the Gregorian calendar will still fall behind the astronomical seasons due to the slowing of the Earth's rotation. By the year 4000, the Gregorian calendar will be between 0.8 and 1.1 days behind solar time, but this is unlikely to affect any current projects……...

1582	OCTOBER					1582
SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

The Gregorian calendar was initially adopted by the Catholic countries of Europe. Protestant and Eastern Orthodox countries continued to use the traditional Julian calendar and only adopted the Gregorian reform after many years, usually for the convenience of international trade[21]. The last European country to adopt the Gregorian calendar was Greece, in 1923.

Numbering the Years

As well as retaining the Julian months, the Gregorian calendar also continued the previous year-numbering system (*Anno Domini*), which counts years from the traditional date of the Nativity. This year-numbering system is the predominant international standard today (although there are other year numbering systems).

Up to the 6th century, each year in the Julian calendar was identified by naming the two *consuls* who took office in Rome on the 1st January of that year[22].

The *Anno Domini* dating system that replaced this naming convention with year numbers was devised in 525 by Dionysius Exiguus, originally to enumerate the years in his Easter table[23]. The term *Anno Domini* (*AD*) is Medieval Latin, translated as *In the year of the Lord*. The start of the year numbering used by Dionysius was based on his estimate of the year of the birth of Jesus of Nazareth. Despite an error of several years in Dionysius' counting, his year numbering convention remains unchanged though to modern times.

Whilst Dionysius stated that the "present year" was "the consulship of Probus Junior", which was 525 years "since the incarnation of our Lord Jesus Christ"; thereby implying that Jesus' Incarnation (birth or conception) occurred 525 years earlier, this assessment was made without Dionysius stating the specific year during which the Incarnation occurred. Nowhere in the exposition of his table does

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[21] The Calendar Act of 1750 introduced the new calendar into Great Britain and its colonies effective from 1752. As well as correcting the calendar by removing 11 days from September, the Act shifted the start of the year from the March 'quarter day' (25th March) to 1st January, and introduced a new calculation of the date of Easter and is related Holy days. The date of fixed holidays (eg, Christmas) remained unchanged.

However, to avoid people losing income (or profiting) due to the loss of 11 days in September, (rents and other payments were traditionally made on the quarter days), the four quarter days were each shifted back by 11 days from their traditional date; this is the reason why the UK tax year still ends on the 5th April each year (11 days after the 25th March): https://en.wikipedia.org/wiki/Calendar_(New_Style)_Act_1750

[22] The *consuls* were the highest elected office in the Roman Republic and whilst they lost most of their powers and responsibilities under the Roman Empire, the tradition of appointing consuls each year continued through to AD 541.

[23] The calculation of Easter depends on both lunar and solar cycles. The First Council of Nicaea (325) established the date of Easter as the first Sunday after the full moon (the Paschal Full Moon) following the March equinox. Calculating the date each year depends on the calendar used (Julian or Gregorian) and astronomical predictions of the sun and moon; thereby creating the need for enumerated tables.

Dionysius relate his system of year numbering to any other dating system or relate the Nativity to any defined year in the Julian calendar.

The Anglo-Saxon historian the Venerable Bede used *Anno Domini* dating in his *Ecclesiastical History of the English People*, finished in 731. Bede also added the Latin term, *"ante vero incarnationis dominicae tempus"* ("the time before the Lord's true incarnation"), equivalent to the English "before Christ", to identify years before the first year of the current era, starting at 1 BC and counting backwards. This AD / BC convention was generally adopted and as a consequence, there is no year zero in scheme we use for numbering the years, the year AD 1 immediately follows the year 1 BC.

Modern scholars and the Roman Catholic Church acknowledge that the birth of Jesus was a few years earlier than AD 1 (somewhere between 2 and 7 years). In consideration of this error, and for religious neutrality, the abbreviations CE and BCE have become more widespread in the later part of the 20th century. CE stands for "common (or current) era", while BCE stands for "before the common (or current) era". These abbreviations date from at least the early 1700s, being used by Jewish academics for more than 100 years, and replacing BC/AD in a number of fields, notably science and academia.

The origins of the 7-day week

The earliest record of a seven-day week comes from ancient Babylon prior to 600 BCE. Babylonians celebrated a holy day every seven days, starting from the new moon, and adjusted the number of days of the final "week" in each month so that months would continue to commence on the new moon.

The number 7 seems to be based on the observable 'wanderers' (Greek: planets), celestial bodies that appeared to move against the backdrop of the stars which had been divided into the 12 segments of the 'zodiac'. In order, slowest to fastest movement, you get: Saturn, Jupiter, Mars, the Sun, Venus, Mercury, and the Moon. Seven important gods, 7 wanders and 7 days per week to honour each god in turn (maybe). The answer may be simpler, 4 x 7 = 28 which is the nearest whole number to the 29.5 day lunar cycle.

The Jewish calendar followed the Babylonian's; however, the Jewish tradition broke from the lunar cycle and celebrated every seventh day as a holy day of rest, within a continuous cycle of seven-day weeks[24].

The origins of the names associated with the seven-day week

Between the 1st and 3rd centuries the Roman Empire gradually replaced the eight-day Roman nundinal cycle with the Jewish / Christian seven-day week with the days named after Roman deities.

The naming convention for the days of the week in Latin was based on a Greek/Egyptian astrological theory from the 3rd century BCE, that did use the 7 gods. The theory assigned power to each god in turn through the 24 hours of each day. This meant different gods were in power at the start of each day and the cycle repeated after 7 days[25].

[24] The seven-day week is strongly identified with Judaism: it appears in the Hebrew Bible (Tanakh) in the Creation account in the Book of Genesis (first of the five books of the Torah), where *Elohim* (God) creates the heavens and the earth in six days and rests on the seventh (Genesis 1:1-2:3). And in the Book of Exodus, the fourth of the Ten Commandments is to rest on the seventh day (Shabbat), which can be seen as implying a socially instituted seven-day week. The Tanakh was probably formalised around 450 BCE but the Torah is much older. The Old Testament in the Christian Bible is based on the Hebrew Bible.

[25] The order of the days was Sun, Moon, Ares, Hermes, Zeus, Aphrodite, and Cronos (Saturn), named after the heavenly bodies that presided over the first daylight hour of each day, according to Hellenistic astrology.

Christians updated the order to make Sunday the first day of the week but otherwise retained the naming convention and sequence as can be seen in Romance languages such as Spanish.

The Germanic peoples adopted the system introduced by the Romans, but used a naming convention based on their own gods in preference to the Roman deities. The date of the introduction of this system is not known exactly, but it must have happened during the final phase or soon after the collapse of the Western Roman Empire but before the Christianity took hold in the region in the 6th and 7th centuries.

HOUR	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8
1	Saturn	Sun	Moon	Mars	Mercury	Jupiter	Venus	Saturn
2	Jupiter	Venus	Saturn	Sun	Moon	Mars	Mercury	Jupiter
3	Mars	Mercury	Jupiter	Venus	Saturn	Sun	Moon	Mars
4	Sun	Moon	Mars	Mercury	Jupiter	Venus	Saturn	Sun
5	Venus	Saturn	Sun	Moon	Mars	Mercury	Jupiter	Venus
6	Mercury	Jupiter	Venus	Saturn	Sun	Moon	Mars	Mercury
7	Moon	Mars	Mercury	Jupiter	Venus	Saturn	Sun	Moon
8	Saturn	Sun	Moon	Mars	Mercury	Jupiter	Venus	Saturn
[…]	[…]	[…]	[…]	[…]	[…]	[…]	[…]	[…]

The Germanic names were used across most of Northern Europe and came into English usage as a consequence of the Anglo-Saxon invasions[26] that followed the collapse of the Roman rule during the 5th century.

Within this Germanic tradition, Saturday is the only day of the week to retain its Roman origin, named after the Roman god Saturn. Sunday and Monday retain their pagan connections to the sun and moon respectively. The other days of the week are named after Norse or Germanic gods: Tuesday = Tiw (Norse Týr), Wednesday = Wodan, Thursday = Thor, Friday = Norse goddess Fríge.

Agreeing the Modern UTC Calendar

None of the foundations outlined above had universal acceptance world-wide. But as global trade expanded in the 19th century, the need for a consistent means of calculating dates and time became increasingly important.

The first step towards a standardised global calendar and time system was achieved at the 1884 International Meridian Conference held in Washington, D.C., when the local mean solar time at the Royal Observatory, Greenwich in England was chosen to define the Universal day[27]. This allowed the development of 'time zones' and the creation of the international date line in the middle of the Pacific ocean.

[26] Modern archology questions the traditional concept of an Anglo-Saxon 'invasion'. However, there was definitely some migration, extensive trade, and the exchange of ideas. Old English is based on the Germanic language group rather than the native Celtic.

[27] Virtually instantaneous communication between Europe and the USA started in 1858 with the completion of the first Trans-Atlantic telegraph cable. Before this the 10 day shipping time for a message between the two continents made the coordination of time unnecessary.

Coordinated Universal Time (UTC), the primary time standard by which the world now regulates time was initiated in 1960 by the International Radio Consultative Committee, and is based on the Greenwich Mean Time[28], the Greenwich Meridian[29] and the Gregorian calendar.

The main difference between UTC, as it is now applied, and the Gregorian calendar is the way seconds are defined. Seconds were originally defined as a fraction of the mean tropical year. This changed in 1967, when the second was redefined as the duration of 9,192,631,770 energy transitions of the cesium atom and ushered in the era of atomic timekeeping.

Despite the precision of UTC, it is desirable that the civil time scale should not be very different from the Earth's time. The current definitions state that UTC cannot differ from UT1 (the earth's actual rotation) by more than 0.9 seconds. A one-second change called a "leap second" is introduced into UTC if it appears that the difference between these two kinds of time is approaching this limit. The last leap second was added to the minute before midnight on the 31st December 2016[30] (which is 10:00AM on the 1st January in my part of Australia).

More recently, as modern global computing systems have become more tightly intertwined and more reliant on hyper-precise timing, sometimes to the billionth of a second, adding extra seconds at random intervals causes significant problems. Consequently, the member states of the international treaty governing science and measurement standards voted in 2022 to suspend the concept of leap seconds from 2035 for at least 100 years.

The other modern innovation (not related to UTC) has been to change the naming convention from AD to Common Era (CE) and BC to Before the Common Era (BCE) to emphasise the secularism of the standard calendar. Unlike UTC, this change in naming convention is by no means universally accepted.

Numbering weeks

What is the first day of the week?
The need for a consistent week number in a year is complicated by deciding the start day of a week. Saturday, Sunday and Monday are options depending on religious beliefs, and assuming the week starts on the day after the Holy 'day of rest'. Genesis 2.2 states: *For in six days the LORD made the heavens and the earth and the sea and all that is in them, but on the seventh day He rested.* But the day of rest in Islam is Friday, Judaism Saturday (the Sabbath) and Christianity Sunday.

Historically, Sunday appears to have the best credentials to be the first day of the week. Sunday has been set aside as the '*day of the sun*' since ancient Egyptian times in honour of the sun-god *Ra.* The

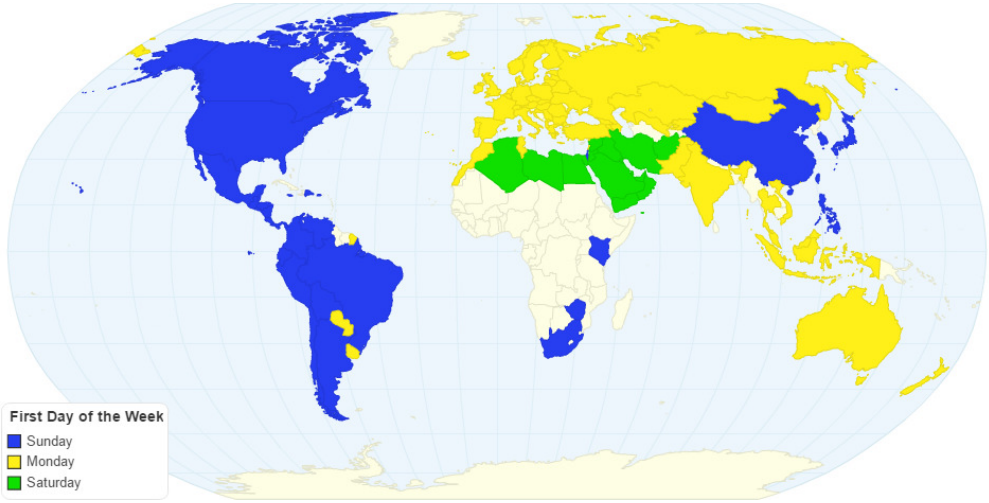
[28] Greenwich Mean Time (GMT), had been used in the UK since 1847 to standardise time across the country and facilitate railway timekeeping. Prior to 1847 local time was based on observations of the sun with a difference of several minutes from East to West.

[29] GMT is based on the Solar noon as measured at the Greenwich Observatory, its marked Prime Meridian line. This meridian differs from the one used in GPS and other systems by about 102 meters. Mapping and navigation systems use the WG S 84 meridian. WG S 84 is a global datum based on calculations of the earth's centre of mass and considers the fact the earth is not a smooth oblate spheroid; and its base point was set in the USA. The difference is in part due to the uneven shape of the earth and in on part due to continental drift. Land surfaces continually move and the relationship between the UK and the USA will have changed appreciably since 1884. In the modern world both time and geographic location are based on calculations rather than the physical geography of the earth's surface.

[30] A table of the years in which leap seconds have been added to the calendar can be found at https://en.wikipedia.org/wiki/Leap_second

Egyptians passed their idea onto the Romans, who also named one of the days of the week the Sun's day, *dies solis*.

Also, Sunday was traditionally regarded as the first day of the week by both Christians and Jews. Both Jewish tradition and the Bible are quite explicit that God rested on the seventh day of Creation, which formed the basis for the Jewish Sabbath (Saturday), the day of rest, making Sunday the first day of the week for both Jews and Christians. This did not change when, on 7th March 321 CE, Constantine the Great issued the first civil Sunday law, compelling all the people in the Roman Empire, except farmers, to rest on Sunday.



The change by Christians to recognising Sunday as the Lord's Day seems to have occurred at the 4th Century Synod of Laodicea (held in 363 or 365 CE). This important meeting[31] decided on the books that would be considered as part of the Bible (Canon 60) and in Canon 29 instructed: *Christians must not judaize by resting on the Sabbath, but must work on that day, rather honouring the Lord's Day; and, if they can, resting then as Christians* (on Sunday).This change to both celebrating the Lord's Day and resting on Sunday (rather than the Jewish Sabbath) does not seem to have changed the concept of Sunday being the first day of the week.

The third option is Islamic, Muslims believe Friday was chosen by God as a dedicated day of worship. Muhammad is quoted as *saying "The best day the sun rises over is Friday; on it Allah created Adam. On it, he was made to enter paradise, on it he was expelled from it, and the Last Hour will take place on no other day than Friday."*

The shift to considering Monday as the first day of the week seems to have been gradual and focused on the secular consideration that Monday is the start of the working week in most societies. A five-day workweek is well-established worldwide and most people (but not all) consider Saturday and Sunday to be the weekend, making it more practical to consider Monday, the end of the break and the start of work, as the beginning of the week. In 1971 the ISO (International Organization for Standardization) made the recommendation that Monday be considered the beginning of the week in daily life and business practices.

The allied problem in day and week numbering is deciding which week is the first week in a year, there are several options. The Gregorian year starts on the 1st January, but the 1st rarely aligns with the start day of a week – on average this occurs once every 7 years regardless of the chosen day.

[31] For more on ***Synod of Laodicea*** (4th Century), see: https://www.newadvent.org/fathers/3806.htm

To overcome these problems and provide international consistency, the definition of the start day of each week, and the first week of any year are contained in ISO 8601[32]. This international standard was first published in 1988 and the latest version was published in 2019. ISO 8601 provides:

1. The first day of the week is Monday (Monday is Day 1 of the week, Sunday Day 7). This convention is used by slightly over 52% of the world's population.
2. The first week of the year is defined as the week containing the first Thursday of the year. This means if 1st January is on a Monday, Tuesday, Wednesday or Thursday, it is in week 01 of the new year. If 1st January is on a Friday, Saturday or Sunday, it is in week 52 or 53 of the previous year. This means Week 01 always contains at least 4 days in the current year.

ISO 8601includes a lot of additional practical standards for defining the format for communicating time and date information around the globe.

Conclusions

The need for a common understanding of time and dates has been driven by the demands of trade over several thousand years. And whilst there are still many different calendars in use for ceremonial, religious and local needs (including the Julian calendar), the effect of an interconnected world has been the steady move towards everyone using UTC and ISO 8601 for business and communication purposes.

Despite the 'universality' of UTC, few people realise the divisions on the circular face of a clock and the surface of a globe owe their divisions to the 6,000-year-old numeric system of the Mesopotamians and the knuckles on an Egyptian's hand. And it is thanks to these ancient civilizations and the Greek astronomers who defined and preserved their divisions of time, modern society still conceives of a day of 24 hours, an hour of 60 minutes, a minute of 60 seconds; and a circle of 360 degrees with each degree divided into 60 minutes and a minute of angle into 60 seconds.

The two thoughts I would like to leave you with is firstly the incredible accuracy of the calculations made by the astronomers who set the basis for both the Julian and Gregorian calendars; working in a time before computers, using quills and parchment their calculations were accurate to a day in every 2000 years. Second the amazing durability of the ancient Mesopotamian and Egyptian systems that still affect our lives and the project schedules we create some 6000 years or more years after they were initially developed.

Note: This article is a compilation and summarisation of many different entries in Wikipedia (http://en.wikipedia.org/) validated from other reference materials where anomalies were noted. It is not intended as a scholarly article.

[32] For more on ***ISO 8601*** see: https://en.wikipedia.org/wiki/ISO_8601