Decalendar and Declock

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2023+221

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# 1. Summary

Decalendar is a [decimal](https://en.wikipedia.org/wiki/Decimal) calendar🗓️system and Declock is a decimal timekeeping⏳system. The goal of Decalendar and Declock is to replace all calendar and timekeeping systems that are based on non-decimal [numeral systems](https://en.wikipedia.org/wiki/List_of_numeral_systems#Standard_positional_numeral_systems). Instead of months, weeks, hours, minutes, and seconds, Decalendar and Declock use a single decimal number called the day-of-the-year (doty).

## 1.1 Demonstrations

### 1.1.1 Timestamps

#### Page load

The Decalendar timestamp below shows the year and doty at the time this webpage was loaded. This timestamp is slightly more **precise** and much more **concise** than a timestamp with hours, minutes, and seconds.

#### Now

A timestamp that doesn’t move isn’t much fun, so here’s one that increments every one ten thousandth () of a day (centimilliday), which in Decalendar is called a beat. It’s like a heart❤️beat! Or if you prefer, a musical🎵beat!

#### Diff

If we subtract the first timestamp from the second, we can see how long this webpage has been open. You don’t have to read it all in one sitting, it’s not a speed-reading🏎️competition, so please feel free to take breaks😄.

### 1.1.2 Date conversion

Enter a [Gregorian calendar](https://en.wikipedia.org/wiki/Gregorian_calendar#:~:text=The%20Gregorian%20calendar%20is%20the%20calendar%20used%20in%20most%20parts%20of%20the%20world.) date below to see the equivalent Decalendar date in doty date format (year+day) and decimal year format (year.yyy). Try special dates like birthdays and anniversaries.

### 1.1.3 Timestamp arithmetic

Doty numbers make working with dates and times a breeze🎐. Use the inputs below to add numbers to the current year and doty. Add a positive number to see a future date or add a negative number to get a past date. You can use decimal doty numbers for times and even decimal years for dates! ✨🤩✨ For example, the decimal year date 1969.84 () is equivalent to the doty date 1969+306.

## 1.2 Day of the year

[Figure 1](#fig-doty) shows the components of the doty number that corresponds to midnight on January 1st in the Gregorian calendar. The first two [digits](https://en.wikipedia.org/wiki/Numerical_digit#Computation_of_place_values) (hundreds and tens) of the doty are the dek number (30 in [Figure 1](#fig-doty)). Deks are groups of 10 days that fulfill the role of both months and weeks in Decalendar. The next digit (ones) of the doty number is the day-of-the-dek (dotd) number (6 in [Figure 1](#fig-doty)), which serves as both the day-of-the-month (dotm) and the day-of-the-week (dotw) in Decalendar. Gregorian calendar dates require us to look up the day of the week, while the doty contains all of the analogous information for Decalendar in its first 3 digits (hundreds, tens, and ones).

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| Figure 1: The components of a day-of-the-year (doty) |

## 1.3 Deks

As mentioned in [Section 1.2](#sec-summary-doty), deks function as both months and weeks in Decalendar. A dek consists of 2 groups of 5 days called pents. Each pent can follow a sequence of workdays and restdays called a pently schedule. The code in [Example 1](#exm-glance) generates [Figure 2](#fig-schedules) which compares the typical weekly schedule and the Schedule 3 pently schedule. Like other pently schedules, Schedule 3 is named after the number of workdays it contains. The 3 workdays in Schedule 3 are followed by a 2-day pentend, the Decalender equivalent of a weekend.

Unlike Schedule 3 and the other pently schedules, the weekly schedule is asymmetric and divides up workdays into proportions that are easier to express as fractions: 3/8 (.375), 1/3 (.3̅), and 7/24 (0.2916̅). In contrast, the proportions of the day in pently schedules are never [repeating decimal](https://en.wikipedia.org/wiki/Repeating_decimal) numbers. Each Schedule 3 workday is split up symmetrically into proportions so that workday starts at .3 (7.2 hours), lasts .4 (9.6 hours), and ends at .7 (16.8 hours). [Section 5.4.3.1](#sec-pently) provides more information on Schedule 3 and the other pently schedules.

**Example 1**

import pandas as pd  
  
ax = (  
 pd.DataFrame(  
 {  
 "Days": ["Mon", "Tue", "Wed", "Thur", "Fri", "Sat", "Sun"],  
 "Evening rest": [7 / 24] \* 5 + [0] \* 2,  
 "Work": [1 / 3] \* 5 + [0] \* 2,  
 "Morning rest": [3 / 8] \* 5 + [1] \* 2,  
 }  
 )  
 .set\_index("Days")  
 .plot.bar(  
 stacked=True,  
 color=["blue", "crimson", "blue"],  
 title="Weekly schedule",  
 fontsize=15,  
 legend=False,  
 xlabel="Days of the week",  
 ylabel="Proportion of the day",  
 rot=0,  
 width=0.8,  
 )  
)  
ax.invert\_yaxis()  
ax.legend(["Rest", "Work"], loc="upper right")  
ax.patch.set\_alpha(0)  
  
for c in ax.containers:  
 labels = [round(v.get\_height(), 3) if v.get\_height() > 0 else "" for v in c]  
 labels = [str(l)[1:] for l in labels if l != 1]  
 ax.bar\_label(c, labels=labels, label\_type="center", color="white", fontsize=15)  
  
ax = (  
 pd.DataFrame(  
 {  
 "Days": ["0 or 5", "1 or 6", "2 or 7", "3 or 8", "4 or 9"],  
 "Evening rest": [0.3] \* 3 + [0] \* 2,  
 "Work": [0.4] \* 3 + [0] \* 2,  
 "Morning rest": [0.3] \* 3 + [1] \* 2,  
 }  
 )  
 .set\_index("Days")  
 .plot.bar(  
 stacked=True,  
 color=["blue", "crimson", "blue"],  
 title="Pently schedule",  
 fontsize=15,  
 legend=False,  
 xlabel="Days of the dek",  
 ylabel="Proportion of the day",  
 rot=0,  
 width=0.8,  
 )  
)  
ax.invert\_yaxis()  
ax.legend(["Rest", "Work"], loc="upper right")  
ax.patch.set\_alpha(0)  
  
for c in ax.containers:  
 labels = [round(v.get\_height(), 1) if v.get\_height() > 0 else "" for v in c]  
 labels = [str(l)[1:] for l in labels if l != 1]  
 ax.bar\_label(c, labels=labels, label\_type="center", color="white", fontsize=18)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | |  | | --- | | (a) Proportion of the day spent working and resting every day of the week | | |  | | --- | | (b) Proportion of the day spent working and resting every day of the pent | |   Figure 2: Weekly and pently schedule comparison |

## 1.4 Declock time

The digits after the decimal in the doty are Declock units. Of these units, mils are notable because they provide the right level of precision for displaying time on clocks and watches. Dimes are also noteworthy because they are used for time zone offsets. [Figure 3](#fig-time) shows how a Declock [fractional day](https://en.wikipedia.org/wiki/Decimal_time#Fractional_days) time can be combined with a time zone offset. The +0 at the end of the time in [Figure 3](#fig-time) indicates that the time is in the Zone 0 time zone, which is equivalent to the [UTC+00:00](https://en.wikipedia.org/wiki/UTC+00:00) time zone of [Coordinated Universal Time (UTC)](https://en.wikipedia.org/wiki/Coordinated_Universal_Time).

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| Figure 3: The components of a Declock time |

## 1.5 Decalendar ordinal date

In addition to being combined with a time zone offset as in [Figure 3](#fig-time), a doty can be combined with a year to form a Decalendar ordinal (deco) date. [Figure 4](#fig-date) shows a deco date that is equivalent to January 1st, 1969 in the Gregorian calendar. The Declock time in [Figure 3](#fig-time) and the deco date in [Figure 4](#fig-date) both use a plus sign (+) as a delimiter. If we combined the deco date from [Figure 4](#fig-date) and the Declock time from [Figure 3](#fig-time), we would obtain a deco stamp: 1960+306.000+0. [Table 1](#tbl-2x2) compares doty and deco dates in its first column and doty and deco stamps in its second column.

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| Figure 4: The components of a Decalendar ordinal (deco) date |

#### [Table 1](#tbl-2x2)

|  |
| --- |
| Click to toggle table expansion |
| Table 1: Comparison of doty and deco dates and stamps   |  | date | stamp | | --- | --- | --- | | doty | 306 | 306.000+0 | | deco | 1969+306 | 1969+306.000+0 | |

# 2. Basic concepts

## 2.1 Fractions analogy

In the simplest terms, Decalendar counts fractions of a year, while Declock counts fractions of a day. The denominator for Decalendar is the number of days in the year, and the Declock denominator is , where is the number of digits in the numerator. In both systems, only the numerator, not the denominator, is provided. In the context ofDecalendar, the numerator is the days that have passed in the year, while in the context ofDeclock, the numerator is the parts of the day that have passed in the day.

To avoid any confusion between the two, we can say “Day 5” to mean the date when 5 days have passed this year or Day 0 to mean the first day-of-the-year (doty). This is like the use of the term “day zero” in other contexts, such as epidemiology. The analogous term for times is Dot. The word Dot conveys that at its core Declock is a system built on [fractional days](https://en.wikipedia.org/wiki/Decimal_time#Fractional_days) expressed as decimal numbers. The 5 in Dot 5 can be thought of as a number after a decimal (0.5) or a numerator (⁵/₁₀), either way it means noon, the time when half the day has passed.

## 2.2 Implied tolerance and duration

The analogy to decimals or fractions is important, because it explains why adding a zero at the end of a time does not change the time, only the implied tolerance of time points or the implied duration of time intervals. If Dot 5 is a time point, it has an implied tolerance of 5% of the day (), because any time after Dot 45 and before Dot 55 () would round to Dot 5. On the other hand, if Dot 5 is the start time for a time interval, that interval is implied to start at Dot 5 and end before Dot 6 () and thus have a duration of 10% of the day (Dot 6-Dot 5). Every additional digit we add decreases the implied tolerance and the implied duration 10-fold.

If we really want to insist on punctuality, we could include up to 5 digits in a time. Specifying times with more than 5 digits is possible, and may be useful for scientific or technical purposes, but it is analogous to providing [extremely long GPS coordinates](https://xkcd.com/2170/); at some point the level of precision stops having relevance to daily life. If we want to strive for the highest level of precision possible, we can add the word “sharp” or the # symbol to the time. Saying “5 Sharp” or writing 5# means as close as possible to noon. Times that include # cannot have an implied duration. We can only add # to a time, so there is no need say “Dot 5 Sharp” or write .5#.

## 2.3 Context clues

Not saying “Day” or “Dot” in general is acceptable, because it is convenient and often the numbers make perfect sense in context. If someone says “let’s have lunch at 5”, it is clear that they are referring to noon (Dot 5) and not the sixth doty (Day 5). Also, the number itself may provide a clue. Numbers greater than 365 could still be a doty, but it would represent a day in an upcoming year, not the current year. The meaning of such dates depends on whether the current year is a common year (n=365) or a leap year (n=366). Saying “500” could mean Day 134 (if n=366) or Day 135 (if n=365) of the subsequent year, but it would most likely mean noon (Dot 500).

## 2.4 Stamps

If a Decalender date and a Declock time are combined, they form a time stamp. The date always goes before the time in any stamp. When said together, the numbers “0” and “5” mean the first doty (Day 0) at noon (Dot 5). In written form, this would be 000.5. This format is called .y, which is read the same way as doty, but emphasizes that the . is used in a floating point decimal doty. In other words, doty can be used instead of “day of the year” in a sentence, whereas .y indicates a stamp, such as 000.5. Ideally, a stamp will include all of the information needed to identify a singular point in time, and thus should include a year and time zone.

## 2.5 Specific dates and times

The stamp in [Section 2.4](#sec-stamp) assumes that the year and time zone are known. A date without a year is like a time without a time zone, both depend on the context. Most likely, we are talking about the current year and the local time zone, but it may be unclear. Including a year allows us to pinpoint a specific day, instead of a day that could happen any year. Similarly, a time with a time zone occurs once every day, rather than once in every time zone per day. The Day 306 of 1969, would be written 1969+306 and said “Year 1969 Day 306” or simply “1969 306”, while midnight in Zone 0 would be written .000+0 and said “Dot 0 Zone 0”, “0 Zone 0”, or “0 0”. Combined together, this date and time form the stamp 1969+306.000+0.

## 2.6 Negative numbers

Every component of Decalender dates and Declock times can be negative. A negative year is before 1 BCE (Before Common Era) and a negative time zone is West of Zone 0. The year is usually provided without a sign, because most people rarely discuss years before 1 BCE, but numeric time zone offset must have a sign. Negative doty numbers work like [zero-based indexes](https://en.wikipedia.org/wiki/Zero-based_numbering) in [computer programming](https://en.wikipedia.org/wiki/Zero-based_numbering#Computer_programming) in that they label the days of the year from to , where is the number of the days in the current year. The first doty is indexed by both and , while the last doty is indexed by both and .

In general, negative numbers show the number of parts that are left in the whole. A negative doty shows how many days remain in the year and a negative time [counts down](https://en.wikipedia.org/wiki/Countdown) to the end of the day. To extend the fractions analogy in [Section 2.1](#sec-frac) to negative numbers, the negative number added to the whole gives us the numerator of the positive fraction (). Positive and negative numbers arrive at the same answer from opposite directions.

In certain contexts, the choice of using a negative number over a positive number may mean that we want to emphasize how much time is left instead of how much has passed. Even though Dot -1 and Dot 9 are synonymous Declock times, the former could highlight that there is only 1 tenth (⅒ or .1) of the day remaining before midnight. Dot 5 and Dot -5 both mean noon, like saying that a glass is half-empty or half-full.

The negative equivalent of 1969+306, the deco date in [Figure 4](#fig-date) and [Table 1](#tbl-2x2), is 1970-059. This negative deco date literally subtracts 59 days from the beginning of year 1970 to arrive at Day 306 of 1969. The year in negative deco dates is always 1 greater than the year in the equivalent positive deco date. Both 1969+306 and 1970-059 translate to January 1, 1970 in the Gregorian calendar. Decalendar years are shifted by two months in relation to the Gregorian calendar years because Decalendar years start on March 1.

This shift causes the Gregorian calendar year to be 1 greater than the year in the positive deco dates during January and February and 1 less than the year in negative deco dates during every other month. For example, the Deco dates 1969+000 and 1970-365 are March 1, 1969 in the Gregorian calendar. Immediately after midnight on this date, the negative doty will change from -365 to -364, while the positive doty will remain at 0 At noon, the positive deco date will be 1969+306.500 and the negative deco date will be 1970-058.500.

## 2.7 Units

Declock times often have three digits because this is the best level of precision for displaying time on clocks and watches. While 3 digits are often best, Declock times can have any number of digits, depending on the desired precision level. Declock provides names for extremely precise time units, but the most relevant units are within a few orders of magnitude from a day, which is the base unit of both Declock and Decalendar. Listing the units of each, as in [Table 2](#tbl-unit), highlights the relationship between the two:

#### [Table 2](#tbl-unit)

|  |
| --- |
| Click to toggle table expansion |
| Table 2: The units of Decalendar and Declock   | Quantity | Name | Symbol | Formal Name | | --- | --- | --- | --- | |  | hekt | ρ | hectoday | |  | delt | δ | deltakeraiayear | |  | qop | ϟ | qoppaday | |  | pi | π | piday | |  | ep | ε | epsilonkeraiayear | |  | om | ο | omicronday | |  | wau | ϛ | waukeraiayear | |  | xi | ξ | xiday | |  | nu | ν | nuday | |  | mu | Μ | muday | |  | lam | λ | lamdaday | |  | kap | κ | kappaday | |  | dek | ι, 旬 | decaday | |  | day | d, 日 | day | |  | dime | ⅒, 更 | deciday | |  | cent | ¢, % | centiday | |  | mil | m, ‰ | milliday | |  | period | . | didecimilliday | |  | phrase | ◠, ‱ | decimilliday | |  | bar | | | dicentimilliday | |  | beat | ♫ | centimilliday | |  | mic | μ | microday | |  | liph | m̑ | decimicroday | |  | lib | m̈ | centimicroday | |  | nan | n | nanoday | |  | roph | μ̑ | decinanoday | |  | rob | µ̈ | centinanoday | |  | pic | p | picoday | |  | noph | n̑ | decipicoday | |  | nob | n̈ | centipicoday | |  | femt | f | femtoday | |  | coph | p̑ | decifemtoday | |  | cob | p̈ | centifemtoday | |  | att | a | attoday | |  | foph | f̑ | deciattoday | |  | fob | f̈ | centiattoday | |  | zept | z | zeptoday | |  | toph | ȃ | decizeptoday | |  | tob | ä | centizeptoday | |  | yokt | y | yoctoday | |  | zoph | z̑ | deciyoctoday | |  | zob | z̈ | centiyoctoday | |  | ront | r | rontoday | |  | yoph | y̑ | decirontoday | |  | yob | ÿ | centirontoday | |  | quek | q | quectoday | |

In [Table 2](#tbl-unit), the units with positive exponents are used for Decalendar, while the ones with negative exponents are used for Declock. Cents (¢) can serve as a useful point of comparison to understand the scale of some of the units in [Table 2](#tbl-unit) above, because each cent is 1 percent of the day, which is about a quarter hour (1% = 14.4 minutes). In comparison to cents, mils are ten times smaller (.1% = 1.4 minutes), dimes (⅒) are ten times larger (10% = 144 minutes), and deks (ι) are 1000 times larger (1000% = 14400 minutes). To be clear, 1 dek contains 10 whole days while the other units are fractions of days.

Declock units smaller than mils are not easy to think of as percents of a day. For phrases (◠) and beats (♫), music serves as a much more useful analogy. In fact, phrases and beats are musical terms. The duration of a musical beat depends on the tempo, but a Declock beat is always precisely 0.864 seconds long. This translates to a tempo of 69.4̅ (69⁴/₉ or 625/9) beats per minute, which is coincidentally also within the normal range of a resting heart rate. Declock beats are organized into groups of 2 called bars or measures, groups of 10 called phrases, and groups of 20 called periods. A real example of music that follows this exact pattern is Haydn’s [Feldpartita](https://en.wikipedia.org/wiki/Period_(music)).

Declock units smaller than beats are too small for typical daily use. For example, a mic (microday, μ) is faster than a blink of an eye. Each frame in a video playing at 60 frames per second will be shown for about 1.93 liphs (milliphrases, m̑). A lib (millibeat, m̈) is not enough time for a neuron in a human brain to fire and return to rest. Sound can travel from a person’s ear to their other ear in about 7 nans (nanodays). Noticing that a sound reaches one ear before the other can help humans to localize the source of the sound, but a roph (microphrase, μ̑) difference might be too fast to notice. In a rob (microbeat, µ̈), a USB 3.0 cable transferring 5 gigabytes per second can send 4.32 kilobytes, the equivalent of a text file with 4320 characters.

# 3. Time zones

Of the units discussed above, dimes are notable, because they are the units of Declock time zones. The times in Zone 1 are one dime earlier than Zone 0 and two dimes earlier than Zone -1. Time zones are important, because different time zones could have very different times and even different dates. Mexico City is in Zone -3 and Tokyo is in Zone 4, meaning for the majority of the day (Dot 7 to be exact) Tokyo is one day ahead of Mexico City. If it is noon on the last day of the year 1999 in Mexico City, it will be Dot 200 on the first day of the year 2000 in Tokyo. This date and time in Mexico City can be written 2000+000.200+4 or 2001-364.800+4, while the equivalent date and time for Tokyo is 1999+365.500-3 or 2000-000.500-3. If we removed the time zone from the end, we would not know that all of these stamps describe the same moment in time.

Declock groups together the 26 [Coordinated Universal Time (UTC) offsets](https://en.wikipedia.org/wiki/List_of_UTC_offsets) (-12:00 to +14:00) into 11 time zones (Zone -5 to Zone 6) by converting hours into dimes () and rounding to the nearest whole number (). This time zone system is simple and facilitates conversion, but locations on the edges of the main time zones may experience a significant difference between Dot 5 and [solar noon](https://en.wikipedia.org/wiki/Noon#Solar_noon), the point when the sun reaches its highest position in the sky.

If we decide to prioritize the amount of sunlight at Dot 5 over simplicity and ease of conversion, we could convert degrees of longitude into cents or mils, instead of converting hours into dimes. For example, we could say that Mexico City is in Zone -275 instead of Zone -3, because the longitude of Mexico City is 99 degrees West, which translates to an offset of -275 mils (). Essentially, we could create as many additional Declock time zones are desired simply by adding digits to the end of each time zone. Adding one digit yields 110 double-digit cent time zones, adding two digits creates 1100 triple-digit mil time zones, and so on.

# 4. Related systems

## 4.1 French Republican calendar

### 4.1.1 French Republican calendar *décades*

The [French Republican calendar](https://en.wikipedia.org/wiki/French_Republican_calendar) and Decalendar both organize days in groups of 10. A group of 10 days in the French Republican calendar is called a *décade*, while a group of 10 days in Decalendar is called a dek. The names of the days in a dek are derived from their [zero-based](https://en.wikipedia.org/wiki/Zero-based_numbering) cardinal numbers (zero, one, two…), whereas the days of the *décade* are named after their ordinal numbers (first, second, third…). In both cases, the names are based on Roman and Greek [numeral prefixes](https://en.wikipedia.org/wiki/Numeral_prefix#Table_of_number_prefixes_in_English). [Table 3](#tbl-dotd) provides the cardinal numbers, one-letter codes, names, and types of the days of the dek as well as the names of their French Republican calendar equivalents.

#### [Table 3](#tbl-dotd)

|  |
| --- |
| Click to toggle table expansion |
| Table 3: The days of the dek and their French Republican calendar equivalents   | # | Code | Name | Type | French | | --- | --- | --- | --- | --- | | 0 | N | Nulday | work | *primidi* | | 1 | U | Unoday | work | *duodi* | | 2 | D | Duoday | work | *tridi* | | 3 | T | Triday | rest | *quartidi* | | 4 | Q | Quaday | rest | *quintidi* | | 5 | P | Penday | work | *sextidi* | | 6 | H | Hexday | work | *septidi* | | 7 | S | Sepday | work | *octidi* | | 8 | O | Octday | rest | *nonidi* | | 9 | E | Ennday | rest | *décadi* | |

### 4.1.2 French Republican calendar time

The French Republican calendar and Declock both break the day down into decimal portions. In Declock, a dime is a tenth (⅒) of a day, a cent is a hundredth (10⁻²) of a day, a mil is a thousandth (10⁻³) of a day, and a beat is a hundred thousandth (10⁻⁵) of a day, whereas the French Republican calendar calls these units decimal hours, decimal minutes, *décimes*, and decimal seconds, respectively. [Table 4](#tbl-dime) shows the start times of each dime (⅒) in a day and its equivalent in 24-hour and 12-hour standard time.

#### [Table 4](#tbl-dime)

|  |
| --- |
| Click to toggle table expansion |
| Table 4: The dimes in a day and their standard time equivalents   | ⅒ | 24-hour | 12-hour | | --- | --- | --- | | 0 | 00:00 | 12:00AM | | 1 | 02:24 | 2:24AM | | 2 | 04:48 | 4:48AM | | 3 | 07:12 | 7:12AM | | 4 | 09:36 | 9:36AM | | 5 | 12:00 | 12:00PM | | 6 | 14:24 | 2:24PM | | 7 | 16:48 | 4:48PM | | 8 | 19:12 | 7:12PM | | 9 | 21:36 | 9:36PM | |

## 4.2 Swatch Internet Time

[Swatch Internet Time](https://en.wikipedia.org/wiki/Swatch_Internet_Time) uses the term “.beats” to describe a thousandth of day (10⁻³). In Declock, a beat is a hundred thousandth of a day (10⁻⁵), because this is the approximate duration of a heartbeat or a beat of music. Another difference is that Swatch Internet Time has only 1 time zone, [UTC+1](https://en.wikipedia.org/wiki/List_of_UTC_offsets#UTC+01:00,_A), limiting its utility outside of Central Europe or West Africa. Declock has 11 main single-digit time zones, but can support as many time zones as needed by adding additional digits. More information on Declock time zones can be found in [Section 3](#sec-zone).

## 4.3 Gregorian calendar

### 4.3.1 Coordinate analogy

In the Gregorian calendar, dates are like a set of coordinates, where the month and the day-of-the-month (dotm) are like longitude and latitude in the [geographic coordinate system](https://en.wikipedia.org/wiki/Geographic_coordinate_system) or x and y in the [Cartesian coordinate system](https://en.wikipedia.org/wiki/Cartesian_coordinate_system). The Decalendar ordinal (deco) date format provides two coordinates in one number: the day-of-the-year (doty). [Table 5](#tbl-greg2doty) shows the doty number of all Gregorian calendar dates.

To locate a specific date in [Table 5](#tbl-greg2doty), first find the month among the columns (think of the month as an x-axis value) and then move down through the rows to the dotm (which is like a y-axis value). To convert a doty number to a Gregorian calendar date, we first find the dek number (the first two digits of the doty) among the rows in [Table 6](#tbl-doty2greg) and then move to the right to the dotd (the last digit of the doty). The dates in [Table 6](#tbl-doty2greg) are shown in mm-dd format.

#### [Table 5](#tbl-greg2doty)

|  |
| --- |
| Click to toggle table expansion |
| Table 5: Gregorian calendar date to doty conversion   | Day | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 0 | 31 | 61 | 92 | 122 | 153 | 184 | 214 | 245 | 275 | 306 | 337 | | 2 | 1 | 32 | 62 | 93 | 123 | 154 | 185 | 215 | 246 | 276 | 307 | 338 | | 3 | 2 | 33 | 63 | 94 | 124 | 155 | 186 | 216 | 247 | 277 | 308 | 339 | | 4 | 3 | 34 | 64 | 95 | 125 | 156 | 187 | 217 | 248 | 278 | 309 | 340 | | 5 | 4 | 35 | 65 | 96 | 126 | 157 | 188 | 218 | 249 | 279 | 310 | 341 | | 6 | 5 | 36 | 66 | 97 | 127 | 158 | 189 | 219 | 250 | 280 | 311 | 342 | | 7 | 6 | 37 | 67 | 98 | 128 | 159 | 190 | 220 | 251 | 281 | 312 | 343 | | 8 | 7 | 38 | 68 | 99 | 129 | 160 | 191 | 221 | 252 | 282 | 313 | 344 | | 9 | 8 | 39 | 69 | 100 | 130 | 161 | 192 | 222 | 253 | 283 | 314 | 345 | | 10 | 9 | 40 | 70 | 101 | 131 | 162 | 193 | 223 | 254 | 284 | 315 | 346 | | 11 | 10 | 41 | 71 | 102 | 132 | 163 | 194 | 224 | 255 | 285 | 316 | 347 | | 12 | 11 | 42 | 72 | 103 | 133 | 164 | 195 | 225 | 256 | 286 | 317 | 348 | | 13 | 12 | 43 | 73 | 104 | 134 | 165 | 196 | 226 | 257 | 287 | 318 | 349 | | 14 | 13 | 44 | 74 | 105 | 135 | 166 | 197 | 227 | 258 | 288 | 319 | 350 | | 15 | 14 | 45 | 75 | 106 | 136 | 167 | 198 | 228 | 259 | 289 | 320 | 351 | | 16 | 15 | 46 | 76 | 107 | 137 | 168 | 199 | 229 | 260 | 290 | 321 | 352 | | 17 | 16 | 47 | 77 | 108 | 138 | 169 | 200 | 230 | 261 | 291 | 322 | 353 | | 18 | 17 | 48 | 78 | 109 | 139 | 170 | 201 | 231 | 262 | 292 | 323 | 354 | | 19 | 18 | 49 | 79 | 110 | 140 | 171 | 202 | 232 | 263 | 293 | 324 | 355 | | 20 | 19 | 50 | 80 | 111 | 141 | 172 | 203 | 233 | 264 | 294 | 325 | 356 | | 21 | 20 | 51 | 81 | 112 | 142 | 173 | 204 | 234 | 265 | 295 | 326 | 357 | | 22 | 21 | 52 | 82 | 113 | 143 | 174 | 205 | 235 | 266 | 296 | 327 | 358 | | 23 | 22 | 53 | 83 | 114 | 144 | 175 | 206 | 236 | 267 | 297 | 328 | 359 | | 24 | 23 | 54 | 84 | 115 | 145 | 176 | 207 | 237 | 268 | 298 | 329 | 360 | | 25 | 24 | 55 | 85 | 116 | 146 | 177 | 208 | 238 | 269 | 299 | 330 | 361 | | 26 | 25 | 56 | 86 | 117 | 147 | 178 | 209 | 239 | 270 | 300 | 331 | 362 | | 27 | 26 | 57 | 87 | 118 | 148 | 179 | 210 | 240 | 271 | 301 | 332 | 363 | | 28 | 27 | 58 | 88 | 119 | 149 | 180 | 211 | 241 | 272 | 302 | 333 | 364 | | 29 | 28 | 59 | 89 | 120 | 150 | 181 | 212 | 242 | 273 | 303 | 334 | 365 | | 30 | 29 | 60 | 90 | 121 | 151 | 182 | 213 | 243 | 274 | 304 | 335 |  | | 31 | 30 |  | 91 |  | 152 | 183 |  | 244 |  | 305 | 336 |  | |

#### [Table 6](#tbl-doty2greg)

|  |
| --- |
| Click to toggle table expansion |
| Table 6: Doty number to Gregorian calendar date conversion   | Dek | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 0 | 03-01 | 03-02 | 03-03 | 03-04 | 03-05 | 03-06 | 03-07 | 03-08 | 03-09 | 03-10 | | 1 | 03-11 | 03-12 | 03-13 | 03-14 | 03-15 | 03-16 | 03-17 | 03-18 | 03-19 | 03-20 | | 2 | 03-21 | 03-22 | 03-23 | 03-24 | 03-25 | 03-26 | 03-27 | 03-28 | 03-29 | 03-30 | | 3 | 03-31 | 04-01 | 04-02 | 04-03 | 04-04 | 04-05 | 04-06 | 04-07 | 04-08 | 04-09 | | 4 | 04-10 | 04-11 | 04-12 | 04-13 | 04-14 | 04-15 | 04-16 | 04-17 | 04-18 | 04-19 | | 5 | 04-20 | 04-21 | 04-22 | 04-23 | 04-24 | 04-25 | 04-26 | 04-27 | 04-28 | 04-29 | | 6 | 04-30 | 05-01 | 05-02 | 05-03 | 05-04 | 05-05 | 05-06 | 05-07 | 05-08 | 05-09 | | 7 | 05-10 | 05-11 | 05-12 | 05-13 | 05-14 | 05-15 | 05-16 | 05-17 | 05-18 | 05-19 | | 8 | 05-20 | 05-21 | 05-22 | 05-23 | 05-24 | 05-25 | 05-26 | 05-27 | 05-28 | 05-29 | | 9 | 05-30 | 05-31 | 06-01 | 06-02 | 06-03 | 06-04 | 06-05 | 06-06 | 06-07 | 06-08 | | 10 | 06-09 | 06-10 | 06-11 | 06-12 | 06-13 | 06-14 | 06-15 | 06-16 | 06-17 | 06-18 | | 11 | 06-19 | 06-20 | 06-21 | 06-22 | 06-23 | 06-24 | 06-25 | 06-26 | 06-27 | 06-28 | | 12 | 06-29 | 06-30 | 07-01 | 07-02 | 07-03 | 07-04 | 07-05 | 07-06 | 07-07 | 07-08 | | 13 | 07-09 | 07-10 | 07-11 | 07-12 | 07-13 | 07-14 | 07-15 | 07-16 | 07-17 | 07-18 | | 14 | 07-19 | 07-20 | 07-21 | 07-22 | 07-23 | 07-24 | 07-25 | 07-26 | 07-27 | 07-28 | | 15 | 07-29 | 07-30 | 07-31 | 08-01 | 08-02 | 08-03 | 08-04 | 08-05 | 08-06 | 08-07 | | 16 | 08-08 | 08-09 | 08-10 | 08-11 | 08-12 | 08-13 | 08-14 | 08-15 | 08-16 | 08-17 | | 17 | 08-18 | 08-19 | 08-20 | 08-21 | 08-22 | 08-23 | 08-24 | 08-25 | 08-26 | 08-27 | | 18 | 08-28 | 08-29 | 08-30 | 08-31 | 09-01 | 09-02 | 09-03 | 09-04 | 09-05 | 09-06 | | 19 | 09-07 | 09-08 | 09-09 | 09-10 | 09-11 | 09-12 | 09-13 | 09-14 | 09-15 | 09-16 | | 20 | 09-17 | 09-18 | 09-19 | 09-20 | 09-21 | 09-22 | 09-23 | 09-24 | 09-25 | 09-26 | | 21 | 09-27 | 09-28 | 09-29 | 09-30 | 10-01 | 10-02 | 10-03 | 10-04 | 10-05 | 10-06 | | 22 | 10-07 | 10-08 | 10-09 | 10-10 | 10-11 | 10-12 | 10-13 | 10-14 | 10-15 | 10-16 | | 23 | 10-17 | 10-18 | 10-19 | 10-20 | 10-21 | 10-22 | 10-23 | 10-24 | 10-25 | 10-26 | | 24 | 10-27 | 10-28 | 10-29 | 10-30 | 10-31 | 11-01 | 11-02 | 11-03 | 11-04 | 11-05 | | 25 | 11-06 | 11-07 | 11-08 | 11-09 | 11-10 | 11-11 | 11-12 | 11-13 | 11-14 | 11-15 | | 26 | 11-16 | 11-17 | 11-18 | 11-19 | 11-20 | 11-21 | 11-22 | 11-23 | 11-24 | 11-25 | | 27 | 11-26 | 11-27 | 11-28 | 11-29 | 11-30 | 12-01 | 12-02 | 12-03 | 12-04 | 12-05 | | 28 | 12-06 | 12-07 | 12-08 | 12-09 | 12-10 | 12-11 | 12-12 | 12-13 | 12-14 | 12-15 | | 29 | 12-16 | 12-17 | 12-18 | 12-19 | 12-20 | 12-21 | 12-22 | 12-23 | 12-24 | 12-25 | | 30 | 12-26 | 12-27 | 12-28 | 12-29 | 12-30 | 12-31 | 01-01 | 01-02 | 01-03 | 01-04 | | 31 | 01-05 | 01-06 | 01-07 | 01-08 | 01-09 | 01-10 | 01-11 | 01-12 | 01-13 | 01-14 | | 32 | 01-15 | 01-16 | 01-17 | 01-18 | 01-19 | 01-20 | 01-21 | 01-22 | 01-23 | 01-24 | | 33 | 01-25 | 01-26 | 01-27 | 01-28 | 01-29 | 01-30 | 01-31 | 02-01 | 02-02 | 02-03 | | 34 | 02-04 | 02-05 | 02-06 | 02-07 | 02-08 | 02-09 | 02-10 | 02-11 | 02-12 | 02-13 | | 35 | 02-14 | 02-15 | 02-16 | 02-17 | 02-18 | 02-19 | 02-20 | 02-21 | 02-22 | 02-23 | | 36 | 02-24 | 02-25 | 02-26 | 02-27 | 02-28 | 02-29 |  |  |  |  | |

### 4.3.2 Gregorian calendar date conversion

In addition to using a conversion table like [Table 5](#tbl-greg2doty), we can convert between Gregorian calendar dates and Decalendar doty dates programmatically. The code in [Example 2](#exm-coor) is derived from the [days\_from\_civil](http://howardhinnant.github.io/date_algorithms.html#days_from_civil) and [civil\_from\_days](http://howardhinnant.github.io/date_algorithms.html#civil_from_days) algorithms described by [Howard Hinnant](https://howardhinnant.github.io/) in [*chrono-Compatible Low-Level Date Algorithms*](http://howardhinnant.github.io/date_algorithms.html) (2014). The output of the greg2doty function is a doty number, while its inverse function, doty2greg, returns an array containing a month and a dotm number.

**Example 2**

#### JavaScript

##### greg2doty

function greg2doty(month = 1, day = 1) {  
 return Math.floor(  
 (153 \* (month > 2 ? month - 3 : month + 9) + 2) / 5 + day - 1  
)}  
  
greg2doty()

306

##### doty2greg

function doty2greg(doty = 306) {  
 const m = Math.floor((5 \* doty + 2) / 153);  
 return [Math.floor(m < 10 ? m + 3 : m - 9), Math.floor(doty - (153 \* m + 2) / 5 + 2)];  
}  
  
doty2greg()

[ 1, 1 ]

#### Julia

##### greg2doty

function greg2doty(month=1, day=1)  
 Int(floor((153 \* (month > 2 ? month - 3 : month + 9) + 2) / 5 + day - 1))  
end  
  
greg2doty()

306

##### doty2greg

function doty2greg(doty = 306)  
 m = floor((5 \* doty + 2) / 153);  
 return Int(m < 10 ? m + 3 : m - 9), Int(floor(doty - (153 \* m + 2) / 5 + 2))  
end  
  
doty2greg()

(1, 1)

#### Python

##### greg2doty

def greg2doty(month=1, day=1):  
 return (153 \* (month - 3 if month > 2 else month + 9) + 2) // 5 + day - 1  
  
greg2doty()

306

##### doty2greg

def doty2greg(doty=306):  
 m = (5 \* doty + 2) // 153  
 return m + 3 if m < 10 else m - 9, doty - (153 \* m + 2) // 5 + 1  
  
doty2greg()

(1, 1)

#### R

##### greg2doty

greg2doty <- function(month = 1, day = 1) {  
 floor((153 \* (ifelse(month > 2, month - 3, month + 9)) + 2) / 5 + day - 1)  
}  
  
greg2doty()

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##### doty2greg

doty2greg <- function(doty = 306) {  
 m <- floor((5 \* doty + 2) / 153)  
 c(ifelse(m < 10, m + 3, m - 9), floor(doty - (153 \* m + 2) / 5 + 2))  
}  
doty2greg()

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### 4.3.3 Gregorian calendar months and years

Decalendar only uses months for converting to and from Gregorian calendar dates. Nevertheless, discussing months can help to explain how Decalendar works. The Decalendar year ends with January and February, as shown in [Table 7](#tbl-gregm). During these two months, the Decalendar year is 1 less than the Gregorian calendar year. To obtain a Decalendar year (dy) from a Gregorian calendar year (gy) and month number (gm), we subtract 1 from gy if gm is less than 3 (). To obtain a Gregorian calendar year (gy) from a Decalendar year (dy) and doty, we add 1 to dy if doty is greater than 305 (). Code to convert between Decalendar and Gregorian calendar years is provided in [Example 3](#exm-gregm).

#### [Table 7](#tbl-gregm)

|  |
| --- |
| Click to toggle table expansion |
| Table 7: The numeric values of months in Decalendar and the Gregorian calendar   | dm | gm | Month | | --- | --- | --- | | 0 | 3 | March | | 1 | 4 | April | | 2 | 5 | May | | 3 | 6 | June | | 4 | 7 | July | | 5 | 8 | August | | 6 | 9 | September | | 7 | 10 | October | | 8 | 11 | November | | 9 | 12 | December | | 10 | 1 | January | | 11 | 2 | February | |

**Example 3**

#### JavaScript

##### greg2year

function greg2year(year = 1970, month = 1) { return year - (month < 3) }  
  
console.log(greg2year());

1969

##### doty2year

function doty2year(year = 1969, doty = 306) { return year + (doty > 305) }  
  
console.log(doty2year());

1970

#### Julia

##### greg2year

function greg2year(year=1970, month=1)  
 year - (month < 3)  
end  
  
greg2year()

1969

##### doty2year

function doty2year(year=1969, doty=306)  
 year + (doty > 305)  
end  
  
doty2year()

1970

#### Python

##### greg2year

def greg2year(year=1970, month=1):  
 return year - (month < 3)  
  
greg2year()

1969

##### doty2year

def doty2year(year=1969, doty=306):  
 return year + (doty > 305)  
  
doty2year()

1970

#### R

##### greg2year

greg2year <- function(year = 1970, month = 1) {  
 year - (month < 3)  
}  
  
greg2year()

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##### doty2year

doty2year <- function(year = 1969, doty = 306) {  
 year + (doty > 305)  
}  
  
doty2year()

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### 4.3.4 Leap years

A leap year has 366 days in both Decalendar and the Gregorian calendar. Day 365 is Leap Day in Decalendar and is synonymous with February 29, the Gregorian calendar leap day. Decalendar positions Leap Day, Day 365, at the end of the year, which requires an adjustment of the Gregorian calendar definition of a leap year. To check if a Decalendar year is a leap, we must first add 1 to the year before plugging it into [Equation 1](#eq-gregl) or the [year2bool](http://howardhinnant.github.io/date_algorithms.html#is_leap) function in [Example 4](#exm-gregl).

Interestingly, years from negative deco dates do not need any adjustment. The first day of Year 1999 is 1999+000 or 2000-366, while the last day is 1999+365 or 2000-001. Year 1999 is a leap year from the perspective of the positive deco dates, 1999+000 and 1999+365, because it goes from Day 0 to Day 365. In the context of the negative deco dates,2000-366 and 2000-001, Year 2000 is a leap year because it goes from Day -366 to Day -1.

**Example 4**

#### JavaScript

##### leap

function year2bool(year = 1970) {  
 return year % 4 == 0 && year % 100 != 0 || year % 400 == 0;  
}  
  
year2bool()

false

#### Julia

##### leap

function year2bool(year=1970)  
 year % 4 == 0 && year % 100 != 0 || year % 400 == 0  
end  
  
year2bool()

false

#### Python

##### leap

def year2bool(year=1970):  
 return year % 4 == 0 and year % 100 != 0 or year % 400 == 0  
  
year2bool()

False

#### R

##### leap

year2bool <- function(year = 1970) {  
 year %% 4 == 0 & year %% 100 != 0 | year %% 400 == 0  
}  
  
year2bool()

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## 4.4 ISO 8601

### 4.4.1 Years

Both Decalendar and [ISO 8601](https://en.wikipedia.org/wiki/ISO_8601) dates show [years](https://en.wikipedia.org/wiki/ISO_8601#Years) as 4-digit numbers. Unlike ISO 8601, Decalendar does not require years to be included in dates. As shown in [Table 1](#tbl-2x2), Decalendar deco dates include years while doty dates do not. Year 0 in both Decalendar and ISO 8601 is 1 BCE (Before Common Era) in the Gregorian calendar. The first day of Year 0 in Decalendar, 0000+000, is called the Decalendar epoch and translates to March 1, 1 BCE in the Gregorian calendar. The first day of Year 0 according to ISO 8601 is -0001+306 in Decalendar and January 1, 1 BCE in the Gregorian calendar.

### 4.4.2 Ordinal dates

Deco dates (year+day) are very similar to [ISO 8601 ordinal (isoo) dates](https://en.wikipedia.org/wiki/ISO_8601#Ordinal_dates) (year-day). Like Decalendar doty numbers, isoo dates count the number of days since the start of the year. Unlike ordinal dates, doty numbers are [zero-based](https://en.wikipedia.org/wiki/Zero-based_numbering) and do not differ across common and leap years. The deco date can be easily obtained from the isoo date using the calculations shown in [Equation 2](#eq-isoo1), [Equation 3](#eq-isoo2), and [Example 5](#exm-isoo). These calculation shift the isoo date by 60 or 61 days to account for the 2-month difference between Decalendar and the Gregorian calendar.

In [Example 5](#exm-isoo), the isoo2doty and doty2isoo functions convert between ISO 8601 ordinal day numbers and doty numbers. We use the year2bool function from [Example 4](#exm-gregl) in [Example 5](#exm-isoo) to correct for the fact that Leap Day shifts ISO 8601 ordinal day numbers by 1 day in leap years. To be clear, we only have to take Leap Day into account when dealing with isoo dates. Decalendar doty numbers are the same in common and leap years, because Leap Day is at the end of the Decalendar year.

**Example 5**

#### JavaScript

##### isoo2doty

function isoo2doty(yd = "1970-001") {  
 const [year, day] = yd.includes("-") ? yd.split("-") : yd.split(/(?=\d{4})/);  
 return [parseInt(year) - (parseInt(day) < (60 + year2bool(year - 1))),  
 (parseInt(day) + 305 - year2bool(year)) % 365]  
}  
  
console.log(isoo2doty())

[ 1969, 306 ]

##### isoo2deco

function isoo2deco(yd = "1970-001") {  
 const [year, doty] = isoo2doty(yd).map(i => i.toString())  
 return `${year.padStart(4, "0")}+${doty.padStart(3, "0")}`  
}  
  
console.log(isoo2deco())

1969+306

##### doty2isoo

function doty2isoo(year = 1969, doty = 306) {  
 return `${doty2year(year, doty).toString().padStart(4, "0")}-${  
 ((doty + 60 + year2bool(year + 1)) % 365).toString().padStart(3, "0")}`  
}  
  
console.log(doty2isoo());

1970-001

#### Julia

##### isoo2year

function isoo2year(year=1970, day=1)  
 year - (day < (60 + year2bool(year - 1)))  
end  
  
isoo2year()

1969

##### isoo2doty

function isoo2year(year=1970, day=1)  
 year - (day < (60 + year2bool(year - 1)))  
end  
  
isoo2year()

1969

##### doty2isoo

function doty2isoo(year=1970, doty=0)  
 (doty + 60 + year2bool(year + 1)) % 365  
end  
  
"$(lpad(doty2year(), 4, '0'))+$(lpad(doty2isoo(), 3, '0'))"

"1970+060"

#### Python

##### isoo2year

def isoo2year(year=1970, day=1):  
 return year - (day < (60 + year2bool(year - 1)))  
  
isoo2year()

1969

##### isoo2doty

def isoo2doty(year=1970, day=1):  
 return (day + 305 - year2bool(year)) % 365  
  
f"{isoo2year():>04}+{isoo2doty():>03}"

'1969+306'

##### doty2isoo

def doty2isoo(year=1970, doty=0):  
 return (doty + 60 + year2bool(year + 1)) % 365  
  
f"{doty2year():>04}+{doty2isoo():>03}"

'1970+060'

#### R

##### isoo2year

isoo2year <- function(year = 1970, day = 1) {  
 year - (day < (60 + year2bool(year - 1)))  
}  
  
isoo2year()

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##### isoo2doty

isoo2doty <- function(year = 1970, day = 1) {  
 (day + 305 - year2bool(year)) %% 365  
}  
  
paste0(sprintf("%04d", isoo2year()), "+", sprintf("%03d", isoo2doty()))

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##### doty2isoo

doty2isoo <- function(year = 1970, doty = 0) {  
 (doty + 60 + year2bool(year + 1)) %% 365  
}  
  
paste0(sprintf("%04d", doty2year()), "+", sprintf("%03d", doty2isoo()))

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### 4.4.3 Calendar dates

ISO 8601 [calendar dates (isoc)](https://en.wikipedia.org/wiki/ISO_8601#Calendar_dates) consist of a four-digit year, a two-digit month, and a two-digit dotm separated by hyphens (year-mm-dd). This format is the current widely accepted standard for displaying Gregorian calendar dates. We can combine code from [Example 2](#exm-coor) and [Example 3](#exm-gregm) to convert between deco dates and isoc dates, as shown in [Example 6](#exm-isoc). The code in [Example 6](#exm-isoc) formats the output of the greg2year and greg2doty functions into deco dates and the output of the doty2year and doty2greg functions into isoc dates.

As mentioned in [Section 4.3.1](#sec-coor), Decalendar uses doty numbers as dates instead of month and day-of-the-month (dotm) numbers, but if required, Gregorian calendar dates can be provided in the Decalendar calendar (decc, pronounced “deck-see”) format (year+m+dd), which is very similar to the isoc date format. The decc format is described in [Section 5.1](#sec-dotm). Examples of the decc format are provided in [Section 5.3](#sec-dotex). To be clear, the decc format is only used to display Gregorian calendar dates and otherwise does not play any role in Decalendar.

**Example 6**

#### JavaScript

##### greg2deco

function greg2deco(year = 1970, month = 1, day = 1) {  
 return `${greg2year(year, month).toString().padStart(4, "0")}+${  
 greg2doty(month, day).toString().padStart(3, "0")}`;  
}

##### doty2isoc

function doty2isoc(year = 1969, doty = 306) {  
 return `${doty2year().toString().padStart(4, "0")}-${  
 doty2greg().map(  
 i => i.toString().padStart(2, "0")  
 ).join("-")}`;  
}

##### greg2isoc

function greg2isoc(year = 1970, month = 1, day = 1) {  
 return `${year.toString().padStart(4, "0")}-${  
 month.toString().padStart(2, "0")}-${  
 day.toString().padStart(2, "0")}`;  
}

#### Julia

##### deco date

"$(lpad(greg2year(), 4, '0'))+$(lpad(greg2doty(), 3, '0'))"

"1969+306"

##### ISO 8601 date

"$(lpad(doty2year(), 4, '0'))-$(join(map((x) -> lpad(x, 2, '0'), doty2greg()), '-'))"

"1970-01-01"

#### Python

##### deco date

f"{greg2year():>04}+{greg2doty():<3}"

'1969+306'

##### ISO 8601 date

f"{doty2year():>04}-{'-'.join(map(lambda i: str(i).rjust(2, '0'), doty2greg()))}"

'1970-01-01'

#### R

##### deco date

paste0(  
 sprintf("%04d", greg2year()), "+",  
 sprintf("%03d", greg2doty())  
 )

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##### ISO 8601 date

paste0(sprintf("%04d", doty2year()), "-",  
 paste(sprintf("%02d", doty2greg()), collapse = '-')  
 )

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### 4.4.4 Time zones

Isoc dates can be combined with the [ISO 8601 time (isot) format](https://en.wikipedia.org/wiki/ISO_8601#Times) (hh:mm:ss) to form isoc timestamps. Likewise, deco dates can be combined with Declock times to form deco timestamps. Both deco (year+day.dddddZ) and isoc (year-mm-ddThh:mm:ssZ) timestamps can end in a Z. This Z is a [military time zone code](https://en.wikipedia.org/wiki/Military_time_zone#Description) that represents the [UTC+00:00](https://en.wikipedia.org/wiki/UTC+00:00) time zone, which is the basis of [Coordinated Universal Time (UTC)](https://en.wikipedia.org/wiki/Coordinated_Universal_Time).

Deco timestamps that are synchronized with UTC can either end in Z (year+day.dddddZ) or +0 (year+day.ddddd+0). Noon UTC can be written .5Z or .5+0 in Declock and 12:00:00Z, 120000Z, 12:00:00+00, or 120000+00 as per ISO 8601. The code in [Example 7](#exm-isoz) converts between UTC offsets and military time zone codes. [Section 3](#sec-zone) provides more information on Declock time zones.

**Example 7**

#### JavaScript

##### hour2zone

function hour2zone(hour = 0) {  
 return hour == 0 ? "Z"  
 : hour > 0 && hour < 10 ? String.fromCharCode(hour + 64)  
 : hour > 9 && hour < 13 ? String.fromCharCode(hour + 65)  
 : hour < 0 && hour > -13 ? String.fromCharCode(Math.abs(hour) + 77)  
 : "J";  
}  
  
console.log(hour2zone(-new Date().getTimezoneOffset() / 60))

Q

##### zone2hour

function zone2hour(zone = "Z") {  
 return (zone = zone.toUpperCase()) == "Z" ? 0  
 : zone > "@" && zone < "J" ? zone.charCodeAt() - 64  
 : zone > "J" && zone < "N" ? zone.charCodeAt() - 65  
 : zone < "Z" && zone > "M" ? -(zone.charCodeAt() - 77)  
 : zone;  
}  
  
console.log(zone2hour(hour2zone(-new Date().getTimezoneOffset() / 60)))

-4

#### Julia

##### hour2zone

# import Pkg; Pkg.add("TimeZones")  
# using TimeZones  
# localzone()  
function hour2zone(hour=0)  
 (  
 hour == 0 ? "Z" :  
 hour > 0 && hour < 10 ? Char(hour + 64) :  
 hour > 9 && hour < 13 ? Char(hour + 65) :  
 hour < 0 && hour > -13 ? Char(abs(hour) + 77) : "J";  
 )  
end  
  
hour2zone()

"Z"

##### zone2hour

function zone2hour(zone="Z")  
 (  
 (zone = uppercase(string(zone))) == "Z" ? 0 :  
 zone > "@" && zone < "J" ? Int(codepoint(only(zone))) - 64 :  
 zone > "J" && zone < "N" ? Int(codepoint(only(zone))) - 65 :  
 zone < "Z" && zone > "M" ? -(Int(codepoint(only(zone))) - 77) : zone;  
 )  
end  
  
zone2hour()

0

#### Python

##### hour2zone

# import time  
# print(int(-time.timezone / 3600))  
def hour2zone(hour=0):  
 return (  
 "Z" if hour == 0 else  
 chr(hour + 64) if 0 < hour < 10 else  
 chr(hour + 65) if 9 < hour < 13 else  
 chr(abs(hour) + 77) if -13 < hour < 0 else "J"  
 )  
  
hour2zone()

'Z'

##### zone2hour

def zone2hour(zone="Z"):  
 return (  
 0 if (zone := zone.upper()) == "Z" else  
 ord(zone) - 64 if "@" < zone < "J" else  
 ord(zone) - 65 if "J" < zone < "N" else  
 -(ord(zone) - 77) if "M" < zone < "Z" else zone  
 )  
  
zone2hour()

0

#### R

##### hour2zone

# Sys.timezone()  
hour2zone <- function(hour = 0) {  
 ifelse(hour == 0, "Z",  
 ifelse(hour > 0 && hour < 10, intToUtf8(hour + 64),  
 ifelse(hour > 9 && hour < 13, intToUtf8(hour + 65),  
 ifelse(hour < 0 && hour > -13, intToUtf8(abs(hour) + 77), "J"))))  
}  
  
hour2zone()

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##### zone2hour

zone2hour <- function(zone = "Z") {  
 ifelse((zone <- toupper(zone)) == "Z", 0,  
 ifelse(zone > "@" && zone < "J", utf8ToInt(zone) - 64,  
 ifelse(zone > "J" && zone < "N", utf8ToInt(zone) - 65,  
 ifelse(zone < "Z" && zone > "M", -(utf8ToInt(zone) - 77), zone))))  
}  
  
zone2hour()

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### 4.4.5 Times

The formula for conversion of standard time to Declock time is shown in [Equation 4](#eq-declock). The value of x in [Equation 4](#eq-declock). can be modified to obtain different units, which are displayed in [Table 8](#tbl-isot). To convert Declock time into standard time, we first convert into hours using [Equation 5](#eq-hour) and the appropriate x value from [Table 8](#tbl-isot). Then, we convert hours into minutes with [Equation 6](#eq-minute) and minutes into seconds with [Equation 7](#eq-second) The hmso2doty and doty2hmso functions in [Example 8](#exm-isot) uses these formulas to convert between standard time and Declock time.

#### [Table 8](#tbl-isot)

|  |
| --- |
| Click to toggle table expansion |
| Table 8: The powers of ten of units based on days   | x | units | | --- | --- | | -1 | deks | | 0 | days | | 1 | dimes | | 2 | cents | | 3 | mils | | 4 | phrases | | 5 | beats | | 6 | mics | |

**Example 8**

#### JavaScript

##### hmso2doty

function hmso2doty(hour = 1, minute = 0, second = 0) {  
 return hour / 24 + minute / 1440 + second / 86400  
}  
  
console.log(hmso2doty())

0.041666666666666664

##### hmso2isot

function hmso2isot(hour = 1, minute = 0, second = 0) {  
 return hour / 24 + minute / 1440 + second / 86400  
}  
  
console.log(hmso2isot())

0.041666666666666664

##### doty2hmso

function doty2hmso(doty = 1 / 24) {  
 const hour = doty \* 24,  
 floorHour = Math.floor(hour),  
 minute = (hour - floorHour) / 60,  
 floorMinute = Math.floor(minute);  
 return [floorHour, floorMinute, (minute - floorMinute) / 60]  
}  
  
console.log(doty2hmso())

[ 1, 0, 0 ]

#### Julia

##### time

##### hmso2doty

function hmso2doty(hour=1, minute=0, second=0)  
 hour / 24 + minute / 1440 + second / 86400  
end  
  
hmso2doty()

0.041666666666666664

##### doty2hmso

function doty2hmso(doty=1/24)  
 hour = doty \* 24  
 floorHour = floor(hour)  
 minute = (hour - floorHour) / 60  
 floorMinute = floor(minute)  
 return floorHour, floorMinute, (minute - floorMinute) / 60  
end  
  
doty2hmso()

(1.0, 0.0, 0.0)

#### Python

##### hmso2doty

def hmso2doty(hour=1, minute=0, second=0):  
 return hour / 24 + minute / 1440 + second / 86400  
  
hmso2doty()

0.041666666666666664

##### doty2hmso

def doty2hmso(doty = 1/24):  
 hour = doty \* 24  
 floorHour = hour.\_\_floor\_\_()  
 minute = (hour - floorHour) / 60  
 floorMinute = minute.\_\_floor\_\_()  
 return floorHour, floorMinute, (minute - floorMinute) / 60  
  
doty2hmso()

(1, 0, 0.0)

#### R

##### hmso2doty

hmso2doty <- function(hour = 1, minute = 0, second = 0) {  
 hour / 24 + minute / 1440 + second / 86400  
}  
  
hmso2doty()

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##### doty2hmso

doty2hmso <- function(doty = 1 / 24) {  
 hour <- doty \* 24  
 floorHour <- floor(hour)  
 minute <- (hour - floorHour) / 60  
 floorMinute <- floor(minute)  
 c(floorHour, floorMinute, (minute - floorMinute) / 60)  
}  
  
doty2hmso()

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### 4.4.6 Timestamps

Decalendar seeks to make months and weeks obsolete. Similarly, Declock aims to deprecate hours, minutes, and seconds in favor of [fractional days](https://en.wikipedia.org/wiki/Decimal_time#Fractional_days) (.day). Deco timestamps, which combine Decalendar dates and Declock times, are more concise and easier to read than ISO 8601 timestamps. An isoc timestamp that includes seconds is 20 characters long (year-mm-ddThh:mm:ssZ), while a deco timestamp with slightly greater precision is only 15 characters long (year+day.dddddZ). ISO 8601 timestamps can omit delimiters except for the T which separates the date and the time (yearmmddThhmmssZ). Without delimiters, isoc timestamps become even more difficult to read and still cannot match the brevity of Decalendar timestamps.

Coincidentally, an ISO 8601 ordinal (isoo) timestamp (year-dayThh:mm:ssZ) without delimiters (yeardayThhmmssZ) is the same length as a deco timestamp (year+day.dddddZ). Deco timestamps cannot exist without delimiters, because removing the plus sign (+) from a deco timestamp turns it into a doty number (ddddddd.ddddd). If we removed the + from the deco timestamp 1969+306.00000, we would obtain the doty number 1969306.00000 would represent midnight 1969306 days from the beginning of the current year. The rules for deco timestamp interpretation are summarized by the code in the deco2doty function in [Example 15](#exm-unixp).

To create a deco timestamp, we can use the doty2deco or the greg2deco functions as shown in [Example 9](#exm-isos). Similarly, [Example 9](#exm-isos) also shows how to create an isoc timestamp with the doty2isoc and doty2isoc functions. All of these timestamp creation functions assume that the provided times are in the UTC+00:00 time zone or Zone 0 and need to be adjusted to the provided time zone by adding the appropriate time zone offset to the timestamp. [Section 4.6.4](#sec-unixb) and [Section 4.6.5](#sec-unixp) further discuss timestamps and provide functions for building, parsing, and converting timestamps.

**Example 9**

#### JavaScript

##### doty2deco

function doty2deco(year = 1969, doty = 306, zone = 0) {  
 return `${year.toString().padStart(4, "0")}+${  
 doty.toString().padStart(3, "0")}`;  
}

##### hmso2doty

function hmso2doty(hour = 1, minute = 0, second = 0) {  
 return hour / 24 + minute / 1440 + second / 86400  
}  
  
console.log(hmso2doty())

0.041666666666666664

##### hmso2deco

function hmso2deco(hour = 0, minute = 0, second = 0) {  
 return (Math.round(hmso2doty(hour, minute, second)  
 \* 1e5) / 1e5).toString().padStart(5, '0')  
}

##### doty2hmso

function doty2hmso(doty = 1 / 24) {  
 const hour = doty \* 24,  
 floorHour = Math.floor(hour),  
 minute = (hour - floorHour) / 60,  
 floorMinute = Math.floor(minute);  
 return [floorHour, floorMinute, (minute - floorMinute) / 60]  
}  
  
console.log(doty2hmso())

[ 1, 0, 0 ]

#### Julia

##### time

##### hmso2doty

function hmso2doty(hour=1, minute=0, second=0)  
 hour / 24 + minute / 1440 + second / 86400  
end  
  
hmso2doty()

0.041666666666666664

##### doty2hmso

function doty2hmso(doty=1/24)  
 hour = doty \* 24  
 floorHour = floor(hour)  
 minute = (hour - floorHour) / 60  
 floorMinute = floor(minute)  
 return floorHour, floorMinute, (minute - floorMinute) / 60  
end  
  
doty2hmso()

(1.0, 0.0, 0.0)

#### Python

##### hmso2doty

def hmso2doty(hour=1, minute=0, second=0):  
 return hour / 24 + minute / 1440 + second / 86400  
  
hmso2doty()

0.041666666666666664

##### doty2hmso

def doty2hmso(doty = 1/24):  
 hour = doty \* 24  
 floorHour = hour.\_\_floor\_\_()  
 minute = (hour - floorHour) / 60  
 floorMinute = minute.\_\_floor\_\_()  
 return floorHour, floorMinute, (minute - floorMinute) / 60  
  
doty2hmso()

(1, 0, 0.0)

#### R

##### hmso2doty

hmso2doty <- function(hour = 1, minute = 0, second = 0) {  
 hour / 24 + minute / 1440 + second / 86400  
}  
  
hmso2doty()

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##### doty2hmso

doty2hmso <- function(doty = 1 / 24) {  
 hour <- doty \* 24  
 floorHour <- floor(hour)  
 minute <- (hour - floorHour) / 60  
 floorMinute <- floor(minute)  
 c(floorHour, floorMinute, (minute - floorMinute) / 60)  
}  
  
doty2hmso()

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### 4.4.7 Time intervals

ISO 8601 specifies three methods of unequivocally representing [time intervals](https://en.wikipedia.org/wiki/ISO_8601#Time_intervals), start/stop, start/span, and span/stop. The Decalendar equivalents of these three time interval representations are start:stop, start>span, and stop<span. Notably, the start/stop syntax is used in Google Calendar “Add to Calendar” links (https://calendar.google.com/calendar/render?action=TEMPLATE&dates=start/stop). Clicking on an “Add to Calendar” link opens an web browser interface for adding an event to an online calendar. The greg2link and doty2link functions in [Example 10](#exm-isoi) create such links for Google, Outlook, Office 365, and Yahoo online calendars.

**Example 10**

### 4.4.8 Repeating time intervals

ISO 8601 time intervals can be made to repeat with the Rn/ prefix (Rn/start/stop, Rn/start/span, Rn/span/stop), where n is the number of repetitions. Such [repeating time intervals](https://en.wikipedia.org/wiki/ISO_8601#Repeating_intervals) are always consecutive and never overlap. The first three 6-hour intervals of 1970 could be written R3/1970-01-01T00:00:00Z/T06 as per ISO 8601. This time interval in Decalendar could be written 1969+306>.75>.25>0. Unlike ISO 8601, Decalendar allows for the creation of non-consecutive and overlapping recurring intervals. If we wanted to include 3-hour breaks in between the three 6-hour intervals, we could write 1969+306>1>.25>.125. Similarly, the three 6-hour intervals could be made to overlap by 3 hours by writing 1969+306>.5>.25<.125.

The Decalendar time interval representations above are called spreads and were inspired by the concept of [array slicing](https://en.wikipedia.org/wiki/Array_slicing) from computer programming. Decalendar allows for the use of both slices (start:stop:step) and spreads (start>span>split>space) to create time intervals. [Slicing of dates and times](https://pandas.pydata.org/pandas-docs/version/1.1/user_guide/timeseries.html#indexing) is fully implemented in the [Pandas Python library](https://pandas.pydata.org/). The pandas code shown in [Example 11](#exm-isor) uses slicing to obtain the start times of the last three 6-hour intervals in Gregorian calendar year 1970, which is 1970+305>.75>.25>0 in Decalendar and R3/1970-12-31T06:00:00Z/T06 as per ISO 8601.

**Example 11**

import pandas as pd  
  
pd.date\_range("1970", "1971", freq="6H")[-4:-1]

DatetimeIndex(['1970-12-31 06:00:00', '1970-12-31 12:00:00',  
 '1970-12-31 18:00:00'],  
 dtype='datetime64[ns]', freq='6H')

## 4.5 Julian dates

A [Julian date](https://en.wikipedia.org/wiki/Julian_day#:~:text=The%20Julian%20date%20(JD)%20of%20any%20instant%20is%20the%20Julian%20day%20number%20plus%20the%20fraction%20of%20a%20day%20since%20the%20preceding%20noon%20in%20Universal%20Time.) is the number of [fractional days](https://en.wikipedia.org/wiki/Decimal_time#Fractional_days) since -4713+268.5, which is noon on November 24, 4714 BC in the Gregorian calendar and January 1, 4713 BC in the Julian calendar. The analogous date format in Decalendar is the day-of-the-[era](https://en.wikipedia.org/wiki/Calendar_era) (dote). Both Julian and dote dates count days from a starting point called an [epoch](https://en.wikipedia.org/wiki/Epoch). The Decalendar epoch is 0000+000.0, which is midnight on March 1, 1 BC in the Gregorian calendar. To convert a Julian date into a dote, we simply subtract 1721120.5 days ().

Like Julian dates, dote dates are very useful for date and time calculations. [Equation 8](#eq-dote) shows how a year and a doty can be turned into a dote. The conversion of a dote into a year and doty requires calculations adapted from the [“civil\_from\_days” algorithm](http://howardhinnant.github.io/date_algorithms.html#civil_from_days) from (Hinnant 2014). Briefly, the dote is used to obtain the [solar cycle](https://en.wikipedia.org/wiki/Solar_cycle_(calendar)#:~:text=400%2Dyear%20cycle%20of%20the%20Gregorian%20calendar%20with%20respect%20to%20the%20week.) in [Equation 9](#eq-cycl), which is then plugged into [Equation 10](#eq-dotc) and [Equation 11](#eq-yotc) to calculate the day-of-the-cycle in (dotc) and the year-of-the-cycle (yotc) in [Equation 11](#eq-yotc). [Equation 12](#eq-year) takes the yotc and the solar cycle and yields the year, while [Equation 13](#eq-doty) generates the doty from the yotc and the dotc.

The conversion between doty and dote is the most important calculation in Decalendar because it defines the behavior of positive and negative deco dates and stamps. The arithmetic

**Example 12**

#### JavaScript

##### doty2dote

function doty2dote(year = 1969, doty = 306) {  
 return doty + Math.floor(year \* 365 + Math.floor(year / 4) - Math.floor(year / 100) + Math.floor(year / 400));  
}  
  
console.log(doty2dote());

719468

#### Julia

##### unix

##### doty2dote

function doty2dote(s=0, ms=0)  
 days = s / 86400 + ms / 86400000 + 719468  
 dote = days - (era = floor((days >= 0 ? days : days - 146096) / 146097)) \* 146097  
 year = Int(floor((dote - dote / 1460 + dote / 36524 - dote / 146096) / 365) + era \* 400)  
 year, days - floor(year \* 365 + year / 4 - year / 100 + year / 400)  
end  
  
y, d = doty2dote(time())  
day = Int(floor(d))  
"$(lpad(y, 4, '0'))+$(lpad(day, 3, '0')).$(lpad(Int(round((d - day) \* 1e5)), 5, '0'))+0"

"2023+221.60132+0"

#### Python

##### doty2dote

from time import time  
  
def doty2dote(s=0, ms=0):  
 days = s / 86400 + ms / 86400000 + 719468  
 dote = days - (era := (days if days >= 0 else days - 146096) // 146097) \* 146097  
 year = int((dote - dote / 1460 + dote / 36524 - dote / 146096) // 365 + era \* 400)  
 return year, days - (year \* 365 + year / 4 - year / 100 + year / 400).\_\_floor\_\_()  
  
y, d = doty2dote(time())  
f"{y:>04}+{(day := d.\_\_floor\_\_()):>03}.{round((d - day) \* 1e5):>05}+0"

'2023+221.60144+0'

#### R

##### doty2dote

doty2dote <- function(s = 0, ms = 0) {  
 days = s / 86400 + ms / 86400000 + 719468  
 dote = days - (era = floor(ifelse(days >= 0, days, days - 146096) / 146097)) \* 146097  
 year = floor((dote - dote / 1460 + dote / 36524 - dote / 146096) / 365) + era \* 400  
 c(year, days - floor(year \* 365 + year / 4 - year / 100 + year / 400))  
}  
  
yd <- doty2dote(as.numeric(Sys.time()))  
  
paste0(sprintf("%04d", yd[1]), "+",  
 sprintf("%03d", (day = floor(yd[2]))), ".",  
 sprintf("%05d", round((yd[2] - day) \* 1e5)), "+0"  
)

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## 4.6 UNIX time

### 4.6.1 Julian time conversion to UNIX time

Building on the conversion of Julian dates into dote and doty numbers, it may be easiest to obtain the official definition of deco dates and Declock times is based on UNIX time. UNIX time is the number of seconds since the UNIX Epoch, which is 1969+306.0 in Decalendar or midnight in the [UTC+0](https://en.wikipedia.org/wiki/List_of_UTC_offsets#UTC%C2%B100:00,_Z) time zone on January 1, 1970 in the Gregorian calendar. A day is exactly 86,400 seconds (100,000 beats) long in UNIX time, Julian dates, deco dates, and Declock times. To obtain UNIX time from a Julian Date, we subtract 2440587.5 from the Julian Date and multiply by 86400 as shown in [Equation 14](#eq-unixj).

### 4.6.2 UNIX time conversion to deco date

To calculate deco dates directly from UNIX time, we can use a calculation adapted the 2014 article entitled [“chrono-Compatible Low-Level Date Algorithms”](http://howardhinnant.github.io/date_algorithms.html#civil_from_days) by [Howard Hinnant](https://howardhinnant.github.io/) (2014). Briefly, the seconds (or milliseconds) in UNIX time are first converted to days (). Then, the days are used to obtain the era ([Equation 9](#eq-cycl)), day-of-the-era ([Equation 8](#eq-dote)), year ([Equation 12](#eq-year)), and doty ([Equation 13](#eq-doty)).

### 4.6.3 UNIX time conversion to Decalendar timestamp

To obtain fractional days, we have to sum up all of the days in previous years and subtract this sum from days to obtain the current Decalendar ordinal (deco) timestamp as shown in [Equation 15](#eq-unixt). The code in [Example 13](#exm-unixt) converts UNIX time into a deco timestamp in the Zone 0 time zone by passing the current UNIX timestamp to the unix2doty function. If we call this function without arguments (unix2doty()) the result will be the year and doty of the UNIX Epoch: 1969 and 306. To see [Example 13](#exm-unixt) in action, visit this [CodePen](https://codepen.io/maptv/pen/oNJZeea) which displays the current deco (year+day.ddddd) and isoc (year-mm-ddThh:mm:ss) timestamps.

**Example 13**

#### JavaScript

##### unix2doty

function unix2doty(ms = 0) {  
 const days = ms / 86400000 + 719468,  
 dote = days - (era = Math.floor((days >= 0 ? days : days - 146096) / 146097)) \* 146097,  
 year = Math.floor((dote - dote / 1460 + dote / 36524 - dote / 146096) / 365) + era \* 400;  
 return [year, days - Math.floor(year \* 365 + year / 4 - year / 100 + year / 400)];  
}  
  
const [year, doty] = unix2doty(Date.now());  
console.log(  
 `${year.toString().padStart(4, "0")}+${  
 (day = Math.floor(doty)).toString().padStart(3, "0")}.${  
 (Math.round((doty - day) \* 1e5)).toString().padStart(5, "0")}+0`  
 );

2023+221.60117+0

#### Julia

##### unix

##### unix2doty

function unix2doty(s=0, ms=0)  
 days = s / 86400 + ms / 86400000 + 719468  
 dote = days - (era = floor((days >= 0 ? days : days - 146096) / 146097)) \* 146097  
 year = Int(floor((dote - dote / 1460 + dote / 36524 - dote / 146096) / 365) + era \* 400)  
 year, days - floor(year \* 365 + year / 4 - year / 100 + year / 400)  
end  
  
y, d = unix2doty(time())  
day = Int(floor(d))  
"$(lpad(y, 4, '0'))+$(lpad(day, 3, '0')).$(lpad(Int(round((d - day) \* 1e5)), 5, '0'))+0"

"2023+221.60132+0"

#### Python

##### unix2doty

from time import time  
  
def unix2doty(s=0, ms=0):  
 days = s / 86400 + ms / 86400000 + 719468  
 dote = days - (era := (days if days >= 0 else days - 146096) // 146097) \* 146097  
 year = int((dote - dote / 1460 + dote / 36524 - dote / 146096) // 365 + era \* 400)  
 return year, days - (year \* 365 + year / 4 - year / 100 + year / 400).\_\_floor\_\_()  
  
y, d = unix2doty(time())  
f"{y:>04}+{(day := d.\_\_floor\_\_()):>03}.{round((d - day) \* 1e5):>05}+0"

'2023+221.60144+0'

#### R

##### unix2doty

unix2doty <- function(s = 0, ms = 0) {  
 days = s / 86400 + ms / 86400000 + 719468  
 dote = days - (era = floor(ifelse(days >= 0, days, days - 146096) / 146097)) \* 146097  
 year = floor((dote - dote / 1460 + dote / 36524 - dote / 146096) / 365) + era \* 400  
 c(year, days - floor(year \* 365 + year / 4 - year / 100 + year / 400))  
}  
  
yd <- unix2doty(as.numeric(Sys.time()))  
  
paste0(sprintf("%04d", yd[1]), "+",  
 sprintf("%03d", (day = floor(yd[2]))), ".",  
 sprintf("%05d", round((yd[2] - day) \* 1e5)), "+0"  
)

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#### Lua

function unix2doty(ms)  
 local days = ms / 86400000 + 719468  
 local era = (days >= 0 and days or days - 146096) // 146097  
 local dote = days - era \* 146097  
 local year = math.floor((dote - dote / 1460 + dote / 36524 - dote / 146096) / 365) + era \* 400  
 return math.floor(year), days - math.floor(year \* 365 + year / 4 - year / 100 + year / 400)  
end  
  
print(unix2doty(0))

function unix2deco(ms)  
 year, doty = unix2doty(ms)  
 return string.format("%s+%s", math.floor(year), math.floor(doty))  
end  
  
print(unix2deco(0))

#### CopyQ

copyq:  
function unix2doty(ms = 0) {  
 const days = ms / 86400000 + 719468,  
 dote = days - (era = Math.floor((days >= 0 ? days : days - 146096) / 146097)) \* 146097,  
 year = Math.floor((dote - dote / 1460 + dote / 36524 - dote / 146096) / 365) + era \* 400;  
 return [year, days - Math.floor(year \* 365 + year / 4 - year / 100 + year / 400)];  
}  
  
const [year, doty] = unix2doty(Date.now()),  
 datetime = `${year.toString().padStart(4, "0")}+${  
 (day = Math.floor(doty)).toString().padStart(3, "0")}.${  
 (Math.round((doty - day) \* 1e5)).toString().padStart(5, "0")}+0`;  
  
copy(datetime)  
copySelection(datetime)  
paste()

### 4.6.4 Building timestamps

The code in [Example 13](#exm-unixt) creates a Decalendar ordinal (deco) timestamp from UNIX time. [Example 14](#exm-unixb) encapsulates this code in a function called unix2deco. The deco timestamps converted from UNIX time are all in the Zone 0 time zone. To switch to a different time zone, we should pass the year and doty we obtain from the unix2doty function to the doty2deco function from [Example 8](#exm-isot) along with the desired time zone.

**Example 14**

#### JavaScript

##### unix2deco

function unix2deco(ms = 0) {  
 const [year, doty] = unix2doty(ms);  
 return `${year.toString().padStart(4, "0")}+${  
 (day = Math.floor(doty)).toString().padStart(3, "0")}.${  
 (Math.round((doty - day) \* 1e5)).toString().padStart(5, "0")}+0`  
};  
  
console.log(unix2deco())

1969+306.00000+0

#### Julia

##### unix

##### unix2deco

function unix2deco(s=0, ms=0)  
 y, d = unix2doty(time())  
 day = Int(floor(d))  
 "$(lpad(y, 4, '0'))+$(lpad(day, 3, '0')).$(lpad(Int(round((d - day) \* 1e5)), 5, '0'))+0"  
end  
  
unix2deco()

"2023+221.60132+0"

#### Python

##### unix2deco

from time import time  
  
def unix2deco(s=0, ms=0):  
 y, d = unix2doty(time())  
 return f"{y:>04}+{(day := d.\_\_floor\_\_()):>03}.{round((d - day) \* 1e5):>05}+0"  
  
unix2deco()

'2023+221.60144+0'

#### R

##### unix2deco

unix2deco <- function(s = 0, ms = 0) {  
 yd <- unix2deco(as.numeric(Sys.time()))  
 paste0(sprintf("%04d", yd[1]), "+",  
 sprintf("%03d", (day = floor(yd[2]))), ".",  
 sprintf("%05d", round((yd[2] - day) \* 1e5)), "+0"  
 )  
}  
  
unix2deco()

### 4.6.5 Parsing timestamps

To extract the components of a Decalendar timestamp, we can use the parse\_dec function in [Example 9](#exm-isos). Parsing timestamps is the first step before any later processes such as timestamp arithmetic or conversion between timestamp formats. The parse\_dec function returns a year, a doty, and a fractional day time zone offset. The year and time zone offset can be omitted in the timestamp provided to parse\_dec. If not specified in the timestamp, the year is the current year and the time zone offset is 0.

**Example 15**

#### JavaScript

##### parse\_dec

function parse\_dec(timestamp = "1969+306.00000Z") {  
 const arr = timestamp.toString().split(/(?=[+-]|[a-zA-Z])/, 3);  
 switch (arr.length) {  
 case 1: return [unix2doty(Date.now())[0], parseFloat(arr[0]), 0];  
 case 2: return (/^[a-zA-Z]+$/.test(arr[1]))  
 ? [unix2doty(Date.now())[0], parseFloat(arr[0]), zone2hour(arr[1]) / 24]  
 : [parseInt(arr[0]), parseFloat(arr[1]), 0];  
 };  
 return [parseInt(arr[0]), parseFloat(arr[1]), /^[a-zA-Z]+$/.test(arr[2])  
 ? zone2hour(arr[2]) / 24  
 : parseFloat(arr[2].replace(/([+-])/, "$1\."))];  
}  
  
console.log(parse\_dec());

[ 1969, 306, 0 ]

# 5. Dot formats

The stamps shown above are in the decimal days of the year (.y) format, which is the main Decalendar format. In addition to the .y format, there are 2 other supplemental datetime formats, which are based on decimal days of the month (decc), and decimal days of the week (.w). [Table 9](#tbl-format) summarizes the three decimal day-of-the ( dot or .) formats:

#### [Table 9](#tbl-format)

|  |
| --- |
| Click to toggle table expansion |
| Table 9: The three dot formats   | Day of the | . | General Form | Specific Example | | --- | --- | --- | --- | | Year | y | year±day.day±z | 1999+365.500-3 | | Month | m | year±m±dd.day±z | 1999+B+29.500-3 | | Week | w | year±ww±d.day±z | 1999+52+5.500-3 | |

In [Table 9](#tbl-format) , day is the 3-digit day of the year (doty) number, dd is the 2-digit day of the month (dotm) number, d is the 1-digit day of the week (dotw) number, and .day is the time in mils.

## 5.1 The .m format

The m in the .m format is the 1-digit month number and is the double-digit dotm. To fit all of the months in a single digit, m is in [hexadecimal](https://en.wikipedia.org/wiki/Hexadecimal) form (Base16 encoded). This means that the first 10 months are represented by the numbers 0 through 9 ([zero-based numbering](https://en.wikipedia.org/wiki/Zero-based_numbering)) while the last two months of the year are represented by the letters “A” and “B” instead of numbers. The .m format is similar to the [ISO8601 calendar date](https://en.wikipedia.org/wiki/ISO_8601#Calendar_dates) format (year-mm-dd).

The [ordinal numerals](https://en.wikipedia.org/wiki/Ordinal_numeral) of September, October, November, and December in Decalendar (Sep=7th, Oct=8th, Nov=9th, Dec=10th) match the [numeral prefixes](https://en.m.wikipedia.org/wiki/Numeral_prefix#Table_of_number_prefixes_in_English) in their names (Sep=7, Oct=8, Nov=9, Dec=10). The m value of a month is based on its cardinal number in Decalendar, which is 1 less than its ordinal number (Sep=6, Oct=7, Nov=8, Dec=9).

To convert a double-digit Gregorian calendar month number (mm) into a single-digit Decalendar m value, we subtract 3 if mm is greater than 2, add 9 if not, as shown in [Equation 16](#eq-dotm1), and then encode into hexadecimal (Base16). To do the inverse (convert m to mm), we decode from hexadecimal, add 3 to m values less than 10 and subtract 9 from other m values, as shown in [Equation 17](#eq-dotm2). After hexadecimal encoding, January is represented by A and February is represented by B (mnemonic: jAn=January, feB=February).

## 5.2 The decw format

The week number in the decw format, ww, ranges from 0 to 53 or -54 to -1. Weeks in the decw format start from Sunday. [Table 10](#tbl-dotw) shows the possible dotw values, which range from 0 to 6 or -7 to -1.

#### [Table 10](#tbl-dotw)

|  |
| --- |
| Click to toggle table expansion |
| Table 10: The weeks in the decw format   | Day | Pos | Neg | | --- | --- | --- | | Sunday | 0 | -7 | | Monday | 1 | -6 | | Tuesday | 2 | -5 | | Wednesday | 3 | -4 | | Thursday | 4 | -3 | | Friday | 5 | -2 | | Saturday | 6 | -1 | |

## 5.3 Dot format examples

[Table 11](#tbl-dotex) builds on the example from [Section 3](#sec-zone) to compare all three . formats. The 3 . formats differ only in their approach to the date, not the time. Therefore, the times below are all shown to 1-digit dime precision (same as time zones) instead of the typical 3-digit mil precision. In Mexico City, the time is +5-3 or -5-3, while the time in London is +8+0 or -2+0 and time in Tokyo is +2+4 or -8+4.

#### [Table 11](#tbl-dotex)

|  |
| --- |
| Click to toggle table expansion |
| Table 11: The time in Mexico City, London, and Tokyo in all three dot formats   | Day of the | . | Mexico City | London | Tokyo | | --- | --- | --- | --- | --- | | Year | y | 1999+365.5-3 | 1999+365.8+0 | 2000+000.2+4 | | Year | y | 2000-001.5-3 | 2000-001.2+0 | 2001-365.8+4 | | Month | m | 1999+B+29.5-3 | 1999+B+29.8+0 | 2000+0+00.2+4 | | Month | m | 2000-1-01.5-3 | 2000-1-01.2+0 | 2001-C-31.8+4 | | Week | w | 1999+52+2.5-3 | 1999+52+2.8+0 | 2000+00+3.2+4 | | Week | w | 2000-01-5.5-3 | 2000-01-5.2+0 | 2001-53-4.8+4 | |

In [Table 11](#tbl-dotex), the .m format tells us that the month in Tokyo is January (Month 0) and the month in Mexico City and London is December (Month B). We could say the .m dates in Mexico City and London as “Year 1999 Month B Day 29” or “Year 1999 Month -1 Day -1” and the Tokyo date as “Year 2000 Month 0 Day 0” or “Year 2000 Month -C Day -31”.

The decw format always starts the year with Week 0, but the year can start on any day of the week. [Table 11](#tbl-dotex) shows that the year 2000 starts on a Saturday (Week 0 Day 6). The decw dates in Mexico City and London could be said “Year 1999 Week 52 Day 2” or “Year 1999 Week -1 Day -5”, while the date in Tokyo could be pronounced “Year 2000 Week 0 Day 3” or “Year 2000 Week -52 Day -4” in Tokyo.

In contrast to the .m and the decw formats, the dates in the .y format are one character shorter and a little easier to say. The spoken form of the .y date in Mexico City and London is “Year 1999 Day 365” or “Year 1999 Day -1” and the spoken form of the Tokyo date is “Year 2000 Day 0” or “Year 2000 Day -365”.

## 5.4 Deks

Even though it provides formats for months and weeks, Decalendar envisions a world in which these units are replaced by deks. In terms of scale, deks are somewhere between a week and a month, precisely half a day less than a week and a half (1.5 weeks - 0.5 days) and approximately a third of month. Deks could provide the functionality of both weeks and months if we followed a dekly schedule instead of weekly and monthly schedules. The transition to a dekly schedule would be a massive undertaking, but could start with the creation of the digital infrastructure needed for the new system. Every desktop and mobile application that uses dates could be adapted to optionally use deks instead of weeks and months.

### 5.4.1 Days of the dek

A major difficulty with the Gregorian calendar is that the date is disconnected from the day of the week. In contrast, the day of the dek (dotd) is simply the last digit of the day number in the .y format. For example, the first day of the year (Day 0) is always a Nulday, the last day of common years (Day 364) is always an Quaday, and the last day of leap years (Day 365) is always a Penday. The day number allows us to distinguish workdays from restdays. Decalendar defines Triday, Quaday, Octday, and Ennday as restdays, which means that days with numbers that end in 3, 4, 8, or 9 are days off from work and school. Each dek consists of 2 pents (pentadays), each pent has 3 workdays called the trep (trepalium) and 2 restdays called the pentend. In total, there are 219 workdays and 146 restdays in a Decalendar year, not counting the only obligatory holiday, Leap Day (Day 365).

### 5.4.2 Workdays

The Gregorian calendar has many more workdays, 260 in common years and 261 in leap year. Despite having many fewer workdays and many more restdays, workers following Decalendar would actually spent slightly more time at work overall, because the Decalendar workday goes from Dot 3 to Dot 7 and thus is 4 dimes (9.6 hours) long, 6.6̅ cents (96 minutes) longer than the typical 9-to-5 work schedule (Dot 375 to Dot 7083̅). In other words, this work schedule starts 75 mils (1.8 hours) earlier than 9AM (Dot 375) and ends 8.3̅ mils (12 minutes) earlier than 5PM (Dot 7083̅). In a typical 40-hour workweek, workers spend 23.80952381 cents per day at work on average, which adds up to 8.6̅ deks (260\*8/240) per common year and 8.7 deks () per leap year. In contrast, workers following Decalendar spend 24 cents per day at work on average, which totals up to 87.6 days () spent at work every year. The default approach of Decalendar is to compensate for having more restdays with longer workdays.

### 5.4.3 Schedules

#### Pently schedules

If necessary, the length of the workday and the number of workdays in the dek can be adjusted according to different schedules. As mentioned above, each half of the dek is called a pent. Each pent can have its own pently schedule. The expectation is that workers will work for 12 dimes per pent. It is possible to split those 12 dimes over the course of 5, 4, 3, or 2 days in each pent. [Table 12](#tbl-pently) displays how the number of workdays and restdays in a pent affects the start time, end time, and duration of the workday. The different pently schedules are named after the number of workdays per pent. People can switch between pently schedules every pent as needed, but unless there is a compelling reason to follow a different pently schedule, everyone should follow the Schedule 3 by default. Schedule 3 has 3 workdays and 2 restdays in each pent. Each Schedule 3 workday starts at Dot 3, ends at Dot 7, and lasts 4 dimes.

#### [Table 12](#tbl-pently)

|  |
| --- |
| Click to toggle table expansion |
| Table 12: The characteristics of the pently schedules   | Schedule | Workdays | Restdays | Start | End | Duration | | --- | --- | --- | --- | --- | --- | | 2 | 2 | 3 | .2 | .8 | .6 | | 3 | 3 | 2 | .3 | .7 | .4 | | 4 | 4 | 1 | .35 | .65 | .3 | | 5 | 5 | 0 | .38 | .62 | .24 | |

#### Daily schedules

Decalendar recommends waking up at Dot 2 and going to bed at Dot 8. This recommendation allots 4 dimes (9.6 hours) for falling asleep and sleeping. To keep daily schedules symmetrical, the time spent awake should be split evenly before and after work. People following Schedule 3 would thus have 10 cents (2.4 hours) to prepare for work and another 10 cents to prepare for bed. [Table 13](#tbl-daily) shows the recommended Schedule 3 daily schedule. Schedule 4 and Schedule 5 allot even more time, 15 cents (3.6 hours) and 18 cents (4.32 hours), respectively, for before-work and after-work activities. The recommended sleep schedule does not fit well with Schedule 2, but this incompatibility does not have to result in a sleep deficit. If the Schedule 2 workdays are not consecutive, people following Schedule 2 can catch up on sleep on their days off by going to bed early before and sleeping in after every workday.

#### [Table 13](#tbl-daily)

|  |
| --- |
| Click to toggle table expansion |
| Table 13: The workday schedule   | Start | End | Duration | Description | | --- | --- | --- | --- | | .2 | .3 | .1 | Wake up and prepare for work | | .3 | .7 | .4 | Work | | .7 | .8 | .1 | End work and prepare for bed | | .8 | .2 | .4 | Go to bed and sleep | |

## 5.5 Subyear units

In addition to serving as a part of the Gregorian date coordinate system described above, months can also indicate the current season or quarter. Deks can also serve as indicator of subyear units like seasons.

### 5.5.1 Seasons

We can use [Table 5](#tbl-greg2doty) to convert any Gregorian calendar date to a positive doty number. This is especially useful for variable dates that have to be converted every year. For example, the dates of the solstices, the longest and shortest days of the year, vary slightly every year. Instead of calculating the exact doty number of the solstices ourselves we could translate from existing Gregorian calendar dates. Solstices and equinoxes (the points in between the solstices) are the basis of the some holidays, such as [Nowruz](https://en.wikipedia.org/wiki/Nowruz).

The dates of the solstices and the equinoxes can be used as definitions of the seasons. Each season has its opposite. The opposite of Spring is Fall and the opposite of Summer is Winter. These opposites are always occurring simultaneously, one opposing season in the Northern hemisphere and the other in the Southern hemisphere. [Table 14](#tbl-soleq) lists the opposing seasons in the North and South columns (which correspond to the Northern and Southern hemispheres) and the approximate dates of the solstices and the equinoxes that mark the start of each season.

#### [Table 14](#tbl-soleq)

|  |
| --- |
| Click to toggle table expansion |
| Table 14: Solstice and equinox Gregorian calendar and doty dates   | Code | North | South | doty | dotm | Date | Event | | --- | --- | --- | --- | --- | --- | --- | | S0 | Spring | Fall | 19 | 0+19 | March 20 | Northward Equinox | | S1 | Summer | Winter | 111 | 3+19 | June 20 | Northward Solstice | | S2 | Fall | Spring | 205 | 6+21 | September 22 | Southward Equinox | | S3 | Winter | Summer | 295 | 9+20 | December 21 | Southward Solstice | |

Using the information in [Table 14](#tbl-soleq), we can group the deks and pents in a year according to the seasons in which they occur. We identify deks using the first 2 digits of the 3-digit day number of any day in that dek. The pent number is twice the dek number plus one if the dotd is greater than 4 (). For example, Day 19 is the last day in Dek 1 and Pent 3, while Day 111 is the second day in Dek 11 and Pent 22.

We can round up the start of the first season and round down the start of the second season to obtain the division of pents by season as summarized in [Table 15](#tbl-season) It is important to note that the last season starts in Pent 59 of one year and ends with Pent 3 of the subsequent year. In common years, each season in [Table 15](#tbl-season) has 18 pents (90 days), except for the season in the second row, which has 19 pents (95 days). In leap years, the season in the last row of [Table 15](#tbl-season) has 18.2 pents (91 days).

#### [Table 15](#tbl-season)

|  |
| --- |
| Click to toggle table expansion |
| Table 15: The pents that begin and end each season   | Code | North | South | First | Last | Duration | | --- | --- | --- | --- | --- | --- | | S0 | Spring | Fall | 4 | 21 | 18 | | S1 | Summer | Winter | 22 | 40 | 19 | | S2 | Fall | Spring | 41 | 58 | 18 | | S3 | Winter | Summer | 59 | 3 | 18 | |

### 5.5.2 Qops, Delts, Eps and Waus

#### Qops

In contrast to the variable length of seasons, other Decalendar units are constant length. Of these constant length units, qops (qoppas, ϟ) are most like seasons. Qops divide the year into four parts, but unlike seasons, qops do not include Pent 72, the last pent of the year. Pent 72 is not included in the last qop so that each qop is 9 deks and 90 days long. The omission of Dek 36 also maintains the pattern of alternating even and odd numbers in each row. This omission leaves out only 5 or 6 days per year, because Dek 36 overlaps with Dek 0. [Table 16](#tbl-q) shows the division of deks by qop.

#### [Table 16](#tbl-q)

|  |
| --- |
| Click to toggle table expansion |
| Table 16: The deks that begin and end each qop   | Code | First | Last | | --- | --- | --- | | Q0 | 0 | 8 | | Q1 | 9 | 17 | | Q2 | 18 | 26 | | Q3 | 27 | 35 | |

#### Delts

In addition to qops shown above, Decalendar describes 3 other similar units called delts (deltas, δ), eps (epsilons, ε), and waus (ϛ). These units do not leave out as many days in each year, because they split the year by day, rather than by dek. Delts, eps, and wau split the year into 4, 5, and 6 parts, respectively. Delts are 91 days long and leave out one day at the end of common years and two days at the end of leap years. Just as above, leaving out a small number of days at the end of the year preserves a pattern that can be useful for remembering the days on which delts start and end. [Table 17](#tbl-d) list the numbers of the days that begin and end each delt. In [Table 16](#tbl-q), not only do rows alternate between even and odd numbers, but the delt number is the last digit of both the start and the end day of the delt.

#### [Table 17](#tbl-d)

|  |
| --- |
| Click to toggle table expansion |
| Table 17: The days that begin and end each delt   | Code | First | Last | | --- | --- | --- | | D0 | 0 | 90 | | D1 | 91 | 181 | | D2 | 182 | 272 | | D3 | 273 | 363 | |

#### Eps

Unlike delts, eps are 73 days long and do not leave out any days from common years. Qops, delts, and eps all leave out leap days in leap years. [Table 18](#tbl-e) list the numbers of the days that begin and end each ep.

#### [Table 18](#tbl-e)

|  |
| --- |
| Click to toggle table expansion |
| Table 18: The days that begin and end each ep   | Code | First | Last | | --- | --- | --- | | E0 | 0 | 72 | | E1 | 73 | 145 | | E2 | 146 | 218 | | E3 | 219 | 291 | | E4 | 292 | 364 | |

#### Waus

The only unit that can include the leap year is a wau (ϛ), which is 61 days long and follows a similar pattern as a delt, except the last wau in common years is 1 day short than all the others. [Table 19](#tbl-w) list the numbers of the days that begin and end each wau. As with delts, the wau number is the last digit of the numbers of its first and last day.

#### [Table 19](#tbl-w)

|  |
| --- |
| Click to toggle table expansion |
| Table 19: The days that begin and end each wau   | Code | First | Last | | --- | --- | --- | | W0 | 0 | 60 | | W1 | 61 | 121 | | W2 | 122 | 182 | | W3 | 183 | 243 | | W4 | 244 | 304 | | W5 | 305 | 365 | |

All of the subyear unit codes can be preceded by a year and followed by a day number. The midpoint of common years is noon on the first day of Delt 2, D2+00.5 or +182.5, and the midpoint of leap years is midnight of the first day of Wau 3, W3+00.0 or +183.0. The first day of Spring in northern hemisphere and Fall in the southern hemisphere in the year 2000 is 2000S0+00 or 2000+020, while the last day of this season is 2000S0+89 or 2000+109. The subyear units are essentially date intervals, series of contiguous dates. Decalendar includes very powerful approaches to describing series of dates, times, and stamps.

# 6. Series

A single doty number, such as Day 0, implies a duration on 1 day. We can indicate a duration of multiple days by listing consecutive days in a series. A series consists of dates, times, or stamps separated by commas (,). The items in a series should all be of the same type. In other words, series should be homogeneous and not mix dates, times, and stamps. The first 3 days of the year in the form of a series would be written 0,1,2, while the last three days would be -3,-2,-1. The first half a day, from midnight to noon, could be written 0,.1,.2,.3,.4.

## 6.1 Slices

Instead of listing every single day in a series, we can “slice” from Day 0 up to but not including Day 3 by writing :3. Simple slices consist of a start and a stop separated by a colon (start:stop). When the start is omitted, slices begin at the first value, which in the context of a year is Day 0 and in the context of a day is midnight. Therefore, writing :3 is the same as writing 0:3, both represent the first 3 days of the year: 0,1,2. Using this approach, we can shorten the series 0,.1,.2,.3,.4 to :.5. If we omit the stop, instead of the start, we would “slice” up to and including the last value.

In the context of doty dates, omitting the stop value obtains all of the days in the year after the start, because the default stop is the number of days in the year (n). For example, the slice 3: has a start of Day 3 and a stop of n, and thus represents every day in the year except the first 3. The number of items we obtain from a slice is called a span. To calculate the span, we subtract the start from the stop (). In a common year, the span of 003: is , while in a leap year it would be . If both the start and the stop are omitted, every day is included (). [Table 20](#tbl-4slice) lists the seasons, qops, and delts in the form of slices. The superscript plus sign (⁺) in [Table 20](#tbl-4slice) indicates a number that has to be incremented in leap years.

#### [Table 20](#tbl-4slice)

|  |
| --- |
| Click to toggle table expansion |
| Table 20: The slices that represent the 4-part subyear units   | Index | Season | Qop | Delt | | --- | --- | --- | --- | | 0 | 20:110 | :90 | :91 | | 1 | 110:205 | 90:180 | 91:182 | | 2 | 205:354 | 180:270 | 182:273 | | 3 | 295:385⁺ | 270:360 | 273:364 | |

## 6.2 Steps

The simple slices (start:stop) described above are a type of time segment, an unbroken time interval. To break up a simple slice into a non-consecutive series, we can add a step value and create a stepped slice (start:stop:step). Stepped slices move in step-sized “steps” starting from start, skipping over items with each “step”, keeping only items that are “stepped” on.

In other words, stepped slices keep items whose index (zero-based position) in the slice is evenly divisible by step. A step value of 1 keeps every item, because every index is divisible by 1, and a step of 2 keeps every other item, those with even-numbered indexes. Day 0 and every other third day in the year thereafter (Day 3, Day 6, etc.) can be represented by the slice ::3.

To create a series of times on days throughout the year, we can use a slice with a series of steps. The slice :365:1,1,3 represents all of the Decalendar workdays in a year. It is necessary to specify 365 as the stop, so that Leap Day (Day 365) is not included as a workday in leap years. Similarly, 3::1,4 is a seq that represents all of the regular restdays, not including the Leap Day holiday.

Stepped slices cannot be included in series, because both use commas (,) and it would not possible to differentiate a series of steps from subsequent items in the series. The simple rule is that slices with more than 1 colon (:) cannot be part of a series. For example, :365:1,1,3 is a stepped slice with a series of 3 steps rather than a series consisting of a slice and two numbers.

## 6.3 Spreads

To create series of consecutive items with breaks in between, it may be better to use a spread than a slice. Simple spreads consist of either a start and a span (start>span) separated by a greater-than sign (>) or a stop and a span (stop<span) separated by a less-than (<) sign. The default start and stop values are the same for both slices and spreads. We can spread forward from the default start to capture the first span days in a year. For example, the first 3 days in a year can be represented by the spread >3, which is synonymous with the slice :3. In this example, the start is 0, while the stop and the span are both 3. In addition to default start and stop values, spreads also have default span values. A spread that only uses default values (> or <) will include every day in the year (). [Table 21](#tbl-4spread) lists the seasons, qops, and delts in the form of spreads.

#### [Table 21](#tbl-4spread)

|  |
| --- |
| Click to toggle table expansion |
| Table 21: The spreads that represent the 4-part subyear units   | Index | Season | Qop | Delt | | --- | --- | --- | --- | | 0 | 20>90 | >90 | >91 | | 1 | 110>95 | 90>90 | 91>91 | | 2 | 205>90 | 180>90 | 182>91 | | 3 | 295>90⁺ | 270>90 | 273>91 | |

If we “spread” forward from a positive start, the default span is . If we spread backward from a positive stop, the default span is stop. We can spread backward from the default stop to capture the last span days in a year. For example, <3 represents the last 3 days of any year. We could also use a negative start of -3, the third to last day of any year, to create the slice -3: and the spread -3>, both of which are synonymous with <3. One advantage of spreads over slices is the ability to access days from the end of a year without negative numbers. A span value of zero does not return any items. Negative span values reverse the direction of the first sign, turning start into stop and vice versa.

## 6.4 Splits

As with stepped slices, we can create non-consecutive series by “splitting” a simple spread (start>span or stop<span) into split spread (e.g. start>span>split) with a split value that works like the opposite of a step. While steps keep items that are “stepped” on, splits exclude items that are used to create the boundaries of the splits. The default split value is span, meaning that the entire span is included in one split.

A split spread with a split value of 1 (start>span>1) is the same as a stepped slice with a step value of 2 (start:stop:2). Split values greater than 1 but less than span will yield a series of segments. If split is zero (start>span>0), the split spread will not return any items. A negative split value reverses the direction of the second greater-than sign (start>span>-2 and start>span<2 are synonymous). This can be useful when providing a series of split values. Negative split values reverse the direction of a split and a split value of zero skips a split. Just like stepped slices, split spreads cannot be included in a series, because every split can have a series of values.

The direction of the second sign in split spreads determines whether we begin creating splits from the start (>) or the stop (<) of the span. If the first two values (start and span or stop and span) are blank, the direction of the first sign does not matter and the first two signs can be combined into a “much greater-than sign” (≫), a “much less-than sign” (≪), a diamond (♢), or simply an x. The split spreads ≫4 and ♢4 are synonymous; both skip every 5th day to create groups of 4 days throughout the year starting with the first 4 days of the year >4. Notably, ≫4 and ♢4 will always end with a segment containing the last 4 days of common years, 360:364, 360>4, or 364<4, even in leap years, because partial splits are not allowed.

## 6.5 Spaces

The patterns described above require that splits are separated by the default space value of 1. We can specify a different space value in the form start>span>split>space. The split spreads ≫3>2 and ♢3>2 create 3-day splits separated by 2-day spaces. This is the pattern of workdays in the Decalendar system. The first segment of ≫3>2 and ♢3>2 can be written as :3, >3, or 3<, while the last segment is 360:363, 360>3, or 363<3. The workdays in the first dek of ≫3>2 and ♢3>2 can be written as the following series of segments: :4,5:8, >3,5>3, or 3<,8<3. Unlike stepped slices and split spreads, simple slices and simple spreads can be used in series.

A space value of 0 may also be useful. For example, delts, qops, eps, and waus can be summarized as split spreads as shown in [Table 22](#tbl-constant). When space is zero, the direction of the third sign does not matter. The split spreads ≫61>0, ♢61>0, ≫61<0, and ♢61<0 all represents the waus in a year. Waus divide leap years evenly and eps divide common years evenly. Therefore, x61>0 and x61<0 can represent all of the waus in leap years, just like x73>0 and x73<0 can represent all of the eps in common years. The seasons can be described by a spread with a series of splits and a space of 0: »90,95,90,90⁺>0.

#### [Table 22](#tbl-constant)

|  |
| --- |
| Click to toggle table expansion |
| Table 22: The spreads that represent the constant length subyear units   | Unit | Spread | | --- | --- | | Delt | ≫91>0 | | Qop | ≫90>0 | | Ep | ≫73>0 | | Wau | ≫61>0 | |

If space is greater than zero and the second and third sign are pointing in opposite directions, the resulting time segments will overlap. The split spreads >1>.4<.2 and <1<.4>.2 both result in the same 4 overlapping time segments: :.4, .2:.6, .4:.8, .6:1. Negative values can be used in a series of spaces to temporarily reverse the direction and intersperse overlapping and non-overlapping segments. The split spread >1>.4<.2,-.1 yields two segments that overlap and one segment that does not overlap: :.4, .2:.6, .6:1.

Overlapping segments could be used to plan work shifts that require a hand-off between teams. The segments created by >1>.4<.2 are shifted by two dimes in relation to each other and overlap by 2 dimes. If these segments are in Zone 0 time, they represent the normal workday (.3:.7) for Zone 3 (:.4), Zone 1(.2:.6), Zone -1(.4:.8), and Zone -3(.6:1). Each of these 4 segments could represent a team working during the normal workday in their respective time zone. All but the last team would have two dimes of overlap with the subsequent team.

## 6.6 Sequential spreads and slices

Split spreads can be combined with other spreads into sequences called seq spreads (sequential spreads). The intuition behind seq spreads and is that each item in the first (outer) spread serves as a starting point for the second (inner) spread. The main use of seq spreads is to first “spread” across days and then “spread” across times in those days. We can combine ≫3>2, a split spread that represents the Decalendar workdays, with .3>.4, a simple spread that provides the start and span of the Decalendar workday, to obtain ≫3>2>.3>.4, a seq spread that represents the time spent at work in a Decalendar year.

In this seq spread, the split is the number of workdays (3), the space is the number of restdays (2), the second-to-last number is the start of the workday (.3) and the last number is the workday span (.4). The spread ≫3>2>.3>.4 first starts at midnight of each workday, then moves forward 3 dimes to the new start of Dot 3, and then “spreads” forward by a span of 4 dimes to the new stop of Dot 7. We could replace the start of the workday in ≫3>2>.3>.4 with the end of workday if we reverse the last sign: ≫3>2>.7<.4, because .3>.4 and .7<.4 are synonymous.

We combine the two spreads with > because we want to move forward from the beginning of each workday, instead of backward to the previous day. If we combined ≫3>2 and .3>.4 with <, the resulting spread ≫3>2<.3>.4 would move backward from midnight of each workday to Dot 7 of each previous day and then “spread” forward to Dot 1 of each workday. We may want to use such a mixed direction seq spreads when dealing with time zones. If we lived in Zone -3 and wanted to know how the workdays in Zone 4 translated into our time zone, we could take the spread ≫3>2>.3>.4 and move its start to 7 dimes earlier: ≫3>2<.4>.4. Seq spreads enable such time zone conversions without the use of negative numbers.

The seq slice equivalent of ≫3>2>.3>.4 is :365:1,1,3:.3:.7. Seq spreads will always be a more succinct way for creating long consecutive sequences with breaks than slices. For example, to include a lunch break in the middle of work, we could simply add a split and a space to the seq spread above: ≫3>2>.3>.4>.18>.04. To do the same with a seq slice, we have to create 17 steps of 0.01 and a step of .04: :365:1,1,3:.3:.7:17\*1%,4%. Here, we are using the replication operator (\*) to avoid writing 0.01 17 times and the percent operator (%) to save a few characters, but even so the seq slice is not as concise as the seq spread. [Table 23](#tbl-workday) shows each part of this schedule in the form of simple slices and simple spreads.

#### [Table 23](#tbl-workday)

|  |
| --- |
| Click to toggle table expansion |
| Table 23: A workday schedule with a lunch break   | slice | spread | spread | label | | --- | --- | --- | --- | | .30:.48 | .30>.18 | .48<.18 | work0 | | .48:.52 | .48>.04 | .52<.04 | lunch | | .52:.70 | .52>.18 | .70<.18 | work1 | |

## 6.7 Pomodoro

Another real-life application of spreads can be to intersperse breaks in between periods of work as in the [Pomodoro technique](https://en.wikipedia.org/wiki/Pomodoro_Technique). The times spent working and resting can vary, but a reasonable translation of the original Pomodoro into the Declock units would be to have each pomodoro consist of 17 mils of work and 3 mils of rest, with a 17 mil break after every 4 pomodoros. To repeat 16 pomodoros throughout the Decalendar workday, we could use the following seq spread: .3>.7>.08>.02⋙.017>.003. Here, we use the “very much greater-then sign” (⋙) instead of a combination of a “much greater-than sign” (≫) and a greater-than sign (>). The pomodoro pattern is difficult to capture with a slice because we have to use \* for the steps of the inner and the outer slice: .3:.7:8\*.01,.02:::17\*.001,.003.

### 6.7.1 Replication operator

The replication operator (\*) is very useful for replacing repetitive values. For example, to divide any year into six parts we could use the spread ≫5\*61,60⁺>0 to create 5 “splits” that are all 61 days long and one last “split” that is 60⁺ days (60 days in a common year or 61 days in a leap year) long. The \* helps us avoid the repetitiveness of writing ≫61,61,61,61,61,60⁺>0. In addition to being used in the split and space of a split spread or the step of a stepped slice, the \* can also be used in the span of a split spread or the stop of a stepped slice to indicate has many cycles of splits or steps we want to complete. For example, >4\*>5\*61,60⁺>0 indicates that we want 4 years (the current year and the 3 subsequent years) “split” into 6 parts for a total of 24 parts. In other words, 4\* means that we want to stop cycling after completing four yearly cycles. We can read 4\* out loud as “four times” because it means we intend to go through the yearly cycle “four times”.

### 6.7.2 Percent, permil, and permyr operators

We can make the seq spread above even shorter by using the per operators: %, ‰, and ‱. Most of the values in .3>2\*>.08>.02⋙.017>.003 are either percents (.01 or ¹/₁₀₀) or permils (.001 or ¹/₁₀₀₀) of a day, we can therefore rewrite this seq spread as .3>2\*>8%>2%⋙17‰>3‰. It may be difficult to write the permil (‰) operator (hex: 2030, html: &permil;, vim: %0, compose: %o), because it does not appear on a typical keyboard, so it is also possible to write .3>2\*>8%>2%⋙17‰>3‰ as .3>2\*>8%>2%⋙17m>3m, with the letter m, which stands for mil, replacing ‰. In addition to the percent (%) and permil (‰) operators, there is also the permyr (‱) operator, which is short for permyriad and represents Declock phrases (10⁻⁴).

### 6.7.3 Pently schedules as seq spreads, splices, and sleds

We can use seq spreads to describe the [pentlyschedules](#sched). Schedule 5 is particularly interesting because it includes all of the days of the year. Spreads that include every item can be written as > or <, but seq spreads must have at least 5 values. The Schedule 5 seq spread ≫≫.38>.24 has 4 blank values, which represent the default start, span, split, and space. Similarly, the Schedule 4 seq spread ≫4≫.35>.3 has 3 blank values, which represent the default start, span, and space. The Schedule 2 and Schedule 3 seq spreads, ≫2>3>.2>.6 and ≫3>2>.3>.4, respectively, only have 2 blank values, the start and the span. As an alternative to seq spreads and seq slices, we can use slice-spread hybrids called sleds or spread-slice hybrids called splices. Sleds put the slice elements first (start:stop:step:start>span>split>space), while splices start with the spread elements (start>span>split>space>start:stop:step). The pentlyschedules are easiest to write as seq spreads and splices, as shown in [Table 24](#tbl-sched).

#### [Table 24](#tbl-sched)

|  |
| --- |
| Click to toggle table expansion |
| Table 24: The seq spreads, splices, and sleds that represent the 4 pently schedules   | Schedule | seq spread | splice | sled | seq slice | | --- | --- | --- | --- | --- | | 2 | ≫2>3>.2>.6 | ≫2>3>.2:.8 | :365:1,4:.2>.6 | :365:1,4:.2:.8 | | 3 | ≫3>2>.3>.4 | ≫3>2>.3:.7 | :365:1,1,3:.3>.4 | :365:1,1,3:.3:.7 | | 4 | ≫4≫.35>.3 | ≫4≫.35:.65 | :365:3\*1,2:.35>.3 | :365:3\*1,2:.35:.65 | | 5 | ≫≫.38>.24 | ≫≫.38:.62 | :365::.38>.24 | :365::.38:.62 | |

## 6.8 Yearly transition

### 6.8.1 Common years

The pently schedules are important for the transition between years. In common years, the last dek of the year (Dek 36) contains the last pent of the current year (Pent 72), and the first pent of the subsequent year (Pent 0). If these two pents follow the default pently schedule, Schedule 3, the natural rhythm of 3 workdays followed by 2 rest days continues undisrupted. [Table 25](#tbl-common) shows the positive and negative doty numbers, names, and types (work or rest) of the days in Dek 36 in common years. Notably, while the positive doty numbers continue counting past the end of the year, the negative doty numbers of the current year turn into the positive doty numbers of the subsequent year. The negative doty numbers in Dek 36 can thus serve as the bridge from the one year to the next.

#### [Table 25](#tbl-common)

|  |
| --- |
| Click to toggle table expansion |
| Table 25: The days in Dek 36 in common years   | Pos | Neg | Name | Type | | --- | --- | --- | --- | | 360 | -5 | Nulday | work | | 361 | -4 | Unoday | work | | 362 | -3 | Duoday | work | | 363 | -2 | Triday | rest | | 364 | -1 | Quaday | rest | | 365 | 0 | Nulday | work | | 366 | 1 | Unoday | work | | 367 | 2 | Duoday | work | | 368 | 3 | Triday | rest | | 369 | 4 | Quaday | rest | |

### 6.8.2 Leap years

In leap years, Dek 36 contains the last 6 days of the current year and the first 4 days of the subsequent year. Interestingly, Dek 36 always contain 6 workdays and 4 restdays, just like every other dek, but in leaps years these days do not follow the typical order of Schedule 3. Leap years end in 3 restdays instead of 2, because Leap Day (Day 365) is always a holiday. Leap day is always a Penday and always followed by a Nulday. After Leap Day, the normal rhythm of Schedule 3 resumes. [Table 26](#tbl-leap) shows the positive and negative doty numbers of the days in Dek 36 in leap years, as well as their names and their types (work or rest).

#### [Table 26](#tbl-leap)

|  |
| --- |
| Click to toggle table expansion |
| Table 26: The days in Dek 36 in leap years   | Pos | Neg | Name | Type | | --- | --- | --- | --- | | 360 | -6 | Nulday | work | | 361 | -5 | Unoday | work | | 362 | -4 | Duoday | work | | 363 | -3 | Triday | rest | | 364 | -2 | Quaday | rest | | 365 | -1 | Penday | rest | | 366 | 0 | Nulday | work | | 367 | 1 | Unoday | work | | 368 | 2 | Duoday | work | | 369 | 3 | Triday | rest | |

## 6.9 Holidays

Leap Day is a important holiday because it occurs only once every four years except for years that start centuries not divisible by 400 and it results in the only time when there are 3 consecutive restdays in Decalendar. Another Decalendar holiday that only occurs in leap years is Dyad Day. At noon on Dyad Day, the positive and negative .y format stamps are the same (+183.5 and -183.5), meaning that 183.5 days have passed in the year and 183.5 days remain in the year. Unlike Leap Day, Dyad Day is naturally a day off. Many Gregorian calendar holidays just so happen to also fall on the first day of a pent (Nulday or Quaday). [Table 27](#tbl-holiday) lists 8 such holidays and their doty, dotm, and Gregorian calendar dates.

#### [Table 27](#tbl-holiday)

|  |
| --- |
| Click to toggle table expansion |
| Table 27: Gregorian calendar holidays that happen to fall on Decalendar restdays   | Name | doty | dotm | date | | --- | --- | --- | --- | | Cinco de Mayo | 65 | 2+04 | May 5 | | Flag Day | 105 | 3+13 | June 14 | | Juneteenth Day | 110 | 3+18 | June 19 | | Independence Day | 125 | 4+03 | July 4 | | All Saints’ Day | 245 | 8+00 | November 1 | | Veterans’ Day | 255 | 8+10 | November 11 | | Boxing Day | 300 | 9+25 | December 26 | | New Year’s Eve | 305 | 9+31 | December 31 | |

Any holiday with a fixed (rather than floating) date in the Gregorian calendar can easily be added to Decalendar. Holidays with floating dates do not follow easily recognizable patterns. Decalendar recommends redefining such dates to always be on the same doty every year. For example, November 25 (Day 269) is a sensible fixed date for Thanksgiving, because it is exactly 30 days before Christmas (December 25, Day 299) and falls on a Decalendar restday. When assigning fixed dates to floating date holidays, we should choose Decalendar restdays to avoid disrupting the normal rhythm of the pently schedules. Instead of gaining days off because of holidays, workers should gain additional time off from their employers. In the United States, the 11 federal holidays (88 hours = 3.6̅ dimes) would translate to 9 Schedule 3 days offs (3.6 dimes).

# 7. References

Hinnant, Howard. 2014. “Chrono-Compatible Low-Level Date Algorithms.” <http://howardhinnant.github.io/date_algorithms.html>.