`Decalendar` and `Declock`

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1 Summary

`Decalendar` is a 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. 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 Page load timestamp

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.

This `Decalendar` timestamp increments every one ten thousandth (10^{-5}) of a day (centimilliday), which is `Decalendar` is called a `beat`.

1.1.2 Date conversion

Enter a Gregorian calendar 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` ($1969 + 306/365$) is equivalent to the `doty` date `1969+306`.

1.2 Day of the year

Figure 1 shows the components of the doty number that corresponds to midnight on January 1st in the Gregorian calendar. The first two digits (hundreds and tens) of the doty are the dek number (30 in Figure 1). 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), 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).

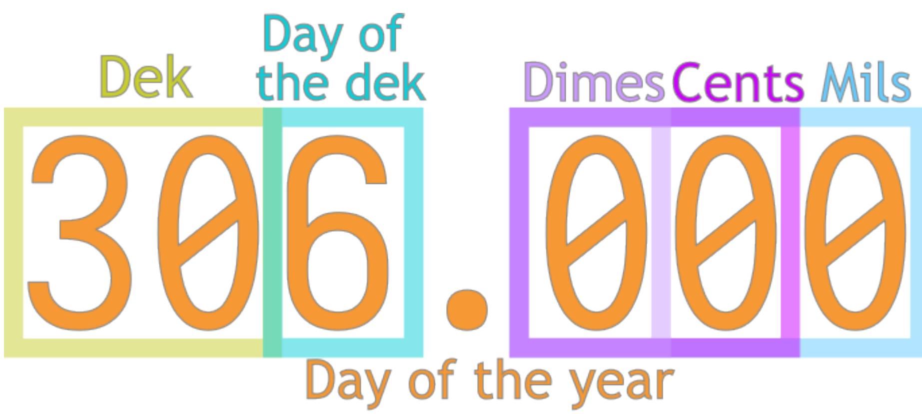


Figure 1: The components of a day-of-the-year (doty)

1.3 Deks

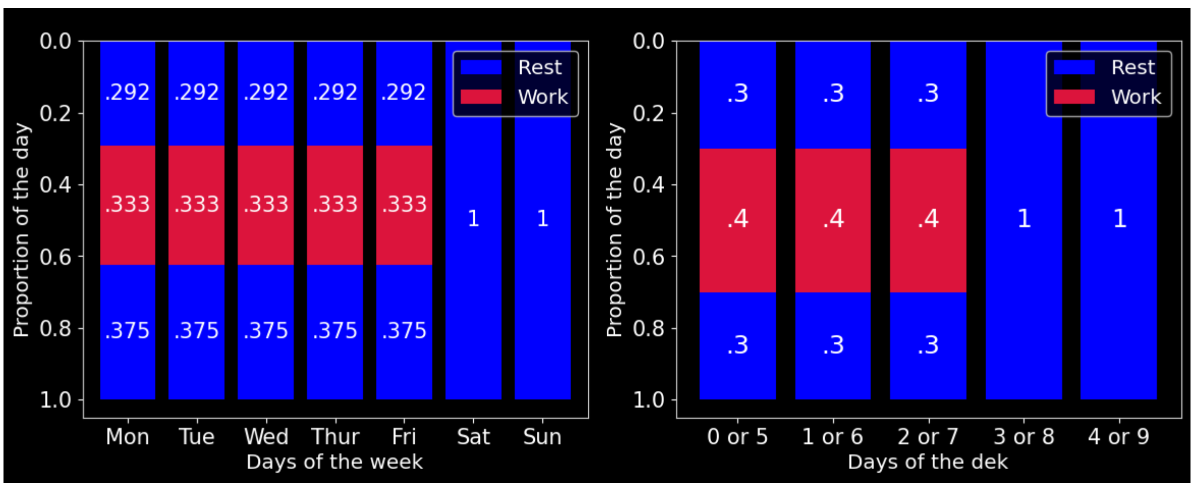
As mentioned in Section 1.2, deks function as both months and weeks in Decalendar. A dek consists of 2 groups of 5 days called pents. Each pent can follow a sequence of workdays and restdays called a pently schedule. The code in Example 1.1 generates Figure 2 which compares the typical weekly schedule 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 (.3), and 7/24 (0.2916). In contrast, the proportions of the day in pently schedules are never 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 provides more information on Schedule 3 and the other pently schedules.

Example 1.1.

```python
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,
        }
```

```python
    )
    .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 shows how a Declock fractional day time can be combined with a time zone offset. The +0 at the end of the time in Figure 3 indicates that the time is in the Zone 0 time zone, which is equivalent to the UTC+00:00 time zone of Coordinated Universal Time (UTC).

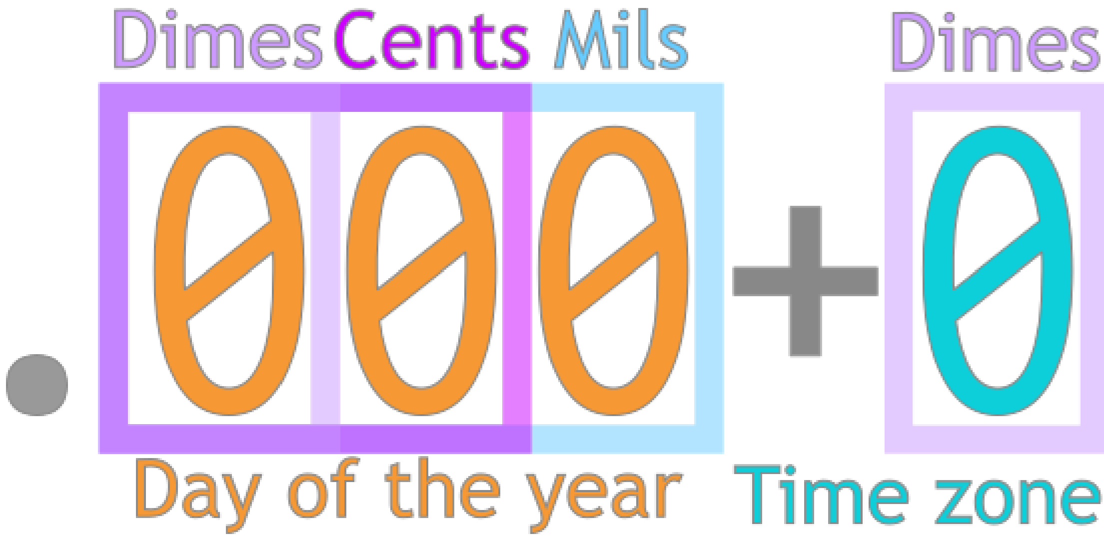


Figure 3: The components of a Declock time

1.5 Decalendar ordinal date

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

Table 1

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

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 10^x, where x is the number of digits in the numerator. In both systems, only the numerator, not the denominator, is provided. In the context of`Decalendar`, the numerator is the days that have passed in the year, while in the context of`Declock`, 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 expressed as decimal numbers. The 5 in `Dot 5` can be thought of as a number after a decimal (0.5) or a numerator (/), 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 ($.5 \pm .05$), because any time after `Dot 45` and before `Dot 55` ($[.45, .55)$) 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` ($[.5, .6)$) 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; 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 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 in computer programming in that they label the days of the year from $-N$ to -1, where N is the number of the days in the current year. The first `doty` is indexed by both 0 and $-N$, while the last `doty` is indexed by both -1 and N.

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 to the end of the day. To extend the fractions analogy in Section 2.1 to negative numbers, the negative number added to the whole gives us the numerator of the positive fraction ($pos = N + neg$). 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 (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 and Table 1, 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, highlights the relationship between the two:

Table 2

Click to toggle table expansion

Table 2: The units of `Decalendar` and `Declock`

Quantity	Name	Symbol	Formal Name
100	hekt		hectoday
91	delt		deltakeraiayear
90	qop		qoppaday
80	pi		piday
73	ep		epsilonkeraiayear
70	om		omicronday
61	wau		waukeraiayear
60	xi		xiday
50	nu		nuday
40	mu	M	muday
30	lam		lamdaday
20	kap		kappaday
10	dek	,	decaday
1	day	d,	day
10^{-1}	dime	,	deciday
10^{-2}	cent	¢, %	centiday

10^{-3}	mil	m, ‰	milliday
2×10^{-4}	period	.	didecimilliday
10^{-4}	phrase	,	decimilliday
2×10^{-5}	bar	|	dicentimilliday
10^{-5}	beat		centimilliday
10^{-6}	mic		microday
10^{-7}	liph	m̄	decimicroday
10^{-8}	lib	m̈	centimicroday
10^{-9}	nan	n	nanoday
10^{-10}	roph	⌢	decinanoday
10^{-11}	rob	µ̈	centinanoday
10^{-12}	pic	p	picoday
10^{-13}	noph	n̄	decipicoday
10^{-14}	nob	n̈	centipicoday
10^{-15}	femt	f	femtoday
10^{-16}	coph	p̄	decifemtoday
10^{-17}	cob	p̈	centifemtoday
10^{-18}	att	a	attoday
10^{-19}	foph	f	deciattoday
10^{-20}	fob	f	centiattoday
10^{-21}	zept	z	zeptoday
10^{-22}	toph	ā	decizeptoday
10^{-23}	tob	ä	centizeptoday
10^{-24}	yokt	y	yoctoday
10^{-25}	zoph	z̄	deciyoctoday
10^{-26}	zob	z̈	centiyoctoday
10^{-27}	ront	r	rontoday
10^{-28}	yoph	ȳ	decirontoday
10^{-29}	yob	ÿ	centirontoday
10^{-30}	quek	q	quectoday

In Table 2, 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 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` ( ) are ten times larger (10% = 144 minutes), and `deks` ( ) 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 69.4 (69 / 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.

`Declock` units smaller than `beats` are too small for typical daily use. For example, a `mic` (`microday`,) 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`, m̃). 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`,˜) 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 (-12:00 to +14:00) into 11 time zones (`Zone -5` to `Zone 6`) by converting hours into `dimes` ($dimes = hours \div 2.4$) and rounding to the nearest whole number ($dimes = \lfloor hours \div 2.4 \rceil$). 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, 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` ($mils = degrees \div .36$). 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 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 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. Table 3 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

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 ( ) 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) of a day, whereas the French Republican calendar calls these units decimal hours, decimal minutes, *décimes*, and decimal seconds, respectively. Table 4 shows the start times of each `dime` ( ) in a day and its equivalent in 24-hour and 12-hour standard time.

Table 4

Click to toggle table expansion

Table 4: The `dimes` in a day and their standard time equivalents

	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 uses the term ".beats" to describe a thousandth of day (10 ^{3}). In `Declock`, a `beat` is a hundred thousandth of a day (10), 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, 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.

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 or x and y in the Cartesian coordinate system. The `Decalendar` ordinal (`deco`) date format provides two coordinates in one number: the day-of-the-year (`doty`). Table 5 shows the `doty` number of all Gregorian calendar dates.

To locate a specific date in Table 5, 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 and then move to the right to the `dotd` (the last digit of the `doty`). The dates in Table 6 are shown in `mm-dd` format.

Table 5

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

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, we can convert between Gregorian calendar dates and `Decalendar doty` dates programmatically. The code in Example 4.1 is derived from the `days_from_civil` and `civil_from_days` algorithms described by Howard Hinnant in *chrono-Compatible Low-Level Date Algorithms* (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 4.1.

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

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

greg2doty()
```

306

doty2greg

```python
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

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

greg2doty()
```

Unable to display output for mime type(s): text/html

doty2greg

```r
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()
```

```
Unable to display output for mime type(s): text/html
```

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. 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 ($dy = gy - [gm < 3]$). 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 ($gy = dy + [dm > 305]$). Code to convert between `Decalendar` and Gregorian calendar years is provided in Example 4.2.

Table 7

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 4.2.

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

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

greg2year()
```

1969

doty2year

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

doty2year()
```

1970

R

greg2year

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

greg2year()
```

```
Unable to display output for mime type(s): text/html
```

doty2year

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

doty2year()
```

```
Unable to display output for mime type(s): text/html
```

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 or the `year2bool` function in Example 4.3.

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`.

$$y \mod 4 = 0 \land year \mod 100 \neq 0 \lor year \mod 400 = 0 \tag{1}$$

Example 4.3.

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()
```

```
Unable to display output for mime type(s): text/html
```

4.4 ISO 8601

4.4.1 Years

Both `Decalendar` and ISO 8601 dates show years as 4-digit numbers. Unlike ISO 8601, `Decalendar` does not require years to be included in dates. As shown in Table 1, `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 (`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 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, Equation 3, and Example 4.4. 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 4.4, the `isoo2doty` and `doty2isoo` functions convert between ISO 8601 ordinal day numbers and `doty` numbers. We use the `year2bool` function from Example 4.3 in Example 4.4 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.

$$(isoordinal + 305 - year2bool(year)) \mod 365 \tag{2}$$

$$(doty + 60 + year2bool(year + 1)) \mod 365 \tag{3}$$

Example 4.4.

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`

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

isoo2year()
```

1969

isoo2doty

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

isoo2year()
```

1969

doty2isoo

```julia
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

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

isoo2year()
```

1969

isoo2doty

```python
def isoo2doty(year=1970, day=1):
    return (day + 305 - year2bool(year)) % 365

f"{isoo2year():>04}+{isoo2doty():>03}"
```

```
'1969+306'
```

doty2isoo

```python
def doty2isoo(year=1970, doty=0):
    return (doty + 60 + year2bool(year + 1)) % 365

f"{doty2year():>04}+{doty2isoo():>03}"
```

```
'1970+060'
```

R

isoo2year

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

isoo2year()
```

```
Unable to display output for mime type(s): text/html
```

isoo2doty

```r
isoo2doty <- function(year = 1970, day = 1) {
    (day + 305 - year2bool(year)) %% 365
}

paste0(sprintf("%04d", isoo2year()), "+", sprintf("%03d", isoo2doty()))
```

```
Unable to display output for mime type(s): text/html
```

doty2isoo

```r
doty2isoo <- function(year = 1970, doty = 0) {
    (doty + 60 + year2bool(year + 1)) %% 365
}

paste0(sprintf("%04d", doty2year()), "+", sprintf("%03d", doty2isoo()))
```

```
Unable to display output for mime type(s): text/html
```

4.4.3 Calendar dates

ISO 8601 calendar dates (`isoc`) 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 4.1 and Example 4.2 to convert between `deco` dates and `isoc` dates, as shown in Example 4.5. The code in Example 4.5 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, `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. Examples of the `decc` format are provided in Section 5.3. To be clear, the `decc` format is only used to display Gregorian calendar dates and otherwise does not play any role in `Decalendar`.

Example 4.5.

JavaScript

greg2deco

```javascript
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())
    )
```

```
Unable to display output for mime type(s): text/html
```

ISO 8601 date

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

```
Unable to display output for mime type(s): text/html
```

4.4.4 Time zones

`Isoc` dates can be combined with the ISO 8601 time (`isot`) format (`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 that represents the UTC+00:00 time zone, which is the basis of Coordinated Universal Time (UTC).

`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 4.6 converts between UTC offsets and military time zone codes. Section 3 provides more information on `Declock` time zones.

Example 4.6.

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()
```

```
Unable to display output for mime type(s): text/html
```

zone2hour

```r
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()
```

```
Unable to display output for mime type(s): text/html
```

4.4.5 Times

The formula for conversion of standard time to `Declock` time is shown in Equation 4. The value of `x` in Equation 4. can be modified to obtain different units, which are displayed in Table 8. To convert `Declock` time into standard time, we first convert into hours using Equation 5 and the appropriate `x` value from Table 8. Then, we convert hours into minutes with Equation 6 and minutes into seconds with Equation 7 The `hmso2doty` and `doty2hmso` functions in Example 4.7 uses these formulas to convert between standard time and `Declock` time.

$$declock = \frac{hour}{24} + \frac{minute}{1440} + \frac{second}{86400} \cdot 10^x \tag{4}$$

$$hour = declock \cdot 24 \cdot 10^x \tag{5}$$

$$minute = \frac{hour - \lfloor hour \rfloor}{60} \tag{6}$$

$$second = \frac{minute - \lfloor minute \rfloor}{60} \tag{7}$$

Table 8

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 4.7.

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()
```

Unable to display output for mime type(s): text/html

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()
```

Unable to display output for mime type(s): text/html

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 (`.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 4.14.

To create a `deco` timestamp, we can use the `doty2deco` or the `greg2deco` functions as shown in Example 4.8. Similarly, Example 4.8 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 and Section 4.6.5 further discuss timestamps and provide functions for building, parsing, and converting timestamps.

Example 4.8.

JavaScript

doty2deco

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

hmso2doty

```javascript
function hmso2doty(hour = 1, minute = 0, second = 0) {
    return hour / 24 + minute / 1440 + second / 86400
}

console.log(hmso2doty())
```

```
0.041666666666666664
```

hmso2deco

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

doty2hmso

```javascript
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

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

hmso2doty()
```

```
0.041666666666666664
```

doty2hmso

```python
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

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

hmso2doty()
```

```
Unable to display output for mime type(s): text/html
```

doty2hmso

```r
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()
```

```
Unable to display output for mime type(s): text/html
```

4.4.7 Time intervals

ISO 8601 specifies three methods of unequivocally representing 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=`
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 4.9 create such links for Google, Outlook, Office 365, and Yahoo online calendars.

Example 4.9.

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 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 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 is fully implemented in the Pandas Python library. The pandas code shown in Example 4.10 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 4.10.

```
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 is the number of 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 (`dote`). Both Julian and `dote` dates count days from a starting point called an 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 ($dote = julian - 1721120.5$).

Like Julian dates, `dote` dates are very useful for date and time calculations. Equation 8 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 from (Hinnant 2014). Briefly, the `dote` is used to obtain the solar cycle in Equation 9, which is then plugged into Equation 10 and Equation 11 to calculate the `day-of-the-cycle` in (`dotc`) and the `year-of-the-cycle` (`yotc`) in Equation 11. Equation 12 takes the `yotc` and the solar cycle and yields the year, while Equation 13 generates the `doty` from the `yotc` and the `dotc`.

$$dote = doty + (365 \cdot year + \lfloor \frac{year}{4} \rfloor - \lfloor \frac{year}{100} \rfloor + \lfloor \frac{year}{400} \rfloor) \tag{8}$$

$$cycle = \lfloor \frac{\begin{cases} dote & \text{if } dote \geq 0; \\ dote - 146096 & \text{otherwise.} \end{cases}}{146097} \rfloor \tag{9}$$

$$dotc = days - cycle \cdot 146097 \tag{10}$$

$$yotc = \lfloor \frac{dotc - \lfloor \frac{dotc}{1460} \rfloor + \lfloor \frac{dotc}{36524} \rfloor - \lfloor \frac{dotc}{146096} \rfloor}{365} \rfloor \tag{11}$$

$$year = yotc + cycle * 400 \tag{12}$$

$$doty = \lfloor dotc - (365 \cdot yotc + \lfloor \frac{yotc}{4} \rfloor - \lfloor \frac{yotc}{100} \rfloor + \lfloor \frac{yotc}{400} \rfloor) \rfloor \tag{13}$$

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 4.11.

JavaScript

doty2dote

```
function doty2dote(year = 1969, doty = 306) {
    return doty + Math.floor(year * 365 + Math.floor(year / 4) - Math.floor(year / 100) +
}

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 * 40
    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+221.54965+0"
```

Python

doty2dote

```python
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+221.54975+0'
```

R

doty2dote

```r
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"
)
```

```
Unable to display output for mime type(s): text/html
```

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 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.

$$unix = (JD - 2440587.5) \cdot 86400 \tag{14}$$

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" by Howard Hinnant (2014). Briefly, the seconds (or milliseconds) in UNIX time are first converted to `days` ($days = seconds \div 86400$). Then, the `days` are used to obtain the `era` (Equation 9), `day-of-the-era` (Equation 8), `year` (Equation 12), and `doty` (Equation 13).

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. The code in Example 4.12 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 4.12 in action, visit this CodePen which displays the current `deco` (`year+day.ddddd`) and `isoc` (`year-mm-ddThh:mm:ss`) timestamps.

$$time = year \cdot 365 + \sum_{n=1}^{year} \left[\begin{array}{rl} y & \mod 4 = 0 \\ \wedge y & \mod 100 \neq 0 \\ \vee y & \mod 400 = 0 \end{array} \right] \tag{15}$$

Example 4.12.

JavaScript

unix2doty

```
function unix2doty(ms = 0) {
    const days = ms / 86400000 + 719468,
        dote = days - (era = Math.floor((days >= 0 ? days : days - 146096) / 146097)) * 14
        year = Math.floor((dote - dote / 1460 + dote / 36524 - dote / 146096) / 365) + era
    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+221.54950+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 * 40
    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+221.54965+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+221.54975+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"
)
```

Unable to display output for mime type(s): text/html

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) + e
    return math.floor(year), days - math.floor(year * 365 + year / 4 - year / 100 + year /
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)) * 14
        year = Math.floor((dote - dote / 1460 + dote / 36524 - dote / 146096) / 365) + era
    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 4.12 creates a `Decalendar` ordinal (`deco`) timestamp from UNIX time. Example 4.13 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 4.7 along with the desired time zone.

Example 4.13.

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'))+
end

unix2deco()
```

"2023+221.54965+0"

Python

unix2deco

```python
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+221.54975+0'

R

unix2deco

```r
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 4.8. 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 4.14.

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 summarizes the three decimal day-of-the (dot or .) formats:

Table 9

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 , `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 form (Base16 encoded). This means that the first 10 months are represented by the numbers 0 through 9 (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 format (year-mm-dd).

The ordinal numerals of September, October, November, and December in `Decalendar` (Sep=7th, Oct=8th, Nov=9th, Dec=10th) match the numeral prefixes 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, 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. After hexadecimal encoding, January is represented by `A` and February is represented by `B` (mnemonic: `jAn`=January, `feB`=February).

$$m = \begin{cases} mm - 3 & \text{if } month > 2; \\ mm + 9 & \text{otherwise.} \end{cases} \tag{16}$$

$$m = \begin{cases} month + 3 & \text{if } month < 10; \\ month - 9 & \text{otherwise.} \end{cases} \tag{17}$$

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 shows the possible `dotw` values, which range from 0 to 6 or -7 to -1.

Table 10

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 builds on the example from Section 3 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

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, 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 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, 6.6 `cents` (96 minutes) longer than the typical 9-to-5 work schedule (`Dot 375` to `Dot 7083`). In other words, this work schedule starts 75 `mils` (1.8 hours) earlier than 9AM (`Dot 375`) and ends 8.3 `mils` (12 minutes) earlier than 5PM (`Dot 7083`). In a typical 40-hour workweek, workers spend 23.80952381 `cents` per day at work on average, which adds up to 8.6 `deks` (260*8/240) per common year and 8.7 `deks` ($261 \times 8 \div 240$) per leap year. In contrast, workers following `Decalendar` spend 24 `cents` per day at work on average, which totals up to 87.6 `days` ($219 \times .4$) 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 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

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 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

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 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.

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 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

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, 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 ($dek \cdot 2 + dotd > 4$). 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 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 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 has 18.2 pents (91 days).

Table 15

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`,) 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 shows the division of `deks` by `qop`.

Table 16

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,), eps (epsilons,), and waus ( ). 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 list the numbers of the days that begin and end each delt. In Table 16, 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

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 list the numbers of the days that begin and end each `ep`.

Table 18

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` ( ), 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 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

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` ($stop - start$). In a common year, the `span` of `003:` is $n - 3 = 362$, while in a leap year it would be $n - 3 = 363$. If both the `start` and the `stop` are omitted, every day is included ($span = n - 0$). Table 20 lists the seasons, `qops`, and `delts` in the form of `slices`. The superscript plus sign ( ) in Table 20 indicates a number that has to be incremented in leap years.

Table 20

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 $step - 1$ 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 ($span = n$). Table 21 lists the seasons, `qops`, and `delts` in the form of `spreads`.

Table 21

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 $n - start$. 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. 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

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 shows each part of this schedule in the form of `simple slices` and `simple spreads`.

Table 23

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. 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/) or permils (.001 or 1/) 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: `‰`, 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).

6.7.3 Pently schedules as seq spreads, splices, and sleds

We can use `seq spreads` to describe the pentlyschedules. `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 `pently`schedules are easiest to write as `seq spreads` and `splices`, as shown in Table 24.

Table 24

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 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

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 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

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 lists 8 such holidays and their `doty`, `dotm`, and Gregorian calendar dates.

Table 27

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 = 3.6 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.