

Jewish Calendar Demystified

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Counting Hours

Although the day starts at sundown, for mathematical purposes we assume that the day starts at 6 PM and count the hours as follows:

Hour 0: 6 PM	Hour 6: midnite	Hour 12: 6 AM	Hour 18: noon
Hour 1: 7 PM	Hour 7: 1 AM	Hour 13: 7 AM	Hour 19: 1 PM
Hour 2: 8 PM	Hour 8: 2 AM	Hour 14: 8 AM	Hour 20: 2 PM
Hour 3: 9 PM	Hour 9: 3 AM	Hour 15: 9 AM	Hour 21: 3 PM
Hour 4: 10 PM	Hour 10: 4 AM	Hour 16: 10 AM	Hour 22: 4 PM
Hour 5: 11 PM	Hour 11: 5 AM	Hour 17: 11 AM	Hour 23: 5 PM

The Effect of the Moon

Each month starts when the moon is directly between the earth and the sun.

Called the *new moon* or *molad*.

Time between molads is one month

One month is defined to be 29 days, 12 hours, 44 minutes, 3 1/3 seconds.

Working with fractional seconds is awkward.

So instead of dividing the hour into minutes and seconds, let's divide it into halaqim (singular: halek)

One hour is divided into 1080 halaqim, which means that a halek is 3 1/3 seconds.

So by definition, one month is 29 days, 12 hours, 793 halaqim.

The Effect of the Sun

Every 19 years is almost exactly 235 months.

So let's define 235 months to be 19 years as follows:

Year 1: 12 months	Year 11: 13 months (leap year)
Year 2: 12 months	Year 12: 12 months
Year 3: 13 months (leap year)	Year 13: 12 months
Year 4: 12 months	Year 14: 13 months (leap year)
Year 5: 12 months	Year 15: 12 months
Year 6: 13 months (leap year)	Year 16: 12 months
Year 7: 12 months	Year 17: 13 months (leap year)
Year 8: 13 months (leap year)	Year 18: 12 months
Year 9: 12 months	Year 19: 13 months (leap year)
Year 10: 12 months	Total: 235 months

Let's name the months and arbitrarily define the days in a month as follows

Tishri 30 days	Nisan 30 days
Heshvan 29 days	Iyyar 29 days
Kislev 30 days	Sivan 30 days
Tevet 29 days	Tamuz 29 days
Shevat 30 days	Ab 30 days
Adar 1 30 days (leap years only)	Elul 29 days
Adar 2 29 days	

This means that:

A common year = 354 days

A leap year = 384 days

The Drift of Tishri 1

One month is 29 days, 12 hours, 793 halaqim (by definition)

A common year (12 months) is 354 days, 8 hours, 876 halaqim

A leap year (13 months) is 383 days, 21 hours, 589 halaqim

A common year is 8 hours, 876 halaqim too short.

A leap year is 2 hours 491 halaqim too long.

Eventually Tishri 1 will come a day before or a day after the molad of Tishri

Solution

Increase or decrease number of days in a year

Increase: add a day to Heshvan (complete year)

Decrease: subtract a day from Kislev (defective year)

	defective year	normal year	complete year
Heshvan	29	29	30
Kislev	29	30	30
Common year	353	354	355
Leap year	383	384	385

The Four Rules

(1) If molad Tishri occurs on Sunday, Wednesday, or Friday, Tishri 1 must be delayed by one day for the following reasons:

Wednesday or Friday would cause Yom Kippur (Tishri 10) to fall on Friday or Sunday making it impossible to prepare food (because of Sabbath restrictions) for the day after the Yom Kippur fast.

Sunday would cause the seventh day of Succoth (Hashanah Rabba) to fall on the Sabbath.

(2) If molad Tishri occurs at 18 hr (i.e., noon) or later, Tishri 1 must be delayed by one day. If this would cause Tishri 1 to fall on Sunday, Wednesday, or Friday, Tishri must be delayed by a second day because of (1). The reason for this rule is to insure that the new crescent moon is visible before the first day of the year finishes.

(3) If molad Tishri in a common year falls on Tuesday at 9 hr 204 hq (i.e., 3:11:20 AM) or later, then Tishri 1 is delayed by one day for the following reason:

Molad Tishri of following year would occur on Saturday at or after 18hr (noon)

Therefore following year must be delayed one day by (2) and then one more day by (1)

This makes the common year in question too long (356 days)

Note that this delay would now cause Tishri 1 to fall on a Wednesday, so it must be then delayed by a second day because of (1)

(4) If molad Tishri following a leap year falls on Monday at or after 15 hr 589 hq (9:32:43 1/3 AM), delay Tishri 1 by one day for the following reason:

Molad Tishri of the leap year occurred on or after Tuesday at 18hr (noon)
Therefore Tishri 1 of that leap year was delayed one day by (2) and one more day by (1)
This would make that leap year too short (382 days)

Note that this delay would now cause Tishri 1 to fall on a Tuesday and that will never cause (1) to trigger a further delay

The Origin of Time

Year 1 was a fictitious year to make the calculation correct.
Creation started on 25th of Elul in the year 1 and ended on 1st of Tishri in year 2 (Friday).
Note that year 2 could start on a Friday because there was no need for Yom Kippur then.

Relating to Secular Calendar

The secular calendar in common use today is the Gregorian calendar. The rules for determining number of days in each Gregorian year are simple and well known (365 for common years, 366 for leap years, a leap year is any year that is divisible by 4 except that if it is divisible by 100 it must also be divisible by 400 to be a leap year). Prior to the Gregorian calendar, the calendar in common use was the Julian calendar. It differed from the Gregorian one in that it did not have the century rule.

We already know how to calculate the number of days since Tishri 1 in the year 1 for any Jewish date. To convert to secular dates, the only additional piece of information that we need is the secular date corresponding to Tishri 1 in the year 1. Specifically, the corresponding Julian date is October 7, 3761 B.C.E. (before the common era) and the Gregorian date is September 7, 3761 B.C.E.

Calendar Creep

The reason for the creep is that the ratio of the Earth's revolution around the sun (one year) to its rotation on its axis (one day) is not an integer. By astronomical calculations, that ratio is 365.2422 days per year. The creep is caused by the inaccuracy in the value of this ratio in the various calendars.

The Jewish calendar is based on a 19-year cycle consisting of 235 lunar months. Each lunar month is defined as being 29 days, 12 hours, 793 halaqim. Therefore the average number of days in a Jewish year is:

$$\begin{aligned} & (235 \times (29 \text{ days} + 12 \text{ hours} + 793 \text{ halaqim})) / 19 = \\ & (6939 \text{ days} + 16 \text{ hours} + 595 \text{ halaqim}) / 19 = \\ & 6939.6896 / 19 \text{ days} = \\ & 365.2468 \text{ days} \end{aligned}$$

That exceeds an astronomical year by .0046 days. Therefore the Jewish calendar will creep one day every 1/.0046 years which calculates to 217 years.

The average number of days in a Julian year is 365.25. That exceeds an astronomical year by .0078 days, which means a creep of one day every 128 years.

The average number of days in a Gregorian year is $(400 \cdot 365 + 100 - 3) / 400 = 365.2425$. That exceeds an astronomical year by .0003 days, which means a creep of one day every 3,333 years.

Hebrew Numerals

The dates of death found on Jewish tombstones are encoded using a Hebrew equivalent of Roman numerals. In particular, the encoding is as follows:

1 א (aleph)	10 י (yud)	100 ק (kuf)
2 ב (bet)	20 כ (kaf)	200 ר (resh)
3 ג (gimel)	30 ל (lamed)	300 ש (shin)
4 ד (dalet)	40 מ (mem)	400 ת (tav)
5 ה (heh)	50 נ (nun)	500 תק (tav kuf: 400+100)
6 ו (vav)	60 ס (samekh)	600 תר (tav resh: 400+200)
7 ז (zayin)	70 ע (ayin)	700 תש (tav shin: 400+300)
8 ח (khet)	80 פ (peh)	800 תת (tav tav: 400+400)
9 ט (tet)	90 צ (tsadi)	900 תקת (tav tav kuf: 400+400+100)

Starting at 1000, numbers are broken into two parts separated by an apostrophe. To the right of the apostrophe is the number of thousands and to the left is the number of units, both using the encoding shown above. Sometimes the thousands part is omitted completely.

Although dates are usually written in a decimal notation (that is, one character representing the units column, another the tens column, etc.), this rule is sometimes violated just as long as the sum of the characters represents the desired result. For example, 15 would be written as yud (10) heh (5) in decimal notation. But these two letters are in the name of God, so the equivalent tet (9) vav (6) is usually used instead. Same goes for 16 which is usually written as tet (9) zayin (7) instead of yud vav.

15 טו (tet vav)

16 טז (tet zayin)