

## ReadMe file — Instructions

This file explains the use of `CalXXXX.tex` and `Cal2000.tex` files, possible modifications and gives the mathematical background for the calculation of the calendar. Both files are for  $\text{\LaTeX} 2_{\epsilon}$ , and use the `array.sty` package. At the end, there are some interesting numerical values and historical facts.

### The use

To print a calendar for a given year, use `CalXXXX.tex` file.  $\text{\LaTeX} 2_{\epsilon}$ it, type in the year (for example 2002), and the calendar for that year is produced. For the year B. C., enter the negative number (for example  $-6$ ), and for the current year, 2006th, you can press the ENTER key only.

To print calendar for the years 1990–2020, use `Cal2000.tex` file.  $\text{\LaTeX} 2_{\epsilon}$ it and you will have the calendar for all that years.

### Possible modifications

In both files there is a piece of code clearly denoted for safe modifications.

In `CalXXXX.tex`, the most important changes are for a language: `\Jan`, `...\Dec` define names of the months. You can also set type of the calendar: Gregorian (`\Julianfalse`) or Julian (`\Juliantrue`). For details, see explanations later. Some misunderstanding could be for 0th year; normally it doesn't exist (before 1st is a  $-1$ st year), but if, for some reason, you need a 0th year, set `\ZeroExisttrue` and the 0th year will exist (before 1st is 0th, and before it  $-1$ st). `\BC` and `\AD` are text after the year (in English,  $-6$ th year is 6 BC and 6th year is 6 AD).

In the `Cal2000.tex`, the most important changes are also for a language. Change definition for `\YearMonths` and `\Day` according to your language.

Both files have a command `\CmRulefalse`. If you change it to a `\CmRuletrue`, you will see a centimeter scale at the right edge.

Beside of these, other modifications are possible, but not recommended.

### Mathematical background

In both files, the day  $x$  (0 for Sunday, 1 for Monday, etc.) for a date  $d.m.y$  is calculated as

$$x = \begin{cases} x_0 \bmod 7 & \text{if } m < 3 \\ (x_0 - (4m + 23) \operatorname{div} 10) \bmod 7 & \text{if } m \geq 3 \end{cases}$$

where

$$x_0 = 365y + 31m + d + 3 + k \operatorname{div} 4 - (k \operatorname{div} 100 + 1) \cdot 3 \operatorname{div} 4$$

and

$$k = \begin{cases} y - 1 & \text{if } m < 3 \\ y & \text{if } m \geq 3 \end{cases}$$

This formulae are used in both files. In `CalXXXX.tex`, you can see how  $\TeX$  calculates. In `Cal2000.tex`, since the years 1990–2020 are fixed, there is no need to calculate anything, but the first day for all months for the years 1990–2020, are produced with the following Pascal code:

```

program cal(output);
var x,y,m,k: longint;
begin writeln('Year   J F M A M J J A S O N D');
  for y:=1990 to 2020 do
    begin write(y,' ');
      for m:=1 to 12 do
        begin x:=365*y+31*m+4; { 4=d+3 }
          if m<3 then k:=y-1 else k:=y;
          x:=x+k div 4-(k div 100+1)*3 div 4;
          if m>=3 then x:=x-(4*m+23) div 10;
          x:=x mod 7;
          write(' ',x)
        end; writeln;
      end;
    end.

```

## Numerical values

The lengths of solar (tropical) year and lunar month in days are

$$Y = 365.24219872, \quad M = 29.530588.$$

(These are values for a period December 31st, 1900, at 12h — since it slowly decreases.) The solar calendar should have about 365.24 days in a year (on average), while the lunar calendar should have months of 29.5 days (usually, 30 and 29 alternately). The lunisolar calendar should have both, but the ratio of these two lengths  $Y/M = 12.36826706\dots$  is not an integer and most years should have 12 and leap years 13 months. In 432 BC, Athens astronomer Meton, discover that in 19 years there are almost exactly 235 lunar months ( $19 \times 12.36826706 = 234.997$ ). This became a base for all calendar with lunar months and solar year.

The Julian year has 365.25 days (on average), and the difference is 0.0078013 days = 11'14" or 1 day in 128 years, while the Gregorian year has 365.2425 days, with the difference of 0.0003013 days = 26" or 1 day in 3319 years. More precise calendar will follow from the expansion of the length of the tropical year in an infinite fraction

$$365.24219872 = 365 + \frac{1}{4 + \frac{1}{7 + \frac{1}{1 + \frac{1}{3 + \frac{1}{5 + \frac{1}{5 + \dots}}}}}}}$$

With the first fraction only, we have  $365 + \frac{1}{4} = 365.25$  days, what is Julian year. With the first two fraction,  $365 + \frac{1}{4+\frac{1}{7}} = 365 + \frac{7}{29} = 365.2414$  and with the three  $365 + \frac{8}{33} = 365.2424$  what is better than Gregorian year. With the four  $365 + \frac{31}{128} = 365.2421875$  with the difference 0.0000112 days = 1" or 1 day in almost 10000 years. So, if in a cycle of 128 years we put 31 leap years, the calendar will be almost perfect.

## Brief History

In Babylon a calendar had 12 lunar months of 30 days each, with added extra month when necessary to keep the months in line with the seasons of the year. Later, a year of 354 days was introduced with 12 months with intercalations in the years 3, 6, 8, 11, 14, 17, and 19 of the 19-year cycle. In Iran, Zoroastrian calendar has year of 12 months of 30 days, plus five days, giving totally 365. The ancient Egyptians measured the solar year as 365 days, divided into 12 months of 30 days each, with 5 extra days at the end. About 238 BC King Ptolemy III added an extra day to every fourth year. In ancient Greece a lunar calendar was in use, with a year of 354 days. In Rome, the year had 10 months with 304 days and began with March. Two more months, January and February were added later in the 7th century BC. Furthermore, an extra month had to be intercalated approximately every second year.

In 45 BC Julius Caesar, upon the advice of the Alexandrian astronomer Sosigenes, decided to use a solar calendar similar to Egyptian. This calendar, known today the Julian calendar, had the normal year at 365 days, and the leap year, every fourth year, at 366 days. In this calendar January, March, May, July, September, and November had 31 days, other months 30 days, while February had 29 or 30 days. This calendar also established the order of the months and the days of the week as they exist in present-day calendars. Julius Caesar also changed the name of the month Quintilis to Julius (July). In 8 AD the emperor Caesar Augustus renamed the month Sextilis to Augustus (August), increased it to 31 days, reduced September and November to 30 days, and increased October and December to 31 days. Such complicated calendar was adopted by Christian church and spread to western world.

Since the year in Julian calendar was some longer than solar year, this discrepancy accumulated until by 1582 the error was 10 days. To fix it, Pope Gregory XIII issued a decree dropping 10 days from the calendar and order that century years divisible by 400 should be leap years only. Catholic states adopted this new calendar immediately, but other countries did that later. Britain adopted it in 1752, Denmark and the Dutch and German Protestant states in 1699-1700, Soviet Union in 1918, and Greece in 1923. The monarch republic Holy Mountain, in Greece, is only territory with the official use of the Julian calendar, but some Orthodox churches also keep the Julian calendar for religious use.

The Islamic calendar is a purely lunar. It has 12 lunar months alternately 30 and 29 days long. In each thirty years the 2nd, 5th, 7th, 10th, 13th, 16th, 18th,

21st, 24th, 26th, and 29th years have the last month as leap month with 30 instead of 29 days. So the year has 354 or 355 days. There are no intercalations of months and the months regress through all the seasons every  $32\frac{1}{2}$  years.

The Jewish calendar is lunisolar, based on 12 lunar months of 29 days or 30 days. Such year has 354 days, but an extra month of 30 days is intercalated in the 3rd, 6th, 8th, 11th, 14th, 17th, and 19th years in a 19-year cycle. This gives an average length of 365.05 days.

The Chinese calendar is also lunisolar, its year consisting of 12 months of alternately 29 and 30 days, equal to 354 days. Intercalary months are inserting to keep the calendar year in step with the solar year of 365 days.

## Notices

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