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0521782538 - Calendrical Tabulations, 1900-2200
Edward M. Reingold and Nachum Dershowitz
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Calendrical Tabulations, 1900–2200

The momentous task of assembling such a comprehensive and accurate collection of calendars could only have been achieved by the authors of the definitive work on calendar algorithms, *Calendrical Calculations*. Using the algorithms from that book, Professors Reingold and Dershowitz have achieved the near-impossible task of simultaneously displaying the date on fifteen different calendars over a three-hundred-year period. Represented here are the Gregorian, ISO, Hebrew, Chinese, Coptic, Ethiopic, Persian, Hindu lunar, Hindu solar, and Islamic calendars; another five are easily obtained from the tables with minimal arithmetic (JD, R.D., Julian, arithmetical Persian, and arithmetical Islamic). The tables also include phases of the moon, dates of solstices and equinoxes, and religious and other special holidays for all the calendars shown.

This set of beautifully produced tables will be of use for centuries by anyone with an interest in calendars and the societies that produce them. It should also prove an invaluable reference tool for astronomers and genealogists.

Edward M. Reingold was born in Chicago, Illinois, in 1945. He has an undergraduate degree in mathematics from the Illinois Institute of Technology and a doctorate in computer science from Cornell University. Reingold was a faculty member in the Department of Computer Science at the University of Illinois at Urbana-Champaign from 1970–2000; he retired as a Professor Emeritus of Computer Science in December 2000 and is now chair of the Department of Computer Science at the Illinois Institute of Technology. His research interests are in theoretical computer science—especially the design and analysis of algorithms and data structures. A Fellow of the Association for Computing Machinery since 1995, Reingold has authored or coauthored more than 50 research papers and 9 books; his papers on backtrack search, generation of combinations, weight-balanced binary trees, and drawing of trees and graphs are considered classics. He has won awards for his undergraduate and graduate teaching. Reingold is intensely interested in calendars and their computer implementation; in addition to *Calendrical Calculations*, he is the author and maintainer of the calendar/diary part of GNU Emacs.

Beyond his expertise in calendars, Nachum Dershowitz is a leading figure in software verification in general and termination of programs in particular; he is an international authority on equational inference and term rewriting. Other areas in which he has made major contributions include program semantics and combinatorial enumeration. Dershowitz has authored or coauthored more than 100 research papers and several books and has held visiting positions at prominent institutions around the globe. He has won numerous awards for his research and teaching. He was born in 1951, and his graduate degrees in applied mathematics are from the Weizmann Institute in Israel. He is currently a professor of computer science at Tel Aviv University.

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Calendrical Tabulations 1900–2200

Edward M. Reingold
University of Illinois at Urbana-Champaign
and
Illinois Institute of Technology

Nachum Dershowitz
Tel Aviv University

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To our beloved wives

Ruth Nothmann Reingold
Schulamith Chava Halevy

ראה חיים עם אשה אשר אהבת כל ימי חיי הבלך קהלת ט,ט

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Preface

> The reader. . . may complain that he could recite the calendar for himself and so save his pocket whatever sum the publisher may think proper to charge for this book.
>
> —Virginia Woolf: *Orlando* (1928)

We give tables for easy conversion of fifteen different calendars. Ten calendars are given explicitly (Gregorian, ISO, Hebrew, Chinese, Coptic, Ethiopic, astronomical Persian, Hindu lunar, Hindu solar, and astronomical Islamic); another five are easily obtained from the tables with minimal arithmetic (JD, R.D., Julian, arithmetical Persian, and arithmetical Islamic). Detailed explanations of the structure and determination of these and many other calendars can be found in [10].

Why produce yet another book of tables given the large number available? And why produce it in book form at all in the computer age? For the latter question, we point out that all available computer programs cover only one or two calendars, have limited ranges, are of dubious accuracy, are difficult for a non-expert to use, or work only on a small subset of computers. Also, books are less ephemeral.

As to the former question, why bother with a new book of tables, all published books of tables have significant flaws: Among general tables, by far the best is Schram [14], which is extensive, but hard to find (a search of the OCLC WorldCat database found fewer than 50 copies, of which a dozen were in non-lending institutions), awkward to use, only goes to 2000, and is in German. The most ubiquitous is Parise [8], so filled with errors as to be useless.

For conversions to and from specific exotic calendars, there are some excellent tables, but usually with a caveat:

- For the Chinese calendar, [9] is hard to find, is in Chinese, and only goes to 2050. [17] and [18] are hard to find and go to only 1951. [20] is in Chinese and only goes to 2050. [7] is very rare and only goes to 1921.

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- For the Hebrew calendar, [16] is excellent and goes to 2100. [11] goes only to 2050 and is awkward to use. The index volume of [12] contains readable tables for 1920–2020. [2] is extensive, rare, and in Hebrew; it also contains somewhat awkward tables for the Julian, Gregorian, Islamic, and French Revolutionary calendars over various ranges. The self-published [13] contains extensive tables for the Hebrew calendar, equinoxes, and lunar conjunctions for 1826–2240; it is extremely rare and primarily in Yiddish with some Hebrew, though with enough English to make it usable without knowledge of Yiddish or Hebrew.
- For the Islamic calendar, [19] is hard to find (a search of the OCLC WorldCat database found fewer than 40 copies, of which half a dozen were in non-lending institutions), in German, and only goes to 2077. [6] is awkward to use.
- For the Coptic/Ethiopic calendar, [5] goes only to 1930, is hard to find (a search of the OCLC WorldCat database found fewer than 40 copies, of which ten were in non-lending institutions), and is in French.
- For the Persian calendar, [3] follows (one of) the arithmetical calendars that is still under debate and is somewhat awkward to use. As noted above, [19] is hard to find.
- For the Hindu calendars, [15] goes only until 2000. [4] is limited to 1879–2000.

Using the Tables

Following this preface is an extended description of the usage of the tables. The description contains sufficient explanatory material to make conversion among the calendars easy, even for readers without a detailed familiarity with the calendars' idiosyncrasies. The reader is strongly cautioned to read the description carefully and to pay close attention to the warnings; for the reader's convenience, the warnings are reprinted at the end of the tables.

Production of the Tables

These tables were produced by Common Lisp driver code that executed the algorithms in [10] (available on a compact disk accompanying that book) to produce LaTeX output, which was in turn used to produce the tables in this book. Because the LaTeX was produced algorithmically, idiosyncratic cases were not handled in an ad hoc way, as would be done in a conventionally typeset book. This has led to minor typographical inadequacies (most notably, instances of overprinting); we preferred to live with these difficulties and eliminate the possibility of corrupting the tables by human editing. There are no typographical errors in the more than one million numbers in these tables!

Though intended as single-use, the driver code had to be run many times as the content and typography of the tables evolved. The final run, which produced the tables in this book, was made over January 7–9, 2002 and required 51.5 hours on a dual-processor Sun Blade® 1000 workstation; that is, the average year's table took about 10.26 minutes. Of that, over two-thirds was for the Hindu lunar calendar.[1] Detailed statistics of the times required to compute the various calendars are given in Table 1.

[1] Only the Hindu lunar and Chinese calendars had any significant variation in the computation times: Of the 301 years, only six Hindu lunar calendars had unusually long computation times (due usually to the rare

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Table 1: Statistics for the computation time (in minutes) of the 301 years of calendars; σ is the standard deviation. The total time for all 301 calendars was somewhat over two full days (3088 minutes = 51.5 hours).

	Average			Shortest		Longest	
Calendar	**Time**	**σ**	**%**	**Time**	**Year**	**Time**	**Year**
Gregorian (verso)	0.51	0.02	4.96	0.47	1999	0.60	2111
ISO Week	0.00	0.00	0.01	0.00	1999	0.02	2189
Julian Day (JD)	0.00	0.00	0.01	0.00	1999	0.02	1972
Hebrew	0.02	0.01	0.22	0.02	2002	0.03	2100
Chinese	0.68	0.26	6.62	0.42	2003	1.23	1976
Coptic/Ethiopic	0.01	0.01	0.13	0.00	2011	0.12	1972
Persian	0.18	0.02	1.77	0.15	2091	0.23	2101
Hindu Lunar	6.94	2.64	67.69	4.98	2011	22.80	2048
Hindu Solar	1.08	0.05	10.56	0.98	1998	1.28	1999
Islamic	0.81	0.04	7.92	0.73	1998	0.95	2136
Gregorian (recto)	0.01	0.01	0.12	0.00	2003	0.02	1974
Year	10.26	2.66	100.00	7.92	2011	26.00	2048

These should be taken with a grain of salt because they are based on file modification times and the workstation was not always otherwise idle during the computation of the tables; moreover, values near zero should be regarded as noise.

Our method of production makes these tables unique in two ways. First, they are the only published calendar tables for which the *precise* details of the underlying calendrical algorithms are public [10]. Second, and much more important, these tables are uniquely accurate—more accurate than any existing tables of any scope. However, the nature of calendars is such that no tables can be completely accurate: Some calendars are based on observation, not calculation, and climatic conditions can unpredictably alter theoretical calculations of visibility. Some calendars are a matter of dispute or regional variation. Some calendars depend on astronomical calculations whose accuracy depends on the underlying model, and these models have and will continue to vary as our understanding of such phenomena improves. Definitions of holidays can change. Finally, we admit that there is an infinitesimal chance that our algorithms in [10] could be flawed.

The Web Page

To facilitate electronic communication with our readers, we have established a home page for [10] and this book on the World Wide Web:

`http://www.calendarists.com`

occurrence of an expunged month in a leap year): 1983 (22.3 minutes), 2048 (22.8 minutes), 2067 (19.7 minutes), 2086 (20.0 minutes), 2124 (20.1 minutes), and 2189 (21.7 minutes); the remaining years all took between 5.0 and 13.3 minutes with an average of 6.7 minutes and a standard deviation of 1.7. Times for the Chinese calendar were bimodal, with the 111 leap years taking an average of 1.0 minutes each and the 190 common years taking an average of 0.5 minutes each, with standard deviations of 0.06 and 0.03, respectively.

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We thank our editor Alan Harvey for putting up with us.

January 21, 2002
Chicago, Illinois E.M.R.
Tel Aviv, Israel N.D.

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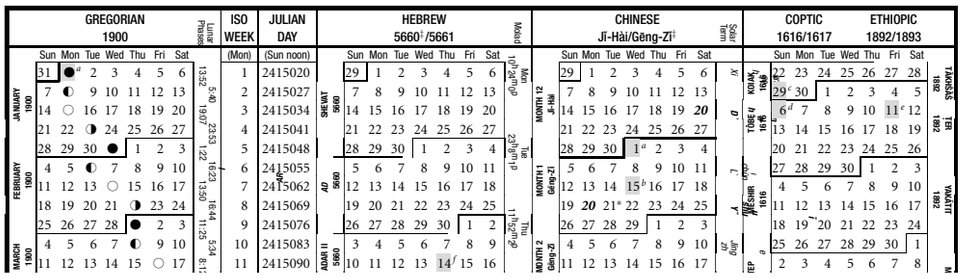
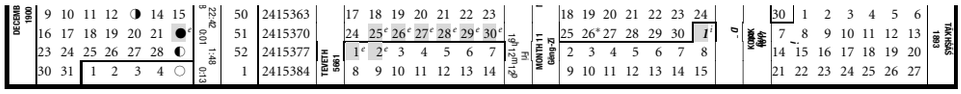
Reading the Tables

Each pair of facing pages shows the weeks of a Gregorian year: The leftmost major column of the verso (left) page and the rightmost major column of the recto (right) page show the year as a sequence of weeks, beginning with the week containing January 1 and ending with the week containing December 31. The remaining major column divisions of the verso page give the ISO week number for the week beginning on the corresponding Monday, the Julian day number (JD) for that Sunday at noon, and the corresponding weeks on the Hebrew, Chinese, Coptic, and Ethiopic calendars:

1900



Footnotes at the bottom of the major columns give holidays and other special dates:



[a]New Year
[b]Spring (1:39)
[c]Summer (21:40)
[d]Autumn (12:20)
[e]Winter (6:41)
● New moon
◐ First quarter moon
○ Full moon
◑ Last quarter moon

‡Leap year
[a]New Year
[b]Yom Kippur
[c]Sukkot
[d]Winter starts
[e]Hanukkah
[f]Purim
[g]Passover
[h]Shavuot
[i]Fast of Av

‡Leap year
[a]New Year (4598, Rat)
[b]Lantern Festival
[c]Qīngming
[d]Dragon Festival
[e]Qiqiǎo
[f]Hungry Ghosts
[g]Mid-Autumn Festival
[h]Double-Ninth Festival
[i]Dōngzhì
*Start of 60-name cycle

[a]New Year
[b]Building of the Cross
[c]Christmas
[d]Jesus's Circumcision
[e]Epiphany
[f]Easter
[g]Mary's Announcement
[h]Jesus's Transfiguration

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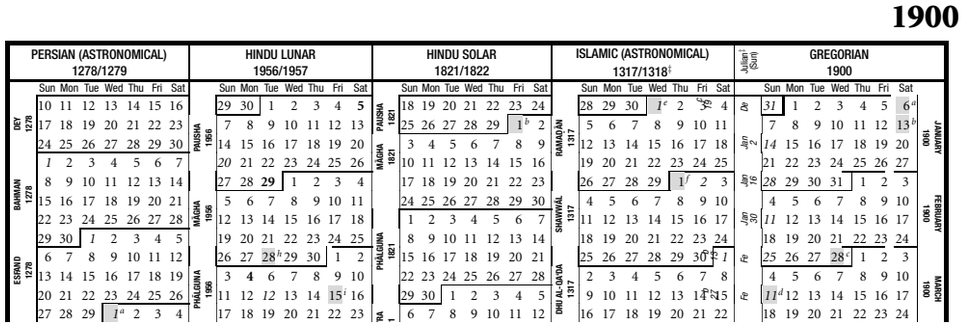
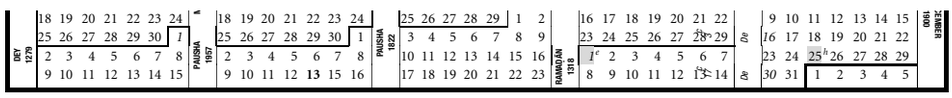
The remaining major column divisions of the recto page give the corresponding weeks on the Persian, Hindu, and Islamic calendars:



Again, footnotes at the bottom of the major columns give holidays and other special dates:



[a]New Year
[b]Sizdeh Bedar

[a]New Year (Śārvari)
[b]Birthday of Rāma
[c]Birthday of Krishna
[d]Ganēśa Chaturthī
[e]Dashara
[f]Diwali
[g]Birthday of Vishnu
[h]Night of Śiva
[i]Holi

[a]New Year (Paridhāvin)
[b]Pongal

‡Leap year
[a]New Year
[d]New Year (Arithmetic)
[b]'Ashūrā'
[c]Prophet's Birthday
[d]Ascent of the Prophet
[e]Start of Ramaḍān
[f]'Id al-Fiṭr
[g]'Id al-'Aḍḥā

‡Julian leap year
[a]Orthodox Christmas
[b]Julian New Year
[c]Ash Wednesday
[d]Feast of Orthodoxy
[e]Easter
[f]Orthodox Easter
[g]Advent
[h]Christmas

The weeks are shown in parallel, so that conversion of a date from one calendar to another requires only looking left or right on the same line to the corresponding day of the week in the other calendar's column (the reader is aided in this by the inclusion with the book of a matching column-ruled bookmark). Month boundaries are shown by a thin line; year boundaries are shown by a thicker line. Additional information for some of the calendars is given in adjacent columns; the details are explained below.

WARNING

❖ ***Changes in font (roman or italic, lightface or bold) are important in the tables. The sections below explain the significance for each calendar.***

The Gregorian and Julian Calendars

A week on the Gregorian calendar (the most widely used calendar in the world) is shown twice, in the major columns on the extreme left and the extreme right of a pair of facing pages. The Gregorian calendar on the extreme left has the month names and year numbers in a minor column at the left; the Gregorian calendar on the extreme right has month names and year numbers in a minor column at the right. The month names and lengths are:

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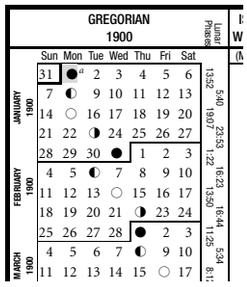
(1)	January	31 days	(7)	July	31 days
(2)	February	28 {29} days	(8)	August	31 days
(3)	March	31 days	(9)	September	30 days
(4)	April	30 days	(10)	October	31 days
(5)	May	31 days	(11)	November	30 days
(6)	June	30 days	(12)	December	31 days

In leap years, indicated by ‡ after the year number, February has 29 days, as indicated in curly brackets.

The leftmost Gregorian calendar,



includes matters of astronomical interest:

Event	Key	When
New Year	[a]	January 1
Vernal (spring) equinox	[b]	March 19–21
Summer solstice	[c]	June 20–22
Autumnal equinox	[d]	September 21–24
Winter solstice	[e]	December 20–23
New Moon	●	About every four weeks
First Quarter	◐	About every four weeks
Full Moon	○	About every four weeks
Last Quarter	◑	About every four weeks

Dates of solstices and equinoxes are shaded and keyed to footnotes giving the exact time (to within a few minutes)—times given are in Universal Time (U.T.), formerly called Greenwich Mean Time (G.M.T.); see Figure 1 for a map relating U.T. to various time zones. The phases of the moon are given by the standard symbols in place of the date—new moons by ●, full moons by ○, first quarter moons by ◐, and last quarter moons by ◑. The exact times of the phases (to within a few minutes) are given in the column just to the right of Saturday, aligned with the week of occurrence; times are given in Universal Time. When, rarely, two phases occur during the same week, the two times are given and correspond, left to right, to the phases shown in that week.

WARNING

❖ ***Times for lunar phases, equinoxes, and solstices are given in Universal Time. The times are close approximations, but may be in error by a few minutes.***

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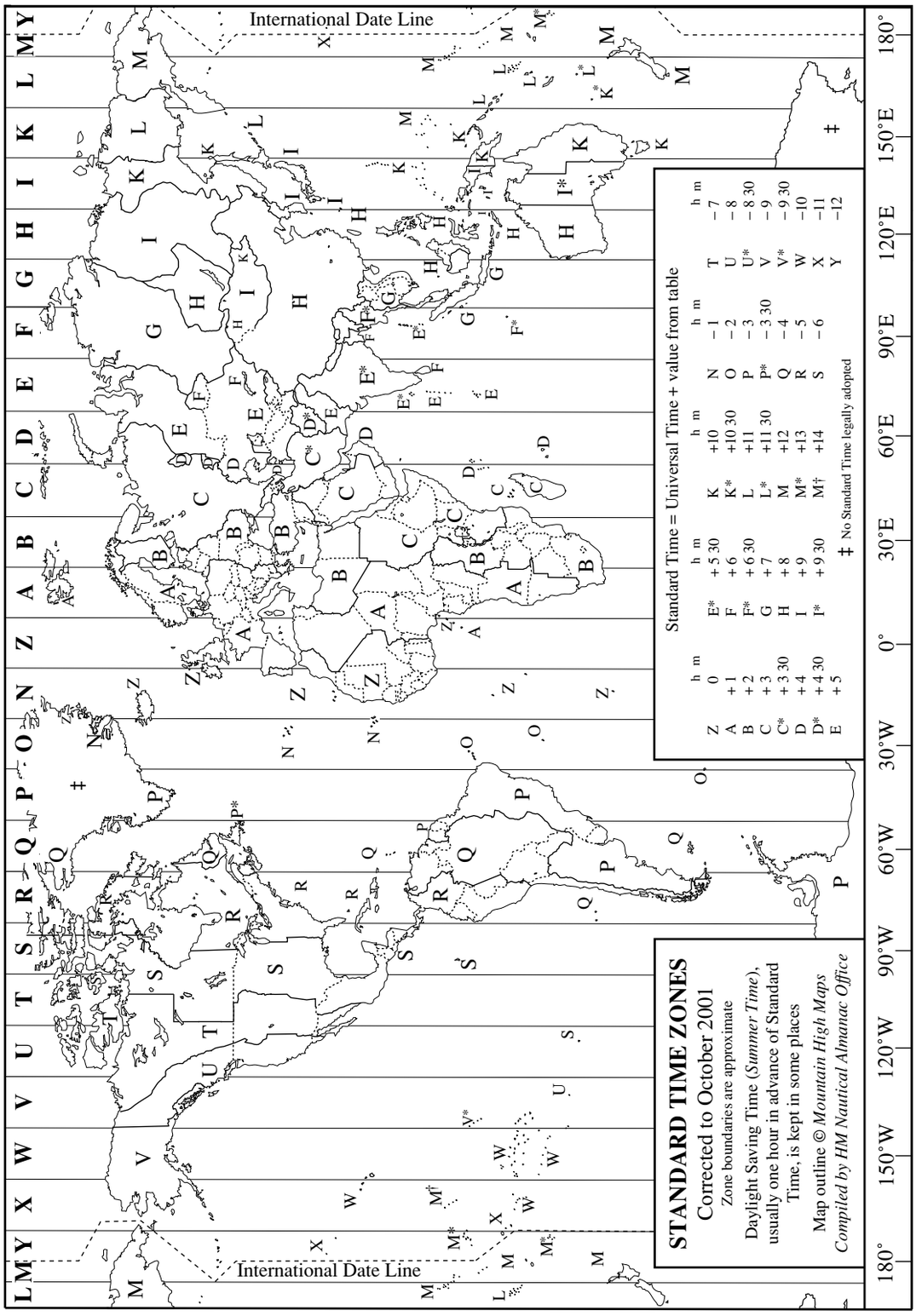

Figure 1: Standard time zones of the world as of 2001. Data supplied by H. M. Nautical Almanac Office; copyright Council for the Central Laboratory of the Research Councils. Used with permission.

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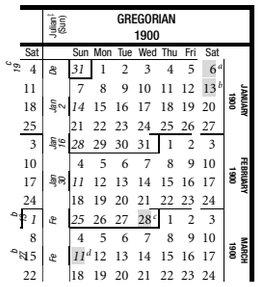
The Gregorian calendar on the extreme right,



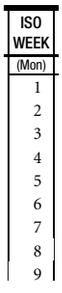
indicates matters of Christian interest: dates of Christmas (both Western and Orthodox), Ash Wednesday, the Feast of Orthodoxy, Easter (both Western and Orthodox), and Advent are shaded and keyed to footnotes:

Event	Key	When
Orthodox Christmas	*a*	December 25 (Julian)
Julian New Year	*b*	January 1 (Julian)
Ash Wednesday	*c*	46 days before Easter
Feast of Orthodoxy	*d*	42 days before Orthodox Easter
Easter	*e*	March 22–April 25
Orthodox Easter	*f*	March 22–April 25 (Julian)
Advent	*g*	Sunday near November 30
Christmas	*h*	December 25

Julian New Year is also shaded and keyed to a footnote, with Julian leap years indicated by ‡ after the word "Julian" in the column heading. A minor column to the left of Sunday gives in italics the corresponding Julian (old style) calendar date for alternate Sundays, which are also shown in italics. This makes conversion of the Gregorian calendar to and from the Julian calendar possible with only minimal arithmetic. Aside from Eastern Europe and Turkey, most countries adopted the Gregorian calendar prior to 1900; an extensive list of dates of adoption of the Gregorian calendar in place of the Julian calendar can be found in [1, pages 414–416].

The ISO Week

The ISO week number (used in parts of Europe) for the seven-day week beginning on the Monday of the week shown, is given as the second major column on the verso page:



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The Julian Day

The Julian day number (JD), as of noon on Sunday of the week shown, is given as the third major column on the verso page:

JULIAN DAY (Sun noon)
2415020
2415027
2415034
2415041
2415048
2415055
2415062
2415069
2415076
2415083

This value is easily used to compute, with minimal arithmetic, the JD of any date, the ordinal number of a day in the year, the number of days between two dates, or the number of days remaining in the year on any of the calendars. Similarly, it is easy to compute the modified Julian day number (MJD), which at midnight between Sunday and Monday is JD − 2400000, or the fixed date (R.D. of [10], with epoch January 1, 1 on the proleptic Gregorian calendar), which at midnight between Sunday and Monday is JD − 1721424.

WARNING

❖ ***Julian day numbers count days from noon to noon, but modified Julian day numbers and fixed day numbers count days from midnight to midnight.***

The Hebrew Calendar

The Hebrew (Jewish) calendar is given as the fourth major column on the verso page, with the month names and year numbers in a minor column on its left:

HEBREW
5660‡/5661

	Sun	Mon	Tue	Wed	Thu	Fri	Sat	
	29	1	2	3	4	5	6	14th of Shevat
SHEVAT 5660	7	8	9	10	11	12	13	
	14	15	16	17	18	19	20	
	21	22	23	24	25	26	27	23rd of Shevat
	28	29	30	1	2	3	4	1st of Adar I
	5	6	7	8	9	10	11	
AD 5660	12	13	14	15	16	17	18	
	19	20	21	22	23	24	25	1st of Adar II
	26	27	28	29	30	1	2	14th of Adar II
ADAR II 5660	3	4	5	6	7	8	9	
	10	11	12	13	14	15	16	

Common years have twelve months; leap years, indicated by ‡ after the year number, have thirteen months. The month names and lengths are:

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(1)	Nisan	30 days	(7)	Tishri	30 days
(2)	Iyyar	29 days	(8)	Ḥeshvan	29 or 30 days
(3)	Sivan	30 days	(9)	Kislev	29 or 30 days
(4)	Tammuz	29 days	(10)	Teveth	29 days
(5)	Av	30 days	(11)	Shevat	30 days
(6)	Elul	29 days	{(12)	*Adar I*	30 days}
			(12) {(13)}	Adar {II}	29 days

The name of the leap month (*Adar I*) is given in italics when it occurs.

This calendar indicates matters of Jewish interest. Starting dates of major holidays, some minor holidays, and other significant days are shaded and keyed to footnotes, as follows:

Event	Key	When
New Year (Rosh ha-Shanah)	*a*	Tishri 1 and 2
Yom Kippur (Day of Atonement)	*b*	Tishri 10
Sukkot (Tabernacles), first day	*c*	Tishri 15
'Winter' starts (Sh'ela)	*d*	Athôr 26 (Coptic)
Ḥanukkah	*e*	Kislev 25 to Teveth 2 or 3
Purim	*f*	Adar {II} 14
Passover, first day	*g*	Nisan 15
Shavuot (Pentecost), first day	*h*	Sivan 6
Fast of Av (Tishah be-Av)	*i*	Av 9 or 10
Solar cycle begins (Birkath ha-Ḥama)	*	Paremotep 30 (Coptic), every 28 years

Two of these events, the beginning of winter and the solar cycle, are correlated with the Coptic calendar (see below).

A minor column to the right of Saturday gives the time of the mean new moon, called the *molad*. This is given with the traditional Hebrew time unit "parts" ($3\frac{1}{3}$ seconds per part).[2]

WARNING

❖ ***On the Hebrew calendar each day begins the prior evening at local sunset.***

The Chinese Calendar

The Chinese calendar is given as the fifth major column on the verso page, with the month numbers and year names in a minor column on its left:

[2] The function given for the calculation of the molad was flawed in the first printing of [10]; a corrected version, used in subsequent printings of [10], was used in preparing these tables.

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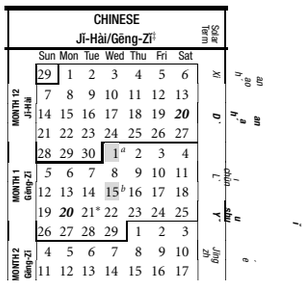

Common years have twelve months; leap years, indicated by ‡ after the year name (see below), have thirteen months. Months are numbered, not named, and month lengths vary in accordance with the actual lunar cycle.

Dates of the festivals are shaded and keyed to footnotes:

Event	Key	When
Chinese New Year	*a*	Day 1 of Month 1
Lantern Festival	*b*	Day 15 of Month 1
Qīngmíng	*c*	April 4–6
Dragon Festival	*d*	Day 5 of Month 5
Qǐqiǎo (Chinese Valentine's Day)	*e*	Day 7 of Month 7
Hungry Ghosts	*f*	Day 15 of Month 7
Mid-Autumn Festival	*g*	Day 15 of Month 8
Double-Ninth Festival	*h*	Day 9 of Month 9
Dōngzhì (Winter solstice)	*i*	December 21–23
Start of 60-name cycle	*	Every 60 days

A minor column to the right of Saturday gives the 24 solar terms or *jiéqì*: The twelve major solar terms called *zhōngqì* are in bold italics and the twelve minor solar terms known by the general term *jiéqì* are given in lightface italics. The dates of occurrence are likewise shown in either bold or lightface italics. The solar terms correspond to 15° segments of solar longitude, with the twelve major terms at 0°, 30°, 60°, . . . , 300°, and 330° of solar longitude and the twelve minor terms at 15°, 45°, . . . , 315°, and 345°.

The Chinese calendar uses a cycle of sixty names. The name is formed by combining a celestial stem, *tiān gān*, with a terrestrial branch, *dì zhī*. The celestial stems,

(1) Jiǎ
(2) Yǐ
(3) Bǐng
(4) Dīng
(5) Wù
(6) Jǐ
(7) Gēng
(8) Xīn
(9) Rén
(10) Guǐ

are untranslatable, though they are sometimes associated with the five elements (tree, fire, earth, metal, and water), each in its male and female form. The terrestrial branches,

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(1) Zǐ	(Rat)	(7) Wǔ	(Horse)
(2) Chǒu	(Ox)	(8) Wèi	(Sheep)
(3) Yín	(Tiger)	(9) Shēn	(Monkey)
(4) Mǎo	(Hare)	(10) Yǒu	(Fowl)
(5) Chén	(Dragon)	(11) Xū	(Dog)
(6) Sì	(Snake)	(12) Hài	(Pig)

are also untranslatable; the English names—traditional animal totems—given for the twelve branches corresponding to the years of the Chinese "Zodiac" are not translations from the Chinese. Names are assigned sequentially, running through the decimal and duodenary lists simultaneously: The first name is *jiǎ-zǐ*, the second is *yǐ-chǒu*, the third is *bǐng-yín*, and so on. Since the least common multiple of 10 and 12 is 60, the cycle of names repeats after the sixtieth name, *guǐ-hài*. The *n*th name of the sexagesimal cycle of names is as follows:

(1) Jiǎ-zǐ	(21) Jiǎ-shēn	(41) Jiǎ-chén
(2) Yǐ-chǒu	(22) Yǐ-yǒu	(42) Yǐ-sì
(3) Bǐng-yín	(23) Bǐng-xū	(43) Bǐng-wǔ
(4) Dīng-mǎo	(24) Dīng-hài	(44) Dīng-wèi
(5) Wù-chén	(25) Wù-zǐ	(45) Wù-shēn
(6) Jǐ-sì	(26) Jǐ-chǒu	(46) Jǐ-yǒu
(7) Gēng-wǔ	(27) Gēng-yín	(47) Gēng-xū
(8) Xīn-wèi	(28) Xīn-mǎo	(48) Xīn-hài
(9) Rén-shēn	(29) Rén-chén	(49) Rén-zǐ
(10) Guǐ-yǒu	(30) Guǐ-sì	(50) Guǐ-chǒu
(11) Jiǎ-xū	(31) Jiǎ-wǔ	(51) Jiǎ-yín
(12) Yǐ-hài	(32) Yǐ-wèi	(52) Yǐ-mǎo
(13) Bǐng-zǐ	(33) Bǐng-shēn	(53) Bǐng-chén
(14) Dīng-chǒu	(34) Dīng-yǒu	(54) Dīng-sì
(15) Wù-yín	(35) Wù-xū	(55) Wù-wǔ
(16) Jǐ-mǎo	(36) Jǐ-hài	(56) Jǐ-wèi
(17) Gēng-chén	(37) Gēng-zǐ	(57) Gēng-shēn
(18) Xīn-sì	(38) Xīn-chǒu	(58) Xīn-yǒu
(19) Rén-wǔ	(39) Rén-yín	(59) Rén-xū
(20) Guǐ-wèi	(40) Guǐ-mǎo	(60) Guǐ-hài

This sexagesimal cycle is used to name years, days, and (in earlier times) months. The starting day of each cycle is indicated by an asterisk. Since leap months (shown in the tables in italics) were unnamed, the cycle of month names repeats after five years; the starting month of each cycle, always an eleventh month, is indicated by an asterisk.

The Chinese calendar does not traditionally count years; rather, years are generally given as regnal years and by sexagesimal name. The popular press, however, usually gives a year number. This year number is given in the footnote marking the new year, along with the animal totem for the year.

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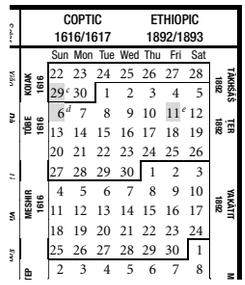
WARNINGS

- ***Historically, on the Chinese calendar for the Gregorian year 1906, Month 4 began on April 24, not April 23 as shown; it thus had 29 days instead of the 30 days shown. The disagreement occurs because our calculations of times of solar and lunar events are more accurate than the seventeenth-century methods used by the Chinese until 1913.***
- ***The year number we give for Chinese New Year is the popular version of the Huángdi era.***

The Coptic and Ethiopic Calendars

The rightmost major column on the verso page gives the Coptic and Ethiopic calendars:



These calendars are identical except for the names of the months and year numbers. Coptic month names and year numbers are given in a minor column on the left; Ethiopic month names and year numbers are given in a minor column on the right. The month names and lengths are:

	Coptic Name		*Ethiopic Name*	
(1)	Thoout	(1)	Maskaram	30 days
(2)	Paope	(2)	Teqemt	30 days
(3)	Athôr	(3)	Ḫedār	30 days
(4)	Koiak	(4)	Tākhśāś	30 days
(5)	Tôbe	(5)	Ṭer	30 days
(6)	Meshir	(6)	Yakātit	30 days
(7)	Paremotep	(7)	Magābit	30 days
(8)	Parmoute	(8)	Miyāzyā	30 days
(9)	Pashons	(9)	Genbot	30 days
(10)	Paône	(10)	Sanē	30 days
(11)	Epêp	(11)	Ḥamlē	30 days
(12)	Mesorê	(12)	Naḥasē	30 days
(13)	Epagomenê	(13)	Pāguemēn	5 {6} days

Leap years have 366 days and are indicated by ‡ after the year number.

The dates of New Year, Coptic/Ethiopic Christmas, Orthodox Easter, and several Coptic holidays are shaded and keyed to footnotes:

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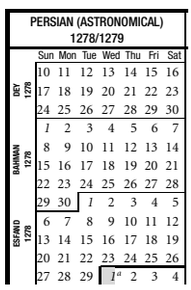
Event	Key	When
New Year	*a*	Thoout 1
Building of the Cross	*b*	Thoout 17
Christmas	*c*	Koiak 29
Jesus's Circumcision	*d*	Tôbe 6
Coptic Epiphany	*e*	Tôbe 11
Easter	*f*	Orthodox Easter
Mary's Announcement	*g*	Parmoute 29
Jesus's Transfiguration	*h*	Mesorê 13

The Persian Calendar

The leftmost major column on the recto page gives the astronomical Persian calendar:



PERSIAN (ASTRONOMICAL)
1278/1279

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
DEY 1278	10	11	12	13	14	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30
BAHMAN 1278	*1*	2	3	4	5	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
ESFAND 1278	29	30	*1*	2	3	4	5
	6	7	8	9	10	11	12
	13	14	15	16	17	18	19
	20	21	22	23	24	25	26
	27	28	29	*1*[a]	2	3	4

When the equinox occurs very close to noon in Tehran (specifically, when the solar longitude θ at noon satisfies $0 \le |\theta| \le 2'$), this is indicated, and the note for the neighboring day gives the solar longitude at noon of the day marked as the new year (Naw Ruz). When the arithmetic calculation of Birashk [3] differs from the astronomically indicated date, the arithmetic start of the year is also noted. The first day of the month on the arithmetic calendar is always shown in italics, so the date on the arithmetic calendar can be determined by counting forward from there; the first days of the astronomical and arithmetic months coincide with very few exceptions (2025-26, 2058-59, 2153-54, 2186-87, and 2190-91) in these tables.

The month names and lengths are:

(1)	Farvardīn	31 days	(7)	Mehr	30 days
(2)	Ordībehesht	31 days	(8)	Abān	30 days
(3)	Xordād	31 days	(9)	Āzar	30 days
(4)	Tīr	31 days	(10)	Dey	30 days
(5)	Mordād	31 days	(11)	Bahman	30 days
(6)	Shahrīvar	31 days	(12)	Esfand	29 {30} days

Leap years have 366 days and are indicated by ‡ after the year number. Leap years on the astronomical calendar are shown, *not* leap years on the arithmetic calendar.

The dates of the Persian holidays Naw Ruz (New Year) and Sizdeh Bedar are keyed to footnotes:

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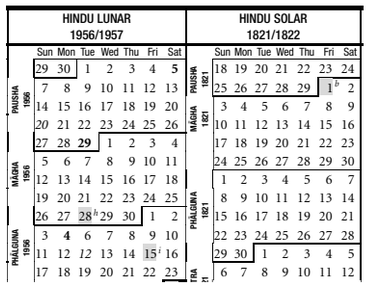
Event	Key	When
New Year (Naw Ruz)	*a*	Farvardīn 1
Near New Year	*	Day before or after Naw Ruz
New Year (Arithmetic)	*â*	Farvardīn 1
Sizdeh Bedar	*b*	Farvardīn 14

WARNINGS

- ***Our Persian calendar is astronomical and the decision to use it or one of the proposed arithmetic forms is uncertain.***
- ***When the equinox occurs very close to noon, our Persian calendar may be off by a day.***

The Hindu Calendars

The second and third major columns on the recto page give the Hindu lunar and solar calendars:



HINDU LUNAR 1956/1957							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
PAUSHA 1956	29	30	1	2	3	4	**5**
	7	8	9	10	11	12	13
	14	15	16	17	18	19	20
	20	21	22	23	24	25	26
	27	28	**29**	1	2	3	4
MAGHA 1956	5	6	7	8	9	10	11
	12	13	14	15	16	17	18
	19	20	21	22	23	24	25
	26	27	28[h]	29	30	1	2
PHĀLGUNA 1956	3	**4**	6	7	8	9	10
	11	12	*12*	13	14	15[i]	16
ITA	17	18	19	20	21	22	23

HINDU SOLAR 1821/1822							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
PAUSHA 1821	18	19	20	21	22	23	24
	25	26	27	28	29	1[b]	2
MAGHA 1821	3	4	5	6	7	8	9
	10	11	12	13	14	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30
PHĀLGUNA 1821	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
ITA	29	30	1	2	3	4	5
	6	7	8	9	10	11	12

The month names are:

(1) Chaitra
(2) Vaiśākha
(3) Jyaishṭha
(4) Āshāḍha
(5) Śrāvaṇa
(6) Bhādrapada
(7) Āśvina
(8) Kārttika
(9) Mārgaśīra
(10) Pausha
(11) Māgha
(12) Phālguna

Intercalated days are given in italics. Because there are extracalated (omitted) days, dates in the calendar may not be consecutive; in such cases, the (civil) day that wholly contains the omitted "lunar" day is given in boldface. Similarly, when a month is skipped on the lunar calendar, the previous month name is in lightface italics.

Lunar years are given according to the elapsed Vikrama era; leap years, indicated by ‡ after the year number, have thirteen months. Solar years are given according to the elapsed Śaka era; leap years, which have 366 days, are indicated by ‡ after the year number. Various different eras have been used in India. The year number of the major eras can be calculated using the following table of offsets from the Śaka:

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Era	Current Year	Elapsed Year
Vikrama	+136	+135
Kali Yuga	+3180	+3179
Śaka	+1	0
Bengal		−515
Kollam	+901	
Nepalese		+955

Significant dates are shaded and keyed to footnotes. For the lunar calendar:

Event	Key	When
New Year (Chandramana Ugadi)	*a*	Chaitra 1
Birthday of Rāma	*b*	Chaitra 9
Birthday of Krishna (Janmāshṭamī)	*c*	Śrāvaṇa 23
Ganēśa Chaturthī	*d*	Bhādrapada 3 or 4
Dashara (Nava Rathri), last 3 days	*e*	Āśvina 8–10
Diwali, last day	*f*	Kārttika 1
Birthday of Vishnu (Ekadashi)	*g*	Mārgaśīra 11
Night of Śiva	*h*	Māgha 28 or 29
Holi	*i*	Phālguna 15

and for the solar calendar:

Event	Key	When
New Year (Sowramana Ugadi)	*a*	Vaiśākha 1
Pongal (Makara Saṃkrāti), main day	*b*	Māgha 1

The name of the Hindu years in the sixty-name *samvatsara* cycle is given in two versions: the common southern version is given with the lunar calendar, and a northern scheme (which skips a name in 1943, 2028, 2114, and 2199) is used with the solar calendar. The year names are:

(1) Vijaya
(2) Jaya
(3) Manmatha
(4) Durmukha
(5) Hemalamba
(6) Vilamba
(7) Vikārin
(8) Śārvari
(9) Plava
(10) Śubhakṛit
(11) Śobhana
(12) Krodhin
(13) Viśvāvasu
(14) Parābhava
(15) Plavaṅga
(16) Kīlaka
(17) Saumya
(18) Sādhāraṇa
(19) Virodhakṛit
(20) Paridhāvin
(21) Praṃādin
(22) Ānanda
(23) Rākshasa
(24) Anala
(25) Piṅgala
(26) Kālayukta
(27) Siddhārthin
(28) Rāudra
(29) Durmati
(30) Dundubhi

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(31) Rudhirodgārin	(41) Śrīmukha	(51) Subhānu
(32) Raktāksha	(42) Bhāva	(52) Tāraṇa
(33) Krodhana	(43) Yuvan	(53) Pārthiva
(34) Kshaya	(44) Dhātṛi	(54) Vyaya
(35) Prabhava	(45) Iśvara	(55) Sarvajit
(36) Vibhava	(46) Bahudhānya	(56) Sarvadhārin
(37) Śukla	(47) Pramāthin	(57) Virodhin
(38) Pramoda	(48) Vikrama	(58) Vikṛita
(39) Prajāpati	(49) Vṛisha	(59) Khara
(40) Aṅgiras	(50) Chitrabhānu	(60) Nandana

WARNINGS

- *There are numerous variants of the Hindu calendar, human calendar calculators use approximations, and dates are determined regionally. Some calendar makers prefer modern astronomical methods.*
- *For the Hindu lunar calendar, we follow the rules of the Sūrya-Siddhānta, as amended by Gaṇesa Daivajna, except that the actual time of sunrise in Ujjain is used.*
- *Hindu lunar months are shown from new moon to new moon; in many regional variants full moon to full moon would be used. The day numbers of the second ("dark") half of each lunar month typically start over from 1; we use 16–30, instead.*
- *Our Hindu solar calendar follows the Orissa rule and actual sunrise in Calcutta, which can differ by a day or two from the rules used elsewhere.*
- *The sequence of Hindu months, and their names, differ regionally. Ours begins the solar year with Vaiśākha, the name of the second month of the lunar year.*
- *On the Hindu calendars each day begins at local sunrise.*
- *There is very wide variance in the precise date of celebration of the various Hindu holidays, and in the length of the celebration.*

The Islamic Calendar

The fourth major column on the recto page gives the astronomical Islamic (Moslem) calendar:[3]

[3] In the first printing of [10], the definition and usage of the crescent visibility function were inconsistent. A corrected version, used in subsequent printings of [10], was used in preparing these tables, and Los Angeles was substituted for the viewing location.

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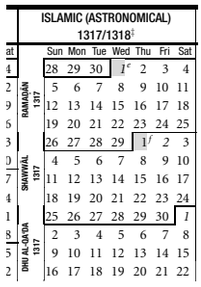

		ISLAMIC (ASTRONOMICAL) 1317/1318‡						
at		Sun	Mon	Tue	Wed	Thu	Fri	Sat
4		28	29	30	*1*[c]	2	3	4
2	RAMAḌĀN 1317	5	6	7	8	9	10	11
9		12	13	14	15	16	17	18
5		19	20	21	22	23	24	25
3		26	27	28	29	1[f]	*2*	3
0	SHAWWĀL 1317	4	5	6	7	8	9	10
7		11	12	13	14	15	16	17
4		18	19	20	21	22	23	24
1		25	26	27	28	29	30	*1*
8	DHU AL-QA'DA 1317	2	3	4	5	6	7	8
5		9	10	11	12	13	14	15
2		16	17	18	19	20	21	22

The months are:

(1) Muḥarram	30 days	(7) Rajab	30 days
(2) Ṣafar	29 days	(8) Sha'bān	29 days
(3) Rabī' I (Rabī' al-Awwal)	30 days	(9) Ramaḍān	30 days
(4) Rabī' II (Rabī' al-Āḥir)	29 days	(10) Shawwāl	29 days
(5) Jumādā I (Jumādā al-Ūlā)	30 days	(11) Dhu al-Qa'da	30 days
(6) Jumādā II (Jumādā al-Āḥira)	29 days	(12) Dhu al-Ḥijja	29 {30} days

Month lengths on the astronomical calendar vary according to the actual lunar cycle; the lengths given above are for the *arithmetic* calendar only. The first day of the month on the arithmetic calendar is always shown in italics, so the date on the arithmetic calendar can be determined by counting forward from there; the first days of the astronomical and arithmetic months are always within one or two days of each other.

Leap years, which have 355 days, are indicated by ‡ after the year number. Leap years on the astronomical calendar are shown, *not* leap years on the arithmetic calendar. An Islamic year y is a leap year on the arithmetic calendar if $(14 + 11y) \bmod 30 < 11$.

Dates of significance in the Islamic year are shaded and keyed to footnotes. The dates so indicated are approximate because the actual dates of occurrence depend on human observations, not calculations.

Event	Key	When
New Year	*a*	Muḥarram 1
New Year (Arithmetic)	*â*	Muḥarram 1
'Ashūrā'	*b*	Muḥarram 10
Prophet's Birthday (Mawlid an-Nabī)	*c*	Rabī' I 12
Ascent of the Prophet	*d*	Rajab 27
Start of Ramaḍān	*e*	Ramaḍān 1
'Īd al-Fiṭr	*f*	Shawwāl 1
'Īd al-'Aḍḥā	*g*	Dhu al-Ḥijja 10

WARNINGS

❖ ***Our Islamic calendar is an approximation based on astronomical determination of when the new crescent moon is likely to be visible in Los Angeles, California; however, the actual date depends on human observation of the crescent moon. Thus, month beginnings and endings can be in error by a day or so, and vary from country to country. Holiday dates are therefore also only approximate and vary from country to country.***

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- *On the Islamic calendar each day begins the prior evening at local sunset.*
- *The italicized dates of the arithmetic Islamic calendar indicated in the tables are based on a fixed thirty-year cycle in which years 2, 5, 7, 10, 13, 16, 18, 21, 24, 26, and 29 are leap years.*

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