Errata and Notes for

Calendrical Calculations

Nachum Dershowitz and Edward M. Reingold
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Do I contradict myself? Very well then I contradict myself.
(I am large, I contain multitudes.)

—Walt Whitman: *Song of Myself*

All those complaints that they mutter about... are on account of many places I have corrected. The Creator knows that in most cases I was misled by following... others whom I will spare the embarrassment of mention. But even were I at fault, I do not claim that I reached my ultimate perfection from the outset, nor that I never erred. Just the opposite, I always retract anything the contrary of which becomes clear to me, whether in my writings or my nature.

—Maimonides: *Letter to his student Joseph b. Yehuda (c. 1190), Iggerot HaRambam, I. Shilat, Maaliyot, Maaleh Adumim, 1987, vol. 1, p. 295 [in Judeo-Arabic]*

It is traditional for the author to magnanimously accept the blame for whatever deficiencies remain. I don't. Any errors, deficiencies, or problems in this book are somebody else's fault, but I would appreciate knowing about them so as to determine who is to blame.

—Steven Skiena: *The Algorithm Design Manual*

If you find errors not given below or can suggest improvements to the book, please send us the details. Our thanks to Helmer Aslaksen, Christian Carey, Laurent & Sophie Cohen, John Cross, Scott Deifik, Idan Dershowitz, Paul Eggert, Robert Fowler, Erich Fussi, Mitch Harris, Thomas Heim, Kees van't Hoff, Jeffrey C. Jacobs, Howard Jacobson, Svante Janson, J. Bruce King, Joe Kress, Michael Krieger, Alan Liu, Baolin Liu, Robert McNally, Jonathan S. Ostroff, Natan Pinsky, Denis Roegel, Trudi de Ruiter, Bruce D. Sinclair, Robert Stone, Michael Terry, Thomas Martin Widmann, Daniel Yaqob, Menasse Zaudou, and Georg Zotti for pointing out errors, making suggestions, and helping with LaTeX and fonts.

The latest version of this document can be obtained from the Web site

`http://emr.cs.uiuc.edu/~calbook`

The severity of an error is indicated by the red asterisks preceding the error number. No asterisk indicates a note or a trivial error, a single asterisk a more serious error, a double asterisk an even more serious error, and so on. An error that has been corrected in some printings is marked by a green circle containing the number of the printing in which the error was fixed.

The printing history of the book is as follows:

Printing	Date	Notes
First	July, 1997	Paperback and hard-cover
Second	January, 1998	Paperback; no corrections
Third	August, 1998	Paperback; most serious errors corrected

The various printings can be identified by looking at page iv (the back of the title page, facing the Hebrew dedication): The first printing has a line saying "First published 1997"; the second printing says in addition "Reprinted 1998"; the (corrected) third printing says "Reprinted 1998 (twice)".

1. Page iv, line −4: In the second printing only, this line, which reads "Typeset in", is spurious.

2. Pages xviii, paragraph labeled "1.": Change "The COBOL programming language usually allocates" to "COBOL programmers usually allocated".

3. Pages xviii, paragraph labeled "1.": Add some more discussion of the Y2K (year 2000 problem). This should be indexed as "Y2K" and "Year 2000 problem." Also mention the year 2038 problem on computers that use 32-bit integers to count seconds since January 1, 1970 and the GPS rollover on August 22, 1999.

4. Pages xviii–xix: Here are more nice examples.

   (a) According to *The New York Times* of March 1, 1997, the New York City Taxi and Limousine Commission chose March 1, 1996 as the start date for a new, higher fare structure for cabs. Meters programmed by one company in Queens forgot about the leap day and charged customers the higher rate on February 29.

   (b) According to the *New Zealand Herald* of January 8, 1997, a computer software error at the Tiwai Point aluminum smelter at midnight on New Year's Eve caused more than $AU 1 million of damage. The software error was the failure to consider 1996 a leap year; the same problem occurred two hours later at Comalco's Bell Bay smelter in Tasmania (which is two hours behind New Zealand). The general manager of operations for New Zealand Aluminum Smelters, David Brewer, said "It was a complicated problem and it took quite some time to find the cause."

   (c) According to *The New York Times* of January 12, 1999, Microsoft Windows 95, 98, and NT get the start of daylight savings time wrong for years in which, like 2001, April 1 is a Sunday; in such cases Windows has DST starting on April 8. An estimated 40–50 million computers are affected, including some in hotels that are used for wake up calls.

   (d) Oracle uses Julian day numbers in their database management system. But, if you query an Oracle database to return the Julian day number of Monday, January 1, 4713 B.C.E. (Julian), it returns 1 instead of the correct 0. But, this gets "corrected" after two months, on March 1, 4713 B.C.E. (Julian) so that if you ask for the Julian day number for the previous day, February 29, 4713 B.C.E. (Julian), Oracle returns an invalid date message! But, of course, 4713 B.C.E. (Julian) is a leap year on the Julian proleptic calendar.

5. Page x, line 8: Change "221" to "219".

6. Page xi, line 10: Change "Frontspieces" to "Frontispieces".

7. Page xi, line 11: Delete the phrase "great work,".

8. Page xi, line 15: Change "Cæser" to "Cæsar".

9. Page xii, lines −2 and −1: Delete the phrase "great work on the world's calendars,".

10. Page xiv–xv: Missing page numbers.

11. Page xvii, line 12: Reference for GNU Emacs should be 7, not 12.

12. Page xvii, line 16: Reference for Common Lisp should be 8, not 1.

13. Page xviii, line 2: Change "minutæ" to "minutiæ".

14. Page xviii, line −10: Change "accomodate [*sic*]" to "accommodate". (Normal scholarly practice would have been to correct the misspelling since that was clearly the author's intent. Our apologies to Ms. Wilkins.)

15. Page xix, line 3: Change to "New Year is wrong for many years; the epoch is wrong for the Ethiopic calendar, and hence that entire table is flawed."

16. Page xix, line 9: Reference for GNU Emacs should be 7, not 12.

17. Page xix, line −13: Change the web page to

    `http://emr.cs.uiuc.edu/~calbook`

18. Page xx, line 12: Change "R.D. 728841" to "R.D. 728,841".

19. Page xx, line −2: Change "1993. Used" to "1993; used".

20. Page xx, last line: Change "84" to "82".

21. Page 2: The photograph is off center vertically and horizontally.

22. Page 2, caption: Delete the phrase "great work,".

23. Page 4, second paragraph: In light of the license, we should soft-pedal the "public domain" comment!

24. Page 4, end of line 24: Add "Appendix C tabulates results of the calendar calculations for 33 sample dates."

25. Page 4, bottom paragraph: We should have forced ourselves to use a typed Lisp.

26. Page 4, line −1: Change the web page to

    `http://emr.cs.uiuc.edu/~calbook`

*27. (3) Page 7, lines −10 through −7: Change both occurrences of "summer" to "winter" and both occurrences of "winter" to "summer".

28. Page 9: If only we had used the quotation "May those who calculate a fixed date... perish." This is a translation (from M. Braude, *Conscience on Trial*, 1952) of a famous Talmudic dictum; the omitted words are "for the coming of the Messiah".

29. Page 9, add to end of first paragraph: The Metonic cycle is currently accurate to within 6.5 minutes a year. Other lunisolar cycles are conceivable: 3 solar years are approximately 37 lunar months (with an error of 1 day per year); 8 years are approximately 99 months (with an error of 5 hours per year); 11 years are approximately 136 months (with an error of 3 hours per year); 84 years are approximately 1039 months (with an error of 33 minutes per year); and 334 years are 4131 months (with an error of 3 minutes per year).

30. Page 9, footnote 3: Reference for Ginzel should be 4, not 2.

31. Page 9, footnote 3: Reference for *Encyclopædia of Religion and Ethics* should be 7, not 8.

32. Page 9, footnote 4: There was some egomania involved too!

33. Page 10: Add the Roman way of referring to the date (see erratum 64).

*34. (3) Page 10, line 11: Change "4, 1939" to "3, 1938".

35. Section 1.3: Perhaps discuss the following points: Why ancient tradition had no 0 A.D. When does a new century begin? Historians (for example Gingerich) versus modernists (for example Goethe). Calendrical traditions that have zero (Babylonian and Mayan, for instance). Cassini invented the origin-0 Gregorian calendar in 1740. We assume year 0 exists for all calendars *except* the Julian (Chapter 4) and the Persian (Chapter 7). Also, see erratum 54.

36. Page 12, line 6: Change "functions in the Appendix," to "functions in Appendix B and sample data in Appendix C," See erratum 257.

*37. (3) Page 14, Table 1.1: The entries for the Ethiopic calendar are wrong. The epoch should be R.D. 2796 = August 27, 8 (Gregorian) = August 29, 8 C.E. (Julian).

38. Page 16, line 1: Replace with "The amod function for positive integer y can also be described as".

39. Page 17, line −5: Change "R.D. d" to "R.D. *date*".

40. Section 1.10: Bresenham's "midpoint line algorithm" (for drawing lines in two dimensions on a discrete raster—see section 3.2.2 of *Computer Graphics: Principles and Practice* by J. D. Foley, A. van Dam, S. K. Foley, and J. F. Hughes, 2nd ed., Addison-Wesley Publishing Co., Reading, MA, 1990) is a special case of the leap year formulas developed here. See "Line drawing and leap years" by M. Harris and E. M. Reingold, in preparation.

41. Page 20, line −9: Change "see [6] for details" to "see [10] for details".

*42. Page 21, line 1: Change "and $k = 1$, since $12/2 \equiv 1 \pmod{10/2}$" to "and $k = 5$, since $10/2 \equiv 5 \pmod{12/2}$".

43. Page 21, line 3: Change "$b \leq b \leq 12$" to "$1 \leq b \leq 12$".

*44. Page 21, line 4: Change the formula to read

$$(a - 1 + 5[5(b - a) \bmod 12]) \bmod 60 + 1$$

45. Page 21, middle: Note that the mathematical properties of Gregorian-like leap year rules are related to Pierce expansions. See "Pierce expansions and rules for the determination of leap years" by J. Shallit, *Fibonacci Quarterly* **32** (1994), pp. 416–423.

46. Page 28: Add a section with functions for the idealized Babylonian calendar of twelve months of thirty days each calendar.

47. Page 28, line 14: Change "200,000 years" to "10,000 years".

48. Page 29, first paragraph: Add the following sentence at the end of the paragraph. "Year 0 is assumed to exist for all calendars *except* the Julian (Chapter 4) and the Persian (Chapter 7)."

49. Page 29: Add a new subsection discussing the accuracy of the calendars and explaining that in discussing accuracy we use *present day values* of astronomical "constants" (really time-varying functions) such as the length of a day, year, etc. Summarize with a table showing the present day versus long term accuracy of the various calendars.

50. Page 30, line 1: Delete the extraneous "3" at the beginning of the citation.

51. Chapter 2: Use the following quote from act II of Gilbert and Sullivan's *Pirates of Penzance*:

> For some ridiculous reason, to which, however, I've no desire to be disloyal,
> Some person in authority, I don't know who, very likely the Astronomer Royal,
> Has decided that, although for such a beastly month as February, twenty-eight as a rule are plenty.
> One year in every four his days shall be reckoned as nine-and-twenty.

52. Page 33: Mention that in Roman times the year began on March 1; it was only in recent centuries that the consensus has been to start the new year on January 1 (see erratum 65).

53. Page 33–34: Which date is the "leap day"? We think of it as being February 29, but it was not always so! In Denmark leap day is considered February 24.

54. Page 34, footnote 1: Add "Dionysius erred by a few years in his determination of the year of Jesus's birth." Perhaps add remarks that much of Christendom used "Anno Diocletiani" for many years (the Julian calendar with Diocletian's reign as the origin—the same origin as the Coptic calendar); Dionysius's innovation was to substitute his estimate of Jesus's natal year for the origin. Also, Dionysius did not invent B.C.—his system started at 1. The "1 B.C.E. is the year before 1 C.E." problem was a result of the system introduced and popularized by the Venerable Bede around 731; Bede didn't know about zero, so he did not use it. See Dick Teresi, "Zero", *The Atlantic Monthly* 280, 1 (July 1997), 88–94.

55. Page 35, lines 2–3: The claim about Switzerland's change to the Gregorian calendar is incorrect—the various cantons changed at different times, much like the various German jurisdictions did.

56. Page 35: Also point out that some countries use the Gregorian calendar with a different era. For example, 1912 is year 1 in the Taiwanese version.

57. Page 35, lines 8–9: Change "1752; Russia... until 1927." to "1752. Russia held out until 1918, after the Bolshevik Revolution which is also known as the October Revolution, because it occurred October 25–26, 1917 C.E. (Julian) = November 7–8, 1917 (Gregorian). Different parts of what is now the United States changed over at different dates; Alaska, for example, changed only when it was purchased by the U.S. in 1867. Turkey did not change to the Gregorian calendar until 1927."

58. Page 35: The following bit of Russian history is relevant. Until the fifteenth century, the Russian year, which followed the Julian calendar, began on March 1. Years were counted from creation, dated 5509 B.C.E. For a brief period the year began on September 1, but around 1700, Peter the Great introduced January 1 as the beginning of the year. In 1918, the Gregorian calendar was adopted. Then on October 1, 1929, an "Eternal Calendar" went into effect, with five days per week and six weeks to a month, plus five extra vacation days per year, corresponding to January 22 (Bloody Sunday), May 1 and 2 (May Day) and November 7 and 8 (Revolution Day) on the Gregorian Calendar. The five-day calendar week, which had staggered days off, was abolished in 1932, in favor of a six day week, with days off on the 6th, 12th, 18th, 24th and 30th. Russia reverted to the Gregorian calendar in 1934, but the work week stayed the same. (Some workers got March 1 off in lieu of February 30.) This situation lasted until 1940, when the seven-day week was reinstated.

59. Page 38, line 2: Change $d_4 + 1$ to d_4.

60. Page 39, lines −6 and −5: Change "*year*" to "*g-year*".

61. Page 40, lines 2–4: Change "*date*" to "*g-date*".

62. Page 46, caption: Change "Cæser" to "Cæsar".

63. Page 47: Use the following quote from Plutarch (*Life of Cæsar*, 59.3) in connection with the Julian calendar reform: "Cæsar set out the problem before the best philosophers and mathematicians and, from the methods available, he concocted his own correction that was more precise."

64. Page 47: Give details of the Roman numbering of days (for example, "XIV Kalendae Decembris").

65. Page 47: Until 1751, the New Year began in England (and presumably in the US) on March 25 (Annunciation of the Blessed Virgin Mary). 1752 began on January 1, so that 1751 was only a bit longer than nine months. This means that care has to be taken with earlier dates: March 20, 1603 was in what we would now call 1604. A relic in Britain is that the Financial year begins on April 6. Prior to the introduction of New Year's Day on 25th March (under the Plantagenets?) was the New Year's Day of the previous 25th December, so that particular change-over year was fifteen months long. For Scotland, the New Year's Day change from 25th March happened on 1st January 1600 (so 1599 there was the same length as 1751 in England).

*66. Page 50: Add the following line 12 (that is, after the definition of y:

$$\mathit{next\text{-}y} = \begin{cases} 1 & \text{if } y = -1, \\ y + 1 & \text{otherwise} \end{cases}$$

Also, change $y + 1$ in the definition of date_2 to *next-y*.

67. Section 4.3: The material on the calculation of Easter should be in a separate chapter entitled "Ecclesiastical Calendars". The opening quote could be the following peculiar reference to Easter for a weather-related matter:

> The winter rains die away about Easter time with a final, slightly heavier onset. The period from mid-June to mid-September is almost completely rainless...

The quote is from 1964 *The Encyclopædia Britannica*, the main entry on "Palestine" in the section on climate by Sir George Grey Aston and William Bayne Fisher.

68. Page 54: Note that Shrove Tuesday is also called Mardi Gras.

69. Page 55, reference [3]: Change the range of pages to "73–79".

70. Page 55, reference [5]: Capitalize "mathematik" and change the range of pages to "217–228".

71. Page 57: Use the quote "This calendar is, indeed, the only intelligent calendar which ever existed in human history." It is from the top of page 81, *The Exact Sciences in Antiquity* by Otto Neugebauer, Princeton University Press, 1952. The calendar thus described is the ancient Egyptian calendar (upon which the Julian calendar was based) of twelve months of thirty days each, followed by a five-day period.

72. Page 57: Here are the month names in Coptic (Sahidic):

(1) Tūt	Ⲑⲟⲟⲩⲧ	(7) Baramhāt	Ⲡⲁⲣⲙⲏⲟⲧⲡ
(2) Bābah	Ⲡⲁⲟⲡⲉ	(8) Baramūndah	Ⲡⲁⲣⲙⲟⲩⲧⲉ
(3) Hātūr	Ⲋⲁⲑⲱⲣ	(9) Bashans	Ⲡⲁϣⲟⲛⲥ̄
(4) Kiyahk	Ⲕⲟⲓⲁⲕ	(10) Ba'ūnah	Ⲡⲁⲱⲛⲉ
(5) Ṭūbah	Ⲧⲱⲃⲉ	(11) Abīb	Ⲉⲡⲏⲡ
(6) Amshīr	Ⲙϣⲓⲣ	(12) Misrā	Ⲙⲉⲥⲟⲣⲏ
		(13) al-Nasī	Ⲉⲡⲁⲧⲟⲗⲗⲉⲡⲏ

And the day names:

Sunday = Tkyriakê	Ⲧⲕⲩⲣⲓⲁⲕⲏ
Monday = Pesnau	Ⲡⲉⲥⲛⲁⲩ
Tuesday = Pšomṇt	Ⲡⲯⲟⲙⲛⲧ
Wednesday = Peftoou	Ⲡⲉⲫⲧⲟⲟⲩ
Thursday = Ptiou	Ⲡⲧⲟⲩ
Friday = Psoou	Ⲡⲥⲟⲟⲩ
Saturday = Psabbaton	Ⲡⲥⲁⲃⲃⲁⲧⲟⲛ

73. Page 59: Here are the month names in Amharic:

(1) Maskaram	መስከረም	(7) Magābit	መጋቢት
(2) Teqemt	ጥቅምት	(8) Miyāzyā	ሚያዝያ
(3) Khedār	ኅዳር	(9) Genbot	ግንቦት
(4) Tākhśāś	ታሕሣሥ	(10) Sanē	ሰኔ
(5) Ṭer	ጥር	(11) Ḥamlē	ሐምሌ
(6) Yakātit	የካቲት	(12) Naḥasē	ነሐሴ
		(13) Pāguemēn	ጳጉሜን

And the day names:

Sunday = Ihud	እሑድ
Monday = Sanyo	ሰኞ
Tuesday = Maksanyo	ማክሰኞ
Wednesday = Rob	ሮብ/ረቡዕ
Thursday = Hamus	ኀሙስ
Friday = Arb	ዓርብ
Saturday = Kidamme	ቅዳሜ

***74. (3) Page 59, line 11: Change "starts on August 29, 7 C.E. (Julian), our R.D. 2430:" to "starts on August 29, 8 C.E. (Julian), our R.D. 2796:". With this change, Coptic and Ethiopic dates differ only in the year number and month names, so the discussion should be simplified accordingly—namely, the section on the Ethiopic calendar could be eliminated and replaced with a paragraph mentioning the different year and a table that combines the Coptic and Ethiopic month names.

***75. (3) Page 59, equation (5.5): Change

ethiopic-epoch $\stackrel{\text{def}}{=}$ **fixed-from-julian** (297 C.E.)

to

ethiopic-epoch $\stackrel{\text{def}}{=}$ **fixed-from-julian** (298 C.E.)

76. Page 59, line −5: Delete "fixed".

77. Page 61, line 3: Change "Practiques" to "Pratiques".

78. Page 63, line −10. Change "The sixth day" to "The day of assembly".

79. Page 63. Here are the day names in Arabic:

Sunday	yawn al-ahad	يَوْمُ الاحد
Monday	yawn al-ithnaya	يَوْمُ الاثنين
Tuesday	yawn uth-thalathaa	يَوْمُ الثلاثاء
Wednesday	yawn al-arba'a	يَوْمُ الاربعاء
Thursday	yawn al-khamis	يَوْمُ الخميس
Friday	yawn al-jum'a	يَوْمُ الجمعة
Saturday	yawn as-sabt	يَوْمُ السَبْت

80. Page 64. Here are the month names in Arabic:

(1) Muḥarram	مُحَرَّم	(7) Rajab	رَجَب
(2) Ṣafar	صَفَر	(8) Šha'ban	شَعبَان
(3) Rabī' I	رَبيع الاَوَل	(9) Ramadān	رَمَضَان
(4) Rabī' II	رَبيع الاَخِر	(10) Šawwāl	شَوَّال
(5) Jumādā I	جُمَادي الاولَى	(11) Ḏu al-Qa'da	ذو القَعدة
(6) Jumādā II	جُمَادي الاَخِرَى	(12) Ḏu al-Ḥijja	ذو الحَجّة

81. Page 66–67: "Quds Day" is a recently established Islamic holiday that occurs on the last Friday of Ramadan.

82. Chapter 7: The calendar implemented is actually the *proposed* modern Persian calendar as described by Birashk; it has not been officially adopted. However, whenever the Iranian government has a calendrical question, they ask Birashk!

83. Page 70. Here are the month names in Farsi:

(1) Farvardīn	فروردین	(7) Mehr	مهر
(2) Ordībehešt	اردیبهشت	(8) Abān	آبان
(3) Xordād	خرداد	(9) Āzar	آذر
(4) Tīr	تیر	(10) Dey	دی
(5) Mordād	مرداد	(11) Bahman	بهمن
(6) Šahrīvar	شهریور	(12) Esfand	اسفند

84. Page 71, lines 8–11: In light of erratum 49, redo the calculation with more significant digits—the Persian calendar is about twice as accurate as stated. According to the International System (SI) definition (as given in the Chemical Rubber Company's *Handbook of Chemistry and Physics*), the second is exactly 1/31,556,925.9747 of the tropical year 1900 at 12 hours, January 0 (this definition was superseded in 1968 by the definition of the "atomic second" which is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium-133 atom). The Persian year is exactly 365 683/2820 days long. If we assume that a day is $24 \times 60 \times 60 = 86400$ seconds (which the SI does *not* specify), the Persian year is therefore exactly 31,556,925 45/47 seconds. The error in the Persian calendar is therefore (.974700000 - 45/47) seconds/year = 0.017253191 seconds/year = 1 day in 5,007,769 years.

85. Pages 85–86: Here are the Hebrew day names:

Sunday	yom rishon	יום ראשון
Monday	yom sheni	יום שני
Tuesday	yom shlishi	יום שלישי
Wednesday	yom r'vi'i	יום רביעי
Thursday	yom ḥamishi	יום חמישי
Friday	yom shishi	יום ששי
Saturday	yom shabbat	יום שבת

86. Page 88, line 2: After "The moment of sunset is *deemed* 6 p.m. and sunrise is *deemed* 6 a.m." add "In other words, seasonal time is used for the calculations." (See al-Bîrûnî.)

87. Page 89, line −18: Change "di Silo" to "ben David da Silva".

88. Page 89, line −14: Change "thou" to "thee".

89. Page 89, last paragraph: Give the details of the repetition of the Hebrew versus Gregorian calendar more clearly: The sequence of characters of years repeats after $19 \times 36288 = 689472$ years because the 19-year cycle contains exactly

    991 weeks, 2 days, 16 hours, and 595 parts,

    and

    2 days, 16 hours, and 595 parts = 69715 parts

    A week has 181440 parts, so it takes

    $$\begin{aligned} \text{lcm}(69715, 181440) &= 2{,}529{,}817{,}920 \text{ parts} \\ &= 36{,}288 \text{ cycles} \end{aligned}$$

    to accumulate into an even number of weeks. The Gregorian calendar repeats in 400 years, so the equivalence of Gregorian-Hebrew dates repeats in

    $\text{lcm}(689472, 400) = 17{,}236{,}800$ years.

90. Page 91, line 14: Change "if that is a problem" to "to avoid such large numbers".

91. Page 93–94: We should not have written the code so that **fixed-from-hebrew** is used in **days-in-hebrew-year**. The code is correct, but the recursion is unneeded and confusing. We should have defined a function **hebrew-new-year** (to be the sum of **hebrew-epoch**, **hebrew-calendar-elapsed-days**, and **hebrew-new-year-delay**) and used it in both **days-in-hebrew-year** and **fixed-from-hebrew**. The function **hebrew-new-year** should then also be used to simplify the definition of $p(y)$ in **hebrew-from-fixed**.

92. Page 94, line 4: Add "+1" to *approx*.

93. Page 94, line 14: Replace "this estimate *approx*" with "the estimate *approx*".

94. Page 95, line −8: Change "observe two days Rosh" to "observe two days of Rosh".

*95. (3) Page 96, line 8: Change "Thursday, September 6, 921 C.E. (Julian), R.D. 336,277" to "Wednesday, September 5, 921 C.E. (Julian), R.D. 336,276".

96. Page 96, line −9: Change "is not delayed," to "is delayed until Thursday,".

97. Page 97, line 5: Delete the extraneous "45" and begin a new paragraph at that point.

98. Page 97, line 6: Change "(heave offering)" to "(sheave offering)".

99. Page 99, line 9: In May, 1997 the Israeli government changed the definition of Yom HaShoah to state that if it falls on a Sunday it will be postponed to the following day.

100. Page 99, line 10: Add "(Israeli Memorial Day)" after "Yom HaZikaron".

101. Page 100, line −9: The function **sh-ela** does not work properly beyond the Gregorian year 5400, when *sh-ela* falls around New Year's.

102. Page 102, equation (9.23): Our function for **yahrzeit** accords with Ashkenazic practice as described, in [14] and in the *Talmudic Encyclopedia: A Digest of Halachic Literature from the Tannaitic Period to the Present Time Alphabetically Arranged*, Talmudic Encyclopedia Publishing Ltd., Jerusalem, vol. I (1951), p. 93; vol. XXIII (1997), cols. 153-154; M. Feinstein (*Iggerot Moshe*, vol. 6, *Yoreh Deah*, part 3, p. 426), on the other hand, rules that *yahrzeit* anniversaries of the last day of a month follow the rules for birthdays.

103. Page 115, line −10: Change "A. Aveni" to "A. F. Aveni".

104. Chapter 12: Add a reference to *The Ever-Changing Sky* by James B. Kaler, Cambridge University Press, 1996. This book contains detailed, readable explanations of nearly all of the topics discussed in our Chapter 12.

105. Page 127, line 11: Delete "through".

*106. Page 129, line 3: Change "**arya-sidereal-month**" to "**arya-solar-month**".

107. Chapter 12: We use the variable name *moment* in (12.2), (12.3), (12.16) to refer to JD times, when—for consistency—we should have used *jd*. We should also have used *jd* in (12.34). It would have been better to base all the astronomical calculations on R.D. moments, rather than JD-based Universal Time.

108. Page 137, line 5: We should mention in this paragraph that the hands on early mechanical clocks were imitating the movement of the shadow of the gnomon (in the northern hemisphere where clocks were developed) as the sun crosses the sky. This is the origin of our notion of "clockwise". See "The Last Word" inside the back cover of *New Scientist*, March 27, 1999.

109. Page 137, **equation-of-time**: For robustness, the result (which is in any case an approximation of limited validity) should be normalized to the range (−0.5,0.5).

110. Page 138, Figure 12.1: Give the vertical axis labels in *fraction-of-day* as calculated by the function **equation-of-time**.

111. Page 138, last line: Change the period at the end of the line to a semicolon.

112. Page 139, equations (12.2) and (12.3): For consistency, we should have made these functions of *jd*, not *moment*.

*113. (3) Page 139, line 10: Change "4.09054" to "4.0989".

114. Page 139, last paragraph: Perhaps mention the odd belief that fresh eggs balance more easily on the day of the vernal equinox. This turned into a minor craze in the United States; see Martin Gardner's "Notes of a Fringe Watcher," *The Skeptical Inquirer*, May/June, 1996.

115. Page 140, equation (12.4): The function **nutation** should have been written in degrees, rather than radians.

116. Page 140, lines 20–26: Move the text "Time, c, is measured... pages 13 and 36, respectively." to the very bottom of page 138, changing the beginning to read "*jd* is converted to "Julian centuries," c, which ...".

117. Page 141, lines −8 and −7: Delete the phrase "of $3\frac{1}{3}$ seconds each".

118. Page 142, last paragraph: Change the opening "We use universal time... of a solar day." to "There are several closely related types of Universal Time. Civil time keeping uses Coordinated Universal Time (U.T.C.), which since 1972 has been atomic time adjusted periodically by leap seconds to keep it close to the prime meridian's mean solar time. We use U.T.C. for calendrical purposes, expressed as a fraction of a solar day." Two relevant references should be added for this section: Dennis D. McCarthy, "Astronomical time," *Proc. IEEE* **79** (1991), 915–920. Terry J. Quinn, "The BIPM and the Accurate Measure of Time," *Proc. IEEE* **79** (1991), 894–905.

119. Page 142, footnote: From 1911 to 1978, local time in France was officially based on Paris Mean Time minus 9:21. France did not formally switch to U.T.C. as the time base until 1978. See *Greenwich Time and Longitude: Official Millenium Guide* by Derek Howse, Philip Wilson Publishers, New York (1997).

120. Page 143, line 6: Change "its local time is 9 minutes 21 seconds after U.T." to "its local mean time is 9 minutes 21 seconds ahead of U.T.".

121. Page 143, first complete paragraph: Though time zones were indeed first imposed by North American railway companies, standard time was first imposed by British railway companies starting in November 1840. See the Howse reference in erratum 119.

122. Page 143, lines 12–13: Delete the parenthetical remark "(excluding Great Britain and Finland)".

123. Page 144, **sidereal-from-jd**: As written this function returns a julian day number, the fractional part of which corresponds to the mean sidereal time. It would have been better to have the function return an answer of type *moment*.

124. Page 144, line 8: Change "The Hindu" to "We do not need this function, but give it only because the modern Hindu lunar".

125. Page 144, line 9: Change "calculation" to "calculations".

126. Page 144, line 11–12: Add (between the lines), "Furthermore, Ephemeris time uses unchanging time units. Since the speed of rotation of Earth—on which Universal time is based—is slowly decreasing, the discrepancy between Universal and Ephemeris time is therefore increasing; it now stands at about 65 seconds and is increasing at about one second per year." (Ephemeris time is the outdated term as of about 1984. Dynamical time, which is slightly different, is now used. Dynamical time comes in various flavors. Specifically, Terrestrial Time is the current term for what we are calculating.)

127. Page 144, line −1: Change "*moment*" to "⌊*moment*⌋".

128. Page 145, equation (12.16): For consistency, we should have made this a function of *jd*, not *moment*.

129. Page 147, Table 12.1: The line with entries 0, 1.163, 0.00813 (right-hand set of columns, fourth line) is superfluous. (The results of the calculation are unaffected by this vestige of other code.)

130. Page 147, equation (12.20): The function **aberration** should have been written in degrees, rather than radians.

131. Page 148, last paragraph, line −3: Change "exactly" to "at least".

132. Page 149, Table 12.2: Change the approximate dates of the spring equinox to March 20, the fall equinox to September 22–23, and the winter solstice to December 21–22.

133. Page 149, line −13: Change "R.D. date" to "R.D. moment".

134. Page 150, section 12.6: Begin the section with the following remarks. Astronomical sunrise is defined as the time of first appearance (of the upper limb) of the sun; sunset is the moment of disappearance (again of the upper limb). This is also the definition used for calendars that begin their day at sunset (for example, the Islamic and Hebrew calendars) or sunrise (the Hindu calendar, for example). Because of the asymmetry involved, on the day of the equinox the intervals from sunrise to sunset and from sunset to sunrise differ by a few minutes. This discrepancy is further compounded by atmospheric refraction which makes the sun visible two to three minutes before a straight line to the sun is actually above the horizon, and keeps the sun visible for a few minutes after it is physically below the horizon at sunset-time.

135. Page 150 and elsewhere: The automated Lisp-to-formula translator sometimes makes lines that are too long.

136. Page 151: The functions **sunset** and **sunrise** should return a moment (the fixed date as the integer part and the time of day as a fraction); right now it just returns the fractional part representing the time of day.

137. Page 152, line −10: Change "one-twelfth of a solar year." to "one-twelfth of a solar year and ranges from 29.44 days in Northern Hemisphere winter (to traverse Capricorn) to 31.43 days in Northern Hemisphere summer."

138. Pages 152–155: The approximations used in **new-moon-at-or-after** (specifically, 12.3685 for the number of synodic months in a Gregorian year) can cause it to err by a month after the year 10,000 C.E. This can cause the function **new-moon-before** to loop when **new-moon-at-or-after** is out of its range of applicable dates. Such problems could be avoided by using date-dependent values for the length of the year and month; see pages 146 and 152.

139. Page 155, line 7: For consistency, the argument to **lunar-longitude** should be called *jd*, rather than *u-time*. We do not actually use the alternative new moon calculations (pages 155–159), based on **lunar-longitude**, in any of the calendar calculations.

140. Page 156, line 7: The "y" at the end of the line is partially cut off.

141. Page 156, lines 18–19: Change "to bring...range.)" to "to minimize loss of significant digits in subsequent arithmetic operations.)"

142. Page 157, Table 12.5: The line with entries 0, 2, 0, −1, −2 (right-hand set of columns, last line) is superfluous. (The results of the calculation are unaffected by this vestige of other code.)

143. Page 159, line 7: In regard to blue moons, 1999 is an unusual year in that it contains *two* blue moons, one in January and second in March, and February has no full moon. This state of affairs was reported in *The New York Times* on January 1, 1999; the article included a list of the various names of full moons (harvest moon, hunter's moon, and so on). *The New York Times* on April 1, 1999 had an article

correcting the definition of a blue moon: a blue moon was originally understood to be a fourth full moon in a season, which normally has only three full moons. See the May, 1999 issue of *Sky & Telescope* for an article giving full details of matter.

144. Page 159: Add a section at this point describing the implementation of purely astronomical solar and lunar calendars.

145. Page 163: Add a section-opening quotation: "... je ne regrette presque plus le calendrier républicain" ("... I almost no longer regret the French Revolutionary calendar") from the January 20, 1806 entry in Stendhal's (= Henri Beyle) *Journal*.

146. Page 164, **french-autumnal-equinox-on-or-before**: This function would be more robust if d' did not depend on **mean-tropical-year** but rather was calculated more precisely from θ. For example, we might use something like $d' = date - 10 - (\theta + 180) \bmod 360$.

147. Page 168, line 1 of caption: K'ang Hsi should be Kāng Xī.

148. Page 170, three places in footnote 2: Hsu should be Xu.

*149. (3) Page 171, Table 14.1: The approximate Gregorian date for Guyu should be April 20, not April 30.

150. Page 171, Table 14.1: The Chinese names given for the solar terms are as follows:

Lìchūn	立春	Beginning of Spring
Yǔshuǐ	雨水	Rain Water
Jīngzhé	惊蛰	Waking of Insects
Chūnfēn	春分	Spring Equinox
Qīngmíng	清明	Pure Brightness
Gǔyǔ	谷雨	Grain Rain
Lìxià	立夏	Beginning of Summer
Xiǎomǎn	小满	Grain Full
Mángzhòng	芒种	Grain in Ear
Xiàzhì	夏至	Summer Solstice
Xiǎoshǔ	小暑	Slight Heat
Dàshǔ	大暑	Great Heat
Lìqiū	立秋	Beginning of Autumn
Chǔshǔ	处暑	Limit of Heat
Báilù	白露	White Dew
Qiūfēn	秋分	Autumnal Equinox
Hánlù	寒露	Cold Dew
Shuāngjiàng	霜降	Descent of Frost
Lìdōng	立冬	Beginning of Winter
Xiǎoxuě	小雪	Slight Snow
Dàxuě	大雪	Great Snow
Dōngzhì	冬至	Winter Solstice
Xiǎohán	小寒	Slight Cold
Dàhán	大寒	Great Cold

Major solar terms are zhōngqì (中气). Minor solar terms are jiéqì (节气). (From *The Pinyin Chinese-English Dictionary*, Beijing Foreign Languages Institute.)

151. Page 173, top line: Change d to $d + 1$.

152. Page 175, italic lines at mid-page: Change "Chinese year" to "winter-solstice-to-winter-solstice period".

153. Page 175: Add a footnote for the italic lines of erratum 152 remarking that the "winter-solstice-to-winter-solstice period" is called suì (岁), while the "chinese-new-year-to-chinese-new-year-period" is called nián (年).

154. Page 175, line −14: Add to the end of the paragraph "It is also possible that a solar month fall entirely within a lunar month; that is, a lunar month can contain *two* major solar terms. Such an occurrence in a 13-month Chinese year can cause two lunar months without major solar terms."

155. Pages 175–176: Replace the last paragraph on page 175, including the first two words on page 176 with the following: "How do we know that a Chinese year cannot require two leap months? That is impossible because the two-solar-year period between the winter solstice of Gregorian year $y-2$ and the winter solstice of Gregorian year y can contain either 24 or 25 lunar months; since the period from the winter solstice of Gregorian year $y-1$ to the winter solstice of Gregorian year y has thirteen months, the period from the winter solstice of Gregorian year $y-2$ to the winter solstice of Gregorian year $y-1$ can have only twelve lunar months and hence no leap month. Thus the first month in a winter-solstice-to-winter-solstice period without a major solar term will be the leap month, and no second leap month is possible." The sentence on the first line of page 176 "To determine whether a given month..." should begin a new paragraph.

156. Page 177, lines −20 and −19: Change "which determines... month m." to "which determines whether there is a Chinese leap month on or after the lunar month starting on fixed day m' and at or before the lunar month starting at fixed date m."

157. Page 177, line −17: Delete the phrase "(but just barely)".

*158. Page 177, line −15: Add at the end of the paragraph the text "Major terms and new moons are considered *without regard to their time of day.* So, for example, even though the major term, dongzhi, occurred in Beijing on December 22, 1984 at about 0:23 a.m., *before* the new moon on that date which occurred in Beijing at about 7:47 p.m., dongzhi (the winter solstice) is considered to be in that month, not the previous month. In contrast, in the modern Hindu calendars (Chapter 15) the precise time of day of an event is critical."

159. Page 178, Figure 14.2: The relative positions of the tick marks for Dahan (above the timeline) and the start of month *12* (below the timeline) ar reversed: Dahan comes the day before the start of month *12*.

160. Page 178, caption: Add at the end the text "Solar and lunar events are specified by the day of occurrence, ignoring the exact time of day. In fact, the new moon of month 11 occurs about 19 hours *after* dongzhi on December 22, 1984, but dongzhi, the winter solstice, is still considered to be *in* the eleventh month."

161. Page 180, middle: It is not traditional to count cycles or years. Still, on January 28, 1998, the U.S. press described the new Chinese year that began on that date as year 4696. However, our code describes the year as year 15 in cycle 78, making it year $60 \times (78-1) + 15 = 4635$ in Chinese chronology. This era agrees with that used in Fritsche [2]. The difference in eras stems from different choices of epoch—we chose the traditional date of the first use of the sexagesimal cycle, February 15, −2636 (Gregorian) = March 8, 2637 B.C.E. (Julian). Some choose to number years from 2698 B.C.E. (Julian), the first year of the Emperor Huangdi, the traditional ancestor of the Chinese nation; Sun Yat-sen used this starting point, which gives 4696 as the number of the Chinese year that began on January 28, 1998.

162. Pages 182–183: For present-day calculations, considering that the twelfth month is never a leap month for astronomical reasons, it follows that Chinese New Year is the first new moon after the sun's longitude reaches 300°, unless there is no new moon in Capricorn (between 270° and 300°), in which case it is the second new moon. This observation would allows the function **chinese-new-year** to be simplified somewhat, except far enough in future, as perihelion moves, winter leap months will become more and more common, including leap twelfth months. See also erratum 168.

163. Pages 180–183: **chinese-from-fixed** (equation 14.12) and **chinese-new-year** (equation 14.13) only work for years −10,000 B.C.E. to 10,000 C.E. Their applicability can be extended by making the changes suggested in erratum 138 and by using December 1 instead of December 15 as the earliest date for the major solar term. Computation of the date of the solstice independent of the Gregorian calendar would provide a much more robust solution—see erratum 146, for example.

164. Page 184, top of page: The English names given for the twelve branches corresponding to the years of the Chinese "Zodiac" are not translations from the Chinese. The twelve branches are traditional names that have no linguistic relationship whatsoever to the animal totems. Here are the ten "heavenly stems" (tiān gān 天干) and twelve "earthly branches" (dì zhī 地支):

Stems	tiān gān	天干	Branches	dì zhī	地支
1	jiǎ	甲	1	zǐ	子
2	yǐ	乙	2	chǒu	丑
3	bǐng	丙	3	yín	寅
4	dīng	丁	4	mǎo	卯
5	wù	戊	5	chén	辰
6	jǐ	己	6	sì	巳
7	gēng	庚	7	wǔ	午
8	xīn	辛	8	wèi	未
9	rén	壬	9	shēn	申
10	guǐ	癸	10	yǒu	酉
			11	xū	戌
			12	hài	亥

(From Feng Yu-Lan, *History of Chinese Philosophy*.) The "untranslatable" celestial stems have another use as well—they correspond to "A, B, C, D, ..." (for example, since written Chinese uses word-symbols, rather than an alphabet Jia, Yi, Bing, and Ding are used as letter grades on Chinese exam papers). Moreover, the 60-element cycle of stem-branch combinations is applied to hours as well as to days, months, and years. Since the "hours" are time-slots (two of our hours in length) they go through a 60-element cycle in 5 days, with the 12-element cycle of branches repeating once a day. The twelve branches are therefore used on Chinese medicine labels, where the herbalist tells you to take the medicine everyday in, say, time slots Yin and Shen.

165. Page 184, line −9: Change "page 20" to "pages 20–21".

**166. (3) Page 184, last line: Change "44" to "50".

167. Page 184, bottom half of page: We perhaps should have defined *chinese-day-name-at-epoch*, *chinese-month-name-at-epoch*, and *chinese-year-name-at-epoch* and used them for the name calculation, just as we did in the Mayan haab and tzolkin calendars. We could then also give a function **chinese-name-difference** and use it to define **chinese-name-day-on-or-before**, etc.

168. Page 185, line 8: Given the current position of perihelion, leap months after months 11, 12 and 1 are (extremely) rare. As perihelion moves, winter leap months will become more and more common.

169. Page 185: Mention the definition of a person's age according to Chinese custom—a person's age is considered to be 1 immediately at birth; a person becomes a year older with each subsequent Chinese New Year, so that a child born a week before the new year is considered age two a week after birth! This difference in the meaning of "age" has caused difficulties in gathering and interpreting sociological data. See "Errors in Chinese Age Statistics," Saw-Swee-Hock, *Demography* **4** (1967), 859–875. Perhaps write a new function **chinese-age** to give a person's age according to Chinese custom.

170. Page 185: Mention that Buddha's Birthday is the eighth day of the fourth month, that this is observed by washing his statue, and that there is an era associated with his birth.

171. Page 186, reference [5], last two lines: Replace with "pan she (People's Education Press), Beijing, 1992."

172. Page 186: Names of people/books in Chinese:

H. C. Hsu	= Xú Xī Qí	= 徐锡棋
Hsin pien Chung-kuo san chien nian li jih chien so piao	= Xīn biān Zhōng-guó sān qiān nián lì rì jiǎn suǒ biǎo	= 新编中国三千年历日检索表
Jen min chiao yu chu pan she	= Rén mín jiào yù chū bǎn shè	= 人民教育出版社
Hsin pien wan nian li	= Xīn biān wàn nián lì	= 新编万年历
ko hsuo pu chi chu pan she	= kē xué pǔ jí chū bǎn shè	= 科学普及出版社
B. L. Liu	= Liú Bǎo lín	= 刘宝琳
C. L. Liu	= Liú Jiǒng lǎng	= 刘炯朗

173. Page 190, line −8: Change "27.3216692···" to "27.321674···".

174. Page 190, line −6: Change "29.5305836989···" to "29.5305879···".

175. Page 191, line 26: Add "or" after "stations".

176. Page 191, line −13: Change "Table 15.3" to "Table 15.1".

177. Page 193, lines −3 and −2: Move these two lines ("Elliptical ... conceptual.") to a footnote anchored at the end of line −4. Add the following sentence to the end of the footnote: "Kepler's Second Law of 1609 C.E. explains that the motion is not uniform."

178. Page 194, line 15: Change "is" to "serve as".

*179. (3) Page 194, footnote: Change both occurrences of "5600" to "5400".

180. Page 195, line 3 of caption for Figure 15.1: Change "a epicycle" to "an epicycle".

181. Page 196, Table 15.2: entries in the fourth column are not aligned properly.

182. Page 200: The code for **hindu-calendar-year** should break "20000 > 1000" into "20000 and 1000".

183. Page 200, last line to page 201, line 1: Change "with the vernal equinox of 79 C.E." to "in the spring of 78 C.E."

184. Page 204, line 4: Change "a lower bound" to "bounds".

185. Page 204–205, **fixed-from-hindu-lunar**: The cumulative error caused by the use of **fixed-from-old-hindu-lunar** as an estimate in this function begins to cause bogus dates after 30,000C.E.

186. Page 207, footnote. Add "It was a common early medieval misconception that precession cycles in this way."

**187. (3) Page 207, lines 8–9: Replace with

$$precession \quad = \quad 1620 - \left| 3240 - \left(\left(1620 + \frac{6480 \cdot 600}{1577917828} \cdot midnight \right) \bmod 6480 \right) \right|$$

(This correction has an increasing effect on the calculation of the time of sunrise in Gregorian years 2299–4099, amounting to up to 20 minutes at the end of that period.)

188. Page 210: We should define constants **hindu-calendar-latitude** and **hindu-calendar-longitude** and use them instead of the numbers 1389 and 4546, respectively, in **hindu-sunrise** and **sunrise-at-ujjain**.

189. Page 211 and elsewhere: Some of the formulas would look better if fractions that just have numbers in the numerator and denominator were set (by the automated Lisp to formula translator) in smaller type.

190. Page 214, line −16: Change "mansion" to "station".

191. Page 214, line −16: Change the name of the function **lunar-mansion** to **lunar-station**.

192. Page 215, line 7: Change "Table 15.3" to "Table 15.1".

193. Page 221: Change the range of *fraction-of-day* to $(-1, 1)$.

194. Page 222, after line −24: Add table entry *list* in left column; other two columns are blank.

195. Page 223: **apparent-from-local** should have parameter type *julian-day-number* not *moment*; it should have result type *julian-day-number* not *moment*.

196. Page 223, after line 31: Add type *time* which is a *list* to table.

197. Page 225: **hindu-day-count** should have parameter type *hindu-moment* not *fixed-date*; it should have result type *hindu-moment* not *integer*.

198. Page 226: **julian-centuries** should have parameter type *julian-day-number* not *moment*; it should have result type *real* not *moment*.

199. Page 226: **local-from-apparent** should have parameter type *julian-day-number* not *moment*; it should have result type *julian-day-number* not *moment*.

200. Page 227: **local-from-standard** should have parameter type (*moment*, *real*) not (*moment*, *minute*).

201. Page 227: **local-from-universal** should have parameter type (*moment*, *real*) not (*moment*, *minute*).

202. Page 227: **location-offset** should have parameter type (*angle*, *real*) not (*angle*, *minute*).

203. Page 226: **lunar-longitude** should have parameter type *julian-day-number* not *moment*.

204. Page 226: Change the name of the function **lunar-mansion** to **lunar-station**.

205. Page 227: **time-of-day** should have result type *time* not *moment*.

206. Page 227: **nth-kday** should have parameter type (*integer, weekday, gregorian-date*) not (*integer*, *weekday*, *fixed-date*).

207. Page 227: **true-position** should have parameter type (*hindu-moment*, *rational*, *positive-integer*, *rational*, *rational*) not (*hindu-moment*, *rational*, *positive-integer*, *rational, non-negative-integer*).

208. Page 227: **standard-from-local** should have parameter type (*moment*, *real*) not (*moment*, *minute*).

209. Page 228: **universal-from-local** should have parameter type (*moment*, *real*) not (*moment*, *minute*).

210. Page 231: Use the quote "You must never forget that programs will be read by people as well as machines. Write them carefully." (George Forsythe in a remark to Alan George—see "Remembering George Forsythe", *SIAM News*, January/February, 1998.)

211. Page 231, line −10: Change the web page to

    `http://emr.cs.uiuc.edu/~calbook`

**212. (3) Page 234, constant `jd-start`, line 4: Change the single precision `-1721424.5` to double precision `-1721424.5d0`. Remarkably, this implementation-dependent error did not affect any of the values in the tables in Appendix C, nor the results of the original French Revolutionary or Chinese calendars for extensive ranges discussed in the book. However, there probably are instances when the wrong date would result.

213. Page 234, after the constant `jd-start`: Add the following material: Common Lisp uses `d0` to specify unscaled double-precision constants. The macro `double-float` coerces a number to double precision; it is not standard Common Lisp, but is predefined in some implementations. The definition is

```
(defmacro double-float (x)
  ;; TYPE -> real
  ;; Convert to double precision.
  `(coerce ,x 'double-float))
```

*214. (3) Page 235, macro `sum`, line 7: Change ' to ` at start of line.

*215. (3) Page 235, macro `sigma`, line 7: Change ' to ` at start of line.

*216. (3) Page 235, macro `binary-search`, line 7: Change ' to ` at start of line.

217. Page 236, function `time-of-day`, line 2: Change `moment` to `time`.

218. Page 239, function `independence-day`, lines 1 and 5: Change `year` to `g-year`.

219. Page 239, function `nth-kday`, line 1: Change parameter `date` to `g-date`.

220. Page 239, function `nth-kday`, line 2: Change parameter type from `(integer weekday fixed-date)` to `(integer weekday gregorian-date)`.

221. Page 240, function `nth-kday`, lines 9 and 11: Change parameter `date` to `g-date`.

*222. Page 243, function `julian-in-gregorian`. Change it to

```
(defun julian-in-gregorian (j-month j-day g-year)
  ;; TYPE (julian-month julian-day gregorian-year)
  ;; TYPE -> list-of-fixed-dates
  ;; List of the fixed dates of Julian month, day
  ;; that occur in Gregorian year.
  (let* ((jan1 (fixed-from-gregorian
                (gregorian-date january 1 g-year)))
         (dec31 (fixed-from-gregorian
                 (gregorian-date december 31 g-year)))
         (y (standard-year (julian-from-fixed jan1)))
         (next-y (if (= y -1)
                     1
                   (1+ y)))
         ;; The possible occurrences in one year are
         (date1 (fixed-from-julian
                 (julian-date j-month j-day y)))
         (date2 (fixed-from-julian
                 (julian-date j-month j-day next-y))))
    (append
     (if ; date1 occurs in current year
         (<= jan1 date1 dec31)
         ;; Then that date; otherwise, none
         (list date1) nil)
     (if ; date2 occurs in current year
         (<= jan1 date2 dec31)
         ;; Then that date; otherwise, none
         (list date2) nil))))
```

***223. (3) Page 245, `ethiopic-epoch`, line 4: Change "7" to "8".

224. Page 248, line numbered 21: Delete hyphen and move left one space.

225. Page 248, line numbered 26: Add three closing parentheses at the end of the line.

226. Page 250, `feast-of-ridvan`, line 3: Change "Bahai New Year" to "Feast of Ridvan".

227. Page 251, line numbered 15: Change "to" to "too".

228. Page 252, `hebrew-from-fixed`, line 6: Replace with

```
(1+ (quotient (- date hebrew-epoch) 35975351/98496)))
```

See errata 92 and 93.

229. Page 259, `hindu-day-count`, line 2: Change `fixed-date -> integer` to `hindu-moment -> hindu-moment`.

230. Page 261: Introduce Section B.14 with "Common Lisp's built in trigonometric functions work with radians, while we have used degrees. The following functions do the necessary conversions:"

231. Page 262, line 16. Delete the line "Common Lisp uses `d0` to specify unscaled double-precision constants."

232. Page 262, `equation-of-time`, line 2: Change "moment" to "julian-day-number".

233. Page 262, `apparent-from-local`, lines 1 and 4: The parameter name should be changed to "jd".

234. Page 262, `apparent-from-local`, line 2: Change "moment" to "julian-day-number" (twice).

235. Page 262, `local-from-apparent`, lines 1 and 4: The parameter name should be changed to "jd".

236. Page 262, `local-from-apparent`, line 2: Change "moment" to "julian-day-number" (twice).

237. Page 262, `universal-from-local`, line 2: Change "minute" to "real".

238. Page 263, `ephemeris-correction`, line 6: Change "`moment`" to "`(floor moment)`".

239. Page 264, `julian-centuries`, lines 1 and 4: The parameter name should be changed to "jd".

240. Page 264, `julian-centuries`, line 2: Change "`moment -> moment`" to "`julian-day-number -> real`.

241. Pages 264–265, `solar-longitude`, lines 10, 18, and 32: Delete the entries 0, 0.00813d0, 1.163d0 (respectively) in each of these lists (see erratum 129).

242. Page 266, `lunar-longitude`, line 2: Change "moment" to "julian-day-number".

243. Page 266, `lunar-longitude`, line 3: Change "sun" to "moon".

244. Page 267, `lunar-longitude`, lines 36, 40, 45, 49, and 58: Delete the last entry in each of these lists (see erratum 142).

245. Page 274, `minor-solar-term-on-or-after`, line 13: Change "`d`" to "`(1+ d)`".

246. Page 274, `prior-leap-month?`: Change the comment on lines 3–4 to read "`True if there is a Chinese leap month on or after lunar month starting on fixed day m-prime and at or before lunar month starting at fixed date m.`"

247. Page 276, `chinese-sexagesimal-name`, line 2: Change "`--`" to "`-`".

248. Page 276, `chinese-name-of-year`, line 2: Change "`--`" to "`-`".

249. Page 277, `chinese-name-of-day`, line 2: Change "`--`" to "`-`".

250. Page 277, `chinese-name-of-month`, line 2: Change "`--`" to "`-`".

**251. (3) Page 277, `chinese-name-of-month`, line 5: Change "44" to "50".

252. Page 278, `true-position`, line 3: Change "non-negative-integer" to "rational".

**253. Page 283, `tropical-longitude`, lines 8–12: Replace with

```
8           (precession
9            (- 1620
10              (abs (- 3240
11                      (mod (+ 1620 (* 6480 600/1577917828 midnight))
12                           6480))))))
```

This code was incorrectly altered from the second to the third printing; neither is correct. (See erratum 187).

254. Page 284, `lunar-mansion`, lines 1 and 3 : Change "mansion" to "station".

255. Page 285, `hindu-lunar-new-year`, line 5: Change "date" to "moment".

256. Page 287: For an explanation of our choice of dates in Appendix C, send an empty email message to `reingold@cs.uiuc.edu` with subject field "send-dates-explanation".

257. Page 288: Note that, as defined in Section 1.3, the negative Julian years in the first two lines of the table are B.C.E. years: 587 B.C.E. and 169 B.C.E., respectively. They appear as negative numbers because the table consists of raw output from the functions. This should be explained in a footnote to the table.

**258. (3) Page 288: Because of errata 75 and 223, the column of data for the Ethiopic calendar is wrong (that is, it agrees with the code as printed, but not the code as corrected). The replacement table is shown in Table 1.

*259. (3) Page 290: The columns for solar and lunar longitude are wrong. The values given are for the R.D. date *considered as a* JD *date* (that is, for example, the solar longitude given for R.D. -214193.5 is actually the solar longitude for JD -214193.5 and the lunar longitude given for R.D. -214193 is actually the lunar longitude for JD -214193). The replacement table is shown in Table 2.

260. Page 290. Add the following quote from Kepler, *Harmonies of the World* at the bottom of the page:

> THE END.
> This work was completed on the 17th or 27th day of May, 1618; but Book v was reread (while the type was being set) on the 9th or 19th of February, 1619.
> At Linz, the capital of Austria—above the Enns.

261. Page 291: Add a new appendix that gives, for each calendar, the range of years for which the code works and why it fails to work outside that range (more than 32 bit arithmetic required, astronomical functions break down, Gregorian and solar calendars are out of alignment, and so on).

262. Page 292, caption: Delete the phrase "great work on the world's calendars,".

263. Page 294: Delete index entry for "**arya-sidereal-month**".

264. Page 294: Add index entry "Aveni, Anthony F., 115".

265. Page 294, index entry for Birkath haḥama: The page numbers should be 99–100.

266. Page 296: Add index entry for Epagomenæ (Coptic calendar) page 57.

267. Page 298, index entry for Ganesa Daivajna: The correct spelling is "Gaṇesa".

268. Page 298: Add index entry for Martin Gardner on the rear cover.

269. Page 298, index entry for Nathan ben Meir Hademer: Delete the extraneous page "ii" and change "cover" to "rear cover".

270. Page 298, index entry for Hezekiah di Silo: Change "di Silo" to "ben David da Silva" and index also under "S".

271. Page 301, index entry for **lunar-mansion**: Change to **lunar-station**.

R.D.	Weekday	Julian Day	Gregorian			ISO			Julian			Coptic			Ethiopic			Islamic			Persian			Bahá'í					Hebrew		
−214193	Sunday	1507231.5	7	24	−586	29	7	−586	7	30	−587	12	6	−870	12	6	−594	12	9	−1245	5	1	−1208	−6	6	3	7	12	5	10	3174
−61387	Wednesday	1660037.5	12	5	−168	49	3	−168	12	8	−169	4	12	−451	4	12	−175	2	23	−813	9	14	−790	−5	9	3	14	13	9	25	3593
25469	Wednesday	1746893.5	9	24	70	39	3	70	9	26	70	1	29	−213	1	29	63	4	1	−568	7	2	−552	−4	2	13	10	17	7	3	3831
49217	Sunday	1770641.5	10	2	135	39	7	135	10	3	135	2	5	−148	2	5	128	4	6	−501	7	9	−487	−4	6	2	11	6	7	9	3896
171307	Wednesday	1892731.5	1	8	470	2	3	470	1	7	470	5	12	186	5	12	462	10	17	−157	10	18	−153	−3	4	13	16	9	10	18	4230
210155	Monday	1931579.5	5	20	576	21	1	576	5	18	576	9	23	292	9	23	568	6	3	−47	2	30	−46	−3	10	6	4	4	3	4	4336
253427	Saturday	1974851.5	11	10	694	45	6	694	11	7	694	3	11	411	3	11	687	7	13	75	8	19	73	−3	16	10	13	7	8	13	4455
369740	Sunday	2091164.5	4	25	1013	16	7	1013	4	19	1013	8	24	729	8	24	1005	10	5	403	2	5	392	−2	14	6	2	17	2	6	4773
400085	Sunday	2121509.5	5	24	1096	21	7	1096	5	18	1096	9	23	812	9	23	1088	5	22	489	3	3	475	−2	18	13	4	8	2	23	4856
434355	Friday	2155779.5	3	23	1190	12	5	1190	3	16	1190	7	20	906	7	20	1182	2	7	586	1	3	569	−1	4	12	1	3	1	7	4950
452605	Saturday	2174029.5	3	10	1240	10	6	1240	3	3	1240	7	7	956	7	7	1232	8	7	637	12	20	618	−1	7	4	20	9	13	8	5000
470160	Friday	2191584.5	4	2	1288	14	5	1288	3	26	1288	7	30	1004	7	30	1280	2	20	687	1	14	667	−1	9	15	1	13	1	21	5048
473837	Sunday	2195261.5	4	27	1298	17	7	1298	4	20	1298	8	25	1014	8	25	1290	7	7	697	2	8	677	−1	10	6	2	19	2	7	5058
507850	Sunday	2229274.5	6	12	1391	23	7	1391	6	4	1391	10	10	1107	10	10	1383	7	1	793	3	22	770	−1	15	4	5	8	4	1	5151
524156	Wednesday	2245580.5	2	3	1436	5	3	1436	1	25	1436	5	29	1152	5	29	1428	7	6	839	11	13	814	−1	17	10	17	16	11	7	5196
544676	Saturday	2266100.5	4	9	1492	14	6	1492	3	31	1492	8	5	1208	8	5	1484	6	1	897	1	21	871	0	1	10	2	1	1	3	5252
567118	Saturday	2288542.5	9	19	1553	38	6	1553	9	9	1553	1	12	1270	1	12	1546	9	30	960	6	28	932	0	4	14	10	12	7	1	5314
569477	Saturday	2290901.5	3	5	1560	9	6	1560	2	24	1560	6	29	1276	6	29	1552	5	27	967	12	14	938	0	5	1	20	4	12	27	5320
601716	Wednesday	2323140.5	6	10	1648	24	3	1648	5	31	1648	10	6	1364	10	6	1640	5	18	1058	3	21	1027	0	9	14	5	6	3	20	5408
613424	Sunday	2334848.5	6	30	1680	26	7	1680	6	20	1680	10	26	1396	10	26	1672	6	2	1091	4	10	1059	0	11	8	6	7	4	3	5440
626596	Friday	2348020.5	7	24	1716	30	5	1716	7	13	1716	11	19	1432	11	19	1708	8	4	1128	5	2	1095	0	13	6	7	12	5	5	5476
645554	Sunday	2366978.5	6	19	1768	24	7	1768	6	8	1768	10	14	1484	10	14	1760	2	3	1182	3	30	1147	0	16	1	5	15	4	4	5528
664224	Monday	2385648.5	8	2	1819	31	1	1819	7	21	1819	11	27	1535	11	27	1811	10	10	1234	5	10	1198	0	18	14	8	2	5	11	5579
671401	Wednesday	2392825.5	3	27	1839	13	3	1839	3	15	1839	7	19	1555	7	19	1831	1	11	1255	1	7	1218	0	19	15	1	7	1	12	5599
694799	Sunday	2416223.5	4	19	1903	16	7	1903	4	6	1903	8	11	1619	8	11	1895	1	21	1321	1	29	1282	1	4	3	2	11	1	22	5663
704424	Sunday	2425848.5	8	25	1929	34	7	1929	8	12	1929	12	19	1645	12	19	1921	3	19	1348	6	3	1308	1	5	10	9	6	5	19	5689
708842	Monday	2430266.5	9	29	1941	40	1	1941	9	16	1941	1	19	1658	1	19	1934	9	8	1360	7	7	1320	1	6	3	11	3	7	8	5702
709409	Monday	2430833.5	4	19	1943	16	1	1943	4	6	1943	8	11	1659	8	11	1935	4	13	1362	1	29	1322	1	6	5	2	11	1	14	5703
709580	Thursday	2431004.5	10	7	1943	40	4	1943	9	24	1943	1	26	1660	1	26	1936	10	7	1362	7	14	1322	1	6	5	11	11	7	8	5704
727274	Tuesday	2448698.5	3	17	1992	12	2	1992	3	4	1992	7	8	1708	7	8	1984	9	13	1412	12	27	1370	1	8	15	20	16	13	12	5752
728714	Sunday	2450138.5	2	25	1996	8	7	1996	2	12	1996	6	17	1712	6	17	1988	10	5	1416	12	6	1374	1	8	19	18	19	12	5	5756
744313	Wednesday	2465737.5	11	10	2038	45	3	2038	10	28	2038	3	1	1755	3	1	2031	10	12	1460	8	19	1417	1	11	5	13	7	8	12	5799
764652	Sunday	2486076.5	7	18	2094	28	7	2094	7	5	2094	11	11	1810	11	11	2086	3	5	1518	4	28	1473	1	14	4	7	6	5	5	5854

Table 1: Replacement for table on Page 288 (see erratum 258).

R.D.	Solar Longitude at 12:00:00 U.T. (degrees)	Next Solstice/Equinox (JD, U.T.)	Lunar Longitude at 00:00:00 U.T. (degrees)	Next New Moon (JD, U.T.)	Sunrise in Jerusalem (31.8° N, 35.2° E Local Time)	Sunset in Jerusalem (31.8° N, 35.2° E Local Time)
−214193	119.47497381	1507293.35106933	245.03658013	1507249.87899175	0.21536906 = 05:10:08	0.79339037 = 19:02:29
−61387	254.25239225	1660053.44358385	209.00937383	1660041.49175222	0.28179130 = 06:45:47	0.70544950 = 16:55:51
25469	181.43526078	1746981.28982460	213.82149258	1746920.30266787	0.24240510 = 05:49:04	0.74634083 = 17:54:44
49217	188.66209324	1770722.08639467	292.10480709	1770662.99756638	0.24590144 = 05:54:06	0.73912182 = 17:44:20
171307	289.08940272	1892803.04141963	156.85121064	1892742.93303138	0.29243450 = 07:01:06	0.71698393 = 17:12:27
210155	59.11935774	1931612.40854394	108.10438174	1931605.18791454	0.20816046 = 04:59:45	0.78724026 = 18:53:38
253427	228.31649723	1974892.91108692	39.41728975	1974867.35429782	0.26632230 = 06:23:30	0.71105605 = 17:03:55
369740	34.46687268	2091223.05280459	98.66179727	2091188.23789340	0.22286705 = 05:20:56	0.77472226 = 18:35:36
400085	63.19392585	2121538.11231267	333.06229775	2121516.07027733	0.20679373 = 04:57:47	0.78903246 = 18:56:12
434355	2.46292133	2155870.82314622	92.33811077	2155801.07120215	0.25051906 = 06:00:45	0.75920974 = 18:13:16
452605	350.48067867	2174039.63006866	78.21191058	2174051.68620893	0.26105749 = 06:15:55	0.75343803 = 18:04:57
470160	13.50223058	2191664.51329005	275.01807834	2191592.07345509	0.24078204 = 05:46:44	0.76433481 = 18:20:39
473837	37.40773343	2195316.92862713	128.42066848	2195283.34822989	0.22143083 = 05:18:52	0.77569054 = 18:36:60
507850	81.03056592	2229284.40943015	89.56325344	2229303.16344207	0.20403811 = 04:53:49	0.79564710 = 19:05:44
524156	313.86245100	2245627.12047327	24.63688022	2245603.74432938	0.28638499 = 06:52:24	0.73318076 = 17:35:47
544676	19.95564076	2266173.81749499	53.50792742	2266127.25230070	0.23475474 = 05:38:03	0.76759416 = 18:25:20
567118	176.06000089	2288547.01158583	187.91071148	2288571.01228326	0.24028035 = 05:46:00	0.75091598 = 18:01:19
569477	344.92345807	2290917.17274034	320.18257980	2290903.70252915	0.26528995 = 06:22:01	0.75092375 = 18:01:20
601716	79.96490680	2323151.51873815	314.04496326	2323151.53342300	0.20404552 = 04:53:50	0.79536448 = 19:05:19
613424	99.30227476	2334932.75910771	145.47571843	2334874.26198570	0.20680618 = 04:57:48	0.79831158 = 19:09:34
626596	121.53542417	2348081.47079217	185.03378271	2348044.86952061	0.21580853 = 05:10:46	0.79296897 = 19:01:53
645554	88.56872054	2366980.50059712	142.20739466	2367003.57531350	0.20456163 = 04:54:34	0.79743449 = 19:08:18
664224	129.28988323	2385701.40771425	253.74406825	2385667.38660027	0.21939959 = 05:15:56	0.78902734 = 18:56:12
671401	6.14691088	2392912.66688454	151.64913469	2392843.47043700	0.24696211 = 05:55:38	0.76108161 = 18:15:57
694799	28.25199403	2416288.12830603	287.98787357	2416232.06336741	0.22740816 = 05:27:28	0.77184187 = 18:31:27
704424	151.78063302	2425878.03615487	25.62676631	2425857.99116135	0.22970884 = 05:30:47	0.77298475 = 18:33:06
708842	185.94586703	2430350.73905671	290.28833521	2430288.09697186	0.24457271 = 05:52:11	0.74180613 = 17:48:12
709409	28.55560818	2430897.80003941	189.91317331	2430848.90492601	0.22740816 = 05:27:28	0.77184187 = 18:31:27
709580	193.34789233	2431081.22816813	284.93176103	2431026.58267497	0.24817497 = 05:57:22	0.73473767 = 17:38:01
727274	357.15126352	2448701.86656868	152.33916565	2448715.70938073	0.25495173 = 06:07:08	0.75684059 = 18:09:51
728714	336.17070971	2450162.83533370	51.66247531	2450161.94766557	0.27248681 = 06:32:23	0.74617249 = 17:54:29
744313	228.18570124	2465779.29199040	26.69187141	2465754.07316893	0.26632230 = 06:23:30	0.71105605 = 17:03:55
764652	116.43929928	2486142.96889150	175.50048689	2486100.69129982	0.21280751 = 05:06:27	0.79556694 = 19:05:37

Table 2: Replacement for table on Page 290 (see erratum 259).

272. Page 301, index entry for Maimonides: Add "(= Rambam)" after his name.

273. Page 301: Add index entry for Martial (= Marcus Valerius Martialis) page 307.

274. Page 303: Move index entry "Orthodox Fast of the Apostles (Orthodox Fast), 55" to "Fast of the Apostles (Orthodox Fast), 55".

275. Page 304, index entry for Rome: Add page 34.

276. Page 304, index entry for Joseph Justus Scaliger: Add pages 85 and 292.

277. Page 304, index entry for William Shakespeare: Add page 293.

278. Page 305: Add index entry for Ian Stewart on the rear cover.

279. Page 307: The epigram should have the title "Envoi" and the running head should be "Envoi", not "Index".

280. Page 307: We might end the book with the following quotation from the diary of Philip Dormer Stanhope, the man who in 1751 introduced the bill in Parliament for reforming the calendar in England:

> I determined, therefore, to attempt the reformation; I consulted the best lawyers and the most skilled astronomers, and we cooked up a bill for that purpose. But then my difficulty began: I was to bring in this bill, which was necessarily composed of law jargon and astronomical calculations, to both of which I am an utter stranger. However, it was absolutely necessary to make the House of Lords think that I knew something of the matter; and also to make them believe that they knew something themselves, which they do not. For my own part, I could just as soon have talked Celtic or Sclavonian to them, as astronomy, and could have understood me full as well; so I resolved... to please instead of informing them. I gave them, therefore, only an historical account of calendars, from the Egyptian down to the Gregorian, amusing them now and then with little episodes... They thought I was informed, because I pleased them; and many of them said, that I had made the whole story very clear to them; when, God knows, I had not even attempted it.