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ON TIME;

INCLUDING SOME QUESTIONS CONNECTED WITH THE CALENDAR.

BY

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Read on Monday, May 12, 1879.

ON MAMMALIAN REMAINS AND TREE-TRUNKS
IN QUATERNARY SANDS AT READING.

BY

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ON TIME;

INCLUDING SOME QUESTIONS CONNECTED WITH THE CALENDAR.

BY R. H. M. BOSANQUET, M.A.

(Abstract.)

EQUAL intervals of time may be regarded as measured by the duration of an event or occurrence occupying time, when repeated in the same manner, and under the same conditions. Thus the emptying of a given sand-glass, under the same conditions, is generally admitted to take always the same time. An ideal of the uniform flow of time can be thus constructed, although it may not be possible to realise it in practice.

The standard of time for practical purposes is the uniform motion of the starry heavens; by means of this the astronomer obtains the time which he furnishes to the world at large.

Mean solar time is the time which would be shown by the sun if its motion in the starry sphere were uniform and in the equator. The equation of time is the difference between this ideal time and the time actually shown by the sun on a sundial.

The length of the tropical year, or year of seasons, is the time between two returns of the sun to the vernal equinox. As this point is not fixed on the starry sphere, the tropical year is not the same as the true sidereal year, or return to the same point with reference to the starry sphere.

The motion of the equinox is called Precession; and the difference in the year caused by it is about $20^m\ 23^s$.

The error of the rule of leap-year is about 3 days in 400 years; this error is corrected in the Gregorian calendar, leaving a further error of about 1 day in 4000 years, by which the Gregorian year is too long.

The Egyptians used a year of 365 days. Assuming that this was wrong by $\frac{1}{4}$ d., the seasons shifted a day in every four years, so

that they went round the months of the year in 1460 years; this was called the Sothic cycle.

True cycle of sidereal year (Sirius) . . 1424 years.
Historical cycle . . . . . 1460 „
True cycle of seasons . . . . 1507 „

The Heliacal rising of Sirius would separate from the solstice about 21 days in a Sothic period.

The Heliacal rising of Sirius would coincide with the summer solstice at the following dates nearly :—

Latitude of Syene (Tropic) . . . . 2440 B.C.
„ Alexandria . . . . 3520 B.C.

The rule of leap-year came into general use shortly before the Christian era.

The rule of Easter was long supposed to have been definitely prescribed by the Council of Nice; it is now pretty certain that, if this Council decreed anything about Easter, it was only that all should observe the Roman rule of Easter.

The Roman rule of Easter was not definitely settled until the time of Dionysius Exiguus, about A.D. 530.

In the calendar, the moon is supposed to have a uniform period of $29\frac{1}{2}$ d. The year is supposed to be 12 moons of 29 and 30 days alternately, and an epact (ἐπακτός), or addition, of 11 days. Epact thus came to mean the number of days over at the end of the year after the last moon, or the age of the moon at the beginning of the following year, to which the epact was then prefixed.

In the old style calendar the beginning of the year was midnight March 22.

When the epact of a year is known, and the Sunday letter, Easter is fixed.

The reformed calendar was constructed under Gregory XIII, and adopted by Catholic nations in 1582; by England in 1752. It is officially expounded in the work of Clavius, published shortly after 1582.

The series of epacts used in the Gregorian Calendar changes from time to time. When leap-year is dropped in the 100th year, the epacts are on the whole diminished by 1. The error of the metonic cycle of the moon, 1 day in 300 years, when corrected, increases the epacts on the whole by 1. This last correction is applied in 1800, 2100, ... When the two corrections come together no change is made.

Mean Time and Sidereal Time.

$$\text{Interval expressed in mean time} = \frac{365 \cdot 24222}{366 \cdot 24222} \times \text{sidereal time}$$

$$= \text{sidereal time} - \frac{\text{sidereal time}}{366 \cdot 24222}.$$

Ex.   Sidereal day in mean time $= 24^h - \dfrac{24^h}{366 \cdot 24222}$

$$= 24^h - 3^m 55^s \cdot 909$$
$$= 23^h 56^m 4^s \cdot 091$$

True sidereal year $= 365^d 6^h 9^m 10^s \cdot 7$.

$$\left. \begin{array}{l} \text{Tropical year,} \\ \text{Year of seasons,} \\ \text{From equinox to equinox,} \end{array} \right\} = 365^d 5^h 48^m 47^s \cdot 8$$

$$= 365 \cdot 24222.$$

$$\left. \begin{array}{l} \text{Julian year} \\ \text{Year of octaetēris} \end{array} \right\} = 365 \cdot 25.$$

Gregorian year $\qquad = 365 \cdot 2425$.

Gregorian year with 4000th years not leap years $= 365 \cdot 24225$.

$$\left. \begin{array}{l} \text{Moon's synodic period} \\ \text{or 1 lunation} \end{array} \right\} \begin{array}{l} = 29^d 12^h 44^m 2^s 8032 \\ = 29 \cdot 530588^d. \end{array}$$

Lunar year $= 12$ calendar moons of 30 and 29 days alternately,
$\qquad = 354$ days.

8 Years Cycle of the Greeks.

Octaetēris $= 8$ years of $354^d + 3$ months of 30 days
$\qquad = 2922^d$

99 lunations $= 2923 \, 528^d$

99 lunations exceed the 8 years cycle by $1^d 12^h 40^m 36^s$.

Metonic Cycle or Cycle of Golden Numbers.

19 tropical years $= 6939 \, 6022^d$

235 lunations $\quad = 6939 \, 6882^d$

19 Julian years $\; = 6939 \cdot 75^d$.

$\qquad = 19 \times 6 \, (30 + 29) + 6 \times 30 + 29 + 4 \cdot 75$.

235 lunations exceed 19 tropical years by $2^h 3^m 50^s$

19 Julian years exceed 235 lunations by $1^h 29^n 0^s$.

Roman Cycle of Indictions.

A period of 15 years.

Solar Cycle.

28 Julian years, after which days of the week recur.

JULIAN PERIOD.

$28 \times 19 \times 15 = 7980$ years.

$$\left. \begin{array}{l} \text{Year 1 of Julian Period} \\ \text{,, ,, Solar Cycle} \\ \text{,, ,, Metonic Cycle} \\ \text{,, ,, Cycle of Indictions} \end{array} \right\} \ldots \text{B.C. } 4713.$$

Intervals between given dates, by Julian period.

Epochs.	Julian Dates.	Current Julian Year.	Interval in Days elapsed.
	B.C.		
Julian Period	Jan. 1, 4713	1	0
Epoch of Olympiads	July 1, 776	3938	1·438·171
Building of Rome, Varronian Epoch, U. C.	April 22, 753	3961	1·446·502
Era of Nabonassar	Feb. 26, 747	3967	1·448·638
Eclipse of Thales	May 28, 585	4129	1·507·900
Epoch of Metonic Cycle	July 15, 432	4282	1·563·831
Epoch of Julian Calendar	Jan. 1, 45	4669	1·704·987
	A.D.		
Epoch of Christian Era (Dionysian Era)	Jan. 1, 1	4714	1·721·424
Epoch of Hejira	July 15, 622	5335	1·948439
Last Day of Old Style in Catholic nations	Oct. 4, 1582	6295	2·299·160
Last Day of Old Style in England	Sept. 2, 1752	6465	2·361·221
	Gregorian Dates.		
New Style Catholic nations	Oct. 15, 1582	6295	2·299·161
New Style in England	Sept. 14, 1752	6465	2·361·222
Epoch of British Association Star Catalogue	Jan. 1, 1850	6563	2·396·759
Epoch of this year	Jan. 1, 1879	6592	2·407·351

TABLE OF SUNDAY LETTERS.

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G                      )                                                        )
                       } 1888                                                   } 1928
A   1871 )        1882 )      1893  1899  1905  1911 )         1922 )
         } 1876                                     } 1916
B   1870 )        1881  1887 )     1898 )      1910 )      1921  1927
                            } 1892       } 1904
C   1869  1875 )       1886 )      1897 )      1909  1915 )      1926
               } 1880                                   } 1920
D        )  1874 )     1885  1891 )     1903 )      1914 )      1925
    } 1868                        } 1896       } 1908
E        )  1873  1879 )       1890 )      1902 )      1913  1919 )
                       } 1884                                   } 1924
F   1867 )        1878 )      1889  1895  1901  1907 )      1918 )      1929, &c.
         } 1872                                     } 1912
G   1866 )        1877  1883       1894  1900  1206 )      1917  1923

A
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Every leap year has two Sunday letters, shown by a bracket preceding the number of the year; the lower of the two letters serves for January and February, the upper for the rest of the year. So far as the finding of Easter is concerned, the upper one of the two letters is alone to be regarded.

Epacts Old Style.	Golden Number.			Epacts till 1899.	Epacts from 1900.				
29	1	1862	1881	30	29	1900	1919	1938,	&c.
11	2	1863	1882	11	10	1901	1920		
22	3	1864	1883	22	21	1902	1921		
3	4	1865	1884	3	2	1903	1922		
14	5	1866	1885	14	13	1904	1923		
25	6	1867	1886	25	24	1905	1924		
6	7	1868	1887	6	5	1906	1925		
17	8	1869	1888	17	16	1907	1926		
28	9	1870	1889	28	27	1908	1927		
9	10	1871	1890	9	8	1909	1928		
20	11	1872	1891	20	19	1910	1929		
1	12	1873	1892	1	30	1911	1930		
12	13	1874	1893	12	11	1912	1931		
23	14	1875	1894	23	22	1913	1932		
4	15	1876	1895	4	3	1914	1933		
15	16	1877	1896	15	14	1915	1934		
26	17	1878	1897	26	26	1916	1935		
7	18	1879	1898	7	6	1917	1936		
18	19	1880	1899	18	17	1918	1937		

The Epact is the moon's age at the moment of the beginning of the year, according to the calendar, not according to the heavens. Consequently Jan. 1 in any year is that day of the moon's age which is represented by the epact increased by 1. This is only true for new style.

Ex. Epact 14. Jan. 1 is 15th day of moon, or full moon of calendar.

Ex. Epact 30. Jan. 1 is 1st day of moon, or new moon of calendar, since 30d is the moon's full age.

True new moon is usually 1d before calendar. Full moon the same day.

TABLE to find EASTER from EPACT and SUNDAY LETTER.

New Style.

EASTER Day is the Sunday following that 14th day of the calendar moon, (not full moon,) which happens upon or next after the 21st of March: so that if the said 14th day be a Sunday, Easter Day is not that Sunday, but the next.

											March.																	April.																		
21	22	23	24	25	26	27	28	29	30	31	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
C	D	E	F	G	A	B	C	D	E	F	G	A	B	C	D	E	F	G	A	B	C	D	E	F	G	A	B	C	D	E	F	G	A	B	C
23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	30	29	28	27	26	25/24							

The Epact, in the lowest row, is under the fourteenth day of the calendar moon: the Sunday next following, shown by the Sunday letter, is Easter Day.

Ex. 1879 has Sunday Letter E and Epact 7.

7 in the lowest row gives April 6 for the fourteenth day of the calendar moon; and this, having the Sunday Letter E, is a Sunday. Easter Day is at the E next following, and is April 13.

To explain the lowest row of the table for Easter, which shows the 14th day of the calendar moon by epacts.

N.B. The calendar moon is for these purposes $29\frac{1}{2}$ days; the half-day is allowed for by reckoning the moons at 30 days and 29 days alternately, the 24th and 25th days being reckoned as one in alternate moons, except in the 2d moon of leap year.

For Epact 13, Jan. 1 is the 14th day of the calendar moon; so are,

$$\text{Jan.} \quad 1 + 30 = \text{Jan.} \quad 31$$
$$\text{Jan.} \quad 31 + 39 = \text{March} \quad 1$$
$$\text{March} \quad 1 + 30 = \text{March} \quad 31 ;$$

or March 31 is the 14th day of the calendar moon for Epact 13. So 13 is written under it in the lowest row of the table for Easter.

Again, for Epact 12, Jan. 1 is 13th day, Jan. 2 is 14th day; so are,

$$\text{Jan.} \quad 2 + 30 = \text{Feb.} \quad 1$$
$$\text{Feb.} \quad 1 + 29 = \text{March} \quad 2$$
$$\text{March} \quad 2 + 30 = \text{April} \quad 1 ;$$

or April 1 is the 14th day of the calendar moon for Epact 12. So Epact 12 is written under it in the lowest row of the table for Easter.

This indicates sufficiently the way the numbers are obtained. Epacts 24 and 25 are entered on the same day, since they appertain to the moon's age in the fourth, or second alternate moon of the year.