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JEAN MEEUS

Dynamical Time and Universal Time

The Universal Time (UT), or Greenwich Civil Time, is based on the rotation of the Earth. The UT is necessary for civil life and for the astronomical calculations where local hour angles are involved.

However, the Earth's rotation is generally slowing down and, moreover, this occurs with unpredictable irregularities. For this reason, the UT is not a uniform time. But astronomers need a uniform time scale for their accurate calculations (celestial mechanics, orbits, ephemerides). From 1960 to 1983, in the great astronomical almanacs such as the *Astronomical Ephemeris*, use was made of the uniform time scale called the *Ephemeris Time* (ET) which was defined by the laws of dynamics and was based on the planetary motions. In 1984, the ET was replaced by the *Dynamical Time*, which is defined by atomic clocks. In practice, the Dynamical Time is a prolongation of the Ephemeris Time.

One distinguishes a Barycentric Dynamical Time (TDB) and a Terrestrial Dynamical Time (TDT). These times differ by at most 0.0017 second, the difference being related to the motion of the Earth on its elliptical orbit around the Sun (relativistic effect). Because this very small difference can be neglected for most practical purposes, we will make no distinction between TDB and TDT, and we will name both simply "Dynamical Time", or TD by dropping the last letter from both TDB and TDT.

TABLE A

$\Delta T = TD - UT$ *(in seconds) for the beginning of some years*
Subtract the value given by this Table in order to convert TD to UT.

Year	ΔT	Year	ΔT	Year	ΔT	Year	ΔT	Year	ΔT
1620	+121	1710	+ 9	1800	+13.1	1890	− 6.0	1960	+33.1
1630	82	1720	10	1810	12.0	1900	− 2.8	1965	35.7
1640	60	1730	10	1820	11.6	1910	+10.4	1970	40.2
1650	46	1740	11	1830	7.1	1920	21.1	1975	45.5
1660	35	1750	12	1840	5.4	1930	24.0	1980	50.5
1670	24	1760	14	1850	6.8	1940	24.3	1985	54.3
1680	14	1770	15	1860	7.7	1945	26.8	1990	56.9
1690	8	1780	16	1870	+ 1.4	1950	29.1	1995	60.8
1700	7	1790	16	1880	− 5.5	1955	31.1	2000	63.8

TABLE B

Approximate values of ΔT

Year	Minutes	Year	Minutes	Year	Minutes
0	177	1000	35	2075	4
100	158	1100	27	2200	8
200	140	1200	20	2300	13
300	123	1300	14	2400	19
400	107	1400	9	2500	26
500	93	1500	5	2600	34
600	79	1600	2	2700	43
700	66	1700	0	2800	53
800	55	1800	0	2900	64
900	45	1980	1	3000	76

Table A gives the value of ΔT for the *beginning* of some years, from 1620 to 2000. For epochs before the year 1620 or in the future, an *approximate* value of ΔT, in seconds, can be deduced from the following relation due to Morrison and Stephenson:

$$\Delta T = -15 + 0.00325 \,(\text{year} - 1810)^2$$

This leads to Table B. It should be noted that for the very past and future, the tabulated values of ΔT may be in error by many minutes, as the fluctuations due to the variable rotation of the Earth are unknown for those remote epochs.

Tabulated times in TD may be converted into Universal Time by *subtracting* from them the quantity ΔT, since we have UT = TD − ΔT.