Time in the Modern World

David Malone <dwmalone@maths.tcd.ie>

Hamilton Institute, NUI Maynooth.

School of Mathematics, TCD.

2006-01-24 18:30 UTC

What is time all about?

It's that incredibly useful stuff that we all use to stop every thing happening at once.

— Jeff Rosson

Mostly time is used for ordering our lives, not measuring how long has passed between events.

If a job application must be in by 5pm, how do you know when that is? What does 5pm mean anyway?

I want to look at this while avoiding tricky physics/philosophical issues.

Years

Seasons: Weather cycles, days lengthen and shorten.

Aim of our calendar: Keep Equinoxes and Solstices at the right time of year, especially the vernal equinox. Tricky: year isn't whole number of days (365.24219).

The time of year: angle between earth's axis and the line from the earth to the sun.

NB: seasons nothing to do with distance to sun. Earth is at its closest (Perihelion) about 4th January 2006.

Counting Years

Count years from the (supposed) year of Christ's birth.

Dionysius Exiguus (AD 523) asked to produce table of Easter Dates.

Unfortunately, Herod died in 4BC, so Dionysius probably got it wrong.

BC dating came somewhat later, along with the missing year zero.

Before that dates were counted since the founding of Rome. 1AD = 754AUC (ab urbe condita).

Months

Need bigger division of years than just days. Moon's phases is next most obvious thing in the sky.

Months roughly to be in sync with the moon (29.5305889 days)? Other calendars are better in this respect.

We've ended up with funny months.

Story says Romulus gave 10 months, a successor added 2 more.

Julian Reform

Ianuarius	29	31	Quinctilis	31	31
Februarius	28	28/9	Sextis	29	31
Martius	31	31	September	29	30
Aprilis	29	30	October	31	31
Maius	31	31	November	29	30
Iunius	29	30	December	29	31

Old leap: Cut Feb at 23/24, intercal of 27 days, irregular. New leap: Once in 4, double Feb 24. Took a 445 day year, and some fumbling to get there. Aiming for 365.24219 day year.

When	Calendar	Length
????	old roman	$355 \pm \text{\pounds}$
45BC	Julian	365.25
1582AD	Gregorian	365.2425

Papal Bull of 24 Feb 1582: 4 Oct followed by 15 Oct.

Equinox back at 21 Mar.

Took a while to catch on: 1752 for us.

Weeks

7 day week is very old. Ptolemaic week by Romans and biblical week by Jews.

Portuguese	English	French	Planet
domingo	Monday	lundi	Moon
segunda-feira	Tuesday	mardi	Mars
terça-feira	Wednesday	mercredi	Mercury
quarta-feira	Thursday	jeudi	Jupiter
quinta-feira	Friday	vendredi	Venus
sexta-feira	Saturday	samedi	Saturn
sábado	Sunday	dimanche	(Sun)

Possibly longest unbroken tradition. Resisted French and Communist reform.







Julian Day Number

Another way of counting days avoiding BC/AD problems. Cycle of 7980 years.

JD 0 designates the 24 hours starting noon on 1 January 4713 BC. Today is 2453759.5 or MJD 53759.

Why start then? Why 7980 years? A combination of Indiction, Golden Number and Solar Number (lcm(15, 19, 28) = 7980).

Hours

Pretty arbitrary divisions of a day. They arise by dividing things into 12.

Were very uneven. Gradually fixed (14C).

Came to us via monastery and Roman army.

In 7C, lots of subdivisions, by middle ages we have *minutae primae* and *minutae secondae*.



If you want to know what time it is, look at one of these.



Varies a bit during the year because of tilted elliptic orbit.

Fix up using Equation of Time

Mean time adopted about 1792.





Dunsink Observatory was make necessary measurements. Usher: 25m7–48s (1787).

Brinkley: 25m22s (1832). Romny-Robbinson: 25m21s (1838).

Legal Time Since

- 1916 Move to GMT with GB
- 1916 Daylight saving
- 1923 Western-European Time
- 1968 Standard Time (GMT+1)
- 1971 Changed mind?
- 1986 Order giving effect to EEC directive
- $2001 \quad 2000/84/EU$ directive currently in force

In this Act the expression 'West-European time' means Greenwich mean time.

Universal Time

All in terms of GMT. There's a problem...

... GMT is dead!

Universal Time is calculated from sidereal time (now ERA) using a formula (which is periodically updated).

 $\begin{array}{l} 86636.55536790872 + 0.000005098097T \\ + 0.000000000509T^2 \end{array}$

(A day is usually 86400 long).

TAI and UTC

International Atomic Time has been available since 1955 (officially since 1972). Uses SI second.

second: In the International System of Units (SI), the time interval equal to 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom. Problem is that UT seconds and SI seconds are different.

Coordinated Universal Time is a compromise. It ticks once per SI second, in sync with TAI.

If UTC is more than one second from UT1 then UTC is adjusted.



Dublin Time Service

Committee of RDS examined clocks (Allied Gass 7m13s, Sydney Parade 3m).

Instituted telegraph based time service, Time Control Committee.

Two lines: Dunsink and RDS (Leinster House).

Dunsink: BoI, Post Office, Port&Docks, Museum Building (TCD).



RDS1: RCS, Maples Hotel, Masonic Hall, Topham and White, RCS, Harcourt St Stn, Richmond and Bridewlee, Racinc & Co, Johnson, Walpole & Co, Andrews & Co, Pim Bros & Co, City Hall, Guinness, Knightsbridge Stn. RDS2: BoI, Royal Bank, National Assurance, Chamber of Commerce, Royal Assurance, Edmundson & Co, Four Courts, Courtney & Stevens, Grangegorman, Broadstone Stn, Kildare St Club, Westland

Row Stn, Chancellor & Son, Arnott & Co, Rotunda,

F Moore.





Radio • 1924 BBC transmit Big Ben. • Later in the year pips follow. • Time signals: US, Rugby in 1927, ... • Speaking Clock: Dial 1191-oven-oscillator. • ESB Mains at 49.9-50.1Hz, Out by < 5s. • RTE pips by control desk. • RTE all use Rugby.



Rugby transmits blips at 60kHz. First second: 60kHz on 60kHz off T=0s T=0.5s T=1s Second x: 60kHz on xВ xА 60kHz off T=x.0s x.3s x.ĺs x.2s Over a minute: 17 25 30 36 39 52 45 А 01111110 reserved year month date day hour minute В DUT offset reserved 0cpppps0

NTP

- Use computer networks to set clocks.
- Stratum 1 are connected to source of time.
- Lower strata get time from higher.
- TCD provides public time service for ie.
- Was at stratum 2, now using GPS.
- ISPs also provide service.







Leap Seconds Debate Makes Headlines

- Timekeeping proposal sparks row.
- Hang on a second, what's the real time?
- Time On Earth Second Thoughts
- Leap Second Lovers are Traitors.





References

The earlier references are less technical.

- 1. 'The Calendar', David Duncan, 1998.
- 2. 'Time', Alexander Waugh, 1999.
- 3. 'Greenwich Time and the Longitude', Derek Howse, 1980/1997.
- 4. 'The Oxford Companion to the Year', Blackburn and Holford-Strevens, 1999.
- 'Dunsink Observatory 1785–1985', Patrick A Wayman, 1987.

- 6. Irish/UK Statute Books.
- 7. Calendar FAQ

http://www.tondering.dk/claus/calendar.html

- 8. sci.astro FAQ http://sciastro.astronomy.net/
- 9. Leap seconds mailing list http:
 //rom.usno.navy.mil/archives/leapsecs.html
- 'Explanatory Supplement to the Astronomical Almanac', P Kenneth SeidelmannEd., 1992.
- 11. Steve Allen's Leap Second Pages
 http://www.ucolick.org/~sla/leapsecs/