How to Tell the Time!

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2020: Calendar Year

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 5^{th} January 2020.



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Counting Years

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

Dionysius Exiguus (AD 523) produced new table of Easter Dates.

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

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

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



February: Calendar Month

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, Numa, added 2 more.

Julian Reform

lanuarius	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
lunius	29	30	December	29	31

Old leap: Cut Feb at 23/24, *intercalarius* of 27 days, irregular. New leap: Once in 4, double Feb 24. Took 445 day year (46BC), and fumbling to get there (8AD). (Astronomical events a useful retrospective!)

Aiming for 365.24219 day year.

When	Calendar	Length		
????	Old Roman	355 ± €€€		
45BC	Julian	365.25		
1582AD	Gregorian	365.2425		

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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.

Monday: Day of Week

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

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

Possibly longest unbroken tradition. Resisted French (10 day) and Communist (5 then 6 day) reform.

Obviously, it gets dark and bright once per day!

Different cultures start days at: sunset, sunrise, midnight, midday, \ldots

Must be something to do with Earth going around.

Solar vs. sidereal days.





Hours

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*.

Apparent vs. Mean Time

In 1792, move from apparent time to mean time.



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Differentiation:

$$\frac{d}{dt}\vec{x} = \vec{v}, \qquad \frac{d}{dt}\vec{v} = \vec{a}$$



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Newton's Second Law:

$$\vec{F} = m\vec{a}$$



Differentiation:

Cross product gives area:

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Area = $\vec{v} \times \vec{x}$

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 $\frac{d}{dt}$ Area = $\vec{v} \times \frac{d}{dt}\vec{x} + \frac{d}{dt}\vec{v} \times \vec{x}$

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Actually Conservation of Angular Momentum!

Area =
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Irish Legal time

Problem with midnight — it depends where you live.

In 1858, case law chooses local time.

In 1880, legislation fixes GMT in England, DMT in Ireland.

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Dunsink Observatory Usher: 25m7–48s (1787). Brinkley: 25m22s (1832). Romney-Robinson: 25m21s (1838). Elliott-(Ray-Drury-Malone): 25m21.02s (2017).

Legal Time Since

1916	Busy year for Ireland
1923	Western-European Time
1941–5	No double Summer Time
1947	No double Summer Time
1968	Standard Summer Time (GMT+1)
1971	Changed mind.
1986	Order giving effect to EEC directive
2001	2000/84/EU directive currently in force
	(from 2002 last Sun in March/October, 1AM GMT)

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

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Seconds: 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 like this:

 $\begin{array}{r} 86636.55536790872 + 0.000005098097\, {\it T} \\ + 0.000000000509\, {\it T}^2 \end{array}$

(A day is usually 86400 long).

Atomic Seconds

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.

How did they pick 9,192,631,770?

Used ET, based on Newcomb's measurements from 1750-1892.

Tidal forces (1.7ms/d/c) mean UT and SI seconds are different (by 2.5ms).

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.





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What next?

Could Brexit have an effect?

However, there's also an argument about daylight savings.

The EU has been regularly reviewing the situation (2007, 2014, 2018).

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Choices Ahead

Summertime

- Sunrise after 9:30 for 1–2 months (light, frost, ...).
- Tried it before not popular *Bloody Stupid Time*.
- Russians tried it 2011–2013.
- Bad for you?
- Could get New Year before London.

Wintertime

- 2 hour gap to Europe?
- Shorter stretch in the summer, winter no worse than now.

• Less time in the evening for activities.

DST

- Some health impacts.
- What about Northern Ireland?
- What about the EU?

Implementing a Change

Originally to be implemented by October 2019.

- 1. Decide what you want to do (with all your EU neighbours).
- 2. Is the global result sensible?
- 3. Pass an EU directive, implement local legislation.
- 4. Update Olsen Timezone database.
- 5. Microsoft/Apple/... update Windows/iOS/ ...
- 6. Find computers set to Dublin/London/Lisbon timezone.
- $\ensuremath{\mathcal{T}}$. Automatically update computers, phones, tablets, TVs, \ldots
- 8. Figure out what to do with Rugby/Frankfurt radio signals.

Negotiation with new Council of Ministers to happen, followed by final decision. Possible by March 2021?



- Thousands of years of clock and calendar reform.
- It's rarely as easy as it looks¹.

¹https://qntm.org/abolish and https://qntm.org/calendar (=) = • • • •