Why is it Thursday, October 31st 2024, 15:00:00 UTC?

David Malone
Hamilton Institute / Dept of Maths&Stats, Maynooth University.

2024-10-31 15:00:00 UTC

2024: Calendar Year

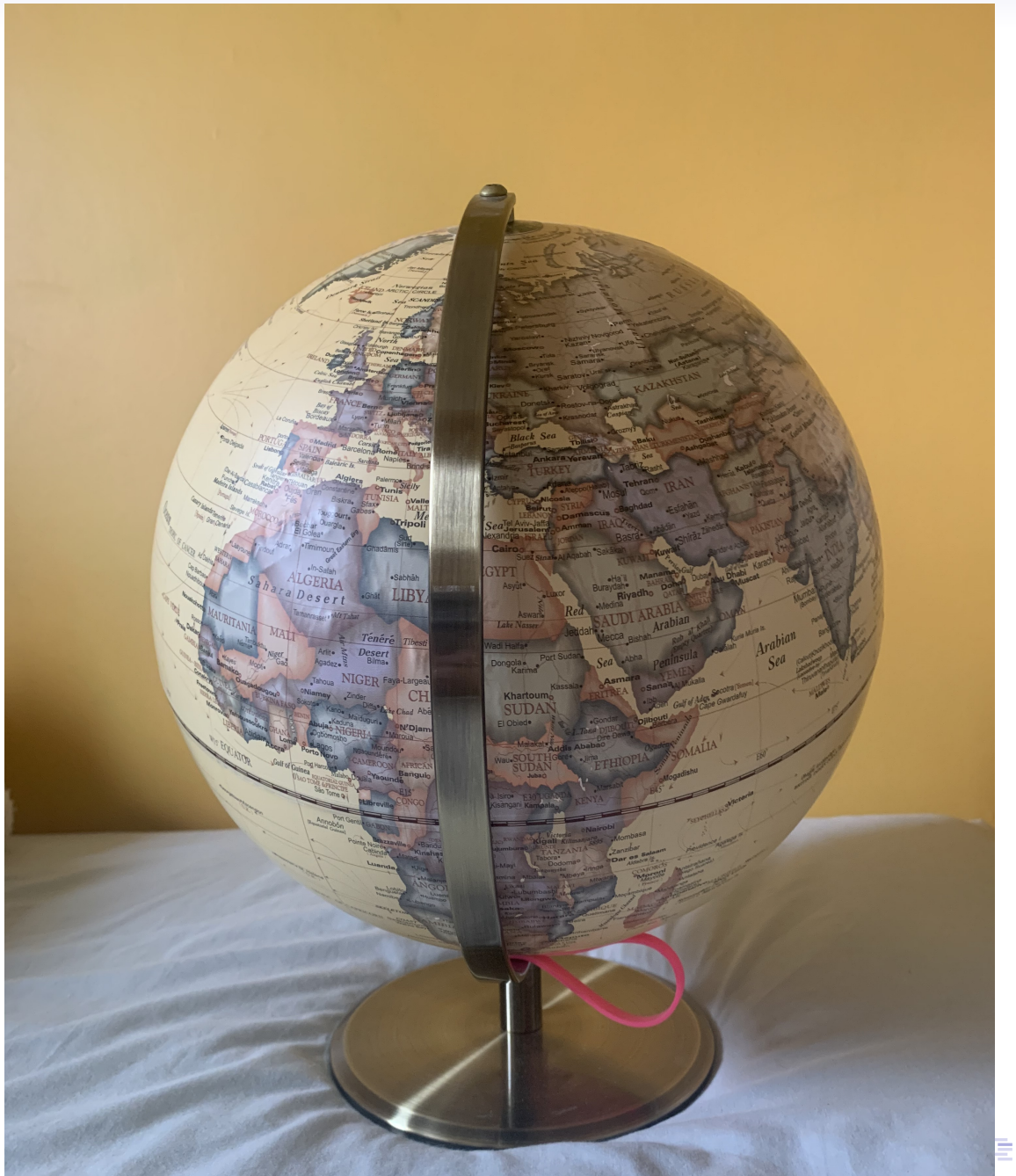
Seasons: Weather cycles, days lengthen and shorten.

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).

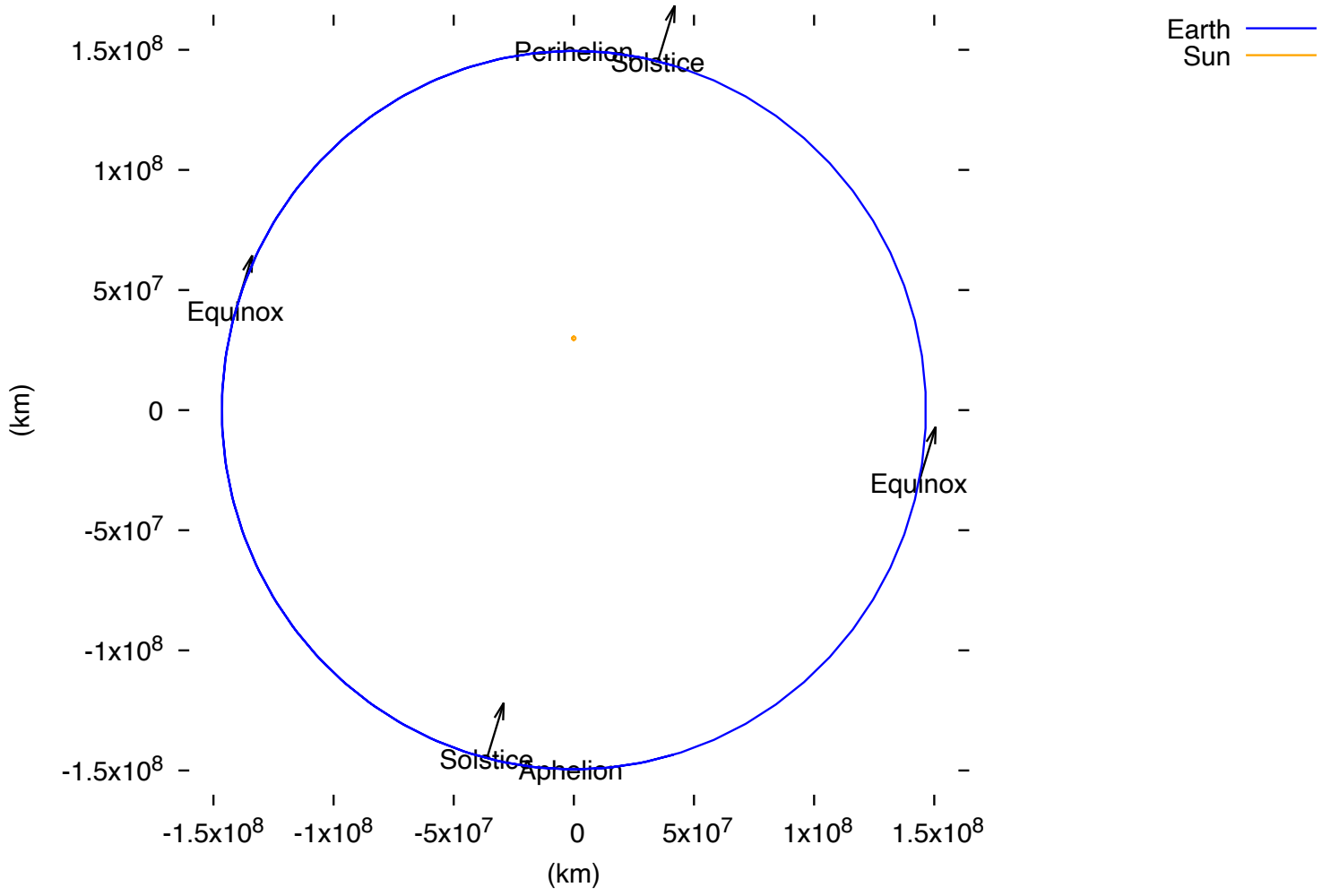
The time of year: angle between earth's axis and the line from the earth to the sun.

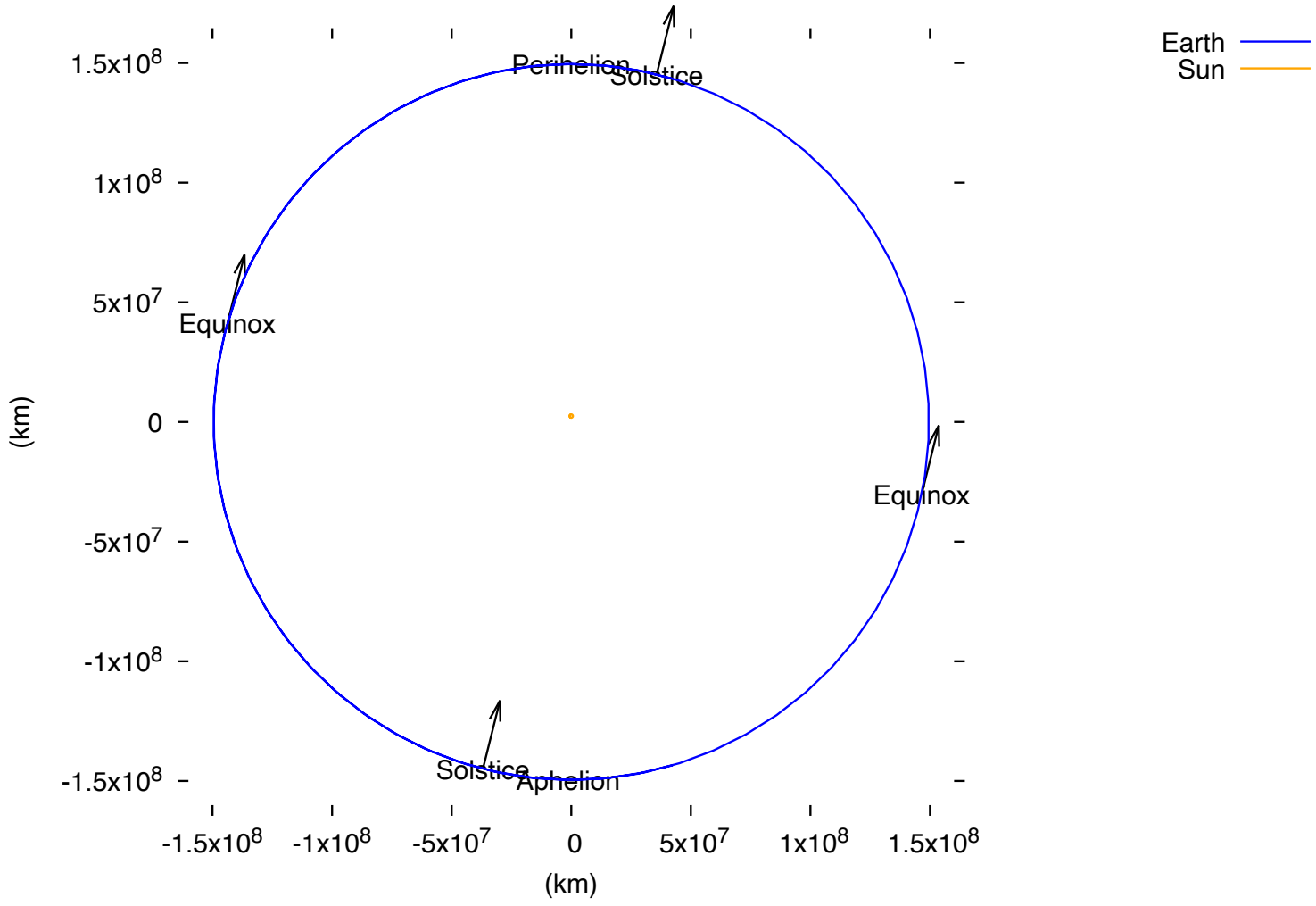
NB: seasons nothing to do with distance to sun. Earth is at its closest (Perihelion) about 2nd January 2024.

Atlantic
Ocean
TROPIC OF CANCER
CAPE VERDE
MAURITANIA
MALI
ALGERIA
Sahara Desert
LIBYA
NIGER
CHAD
SUDAN
EQUATOR
LIBERIA
GHANA
NIGERIA
CAMEROON
ANGOLA
NAMIBIA
BRAZIL
South Atlantic Ocean
TROPIC OF CAPRICORN
#BOIstudents


ALGERIA
Sahara Desert
LIBYA
MALI
NIGER
SUDAN
ETHIOPIA
SOMALIA
KENYA
SAUDI ARABIA
Arabian Sea
Red Sea
Black Sea
TURKEY
IRAN
EGYPT
Khartoum
Addis Ababa
Nairobi
Cairo
Tehran
Baghdad
Damascus
Riyadh
Mecca
Sanaa
Tripoli
Tunis
Algiers
Barcelona
Rome
Athens
Ankara
Yerevan
Tbilisi
Baku
Volgograd
KAZAKHSTAN
Lake Chad
Lake Nasser
Niamey
Abuja
Yaounde
Kinshasa
Luanda
Mombasa
Dar es Salaam
Zanzibar
Kigali
Djibouti
Mogadishu
Jeddah
Muscat
Dubai
Karachi
Kuwait
Amman
Baghdad
Basra
Shiraz
Isfahan
Nicosia
Beirut
Damascus
Tel Aviv-Jaffa
Jerusalem
Alexandria
Port Sudan
Asmara
Gulf of Aden
Arabian Peninsula
Equator

ALGERIA
Sahara Desert
LIBYA
MAURITANIA
MALI
NIGER
CHAD
GUINEA
LIBERIA
GHANA
NIGERIA
CAMEROON
SUDAN
W15° EQUATOR
Gulf of Guinea
Port Gentil
GABON
Annobón
Brazzaville
Kinshasa
Luanda
ANGOLA
ZAMBIA
Lusaka
Georgetown
Ascension
(U.K.)
Jamestown
St. Helena
(U.K.)
BRAZIL
SKELETON
COAST
NAMIBIA
BOTSWANA
TROPIC OF CAPRICORN
Swakopmund
Walvis Bay
Windhoek
Gaborone
Pretoria
Johannesburg
Maputo
South Atlantic Ocean
Lüderitz
Alexander Bay
SOUTH AFRICA
Cape Town
Cape of Good Hope
Tristan da Cunha Group
(U.K.)
Gough Island
(U.K.)
GREENWICH MERIDIAN


Earth
Sun
Perihelion
Solstice
Equinox
Equinox
Solstice
Aphelion
1.5x10^8
1x10^8
5x10^7
0
-5x10^7
-1x10^8
-1.5x10^8
(km)
(km)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1.5x10^8
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5x10^7
0
-5x10^7
-1x10^8
-1.5x10^8
(km)
(km)

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).

VIII.VIC
D 1844

October: 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

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, *intercalarius* month, 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 $\pm$ €€€
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.

Thursday: Day of Week

7 day week is very old. Ptolemaic week by used Romans and biblical week from Jewish tradition.

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 Soviet (5 then 6 day) reform.

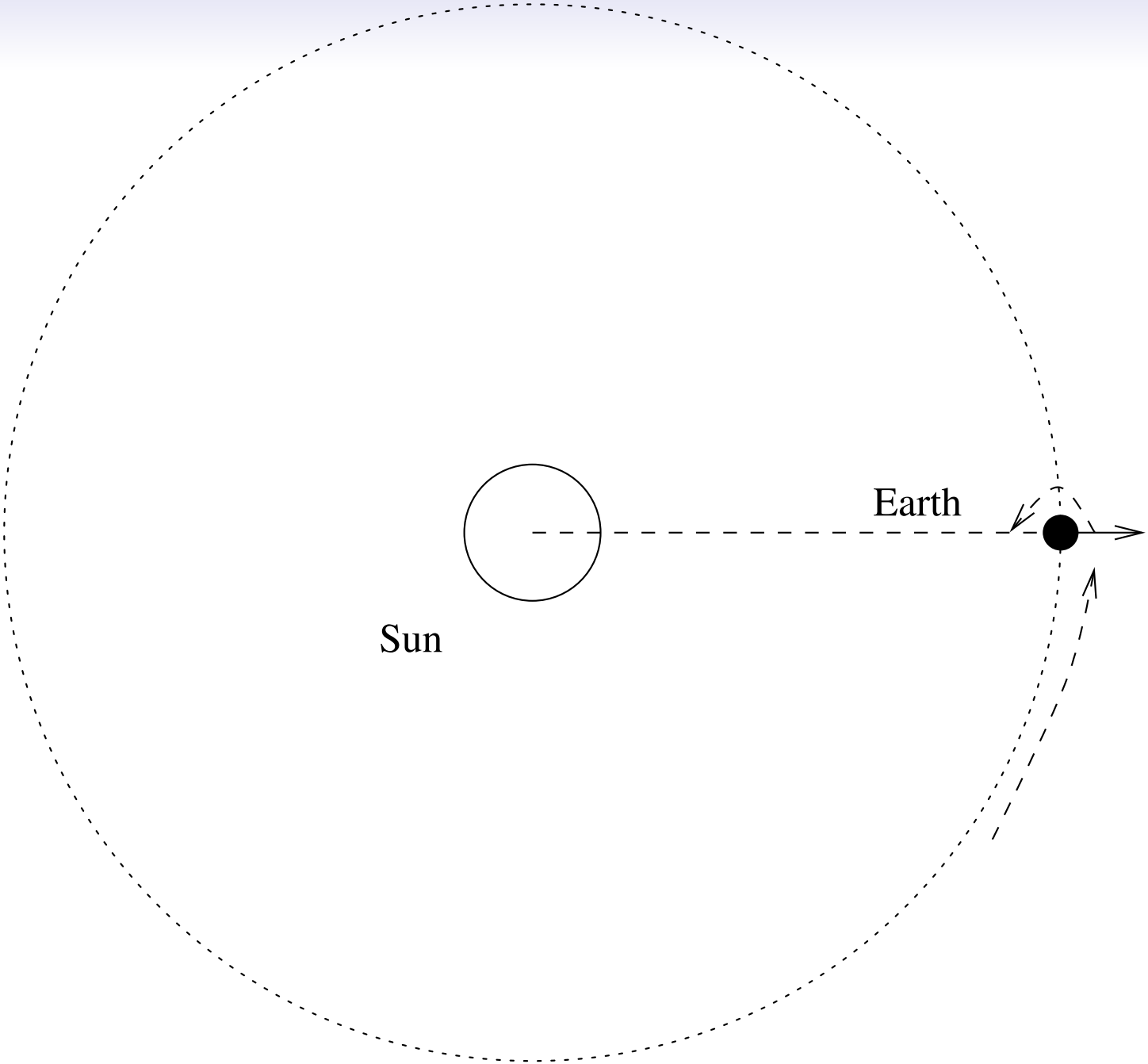
Days

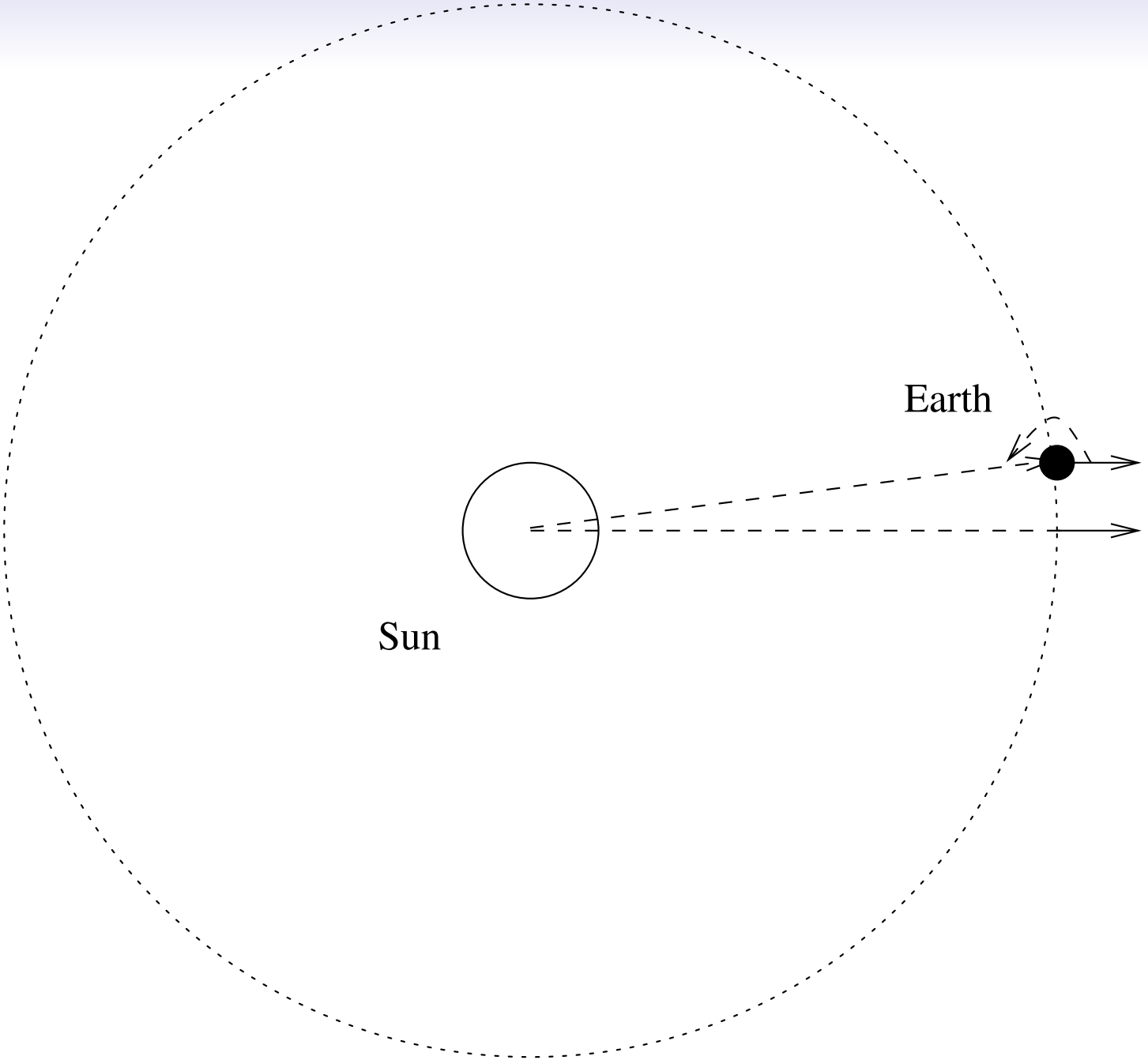
Obviously, it gets dark and bright once per day!

Different cultures start days at: sunset, sunrise, midnight, midday, ...

Must be something to do with Earth going around.

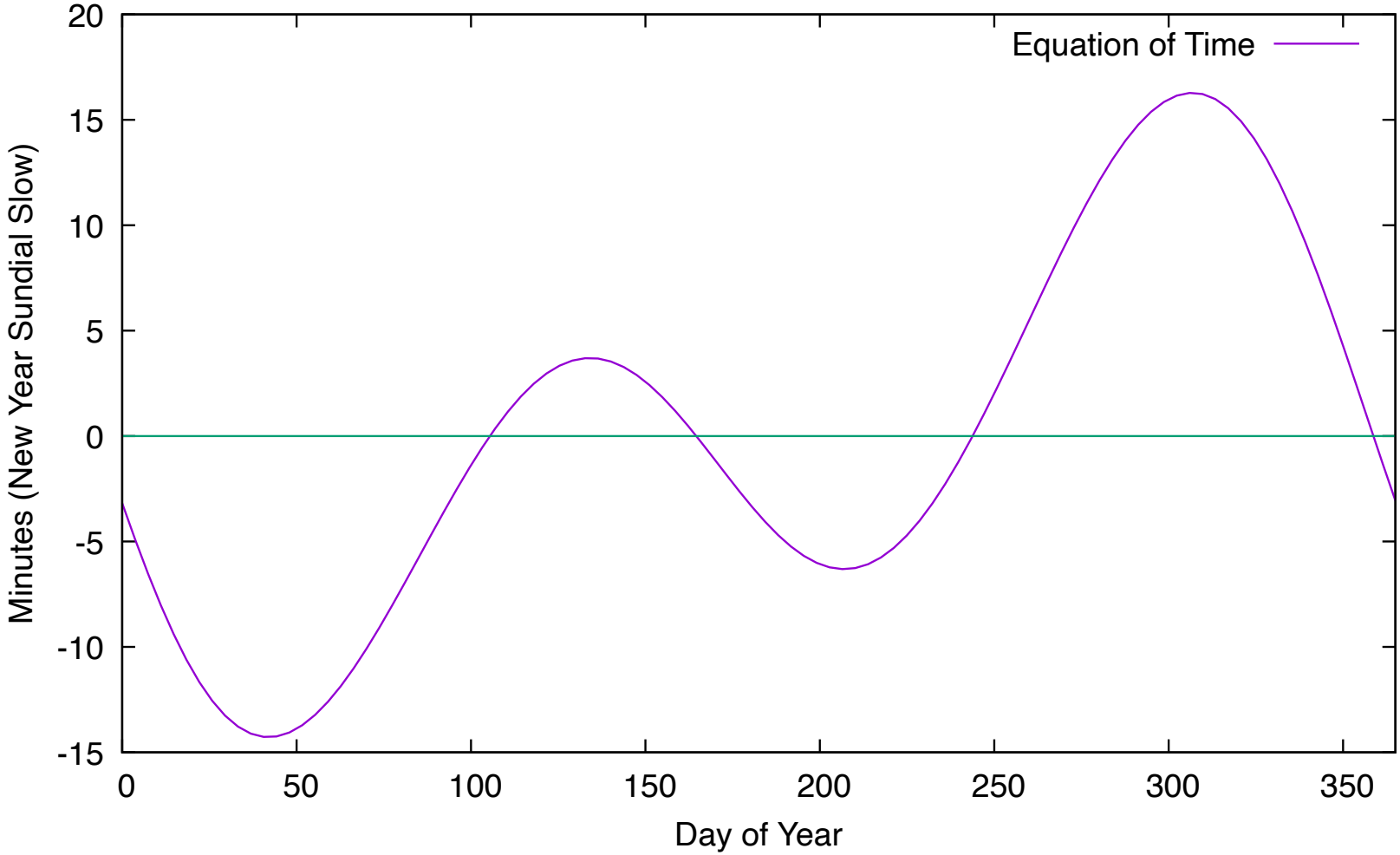
Solar vs. sidereal days.


Earth
Sun

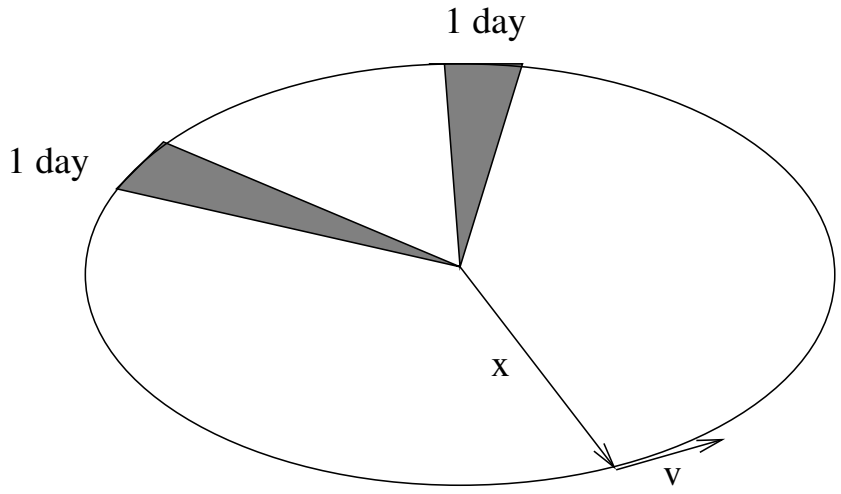

Earth
Sun

Apparent vs. Mean Time

In 1792, move from apparent time to mean time.



Kepler's Second Law



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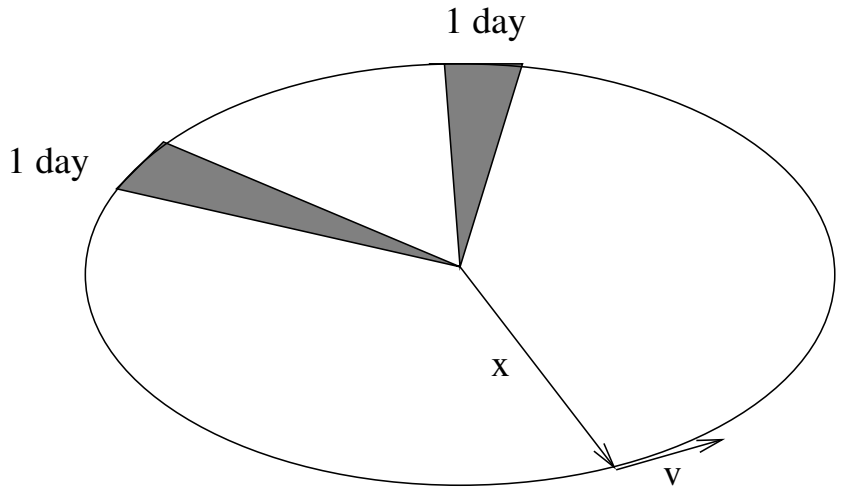
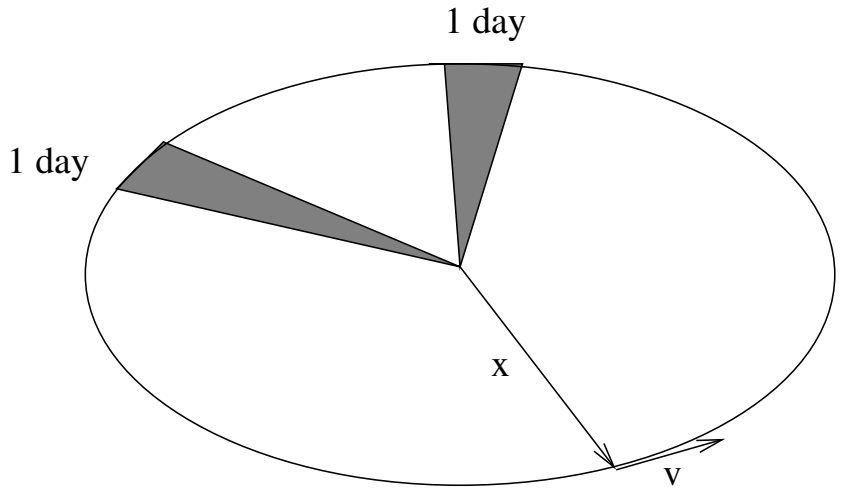


Differentiation:

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

Kepler's Second Law



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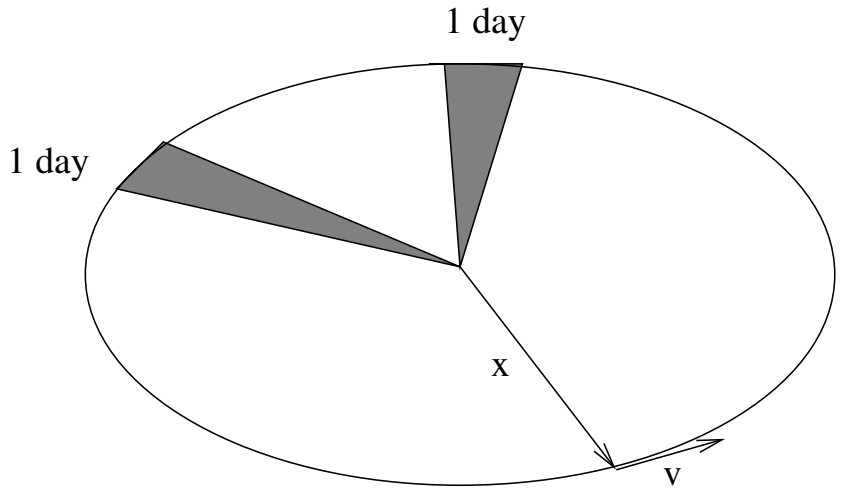
Newton's Second Law:

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

Kepler's Second Law



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

Cross product gives area:

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

Newton's Second Law:

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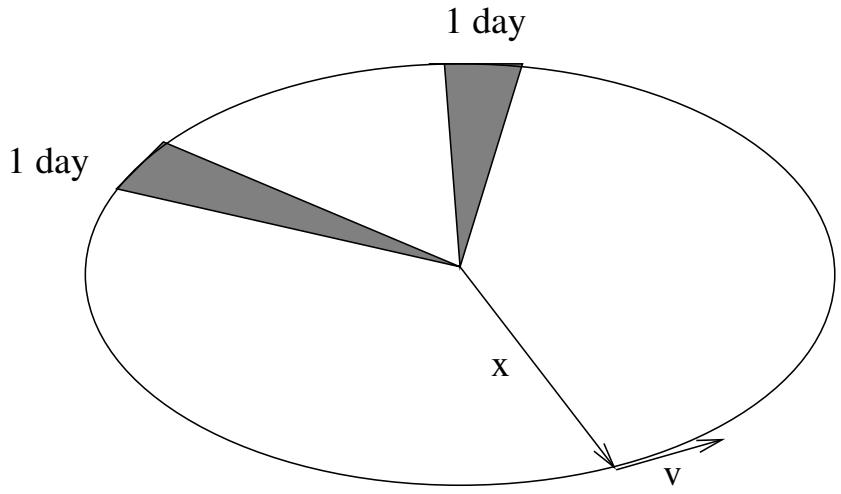
Kepler's Second Law



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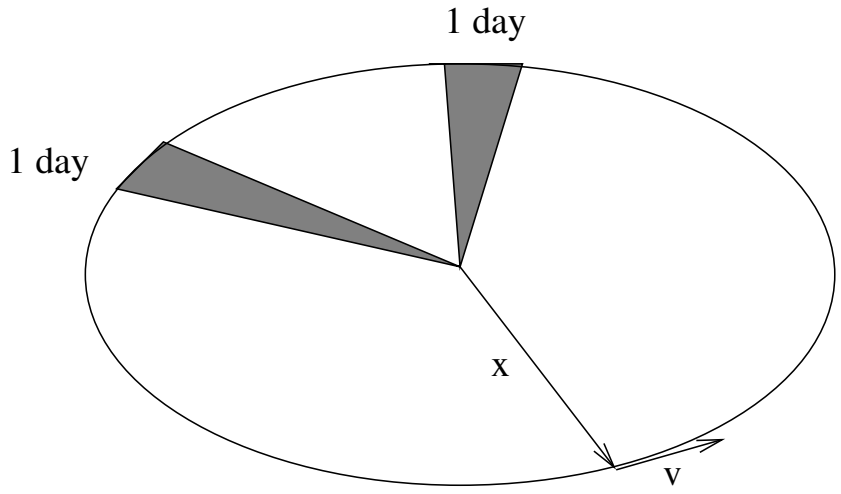

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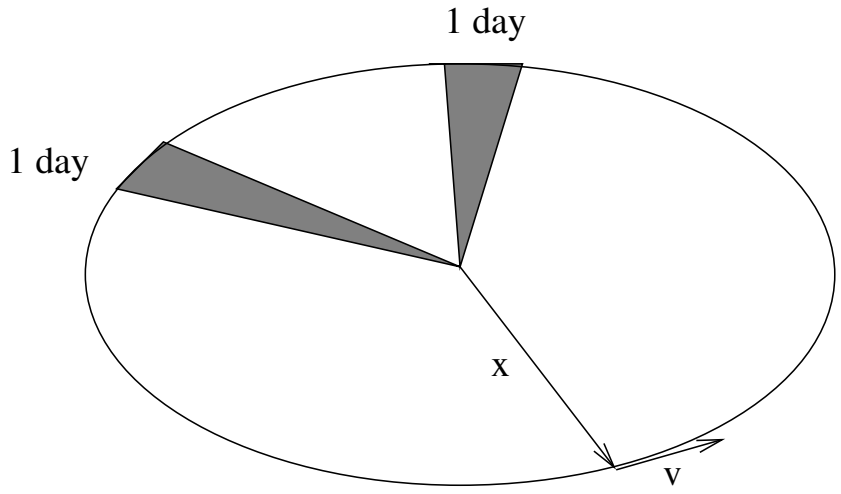
Kepler's Second Law



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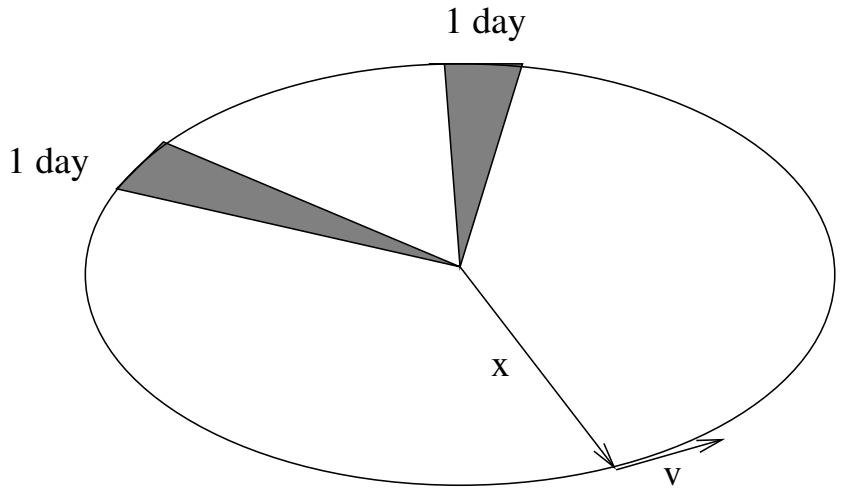

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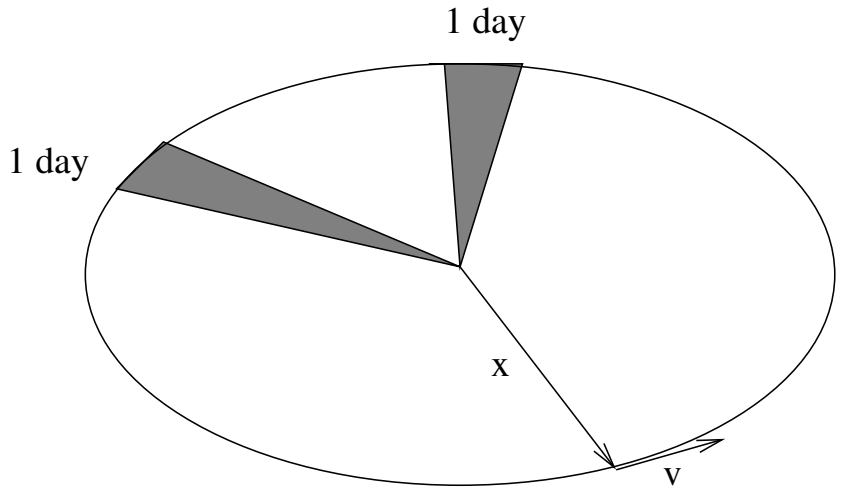

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Actually Conservation of Angular Momentum!

HH:MM:SS

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*.

Irish Legal time

Problem with midnight — it depends where you live.

In 1858, case law chooses local time.[1]

In 1880, legislation fixes GMT in England, DMT in Ireland.[2]

---

[1] Curtis v. March at Dorchester.

[2] Whenever any expression of time occurs in any Act of Parliament, deed, or other legal instrument, the time referred shall, unless it is otherwise specifically stated, be held in the case of Great Britain to be Greenwich mean time, and in the case of Ireland, Dublin mean time.

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[3]
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)
	EU reviews in 2007, 2014, 2017, . . .

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

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:

$$86636.55536790872 + 0.000005098097\,T + 0.000000000509\,T^2$$

(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.

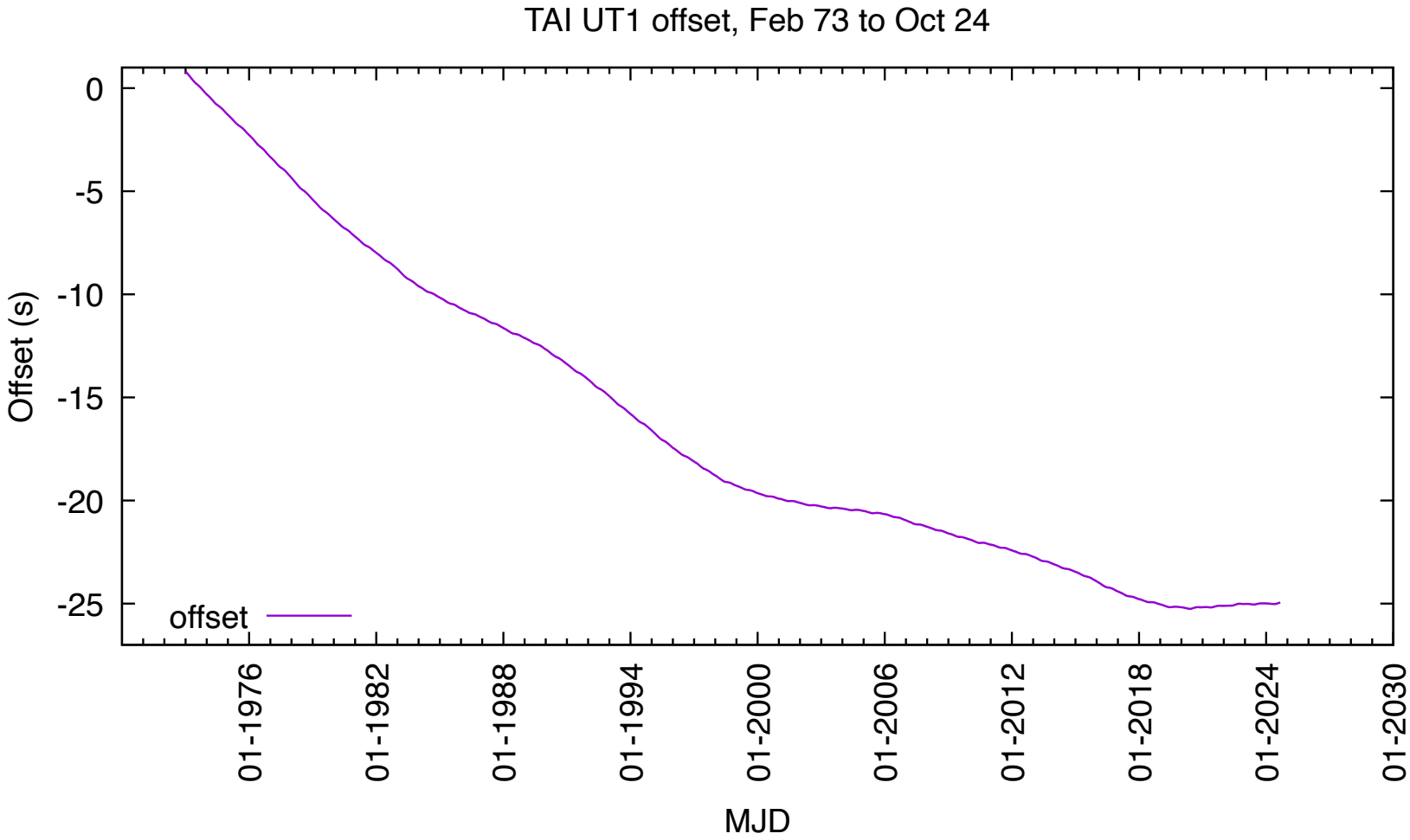
Coordinated Universal Time is a compromise. It ticks once per SI second, in sync with TAI.

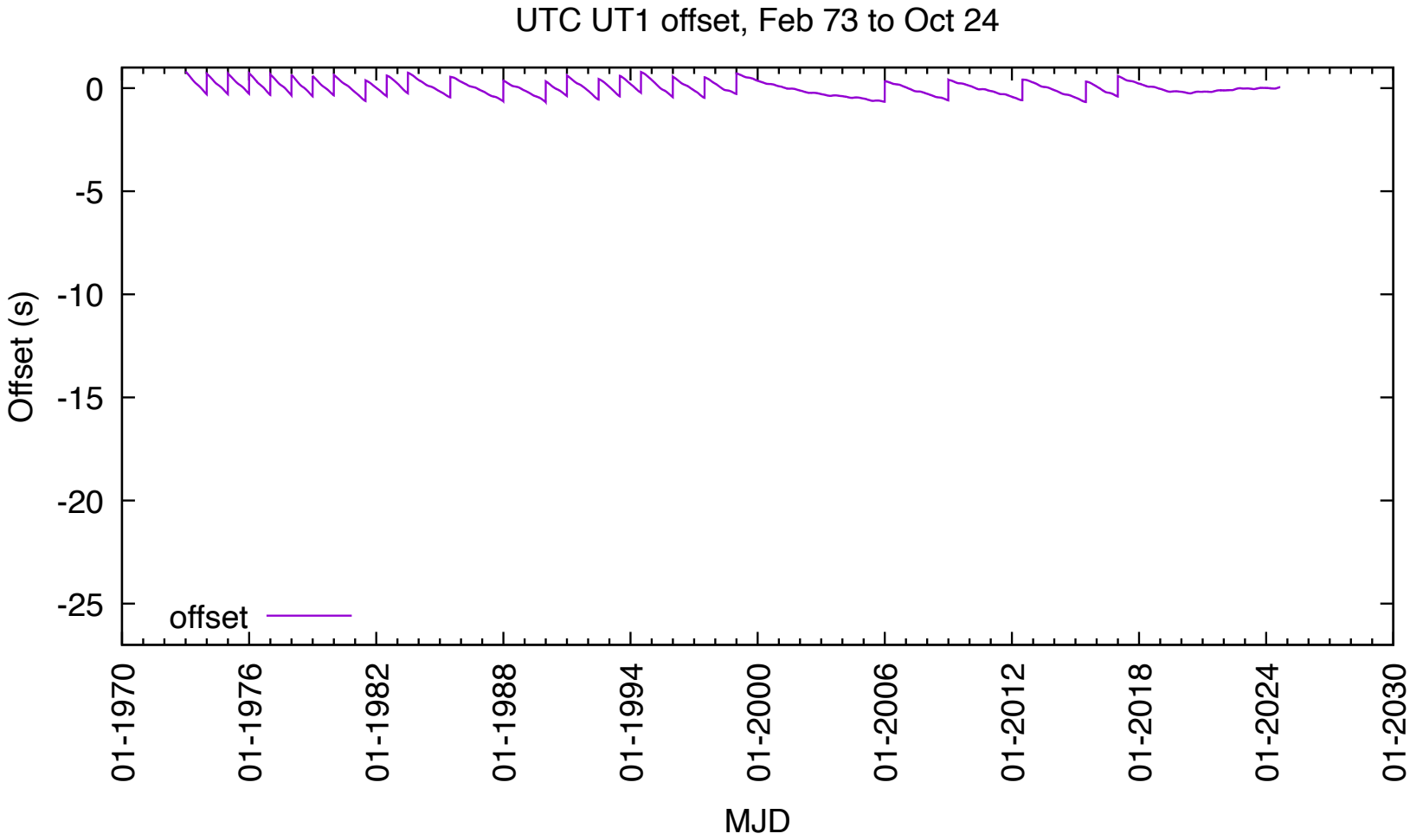
If UTC is more than one second from UT1 then UTC is adjusted.

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).


TAI UT1 offset, Feb 73 to Oct 24
Offset (s)
0
-5
-10
-15
-20
-25
offset
01-1976
01-1982
01-1988
01-1994
01-2000
01-2006
01-2012
01-2018
01-2024
01-2030
MJD


UTC UT1 offset, Feb 73 to Oct 24
Offset (s)
0
-5
-10
-15
-20
-25
offset
01-1970
01-1976
01-1982
01-1988
01-1994
01-2000
01-2006
01-2012
01-2018
01-2024
01-2030
MJD

How do you know?

How do you set yours?

- The speaking clock.
- TV or radio.
- Your computer/phone.
- Radio controlled clock.
- GPS!
- From other clock.

Need to know about DST, leap seconds, . . .

New *National Timing Grid* — `https://ntg.ie`.

Final Thought

The Earth is not a good timekeeper.

vs.

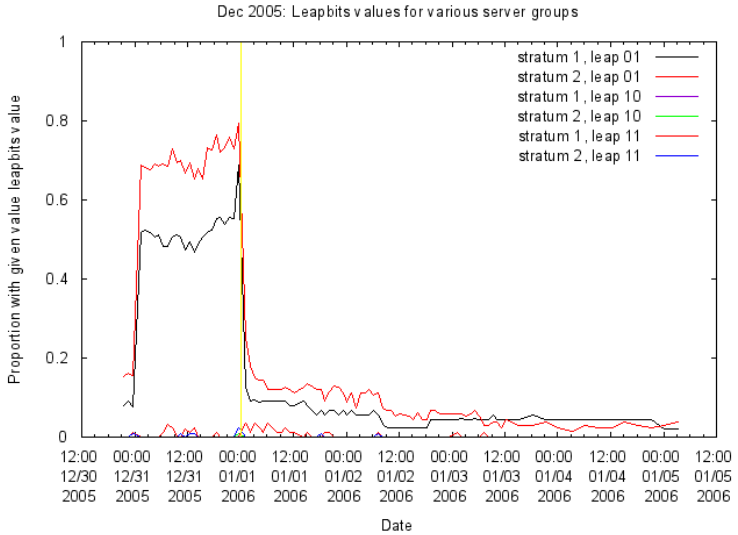
The Earth is what we are trying to measure.

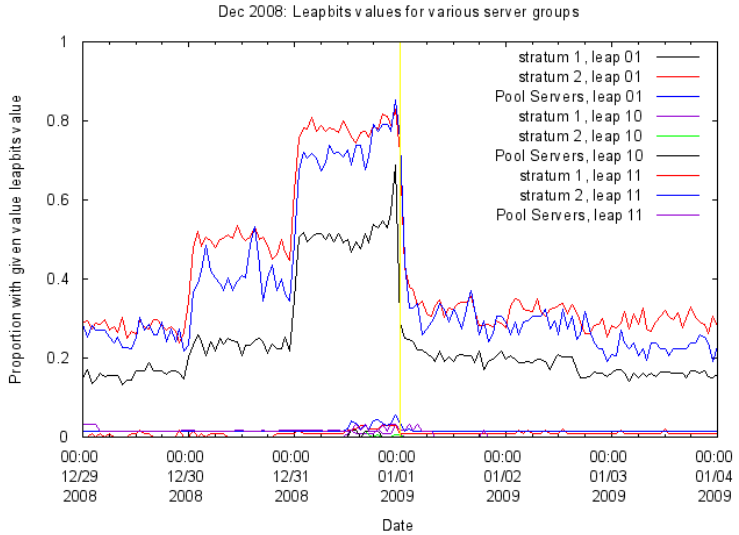
What did I do?

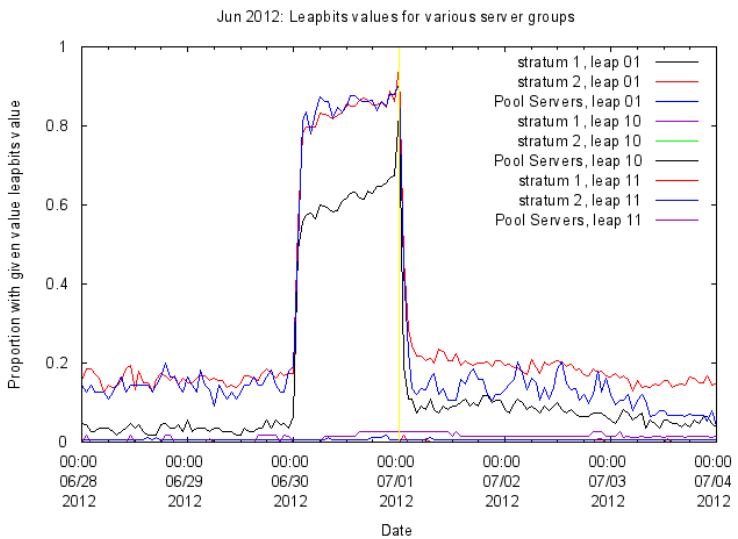
- Set up GPS based time server (1999).
- Tardis Time Server Incident (2002)[4].
- Monitoring Leap Seconds (2005–).
- GPS NTP server and 1024-week rollover (2013).
- Where is Dunsink? (–2017)
- Daylight Savings and Brexit. (2016)

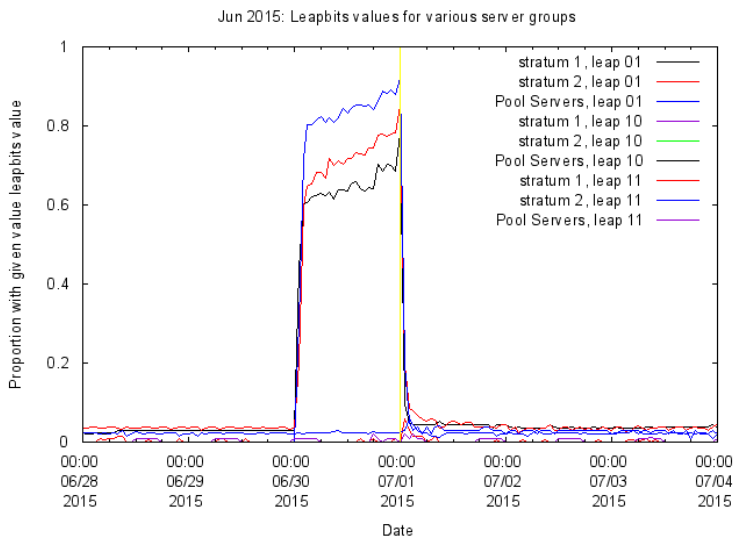
[4] `https://www.usenix.org/system/files/login/articles/900/malone.pdf`

Monitoring Leap Seconds









https://www.maths.tcd.ie/~dwmalone/time/leaps/

US GPS

Spotted on Civil GPS Service Interface Committee:

GPS.GOV

Official U.S. Government information about the Global Positioning System (GPS) and related topics

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CGSIC opinion on the redefinition of UTC now under consideration by the International Telecommunications Union (ITU)

Prepared by CGSIC Timing Subcommittee and endorsed by the CGSIC Executive Committee on 8-9 September 2014

The Civil GPS Interface Committee,

Considering that

- In 1971, the ITU-R (formerly CCIR, International Consultative Committee for Radiocommunications) proposed the present form of Coordinated Universal Time (UTC), which is based upon the SI second but remains linked to the variable rotation of the Earth through the introduction of leap seconds, which are inserted preferentially at the end of December 31 or June 30 in such a manner that |UT1-UTC| will always be less than 0.9 second.
- This proposal was accepted after discussions with BIH (Bureau International de l'Heure), URSI, IAU, IUGG, and other bodies active in positioning and navigation.
- At the time of introduction, the future implementation of satellite and other systems which cannot easily incorporate the leap second was not foreseeable.
- A proposal on the redefinition of UTC is under consideration by ITU, about which the ITU has solicited the opinion of several international bodies.

Interesting...

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And further considering that,

- leap second insertions have increasingly been associated with failures of navigational as well as timing systems, among them the ground, transmission, or accounting systems of GPS, LORAN, and commercial air travel,
- in one instance uncorrected mis-programming of a GPS receiver was responsible for a failure in mid-month, at a time when no leap second would have been expected,
- approximately 10% of the world's Network Time Protocol (NTP) servers, which provides an internet-based timing structure upon which many navigational systems depend, failed to correctly handle the leap second insertion of 2012,
- never as long as NTP servers have been monitored has every one correctly predicted the presence or absence of leap second on a December 31 or June 30,
- some systems have been mis-programmed to insert leap seconds after 23:59:59 local time instead of 23:59:59 UTC,
- many corporations, governments, providers of navigational systems, and other groups do not report failures as a matter of policy,
- and in the interests of safety some systems cease operations at the time a leap second is to be introduced,
- although navigational systems must and do continue operating through leap second insertions.

NTP leap second failures are a *known known*

- If correctly configured, NTP and PTP can handle leap seconds
- Never has every NTP server monitored been known to handle a December 31 or June 30 correctly
  - At least since serious monitoring began, January 2008
  - http://www.maths.tcd.ie/~dwmalone/time/leaps/
- 10% of the servers in the "NTP pool" got it wrong in 2012
  - Most were fixed within an hour of the insertion
  - Others, not in pool, took up to a day
  - Some added a leap second on July 31, 2012
    - https://groups.google.com/forum/#!topic/comp.protocols.time.ntp/vhVlH4ENsJQ
  - Hackers have been accused of exploiting/causing this

Where is Dunsink?

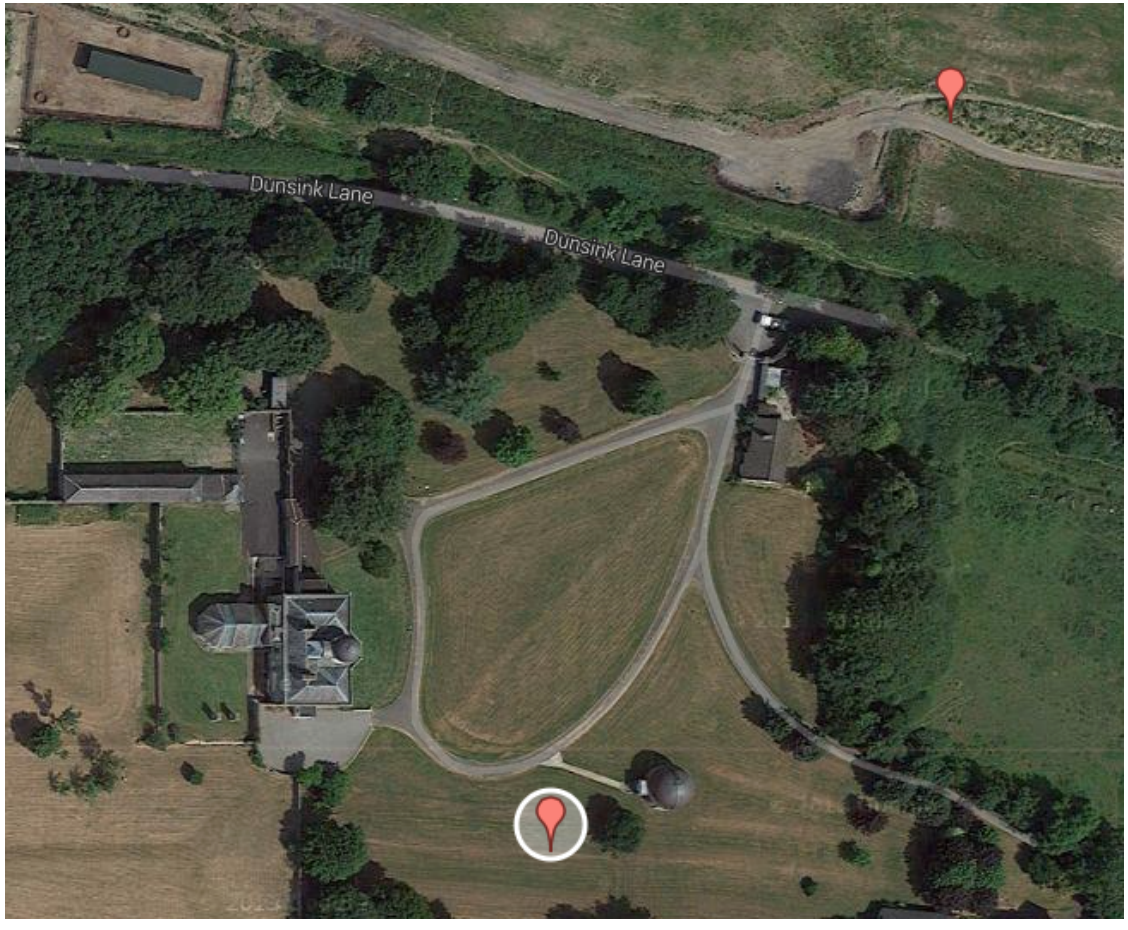

Image: Google Maps

$6°20.3′,53°23.2′$ vs $6°20.2′,53°23.3′$

Swapped 1992, fixed 2017.

Messing with DST

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.
7. Automatically update computers, phones, tablets, TVs, ...
8. Figure out what to do with Rugby/Frankfurt radio signals.

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

References

1. 'Greenwich Time and the Longitude', Derek Howse, 1980/1997. (2000 reprint)
2. 'The Oxford Companion to the Year', Blackburn and Holford-Strevens, 1999.
3. 'Dunsink Observatory 1785–1985', Patrick A Wayman, 1987.
4. 'The Great Calendar Reform', Michael J. Walsh, 2018.
5. Calendar FAQ `http://www.tondering.dk/claus/calendar.html`
6. sci.astro FAQ `http://sciastro.astronomy.net/`
7. Leap seconds mailing list `https://pairlist6.pair.net/mailman/listinfo/leapsecs`
8. 'Explanatory Supplement to the Astronomical Almanac', P Kenneth Seidelmann Ed., 1992.
9. Steve Allen's Leap Second Pages `http://www.ucolick.org/~sla/leapsecs/`
10. It's rarely as easy as it looks `https://qntm.org/abolish` and `https://qntm.org/calendar`.