Astronomy and the Social Concept of Time

OLLI Notes

11 February 2014
(Updated 24 Feb 2014)

Outline

- Definition of Time
- What time is it?
- Some Astronomy Basics
- How do we know what time it is?
  - Circadian Rhythm
  - Sundials
  - Early Clocks
- Astronomy Basics
- The Drivers for Time
  - Agriculture
  - Religion
  - Industry
  - Transportation
  - Science (Weather, Navigation…)
- The Calendar
- Local Time to Simultaneous Time
- Story of Standard Time
  - 1884 Washington DC Conference
  - Standard Time Act of 1918
- World Standard Time Zones
- From Sundial to Standard Time revisited

What Time is it?

This course started with the question about why clock time is different from sundial time

How do we know what day it is? (calendar)

What did people do before there were calendars, watches and clocks?

Why did they invent them?

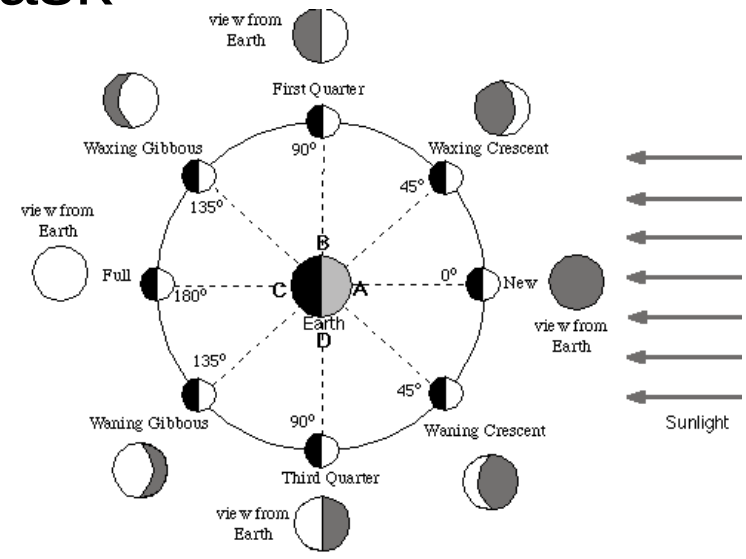
Photos by Jeff Kretsch

Webster's Definition of Time

1a. The measured or measurable period during which an action, process, or condition exists or continues: Duration, 1b. A non-spatial continuum that is measured in terms of events which succeed one another from past through present to future, 1c Liesure e.g. for reading, 2. The period in when something occurs: Occasion, 3a. an appointed fixed, or customary moment when something occurs, 3b. An opportune or favorable Moment (decided it was ~ to retire) often used in the phrase about time (about ~ for a change) 4a. An Historical period: Age 4b. A division of geological chronology, 4c. conditions at present or some specified time, 4d: the present time (conditions at the present ~) (~s are hard), (move with the ~s), 5a. Lifetime, 5b. A period of apprentenc-ship, 5c. A period of military service, 5d. A prison sentence, 6. Season (very hot for this ~ of year), 7a rate of speed, 7b, the grouping of beats of music, 8a. A moment or hour, day, or year as indicated by a clock or calendar (what ~ is it?), 8b, any of various Systems (such as sidereal or solar) of reckoning time, 9a. One of a series of recurring Instances or repeated actions (you've been told many ~s) 9b, plural (1) added or accumulated quantities or instances (five ~s greater) (2) equal fractional parts of Which an indicated number equal a comparatively greater quantity…

How do we know what time it is?

- Your internal clock
  - Biological (e.g. Circadian Rhythm)
  - How long it takes to do a task
- External Time keepers
  - The Sky
    - Day/Night (sunrise, noon,
      - sunset)
    - Month (moon)
    - Year (seasons)
  - Seasons and Climate

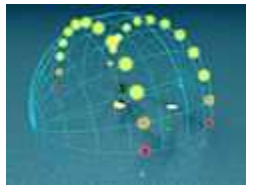


The Sun-Moon angle is the angle defined by Sun->Earth->Moon with Earth (where *you* are) as the angle vertex. As the Sun-Moon angle increases we see more of the sunlit part of the Moon. Note that if this drawing were to scale, then the Moon would be half this size and its orbit would be about 22 **times** larger in diameter and the Sun would be about 389 **times** farther away than the Moon!

http://www.bing.com/images/search?q=Astronomy+Moon+Phases+Images&qpvt=Astronomy+Moon+Phases+Images

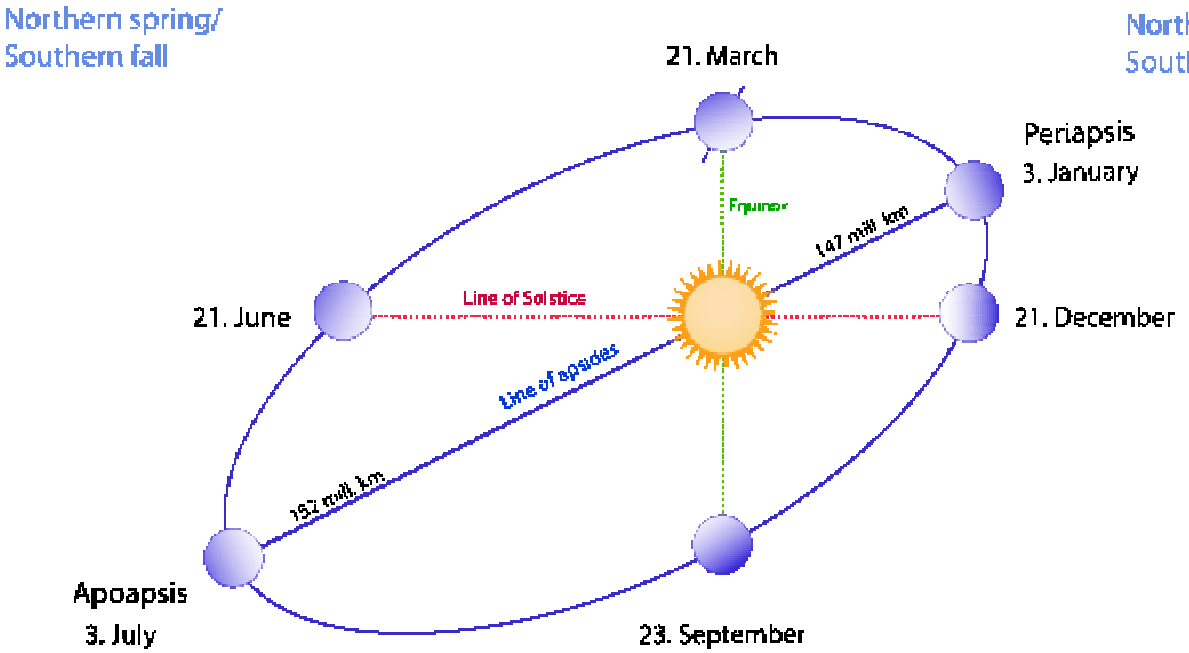
Astronomy Basics

Day Arcs



Equator

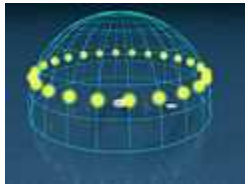
50 degrees



Source: http://huminities.blogspot.com/

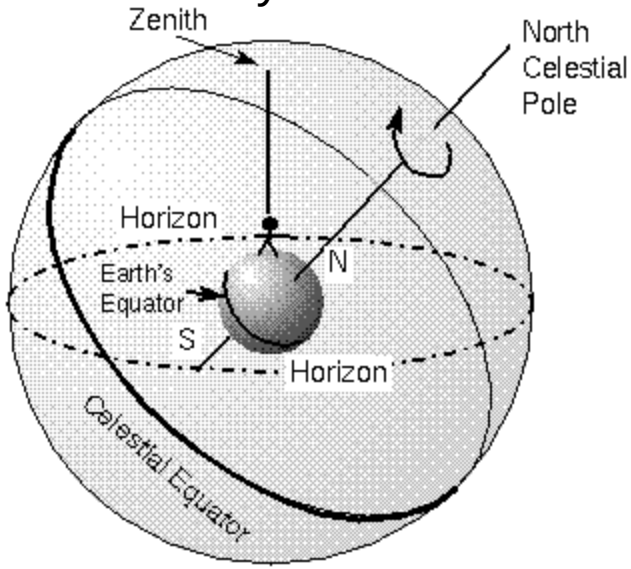
Mean Sun: Uses average apparent speed of the Sun used. The actual sun varies in apparent Angular speed in different parts of our orbit

70 degrees

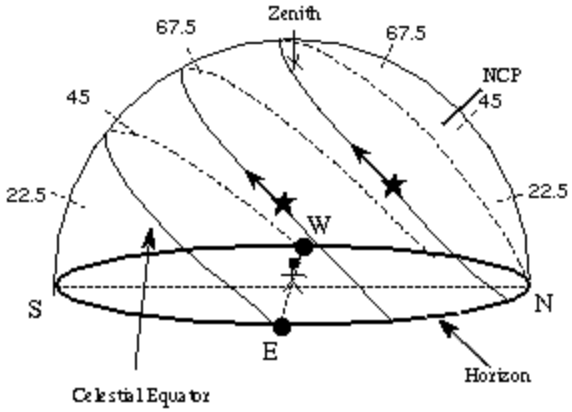


Pole

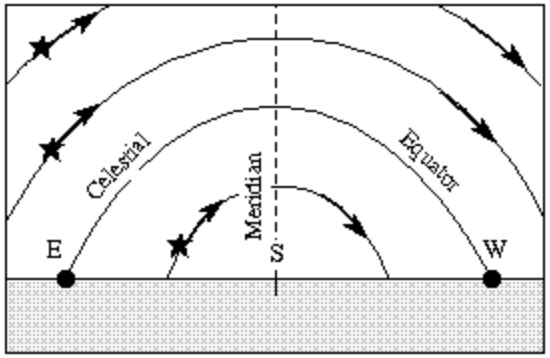
http://www.astronomynotes.com/nakedeye/s4.htm



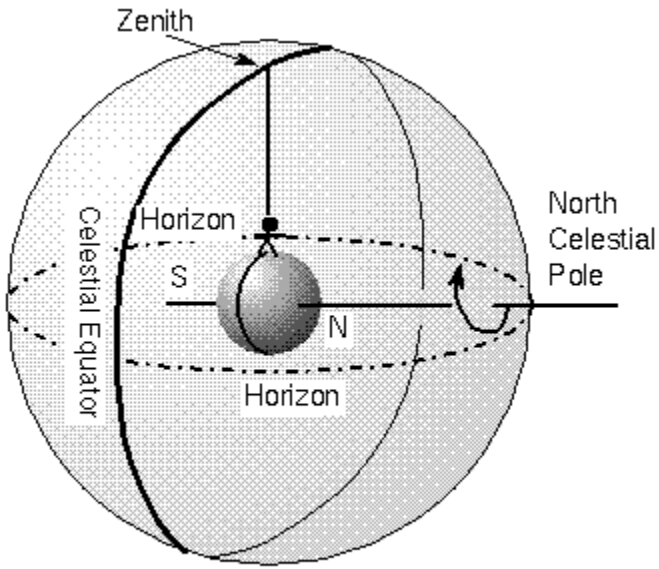
The celestial sphere for an observer in Seattle.
The angle between the zenith and the NCP = the angle between the celestial equator and the horizon.
That angle = 90° – observer's latitude.



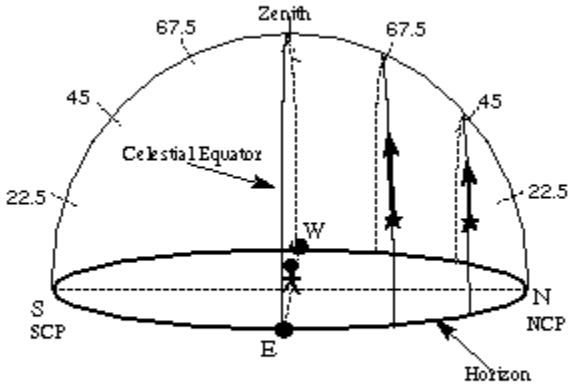
Stars motion at Seattle. Stars rotate parallel to the Celestial Equator, so they move at an angle with respect to the horizon here. Altitudes of 1/4, 1/2, and 3/4 the way up to the zenith are marked.



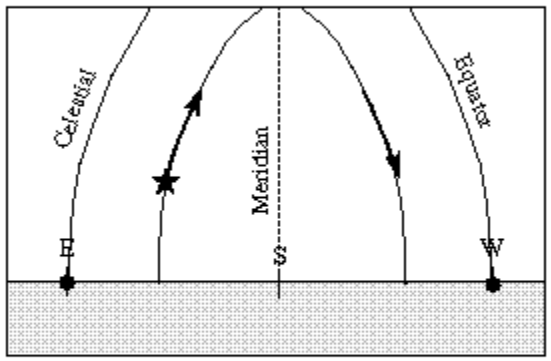
Your view from Seattle. Stars rise in the East half of the sky, reach maximum altitude when crossing the meridian (due South) and set in the West half of the sky. The Celestial Equator goes through due East and due West.



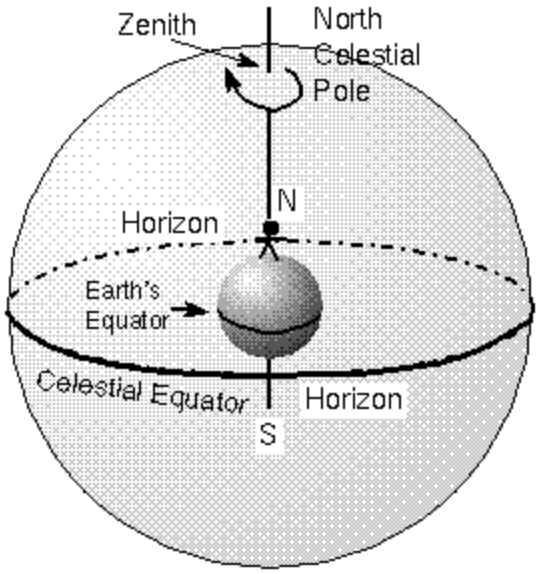
The celestial sphere for an observer on the Equator. The angle between the NCP and the horizon = observer's latitude. The Celestial Equator goes through the zenith.



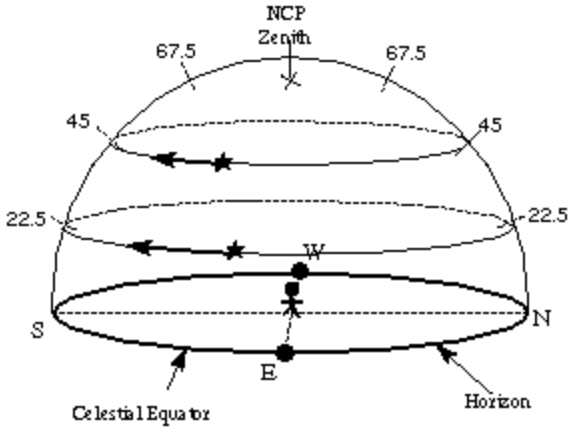
Stars motion at the Equator. Stars rotate parallel to the Celestial Equator, so they move perpendicular to the horizon here. All stars are visible for 12 hours. Both celestial poles are visible on the horizon.



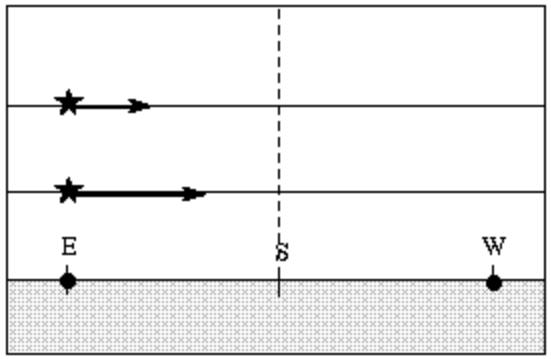
Your view from the Equator. Stars rise and set perpendicular to the horizon (a star south of the Celestial Equator is shown here). The Celestial Equator reaches zenith and goes through due East and due West on the horizon.



The celestial sphere for an observer at the North Pole. The NCP is straight overhead at the zenith and the celestial equator is on the horizon.



Stars motion at North Pole. Stars rotate parallel to the Celestial Equator, so they move parallel to the horizon here---they never set! Altitudes of 1/4, 1/2, and 3/4 the way to zenith are marked.



Your view from the North Pole. Stars move parallel to the horizon. The Celestial Equator is on the horizon.

The 24 Hour Day

- Why is the day divided into 24 hours?
  - Seems to go far back into antiquity (Babylonians and Egyptians)
  - 24 = 2*3*4 Twenty four hours can be divided into whole fractions, 12 hour half day, 8 hour third of a day, 6 hour quarter day, 3 hour eight of a day
  - Zodiac has twelve constellations, one for each hour of day and night

Days of the Week

Latin	Anglo-Saxon	English
Dies Solus	Sun's Day	Sunday
Dies Lunae	Moon's Day	Monday
Dies Martis	Tiw's Day	Tuesday
Dies Mecurii	Woden's Day	Wednesday
Dies Jovis	Thor's Day	Thursday
Dies Veneris	Frigg's Day	Friday
Dies Saturni	Seterne's Day	Saturday

Ancients ordered planets
By how fast they moved from
Zodiac constellation to constellation
'

Saturn
Jupiter
Mars
Sun
Venus
Mercury
Moon

Days were named by the planet that controlled the first hour. Hours cycled by sevens for each planet

Months of the Year

January
February
March
April
May
June
July
August
September
October
November
December

Only later was Jan 1st made into New Years

Roman leap day was Feb 22nd repeated twice

March 21st was original New Years

Summer Solstice was Mid-Summer

Named after the Caesar's

Romans numbered months from March, the start of the year was the spring equinox. It was only later we started the year from January 1

Winter Solstice 21 December
(Roman feast of Saturnalia became Christmas eventually)

Modern Calendar

46 BC

- Julian Calendar
  - Was 11 minutes too long, shifting days earlier*

Wanted equinoxes to fall on the same Days of the year

(Sosogines was the astronomer)

- Gregorian Calendar

1582 AD

Christopher Clavius

4 Oct followed by 15 Oct
In 1582

Images from wikipedia

*Measure change in year length by determining date of equinox when sun crosses equator. In 45 BC equinox occurred on 21 March, in 1582 AD it was on 10 March – which works out to about 11 minutes/year

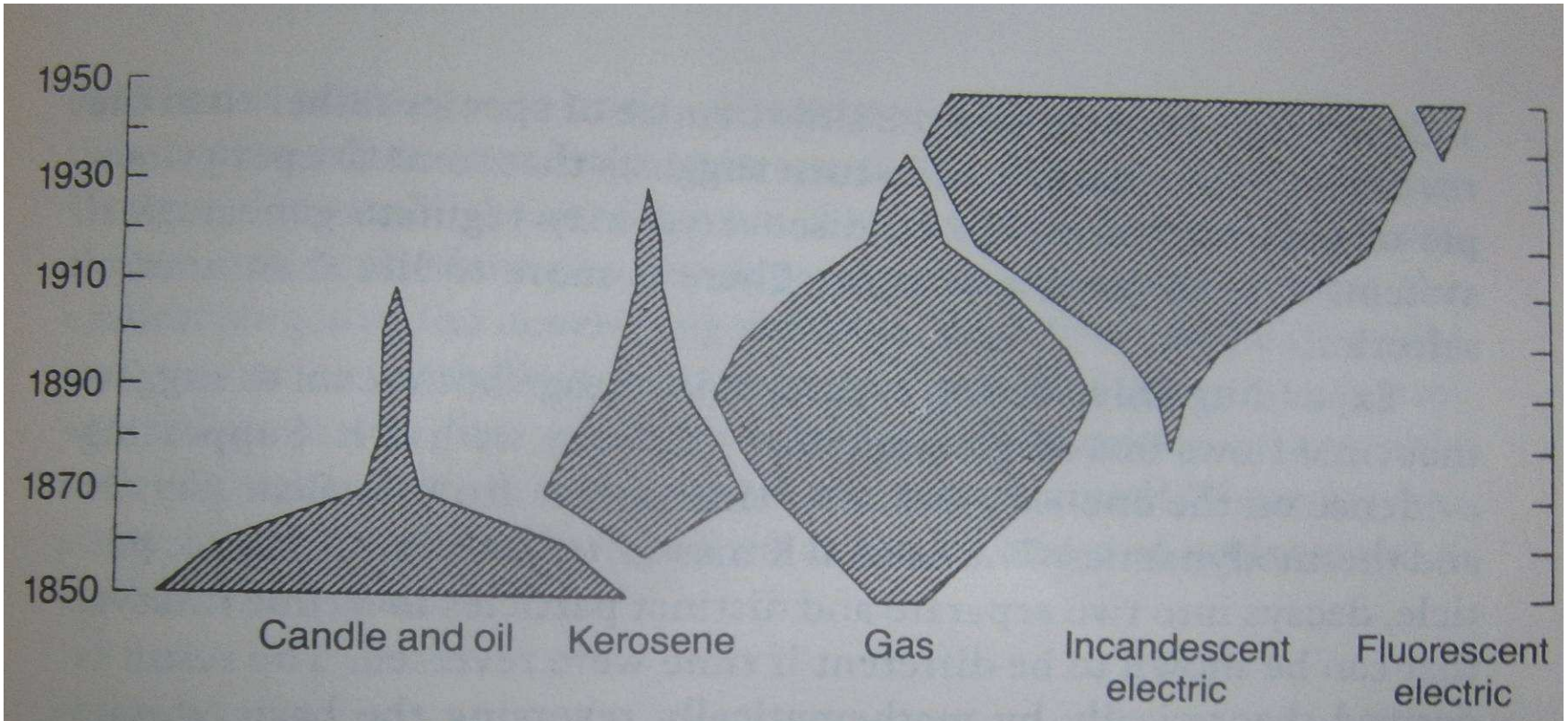


FIGURE 4.6 Clade diagrams show the growth and decay of artificial lighting devices. If there are as many bottom-heavy as top-heavy clades, diversification may not depend on which way time's arrow points. SOURCE: S. J. Gould, "Asymmetry of Lineages and the Direction of Evolutionary Time," *Science* 236 (1987):1437–41, fig. 6. Copyright © 1987 by the American Association for the Advancement of Science.

The Drivers for Time

- Agriculture
- Religion
- Industry
- Transportation
- Science
  - weather,
  - navigation

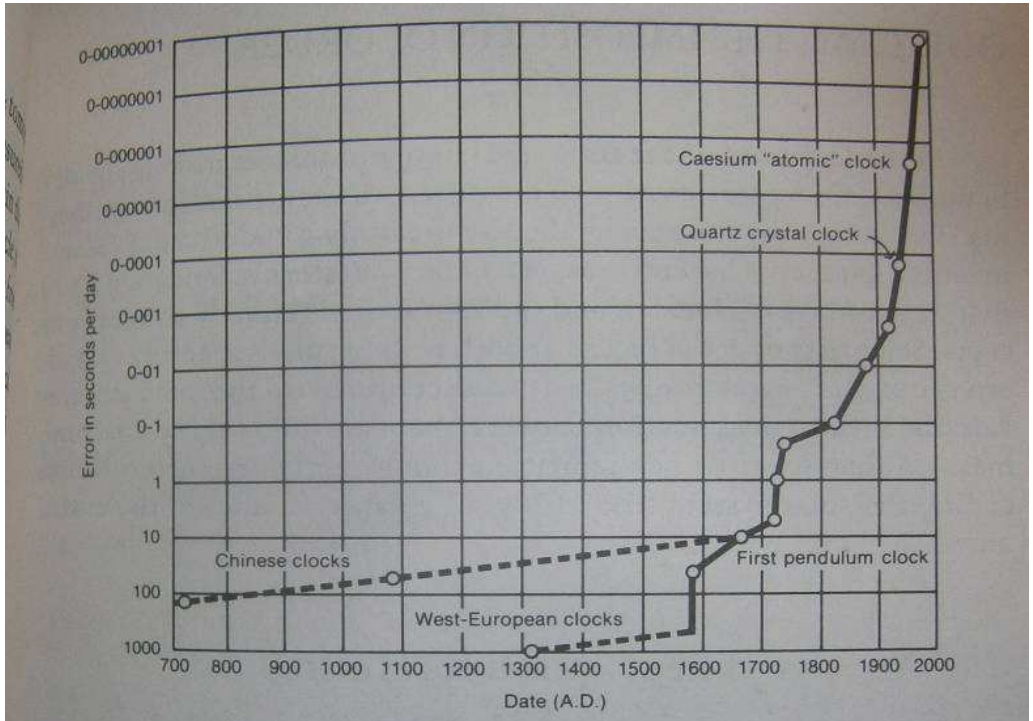
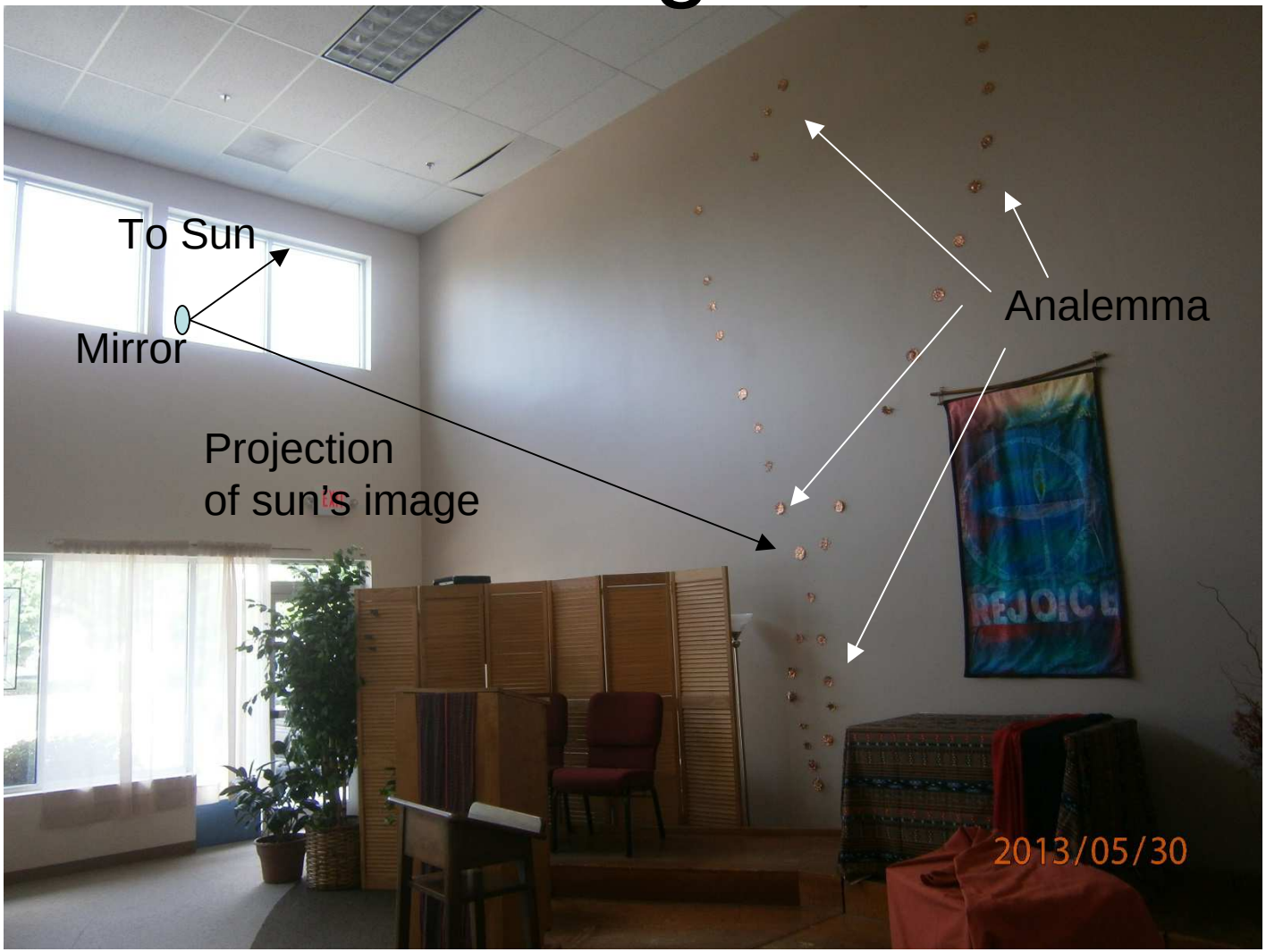


FIGURE 3.1 The progress of precision in time measurement. This plot shows the increase in the accuracy of mechanical clocks from the time of their invention up to the present. SOURCE: An updated redrawing of a graph in H. A. Lloyd, "Time-Keepers—An Historical Sketch," in *The Voices of Time*, J. T. Fraser, ed. (Amherst, Mass.: University of Massachusetts Press, 1981), fig. 3, p. 400. Copyright © 1981 by J. T. Fraser.

Agriculture

http://www.bing.com/images/search?q=Seasons+and+Agriculture+Medival+Images&id=DBC944371971AA8C765A9565EBCC6E171E6F0EA5&FORM=IQFRBA

Religion


To Sun
Mirror
Projection
of sun's image
Analemma
REJOICE
2013/05/30

Industry

Early 20th Century
Time Clock

- Time
  - For Employee
  - For Production and Delivery
  - Communication
  - Planning

http://en.wikipedia.org/wiki/Time_clock

Science and Navigation

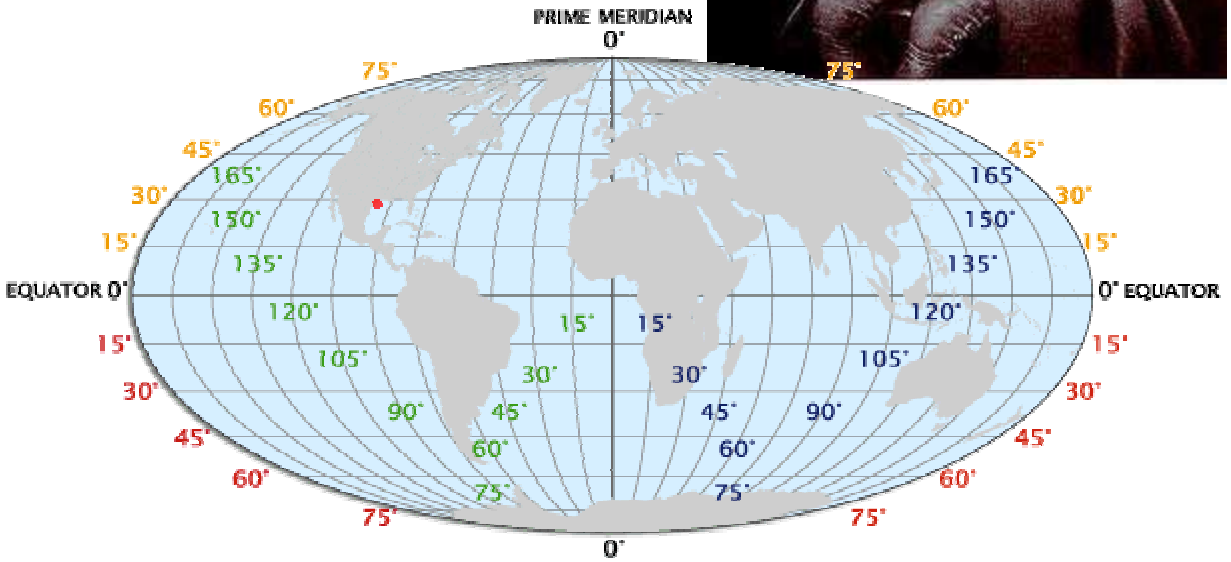
- Weather

Navigation

P.L. Tassaert's half-tone print of Thomas King's original 1767 portrait of John Harrison, located at the Science and Society Picture Library, London

Born	24 March 1693
Foulby, near Wakefield, West Yorkshire	
Died (aged 83)	24 March 1776
London	
Residence	Red Lion Square
Nationality	United Kingdom
Fields	Horology
Known for	Marine chronometer
Notable awards	Copley Medal

1. How do we know where we are?
2. The problem of longitude



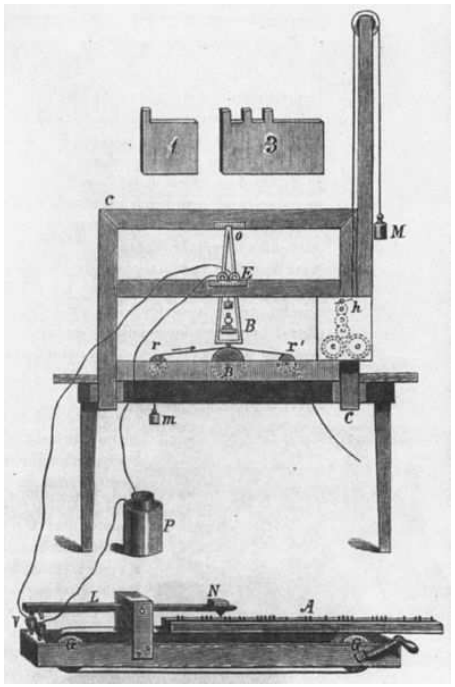
Images from wikipedia

Local Time to Simultaneous Time

Travel

(Photo by Jeff Kretsch)

Communication

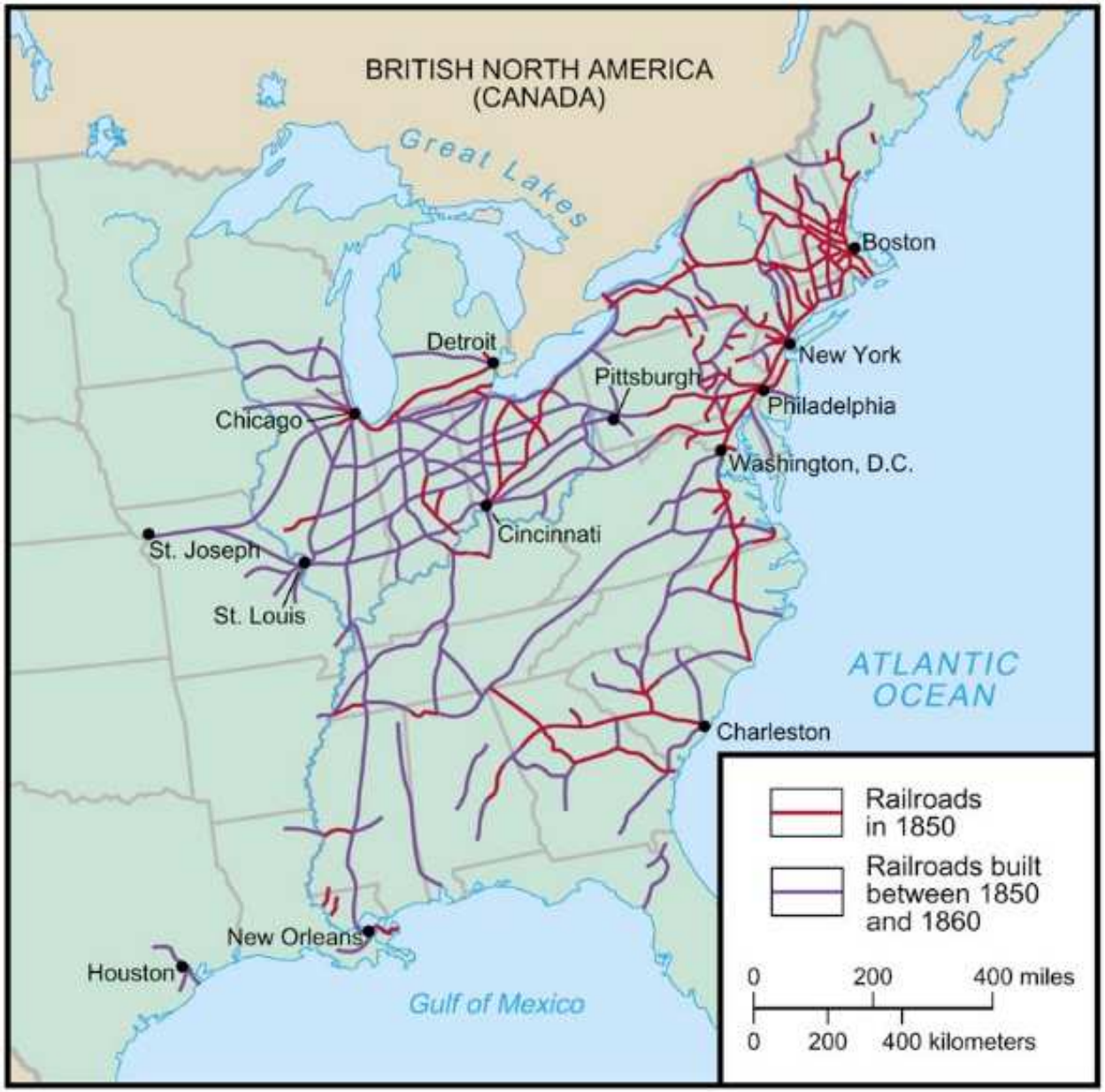


Samuel Morse

http://en.wikipedia.org/wiki/Samual_Morse

Story of Standard Time

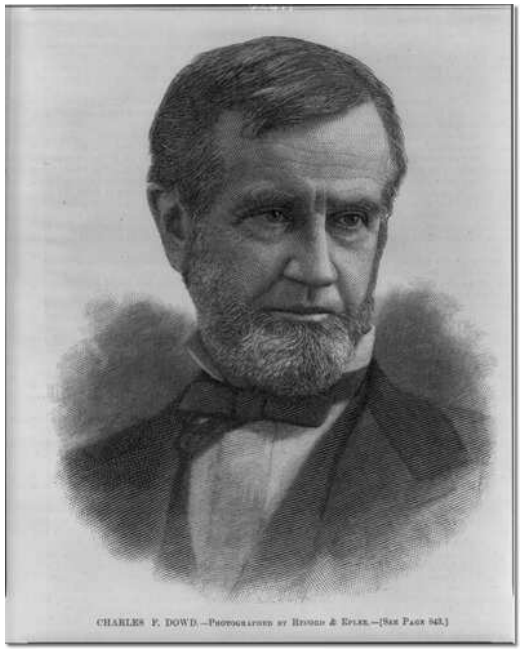
- The Need
- Initial Proposals
- Railroad Standard Time
- International Conference of 1884 in Washington DC
- Standard Time Act of 1918 (Calder Act)



RAILROADS, 1850 AND 1860

http://jb-hdnp.org/Sarver/Maps/railroads_1850-1860.jpg

Image from wikipedia



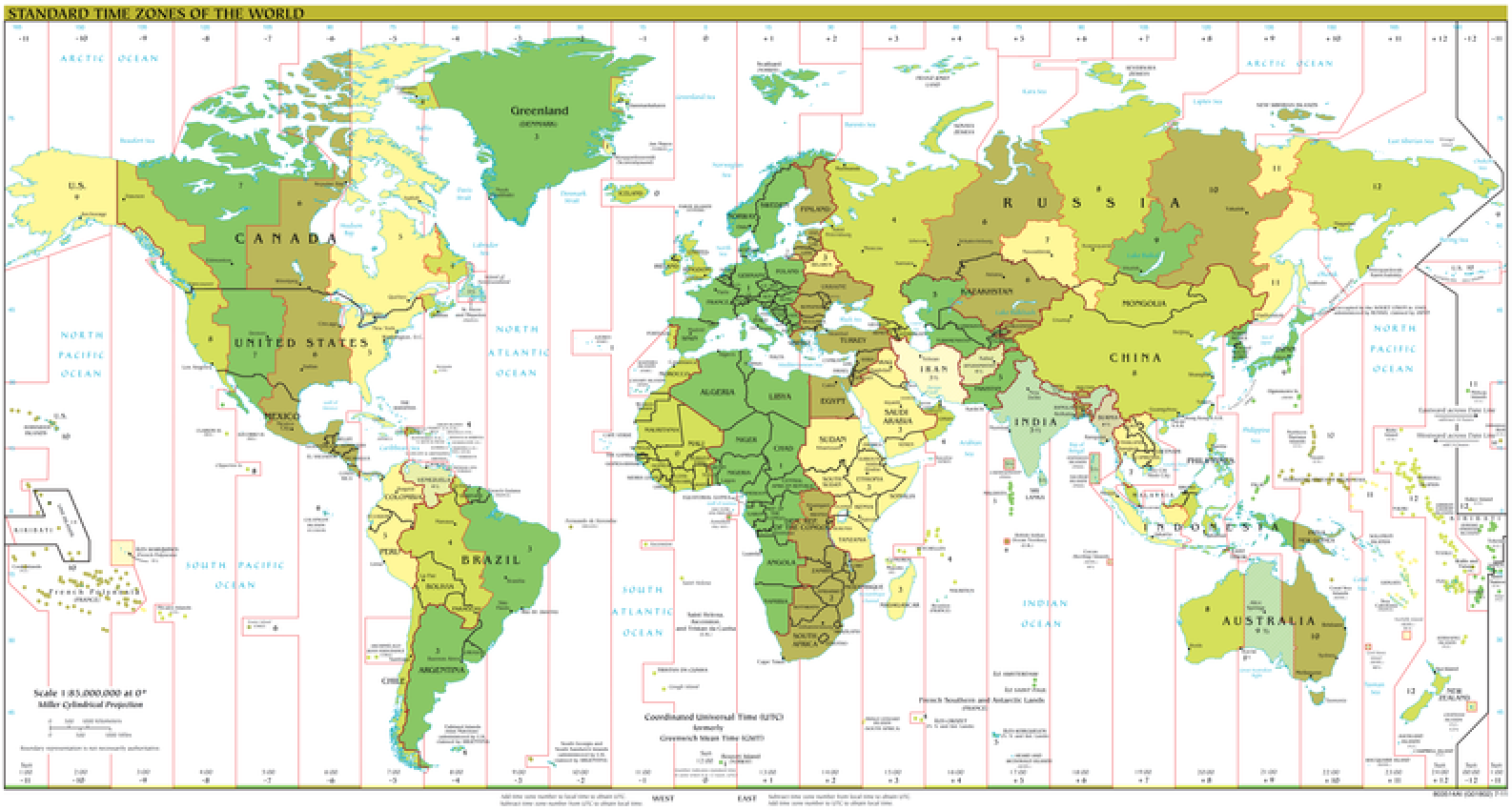
Sandford Fleming
Engineer
Sir Sandford Fleming, KCMG was a Scottish-born Canadian engineer and inventor.
He proposed worldwide standard time zones, designed Canada's first postage stamp, left a huge body of surveying and map ... Wikipedia
Born: January 7, 1827, Kirkcaldy, United Kingdom
Died: July 22, 1915, Halifax, Canada

Charles Ferdinand Dowd

In 1869 **Charles F. Dowd**, principal of a school in Saratoga Springs, N.Y., proposed the use of time zones, within which all localities would keep the same time. Others, including Sir Sandford Fleming, a Canadian civil engineer, strongly advocated this idea. Time zones were adopted by U.S. and Canada..

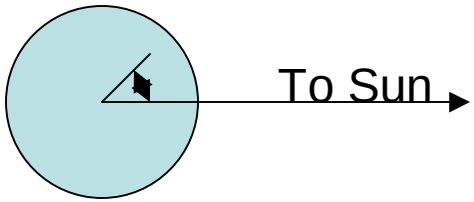
http://www.watch-test.com/wp-content/uploads/2012/10/4.-GP_Colección-WWTC.jpg

Standard Time Zones



http://en.wikipedia.org/wiki/Standard_time

How to loose a day and win a bet…



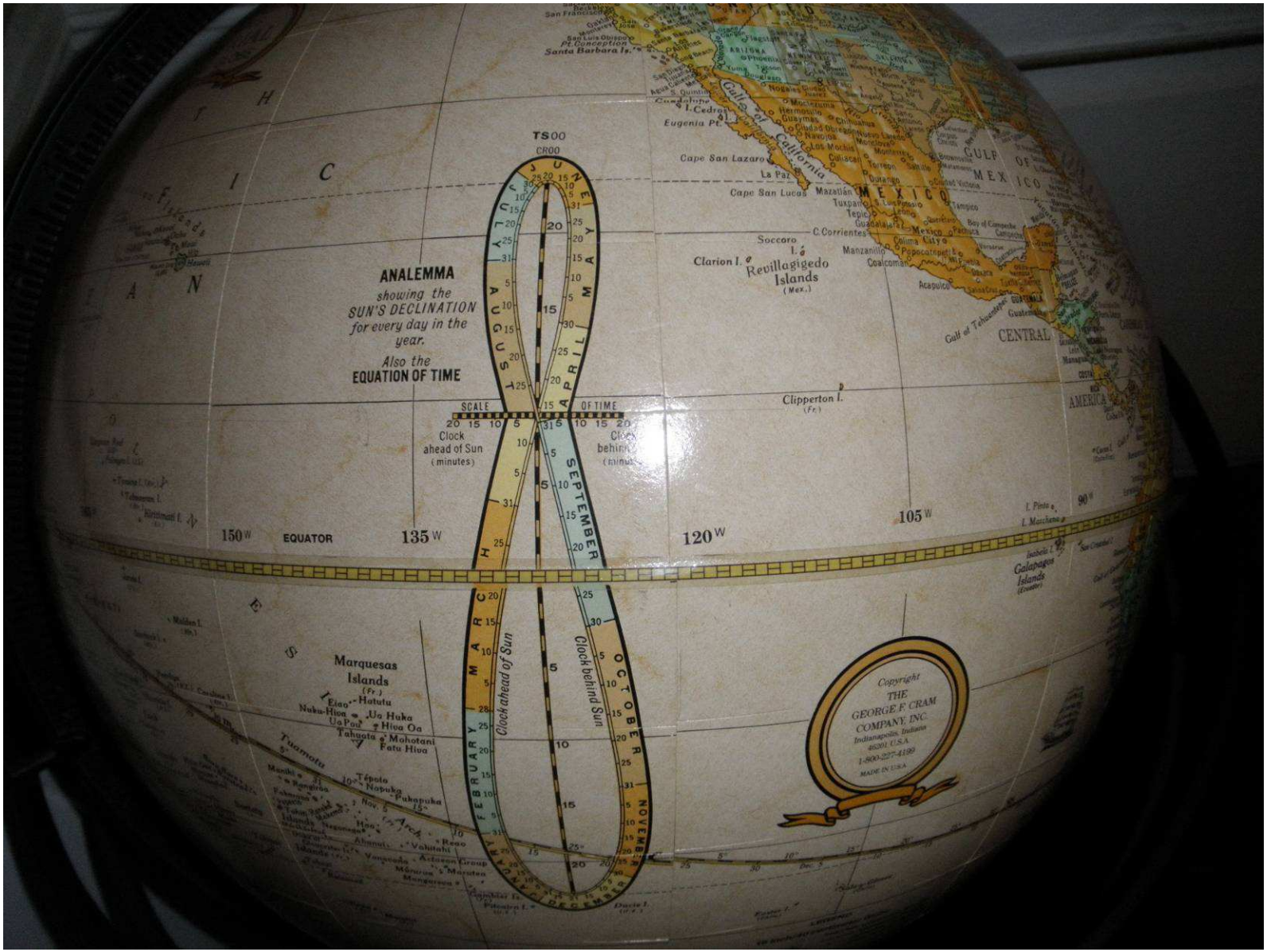
Earth rotates, imagine movement instead of being at a stationary point.

Case I: Plane exactly matches rotation rate: sun stationary in the sky
Case II: Plane exceeds rotation rate: sun goes backward
Case III: Plane goes against rotation rate: sun speeds up, short day

Around the World in 80 Days – Jules Verne

Phineas Fogg looses a day on his trip around the world counting by the sun,
His local time, wins the bet he thought he lost when he realizes it.

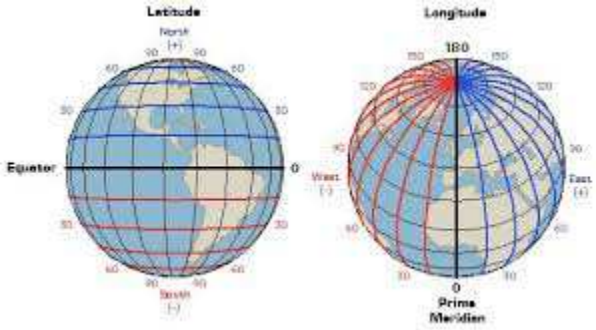
Modern Analemma



From Sundial Time to Standard Time

Procedure

1. Read time off of the sundial
2. Longitude Correction (constant for location)
3. Equation of Time
4. Daylight savings time correction



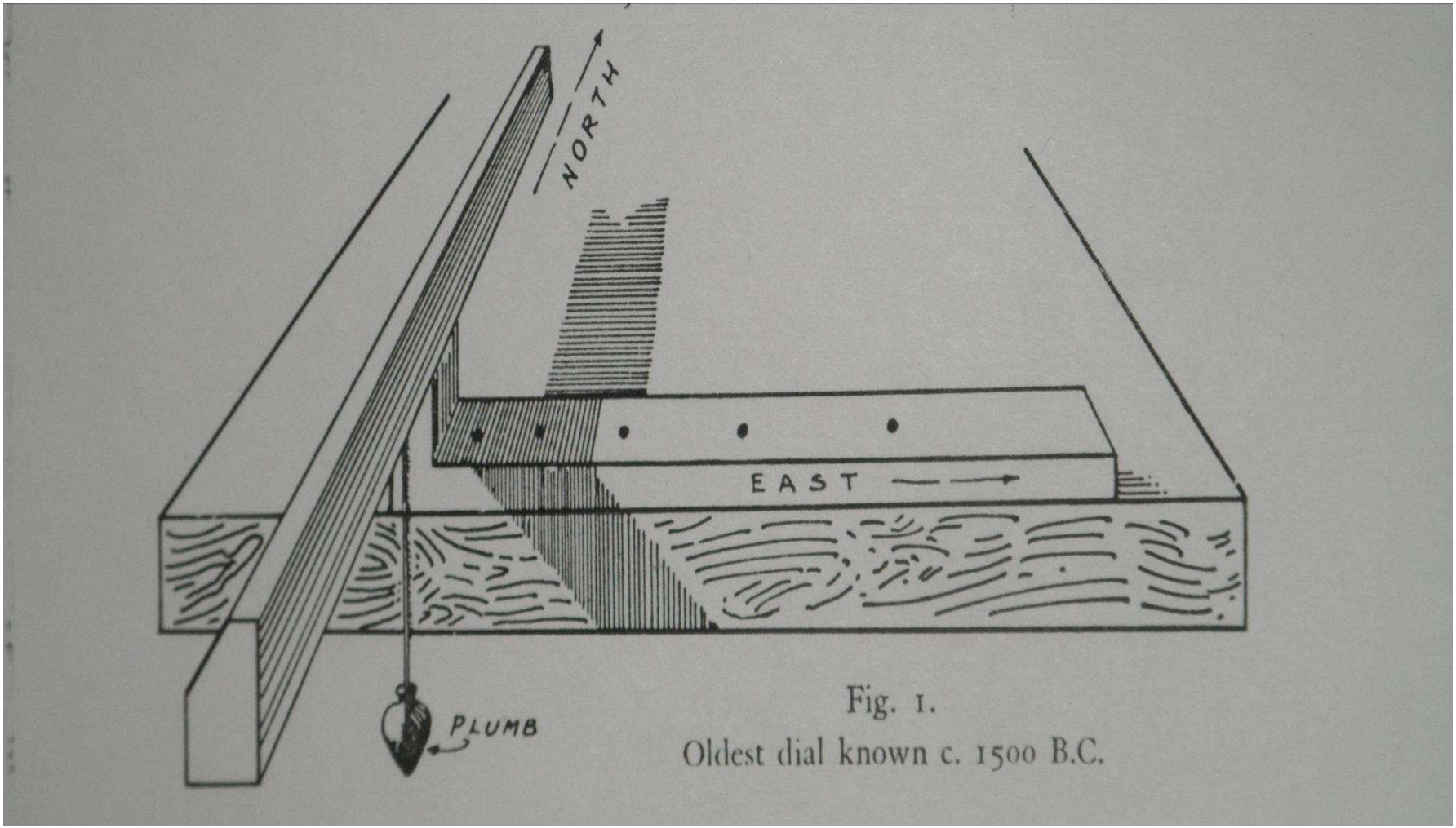


Fig. 1.
Oldest dial known c. 1500 B.C.

From “Sundials” by Mayall and Mayall, 1938

References

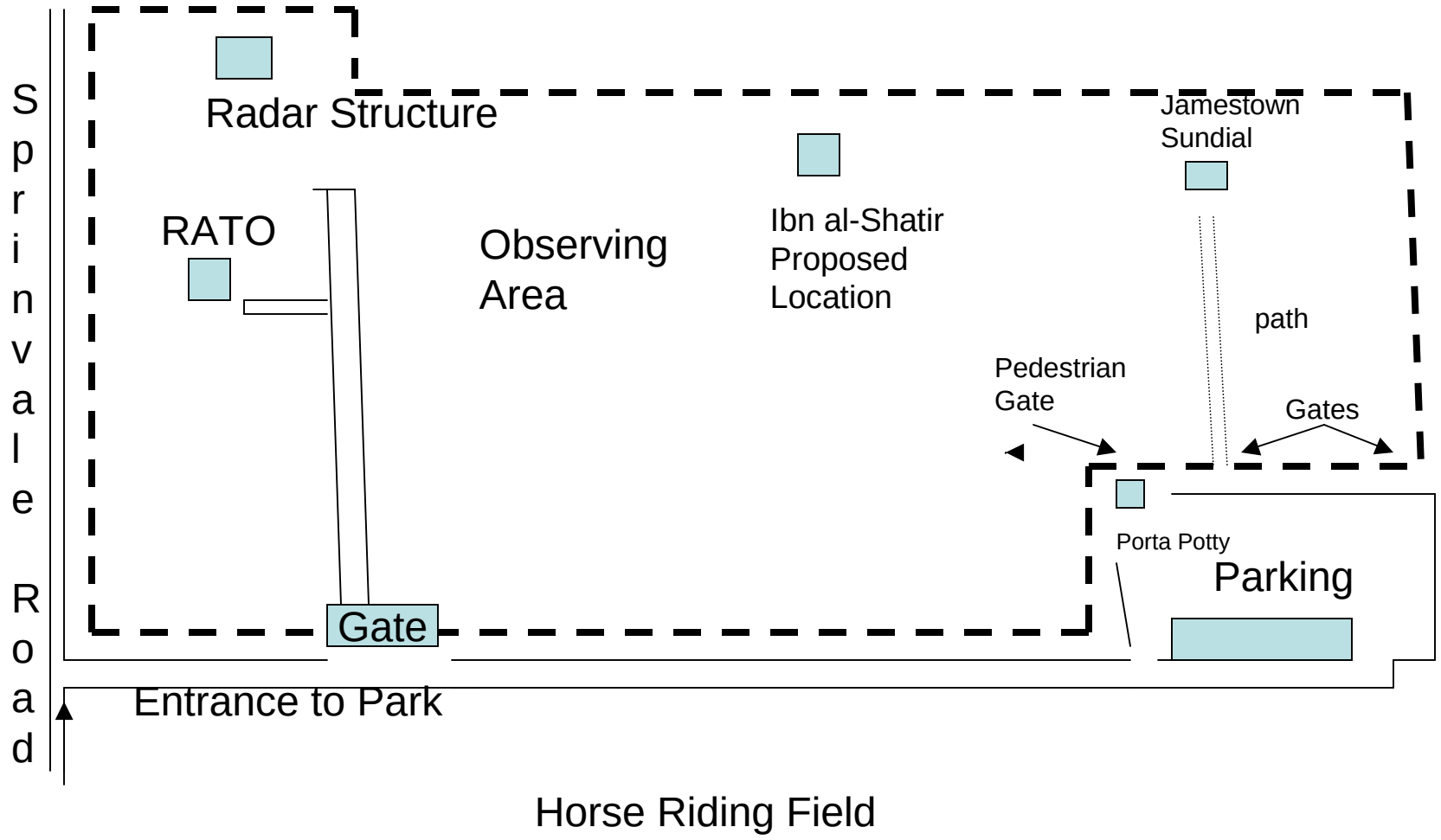
- http://io9.com/astronomical-clocks-were-a-wonder-of-the-medieval-world-1484069867
- Aveni, Anthony, “Empires of Time – Calendars, Clocks, and Cultures”, 1989
- Judge, Michael, “Dance of Time – The Origins of the Calendar”, 2004
- Richards, E.G., “Mapping Time – The Calendar and its History”, 1998
- Huth, John Edward, “The Lost Art of Finding Our Way”, 2013
- https://en.wikipedia.org/wiki/Time_zone

References II

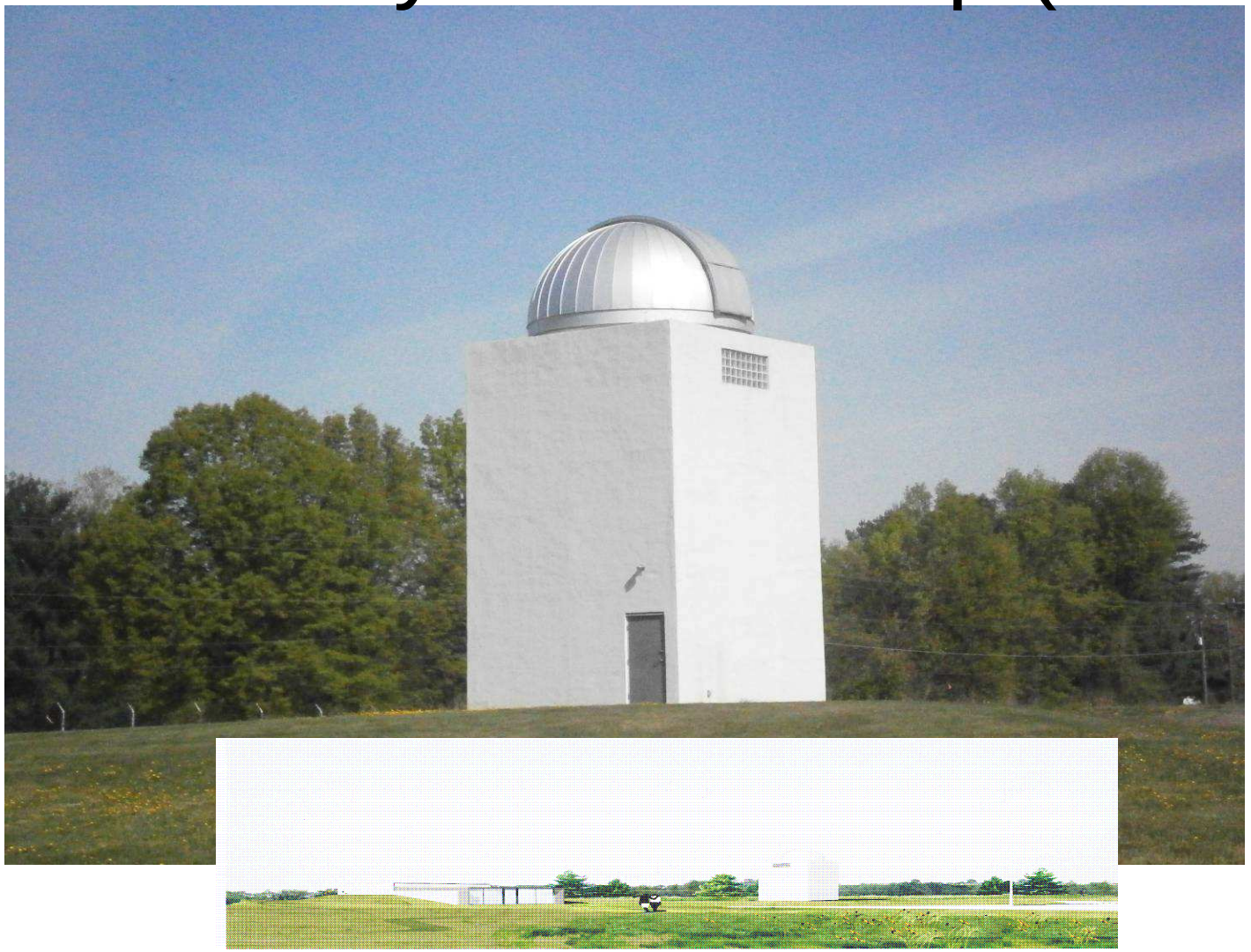
- http://adsabs.harvard.edu/full/1942PA.....50..204M (Charles F Dowd reference)
- http://people.hofstra.edu/geotrans/eng/ch2en/conc2en/american_rail_network_1861.html
- Sobel, Dava, “Longitude – The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of his Time”, 1998
- Mayall and Mayall, “Sundials”, 1938

Observatory Site Pre-1994

Observatory Park Layout 2014



Remote Access Telescopic Observatory and Roll Top (Inset)



School Night at Observatory Park January 31, 2014

OBSERVING MENU

The following are definitions of the objects we may view tonight. Below each definition is the name or catalogue number of each.

Moon – New Moon, not visible

<u>Planet:</u> Large body that orbits the sun.

Jupiter – Largest planet in our solar system, see its cloud belts and Galilean Moons

<u>Open Cluster:</u> Loosely bound group of 10's to 100's of stars.

- Pleiades
- Double cluster in Perseus

<u>Globular Cluster:</u> Tightly bound group of 100's of thousands of stars.

- M79 in Lepus

<u>Nebula:</u> Large cloud of dust and gas where stars form.

- Orion Nebula, M42

<u>Planetary Nebula:</u> Ejected gas clouds from a dying star.

- Crab Nebula M1
- Eskimo Nebula; NGC 2392

<u>Double stars:</u> Two stars that appear near each other.

- Gamma Andromeda
- Castor (Alpha Gemini)

<u>Galaxy</u>: A group of ~100 billion or more stars.

- Andromeda Galaxy; M31
- M81 & M82 in Ursa Major

1. ***Osher Lifelong Learning Institute***
2. **Special thanks to the Northern Virginia Astronomy Club (www.novac.com)**