Eugene Astronomical Society Presentation - February 15, 2012

Sun Position Fun

Observing and understanding the sun's position and movement, indoors and outdoors, day and night

John Hartman

softwareunderstanding.com/sun

A Brief History of Telling Time
and Sun Consciousness

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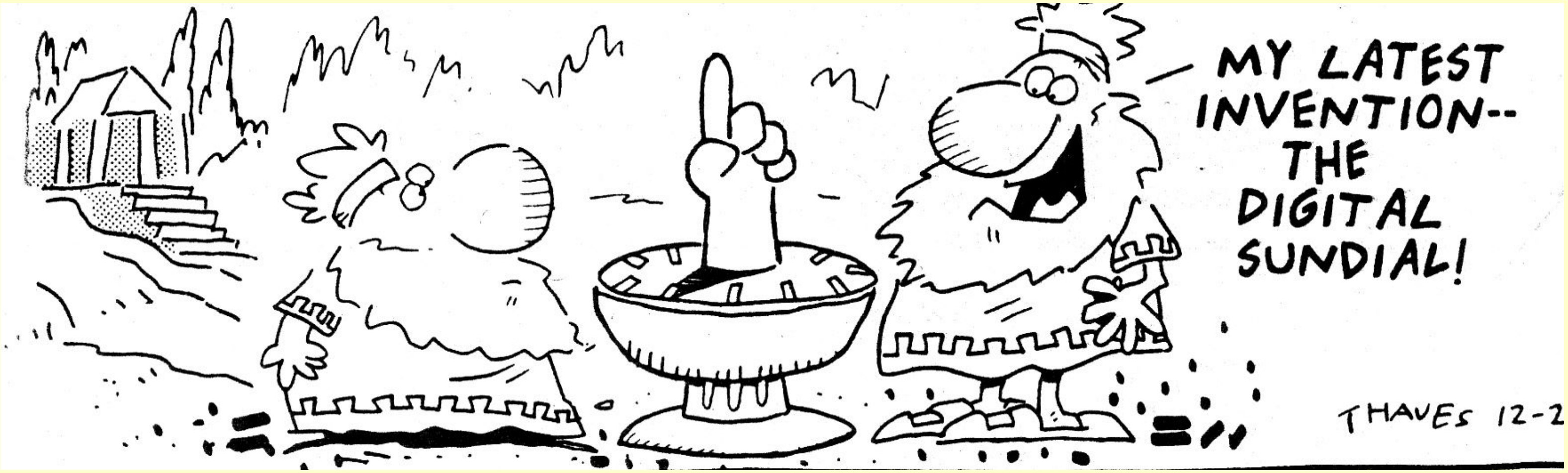
and Sun Consciousness

Time = Sun

A Brief History of Telling Time
and Sun Consciousness

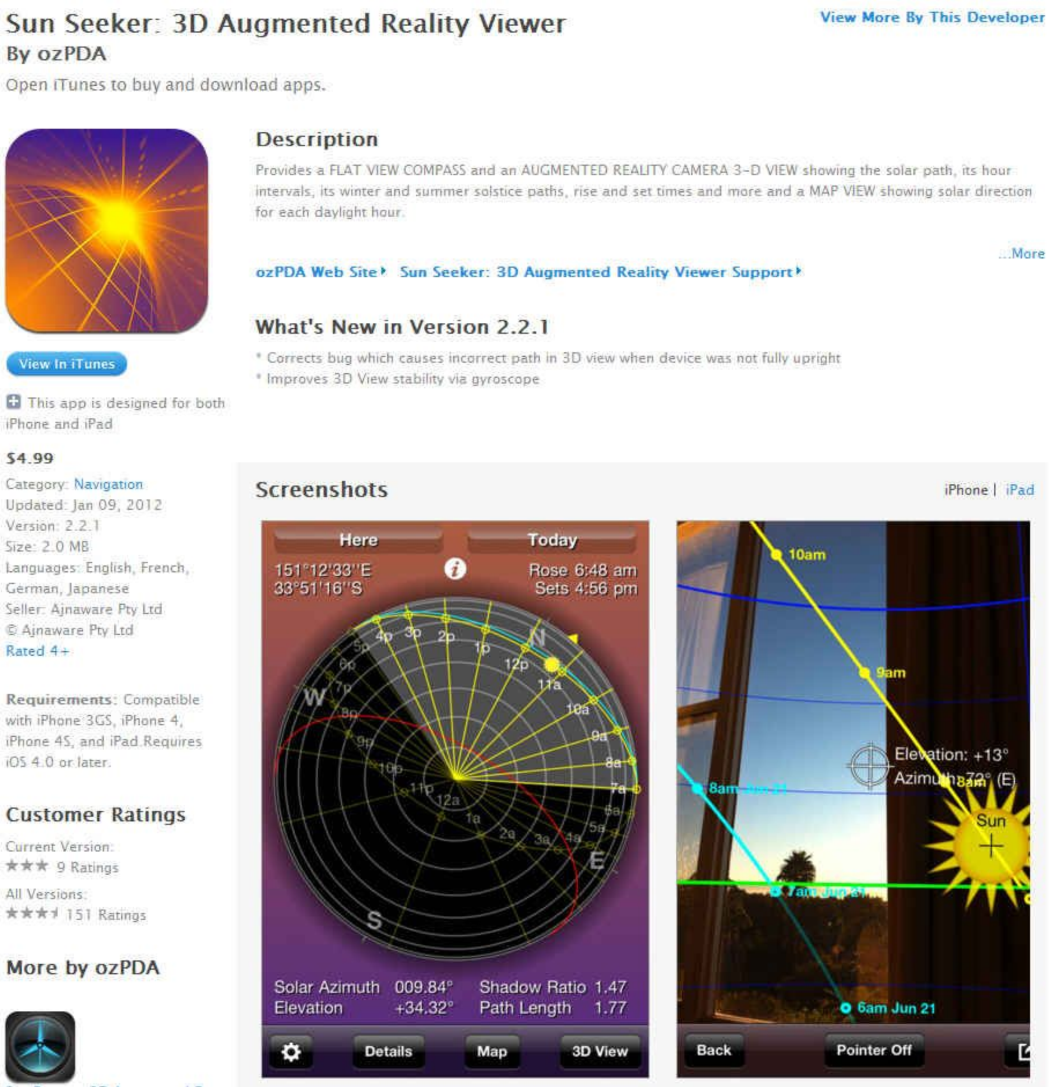


A Brief History of Telling Time
and Sun Consciousness

Time ≠ Sun

A Brief History of Telling Time
and Sun Consciousness

App: Augmented reality camera showing sun's path



Sun Seeker: 3D Augmented Reality Viewer
By ozPDA
Open iTunes to buy and download apps.

View More By This Developer

View In iTunes

This app is designed for both iPhone and iPad

$4.99
Category: Navigation
Updated: Jan 09, 2012
Version: 2.2.1
Size: 2.0 MB
Languages: English, French, German, Japanese
Seller: Ajnaware Pty Ltd
© Ajnaware Pty Ltd
Rated 4+

Requirements: Compatible with iPhone 3GS, iPhone 4, iPhone 4S, and iPad. Requires iOS 4.0 or later.

Customer Ratings
Current Version:
★★★ 9 Ratings
All Versions:
★★★½ 151 Ratings

More by ozPDA

Description
Provides a FLAT VIEW COMPASS and an AUGMENTED REALITY CAMERA 3-D VIEW showing the solar path, its hour intervals, its winter and summer solstice paths, rise and set times and more and a MAP VIEW showing solar direction for each daylight hour.

...More

ozPDA Web Site ▸ Sun Seeker: 3D Augmented Reality Viewer Support ▸

What's New in Version 2.2.1
* Corrects bug which causes incorrect path in 3D view when device was not fully upright
* Improves 3D View stability via gyroscope

Screenshots
iPhone | iPad

Sun Consciousness

Observe and Understand

Minnaert, <u>The Nature of Light and Colour in the Open Air</u>

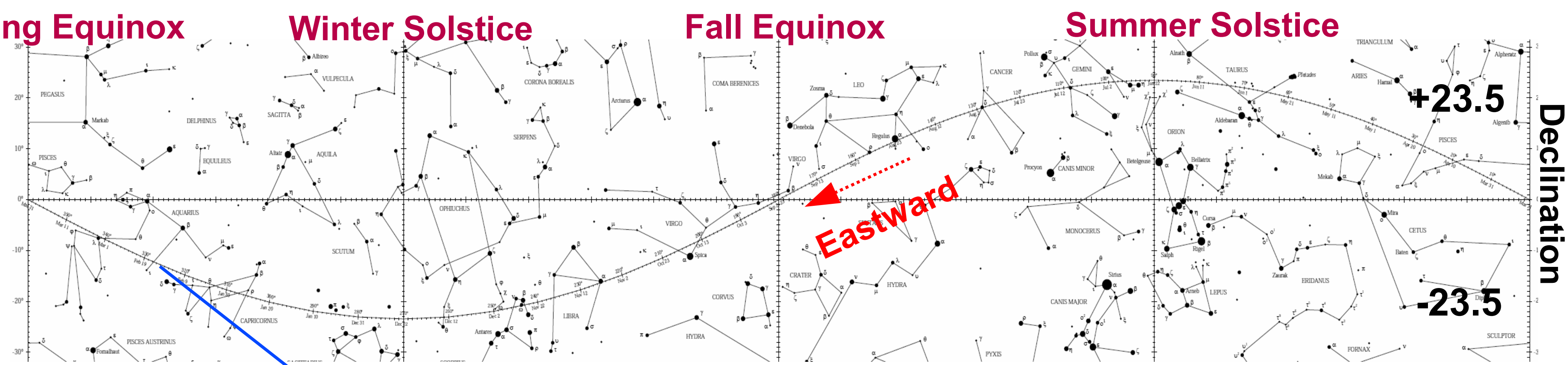
Position and Movement - day, seasons, year

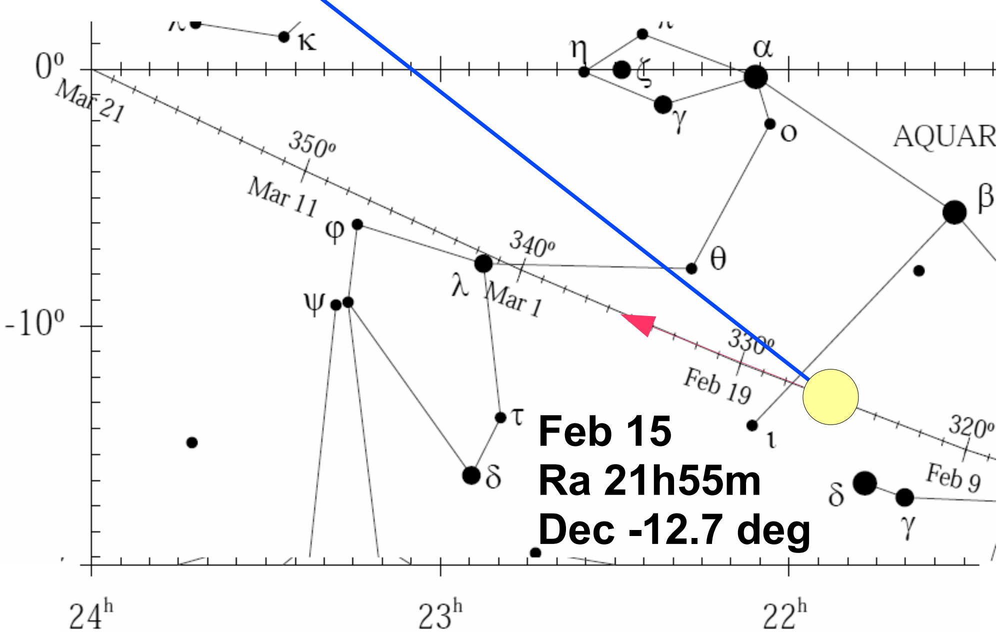
Topics

1. Background
2. Observing Methods and Examples
3. Solar Time
4. Daily Movement
5. Altitude/Azimuth and Astrolabe
6. Finding Direction and Location
7. The Analemma
8. Sundials
9. Sun At Night
10. Public Sun Instruments and Art

Background

Celestial Sphere Cut by Ecliptic, Unwrapped





Dec change

.3 deg/day

RA change

3m 53s/day (vs. 3m 56s mean)

orbital speed + orbital tilt

→ Our Sky

Observing Methods

- Estimate
- Sight
- Project
- Reflect
- Photograph
- Instruments
  - Telescope mount setting circles

X

Body measures, fraction of zenith

Azimuth

Landscape, gunsights, slots, tubes

Shadows, gnomon, spheres

Mirrors

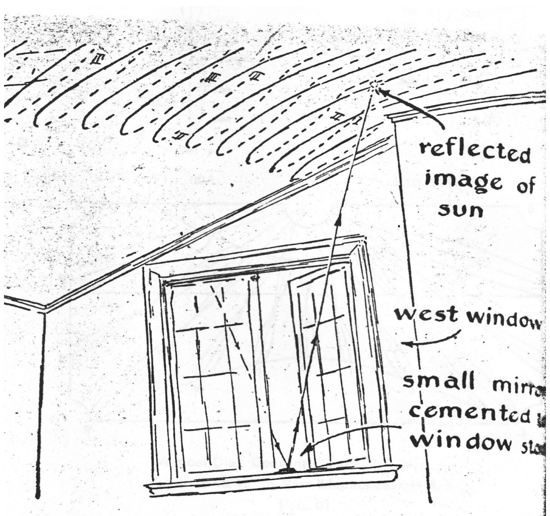
Lenses

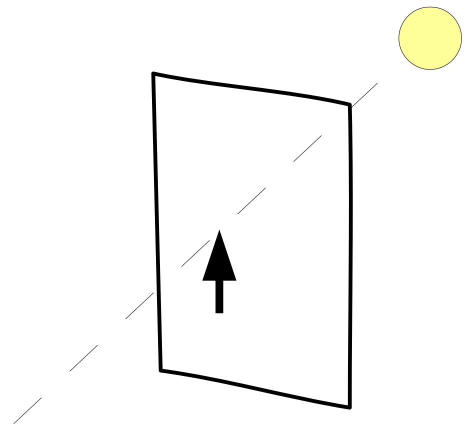
Fiber Optics

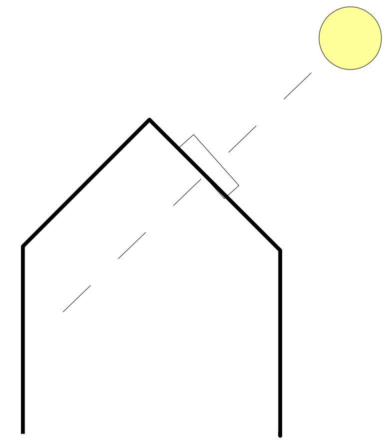
Film, CCD, motion

Measurements

Indoor Observing







Mirror, Shadow, Lens, Pinhole...

Estimate Time To Sunset

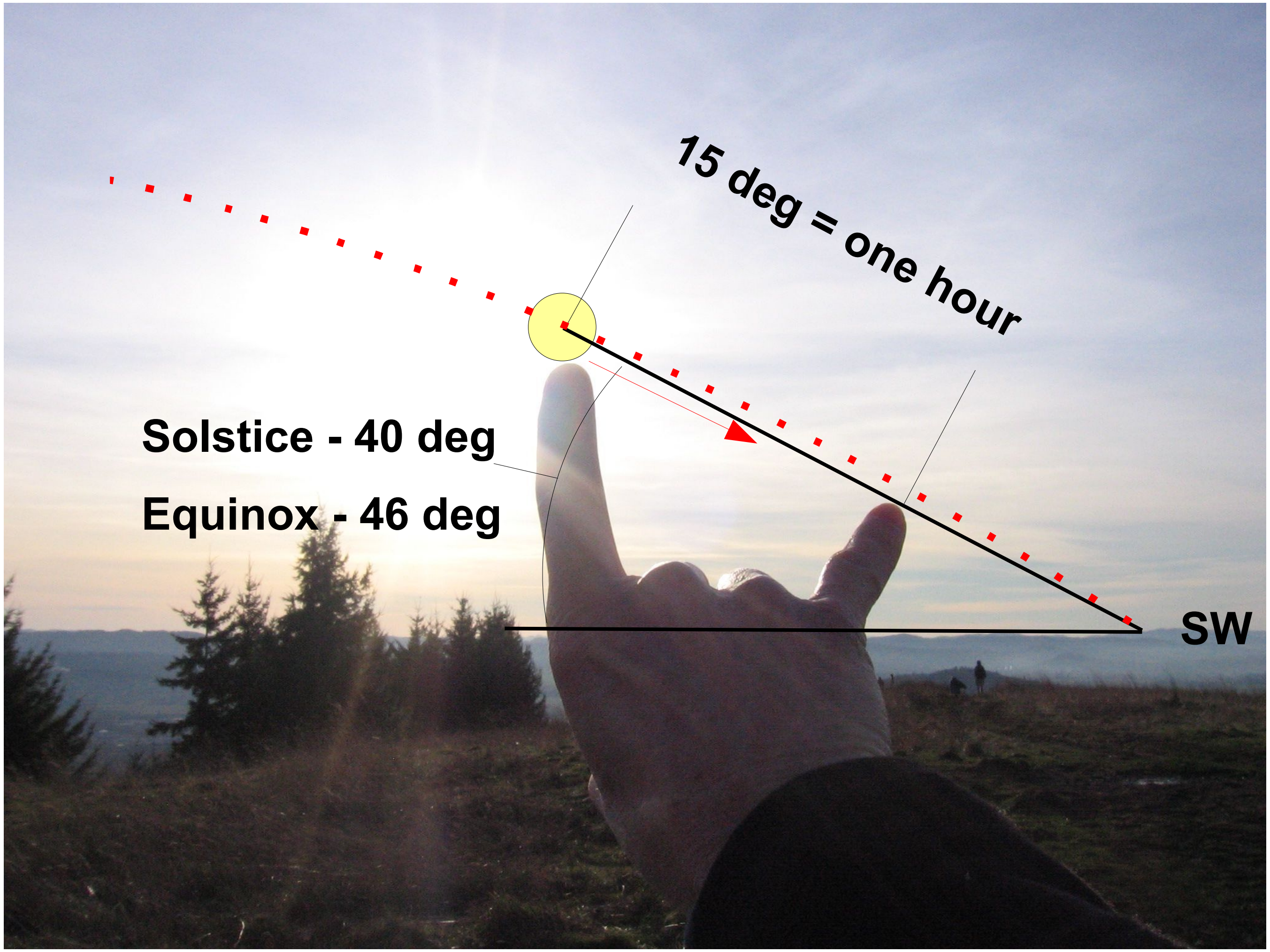
Noon Altitude

70 deg Summer Solstice

46 deg Equinoxes

23 deg Winter Solstice

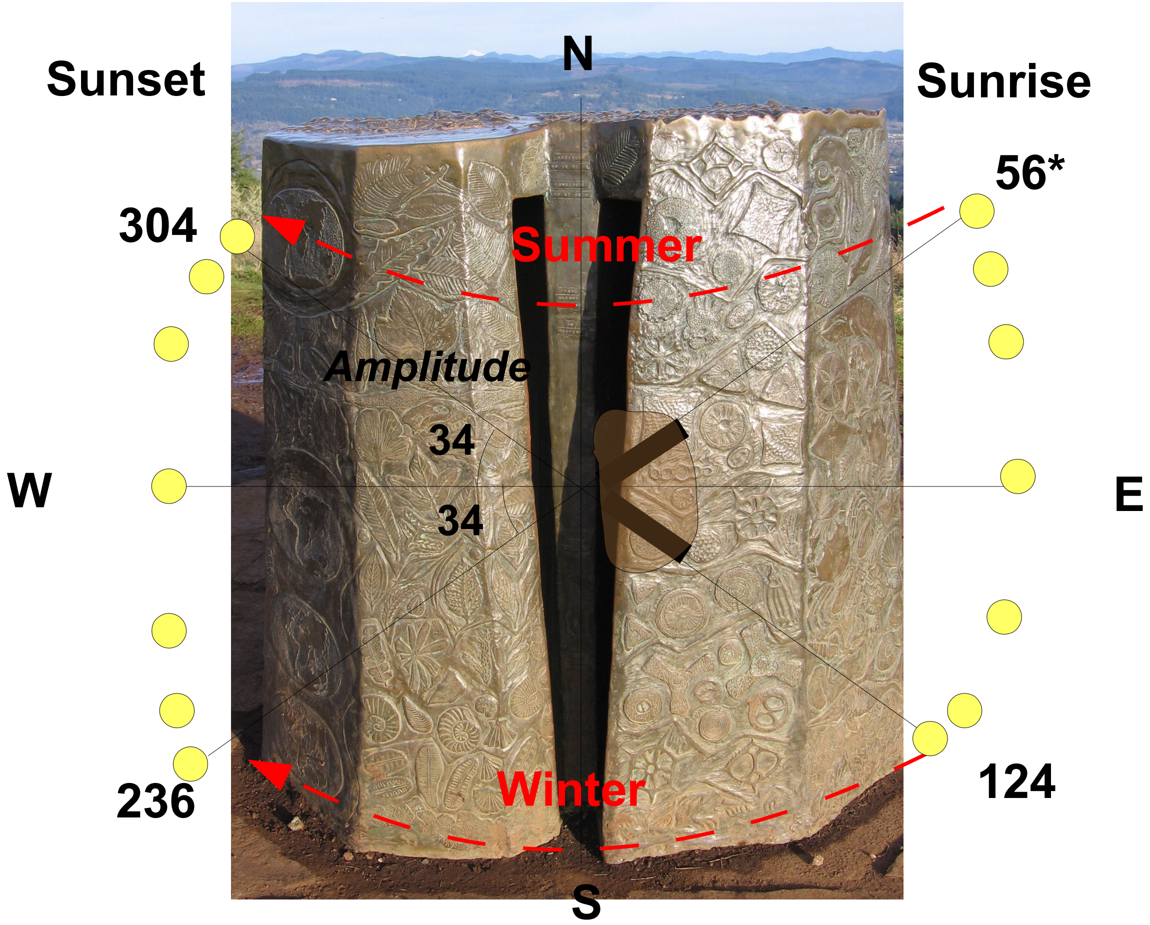
S



Sights

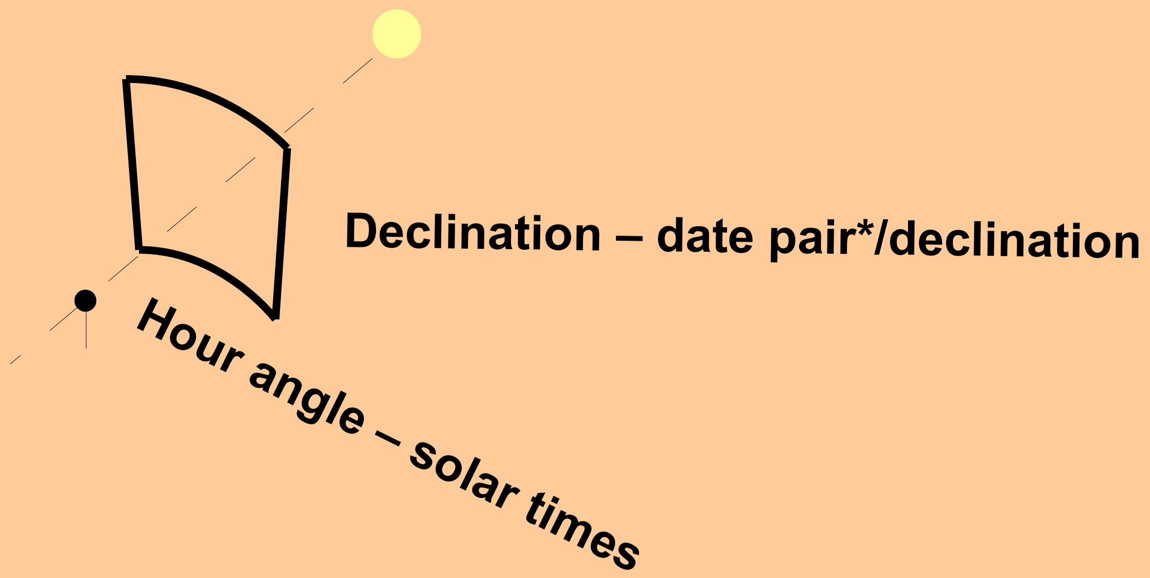
Mark a given position of the sun – time and day(s)

Example: Solstice sunrise and sunset - *Standstill*



Project 1: Sun Sight

Make a sight to mark days, times, seasons...



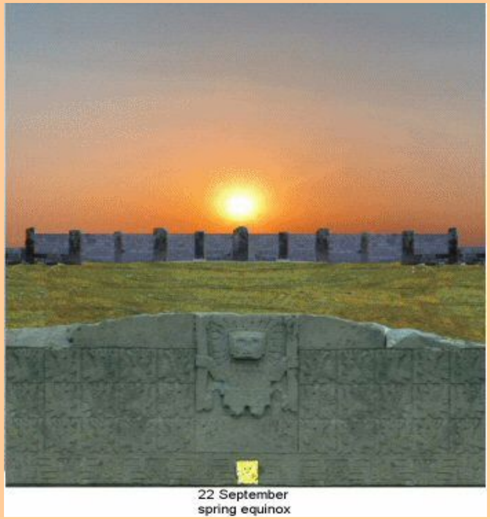
Date range – horizon rise/set or declination point/slot

Time range – hour angle point/slot

Gun sights, tubes, shadows, masks, lenses, mirrors, fiber optics...

Sun Sight Examples

Day Marks – horizon or declination



Event – time and day, ha x dec

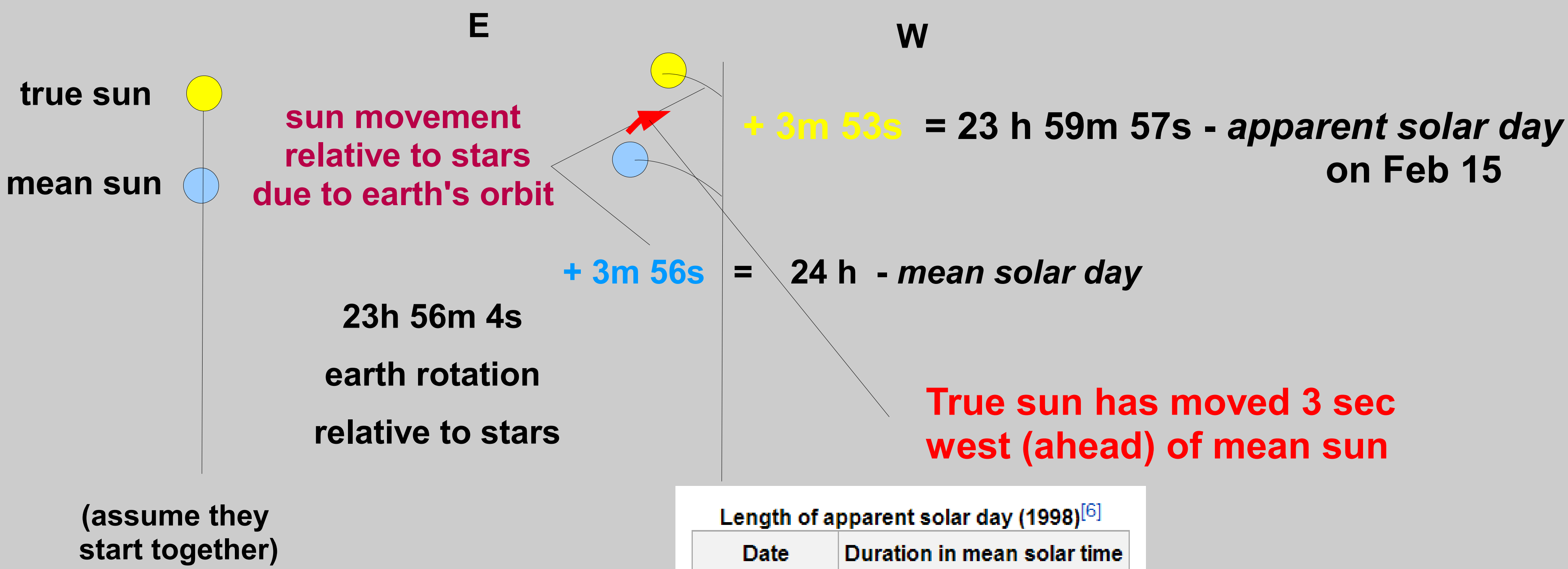
- **resolution**
- **2 x except solstices**

Archeoastronomy

Period– solar time/hour angle range

(x) Season pair – declination range

Solar Day



Feb 15: 24h - 3s

Length of apparent solar day (1998)[6]

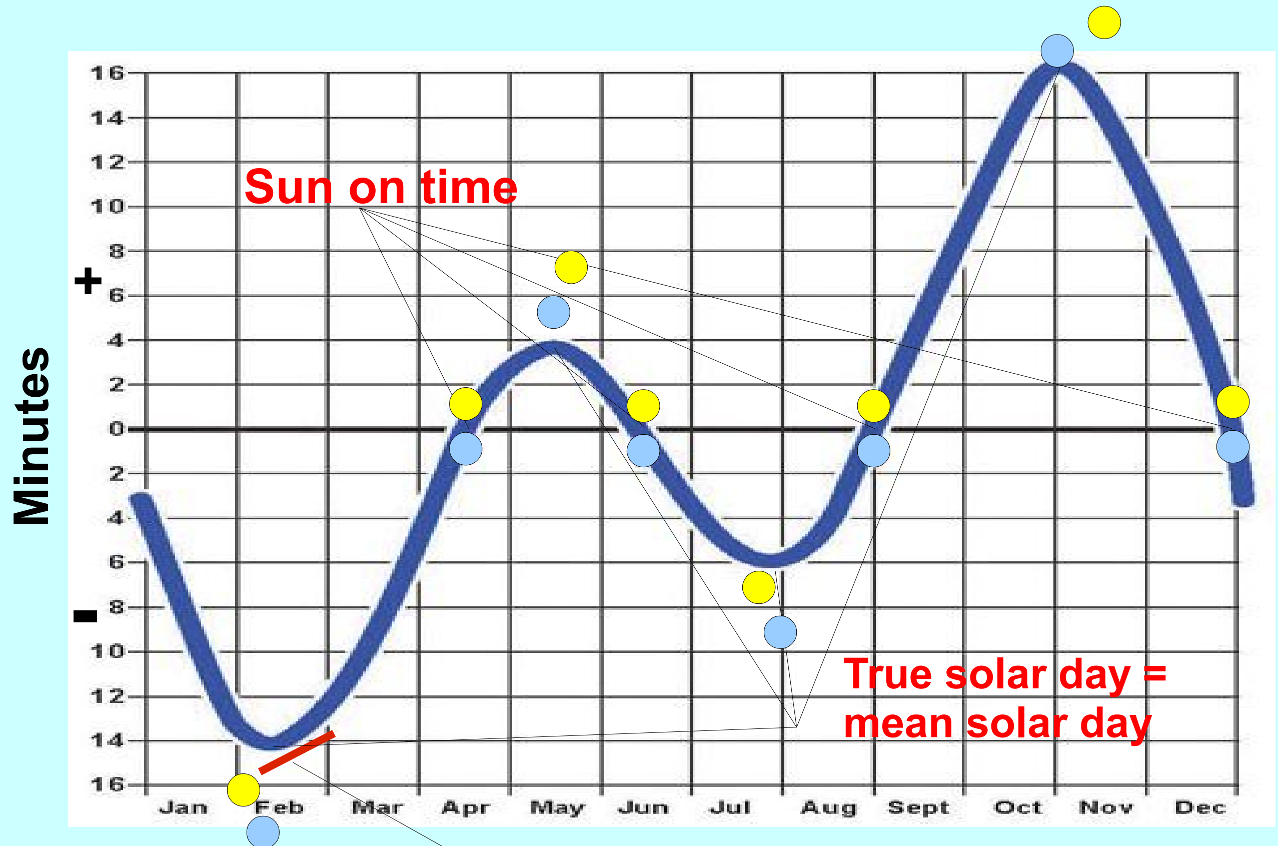
Date	Duration in mean solar time
February 11	24 hours
March 26	24 hours − 18.1 seconds
May 14	24 hours
June 19	24 hours + 13.1 seconds
July 26	24 hours
September 16	24 hours − 21.3 seconds
November 3	24 hours
December 22	24 hours + 29.9 seconds

Equation of Time

Difference Between True Sun and Mean Sun

True sun ahead

True sun behind



Accumulated difference between apparent and mean solar day

From orbital tilt, varying speed

Feb 15: -14:07*

Feb 14: -14:10*

True sun moved 3 sec W relative to mean sun (catching up)

→ **Our Sky**

Solar Time and Noon

Clock Time

12:00

(+ Daylight Savings Time)

Mean time at zone meridian 120 W

Set Watch

Solar Time and Noon

Clock Time

12:12

(+ Daylight Savings Time)

Mean time at zone meridian 120 W

Set Watch

Longitude Correction

(123-120) x 4 min/deg = 12 min

(Local) Mean Solar Time

12:00

Mean time at Eugene 123 W

Set Planisphere*

Solar Time and Noon

Clock Time	Longitude Correction	(Local) Mean Solar Time	Equation Of Time Correction	True Solar Time
12:26	(123-120) x 4 min/deg = 12 min	12:14	-14:07 on Feb 15	12:00
(+ Daylight Savings Time)				
Mean time at zone meridian 120 W		Mean time at Eugene 123 W		Solar Time at Eugene on Feb 15
Set Watch		Set Planisphere*		Sun, Sundials Sun on Planisphere Use

2. Noon Mark and Solar Time

- **Make a Noon Mark**

  Sight that marks *solar noon*

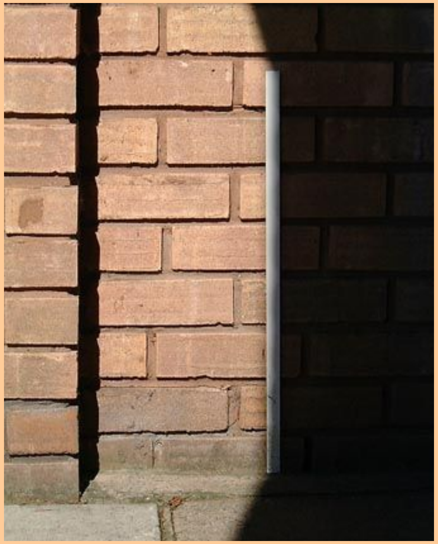
  – sun due S and highest, ha=0

- **Set a clock to solar time**

  How often do you have to adjust?

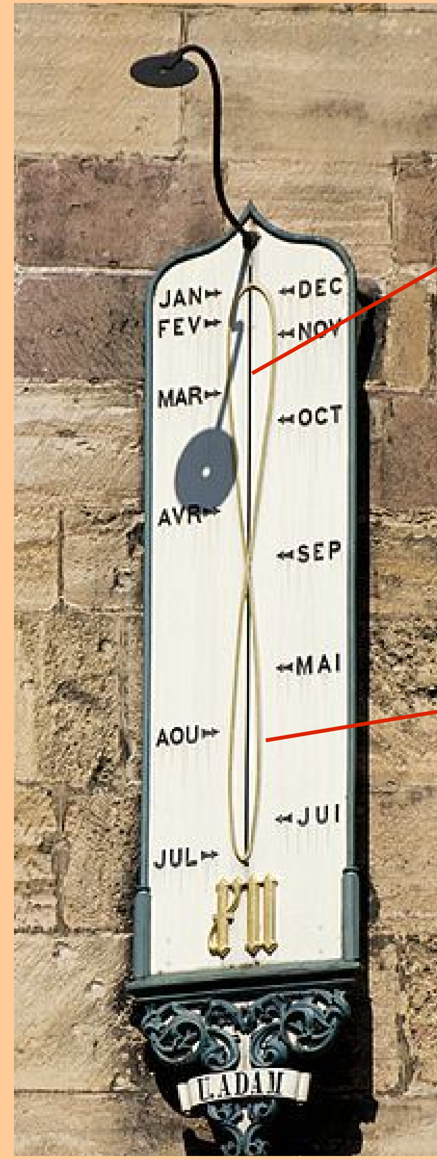
  And/or local mean time

Noon Mark Examples



Shadow
(vs. N/S slot)

Pinhole
+ days (dec)

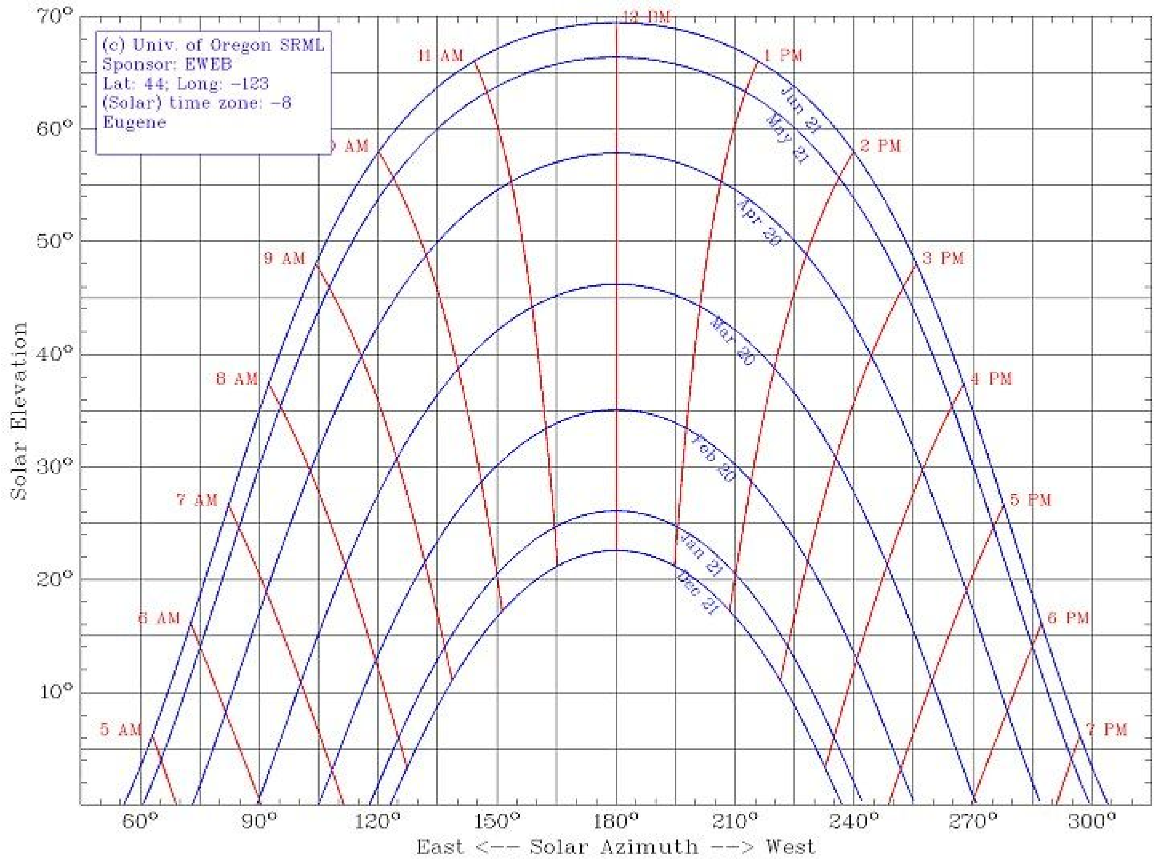


true solar noon

mean noon

What does analemma do?

Daily Movement



6/20	**6**	*10*	**16**	*11*	**27**	*11*	**37**	*11*	**48**	*10*	**58**	*8*	**66**	*3*	**69**	
3/20 Alt			**0**	*11*	**11**	*11*	**22**	*11*	**33**	*8*	**41**	*6*	**47**	*2*	**49**	
12/21							**3**	*8*	**11**	*6*	**17**	*4*	**21**	*2*	**23**	
6/20	**63**	*10*	**73**	*10*	**82**	*10*	**92**	*12*	**104**	*16*	**120**	*24*	**144**	*36*	**180**	
3/20 Az			**90**	*10*	**100**	*11*	**111**	*12*	**123**	*16*	**139**	*19*	**158**	*22*	**180**	**Use**
12/21							**127**	*11*	**139**	*13*	**151**	*14*	**165**	*15*	**180**	
Solar time	**5**		**6**		**7**		**8**		**9**		**10**		**11**		**12**	

Altitude/Azimuth and Astrolabe

Early Science

- **Celestial system - RA/ha , dec**
- **Horizon System - alt, az**

Conversion

Models like armillary sphere, projections, analog computers,

Spherical trigonometry, celestial navigation tables...

Astrolabe (Planispheric)

- **More complete and accurate model than planisphere**
- **Latitude specific plate**
- **Many calculations**
- **Historical variations**

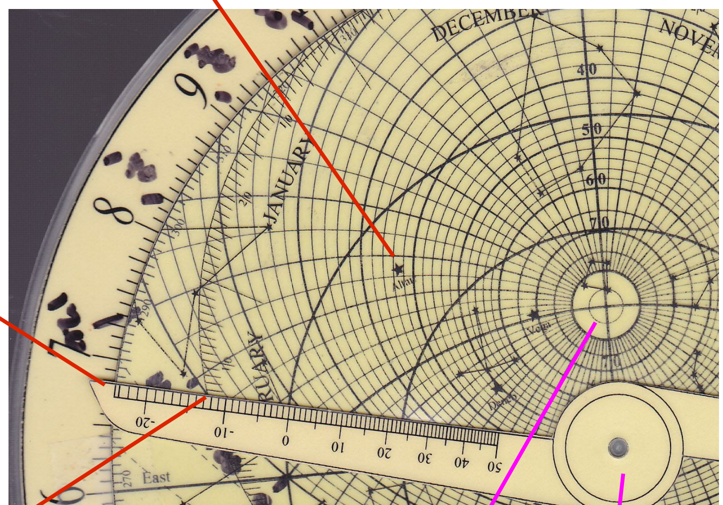
Modern Astrolabe

Altair

Az = 117

Alt = 37

Solar time
6:47
(+12 lng +14 eqtim
= 7:13 clock)



True sun rising 2/15*

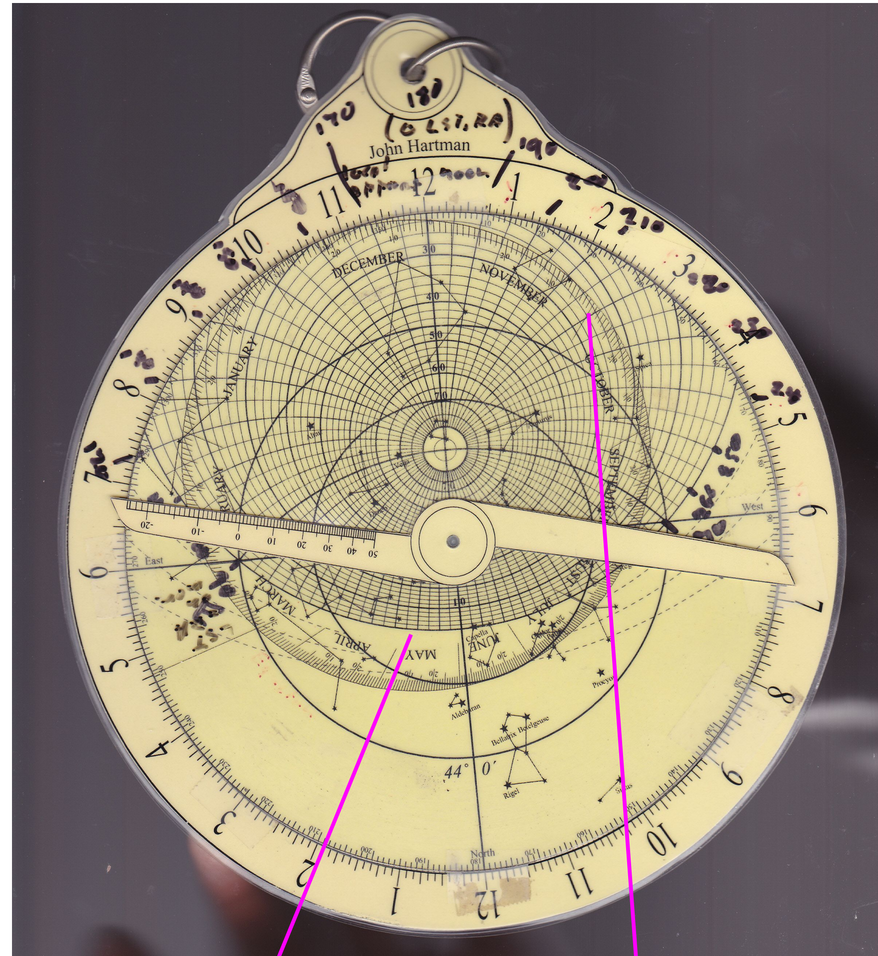
Az = 107

Alt = 0

(Dec = -13)

Zenith

Pole



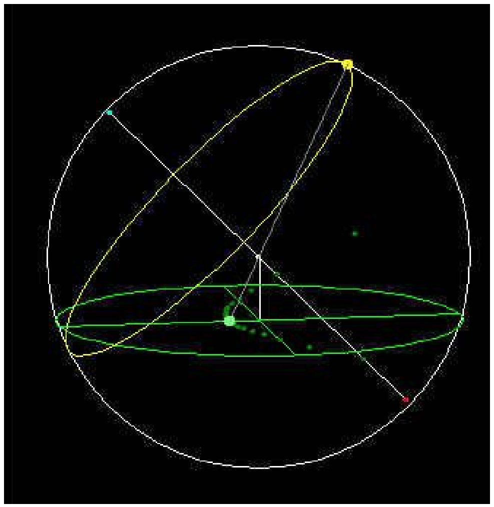
Horizon

Ecliptic

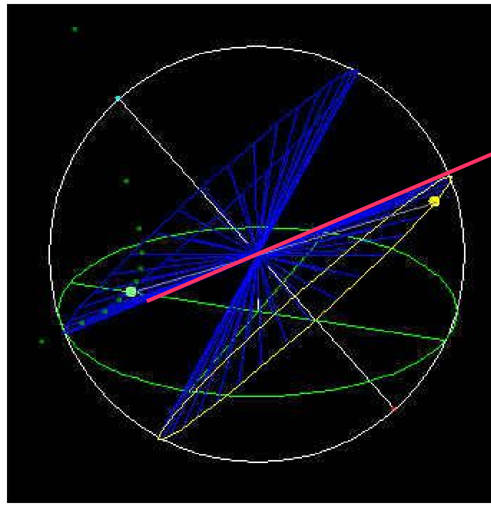
Look down on celestial sphere

James Morrison, astrolabes.org

Sun Traces Declination Lines

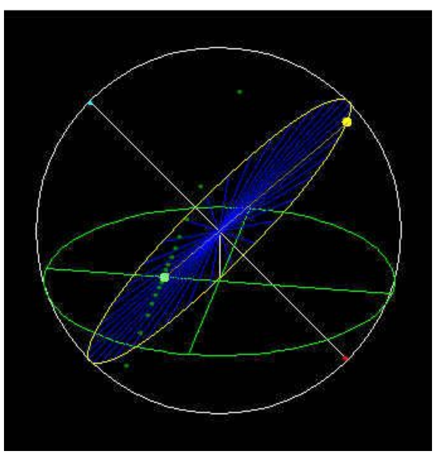


Summer



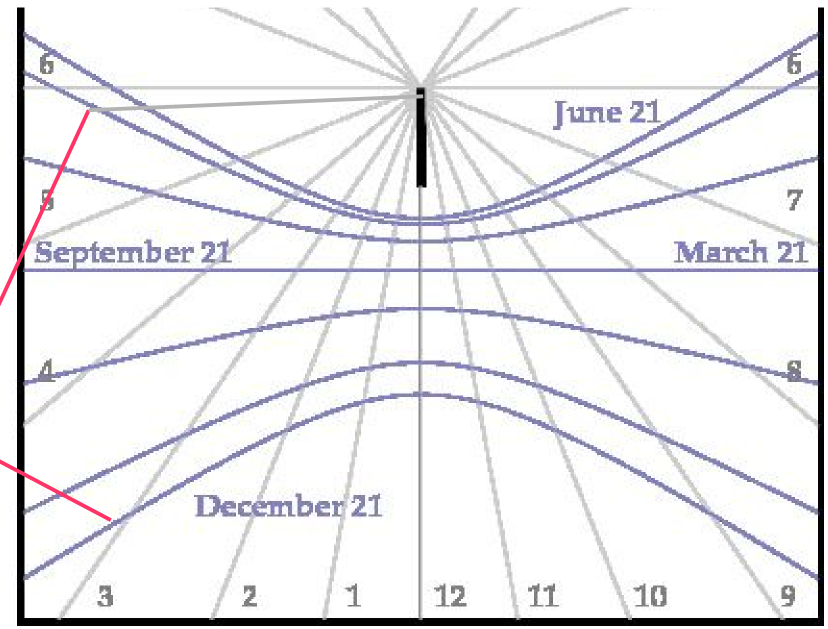
Winter

Cone cut by plane



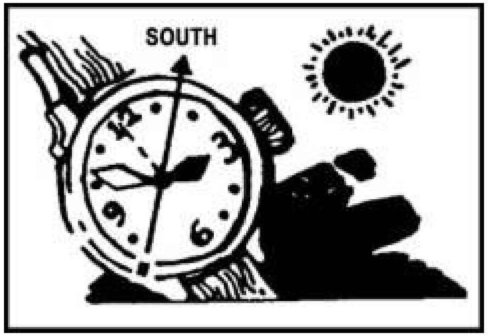
Equinoxes

Shadow of point traces hyperbola* for each day/declination



Primitive Direction Finding

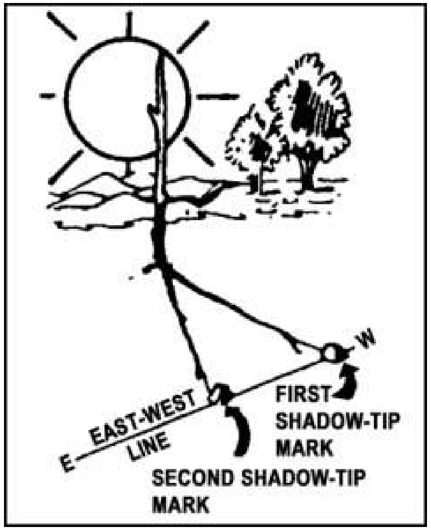
Watch Method



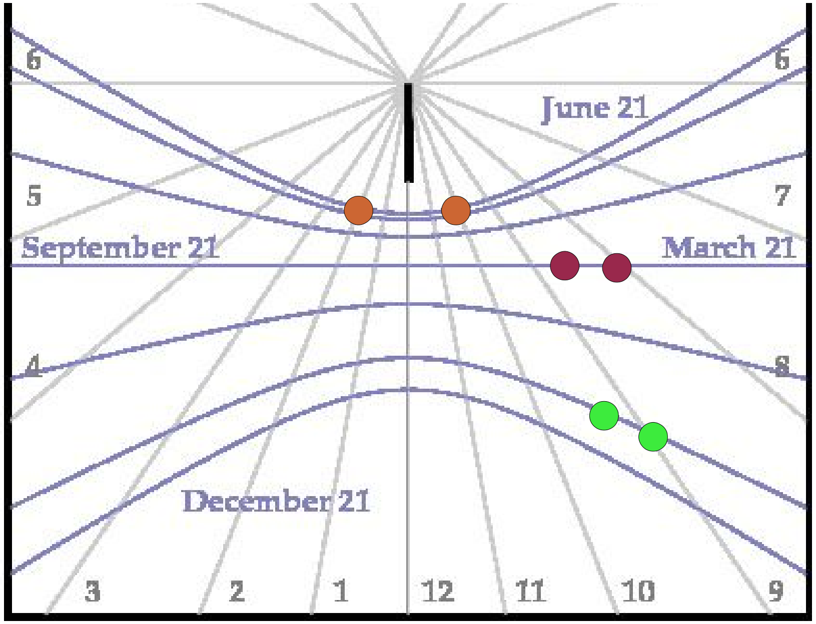
Assumes

- •watch gives solar time
- •azimuth of 15 deg/hour

Two Point Method

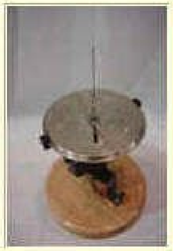


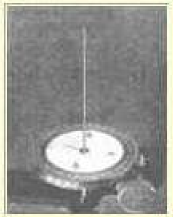
When do pairs of points show E-W?

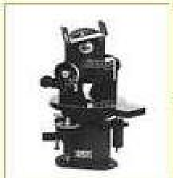


Sun Compasses


Abrams sun compass


Cole sun compass


Bagnold sun compass


Astro compass


Howard sun compass


Rolex

with tables/charts

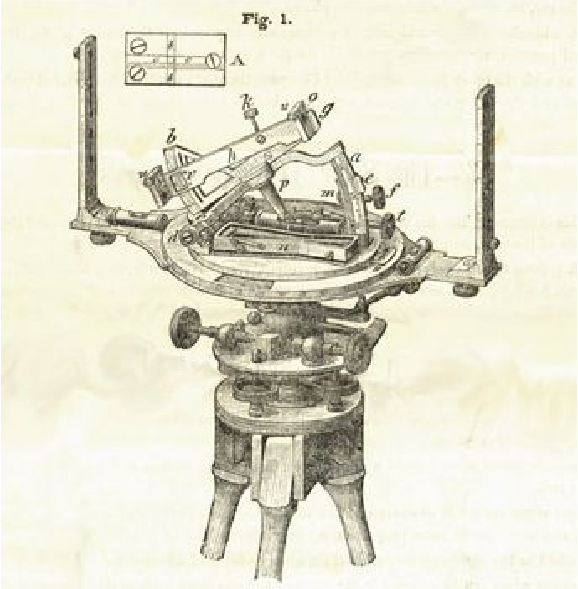


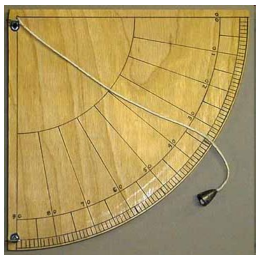
Diagram of Burt's Solar Compass "as improved by W. & L.E. Gurley" of Troy, New York in 1850, fourteen years after Burt first patented it. (Image from pamplet in WHS Museum accession file 1962.60)

Burt Solar Compass

- **surveyed Willamette Meridian, townships –> your property**
- **like aligning equatorial mount**

Atwood, Chaining Oregon

Location Using Noon Altitude



Longitude = (UT - 12h) – eqn time

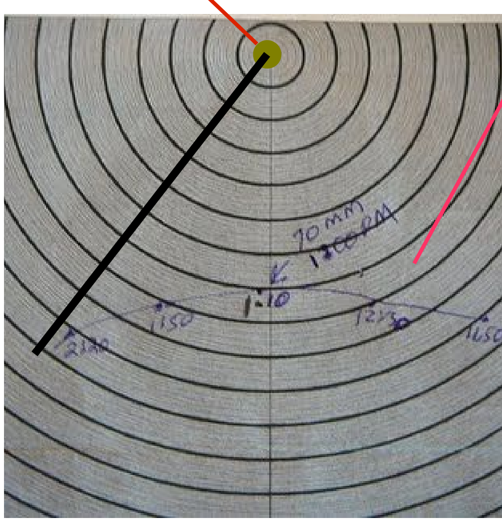
= (20h 26m - 12h) -14m

= 8h 12m = 492 m

x deg/4m = 123 deg W

Time of greatest altitude, shortest shadow (interpolate)

stick



Latitude = 90 – alt – dec

= 90 – 33 - (-13)

= 44 deg N

Precision

Longitude: 13 miles/min

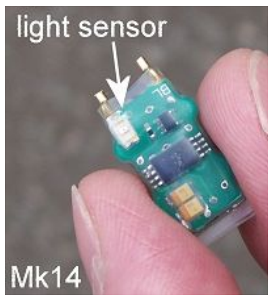
Latitude: 69 miles/degree

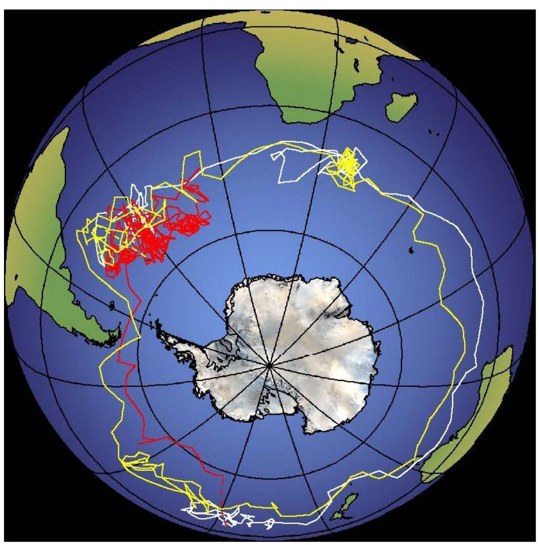
Sobel, <u>The Illustrated Longitude</u>

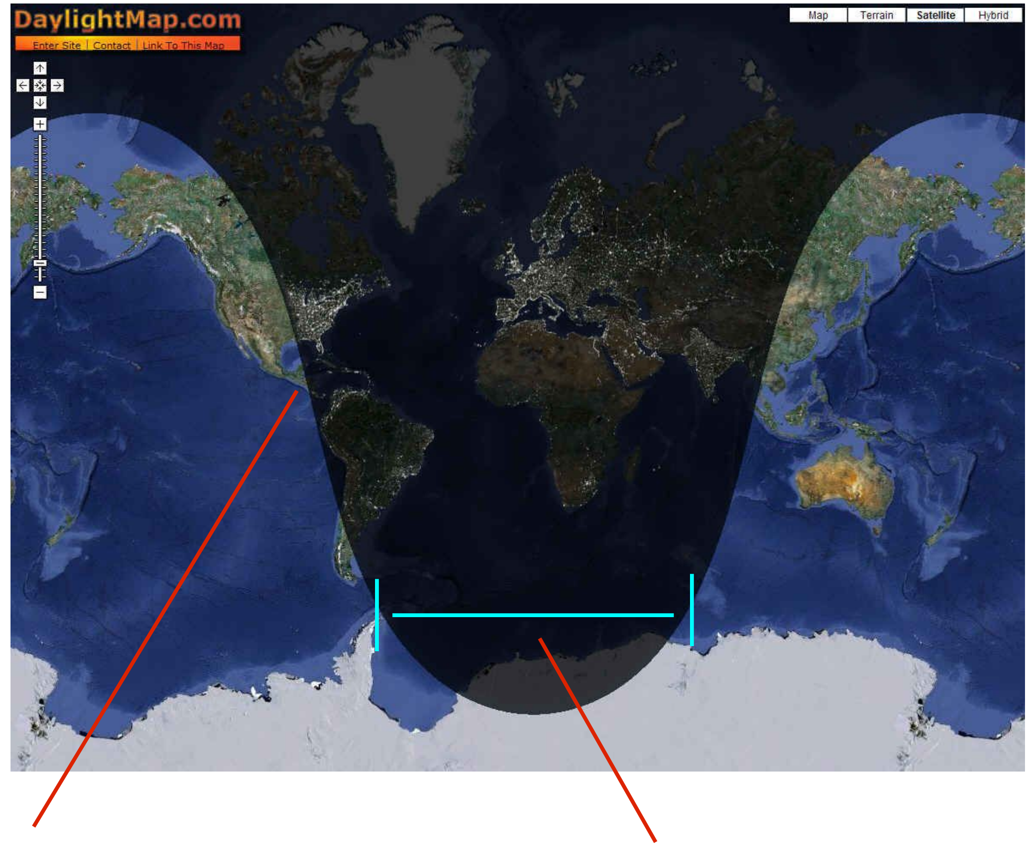
Location Using Sunlight

Antarctic bird tracking

log sunrise and sunset





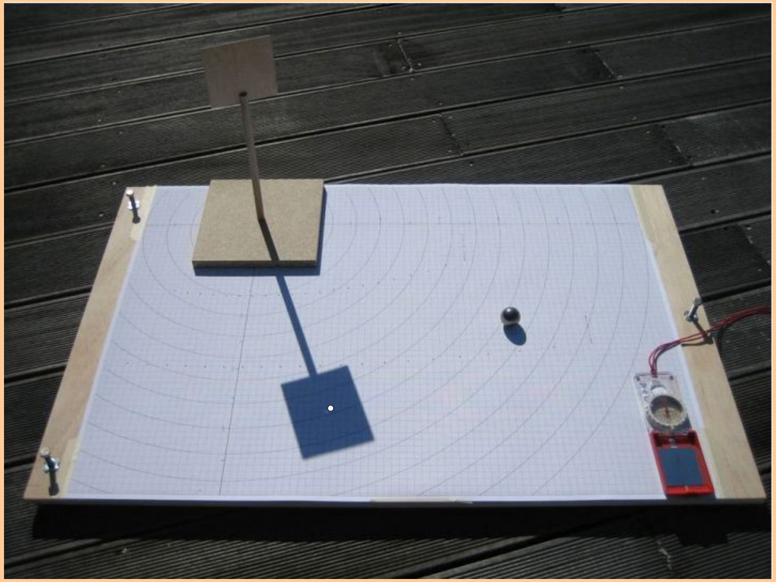


Sunset time and night length

give location

Problems?

3. Shadow Stick Astronomy



Mark time

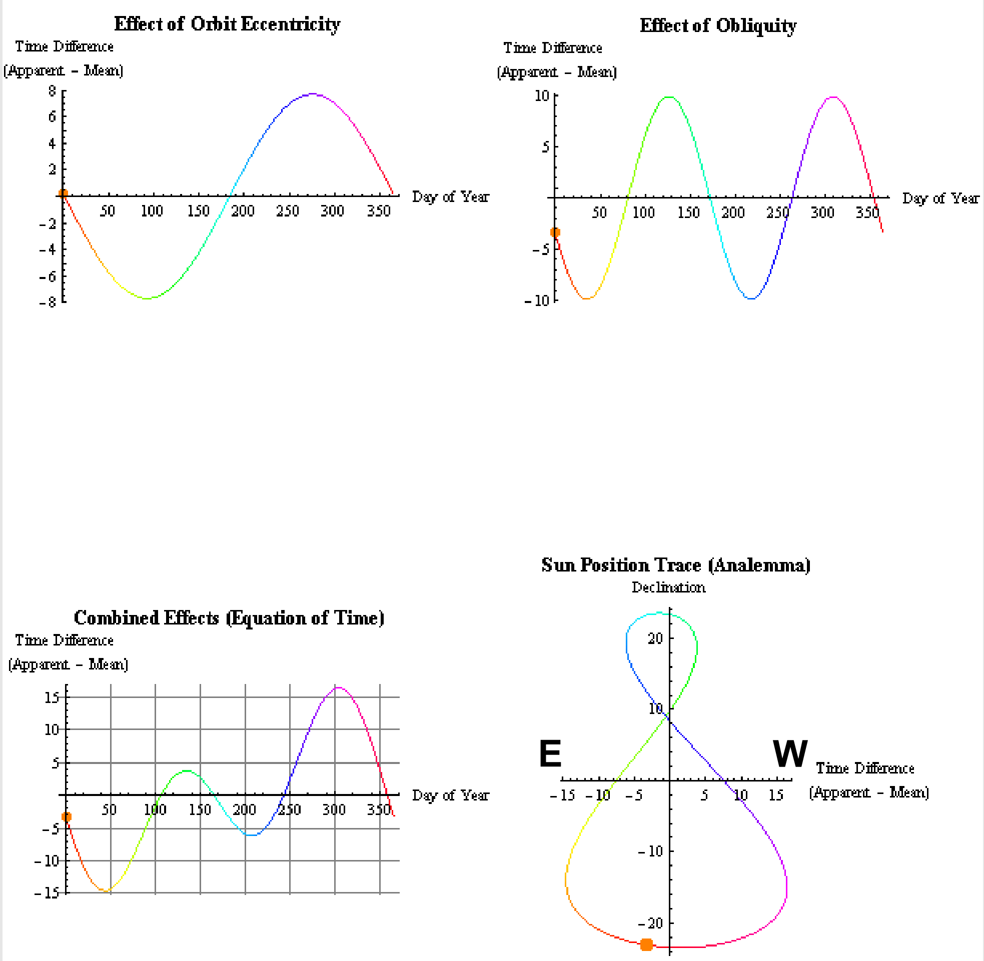
Trace path

Measure altitude and azimuth

Find Location

The Analemma

Sun at given **clock time** for a year

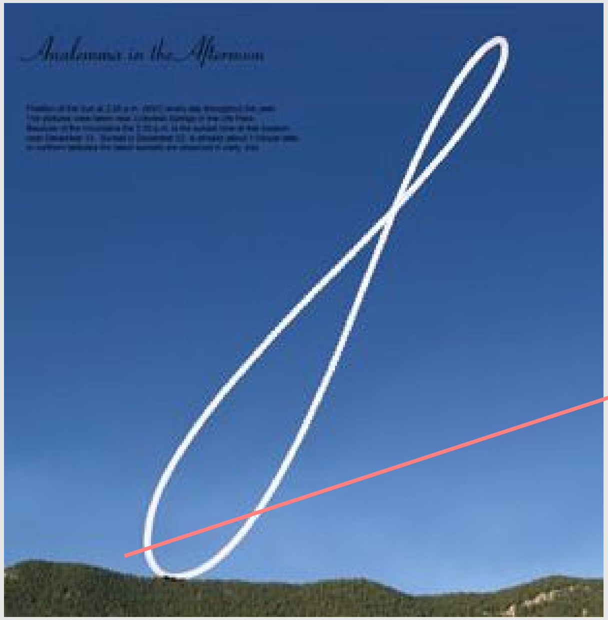


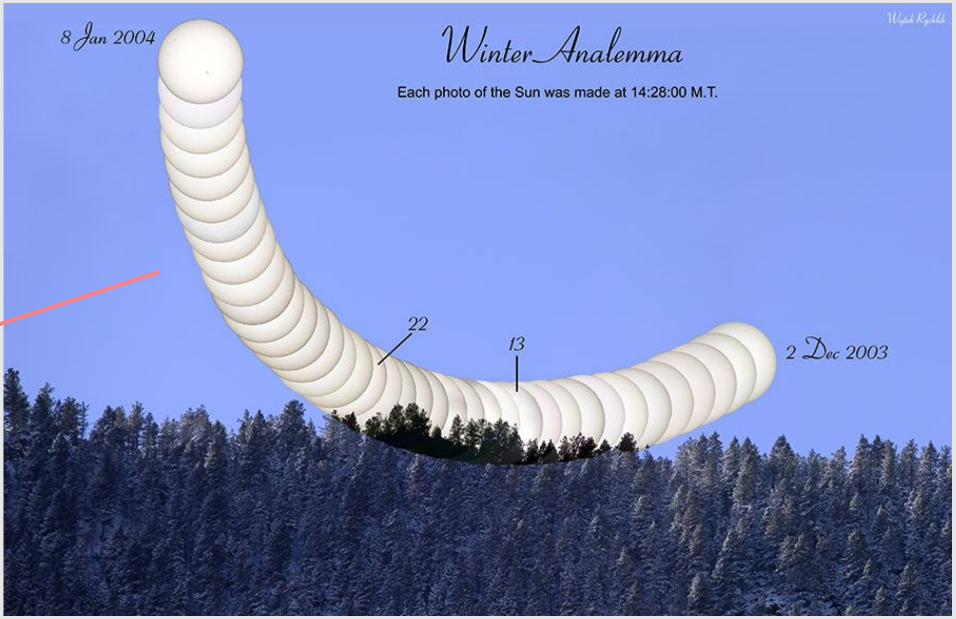
www.analemma.com

Earliest Sunset

~ Dec. 7, not solstice

pikespeakphoto.com/analemma.html

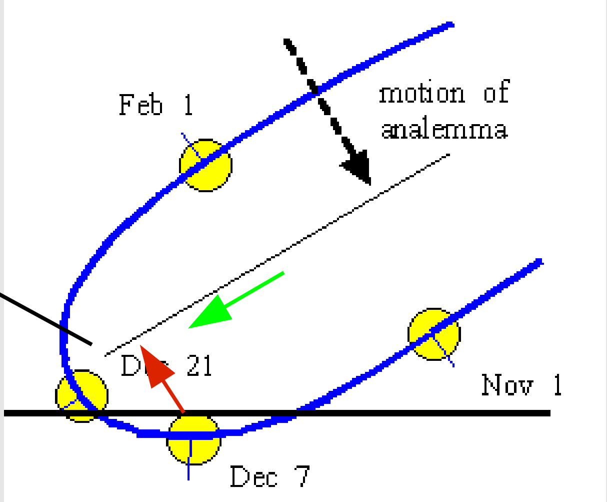




Equation of Time causes

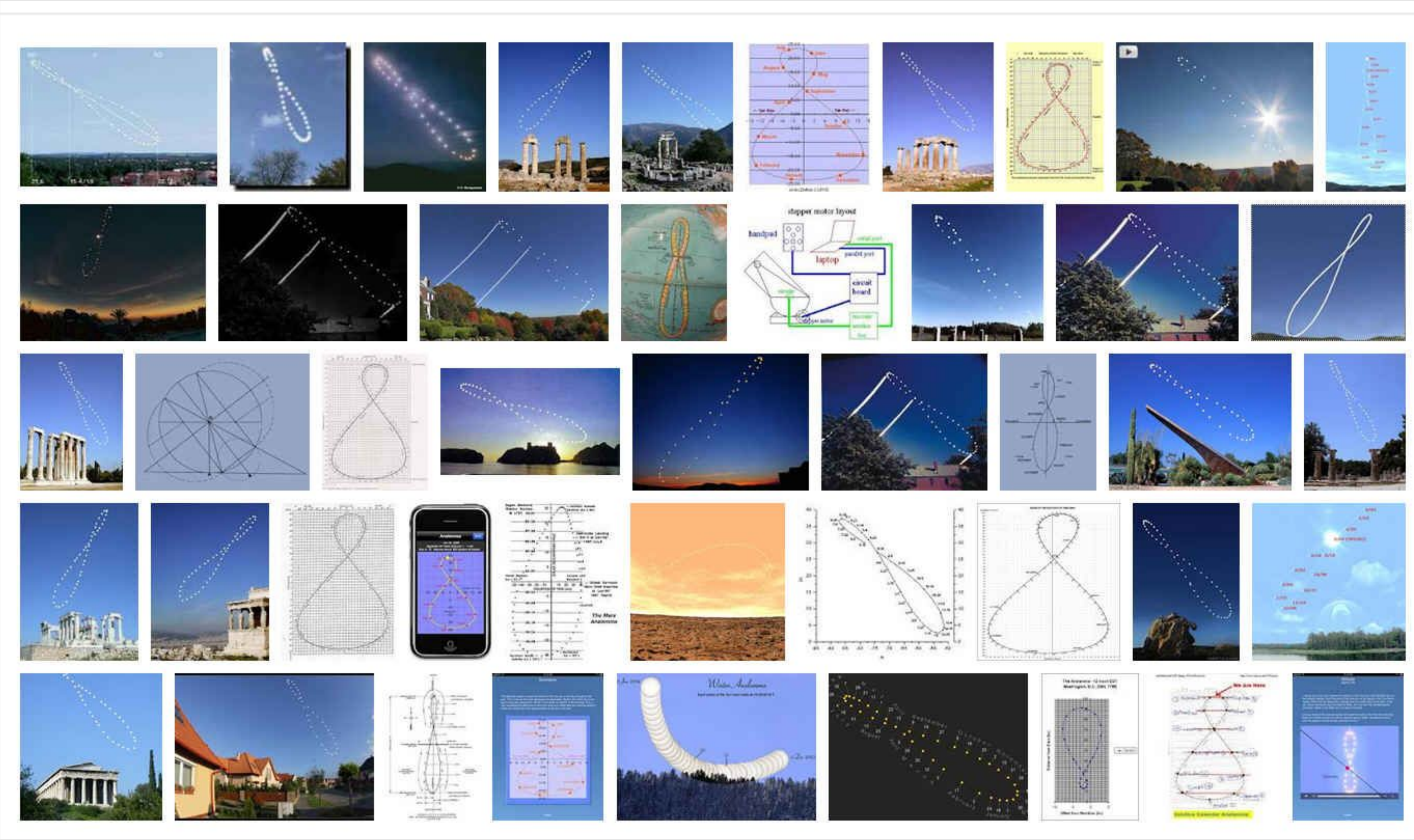
sun to move later

overcoming declination change



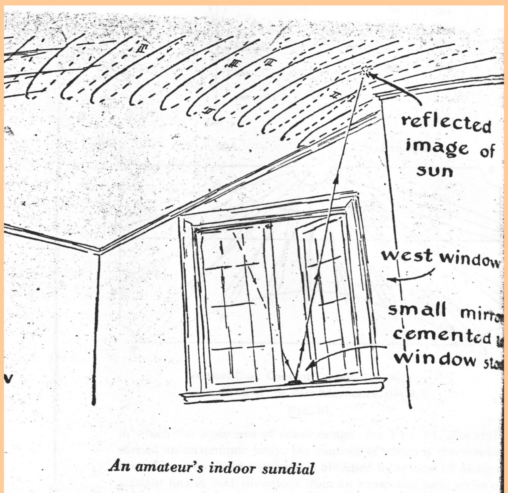
Similar for earliest/latest rise/set

Analemma Examples



4. Make an Analemma

Sun at given clock time for a year



Points, analemmas at time intervals tell time (knowing season)

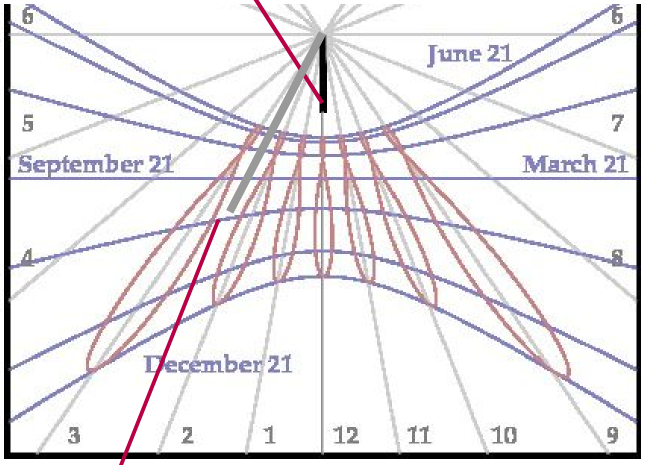
Design and/or record data:

dec on a meridian x eqn of time

Sundials

Point uses azimuth

Stick point



Point's shadow

Gnomon uses hour angle

N celestial pole

Latitude

Sharp shadow

Sundial Types

Altitude

Azimuth

Hour angle

Measurement x Projection

(Correction, Embellishments)

E Bowstring Equinoctial Dial by s
Adler Planetarium, Chicago. (Clutt

D.Polar Dial with cranked 'wing
Flat polar dials cannot show ear

F Analemmatic Sundial. If the
on the central panel the shadow

analemma

Clark College
Vancouver, WA

A Horizontal Sundial with Equation of Time graph.

B Declined Vertical Dial 54° 20

C Universal Equatorial Dial. Adjustable for any Latitude.
(Northern Hemisphere Summertime and Wintertime Faces)

Digits from shadows of fractal masks

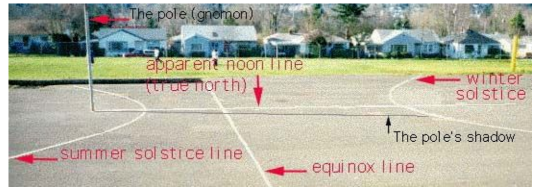
G Polyhedral Sundial. Twenty
several declined and 'reclined'

I A Heliochronometer convert

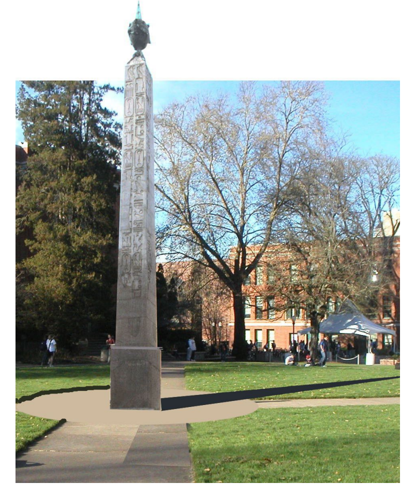
sundials.org sundialsoc.org.uk precisionsundials.com/sundialtalk.ppt

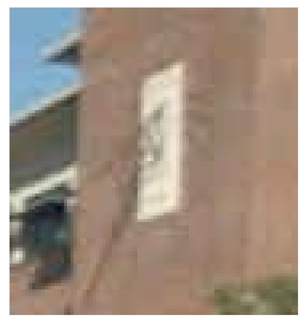
Local Sundials

Plaza between
Deschutes Hall
and Huestis Hall

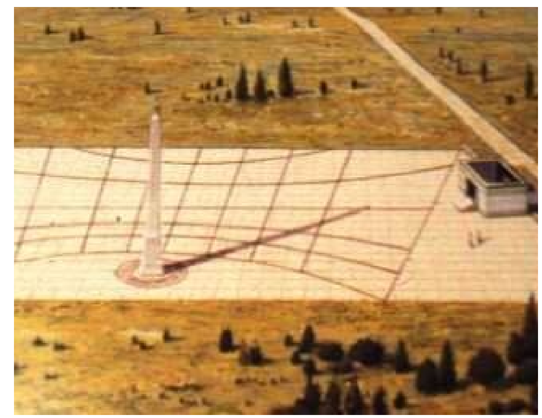


Harris School





10th and Mill



UO prototypes,
analemmas N side
of Lillis Hall

NASS 2009 Portland conference, tour

Seattle, Puget Sound Sundial Trails

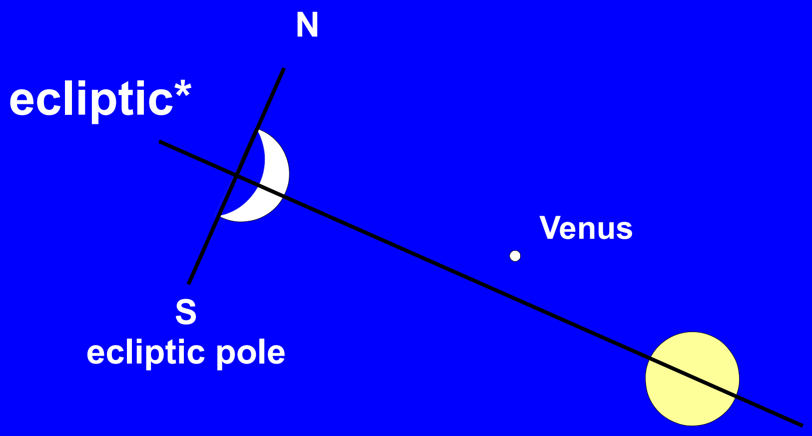
5. Make a Sundial

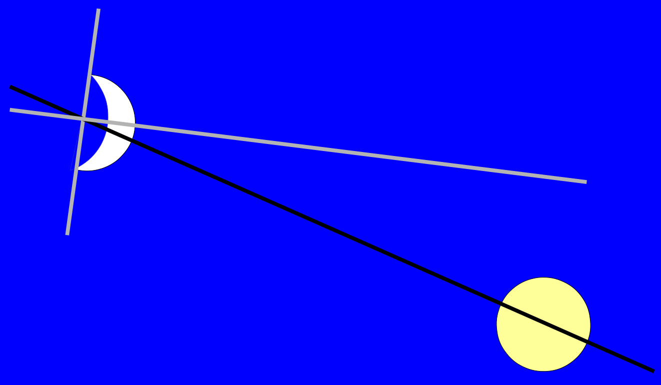
Similar to telescope making

Creative scope

Mirrors, lenses?

Sun, Moon and Ecliptic





Observed?

Moon Tilt Illusion

vs. stretched string

Minnaert

Night

Visualize
Position and Movement

Sun and anti-sun

Ecliptic using

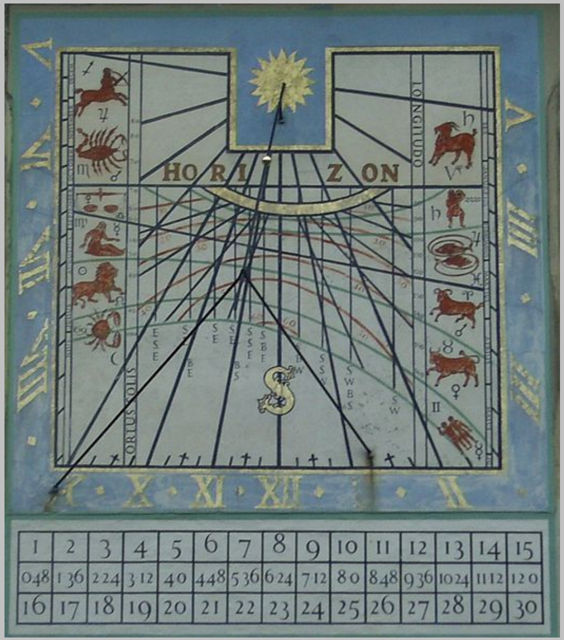
- **Moon, planets**
- **Future sun - set, transit, rise**

Sun – moon line

Moondials

Hour angle of moon from sundial

Correct for age of moon



Public Sun Instruments and Art

Sun + instrument, art, architecture...

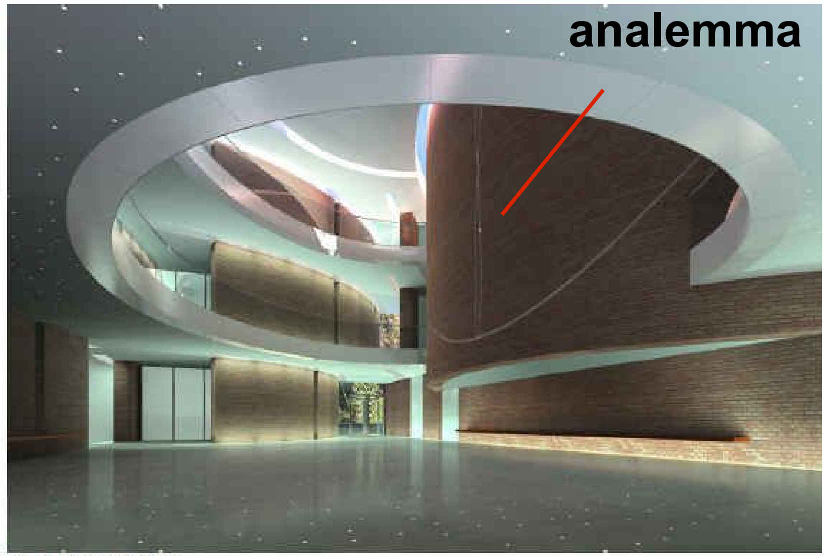
NYC: McGraw-Hill Building Plaza Sun Triangle

The Sun Triangle, designed by meteorologist and oceanographer Athelstan Spilhaus, was installed in inside the sunken plaza outside the McGraw-Hill Building, located at 1221 Avenue of the Americas, in 1973. The outline of the 50-foot stainless steel triangle points too a seasonal position of the sun at solar noon in New York City. The shortest bottom side points to the sun's lowest noon position on the winter solstice, an altitude of 26°, on December 21; the steepest side points to the sun's highest position on the summer solstice, an altitude of 73°, at 1:00 pm (noon if it weren't for daylight savings time) on June 21; and the longest side, the upper leg, points to the sun at noon on the spring and autumn equinoxes on March 21 and September 23. There are maps imbedded in the pavement of the plaza which illustrate the earth's land and water masses. The plaza also has a reflecting pool, symbolizing the sun, and nine stainless steel spheres, representing the nine planets.

analemma

At solar noon on the day of summer solstice, *Solar Rotary*'s shadow caster casts a circle of light around the central seat. On five specific days of the year, at times specific for each day, *Solar Rotary* casts its circle of light around plaques placed in the ground plane of the plaza that mark historic events for the State of Florida and the city of

Public Sun Instruments and Art



The Analemma Skylight

In a collaborative project with artist James Turrell, our team, working with astronomer Dick Walker (who, unfortunately, did not live to see the completion of this project), designed a skylight which would admit a spot of light into the building for a specified period each day of the year (from 11A.M. to 1 P.M.), and modeled the "analemma," or path that this spot would strike on the curved brick wall pictured at noon each day.

A Monumental Sun Pointer

The large arrow on this remarkable new sundial in Amersfoort, the Netherlands, always points to the Sun, even at night. According to artists Jurgen Bey and Jan Konings, it is probably the only instrument of its kind in the world. The short lower part of the pole is parallel to the Earth's axis and rotates once per sidereal day (23 hours 56 minutes 4.1 seconds), so that it stays forever fixed with respect to the stars. The long upper part, above the 23½° bend, is perpendicular to the Earth's orbit (the plane of the ecliptic) and rotates once per year, following the Sun's annual movement around the constellations.

6. Public Sun Instruments and Art

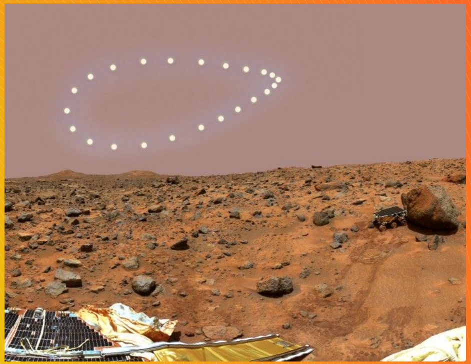
What would be cool?

Eugene – point to sun instead of using sun

Possible Topics

- Other Latitudes
- Rise/Set Times, Twilight
- Celestial Navigation,

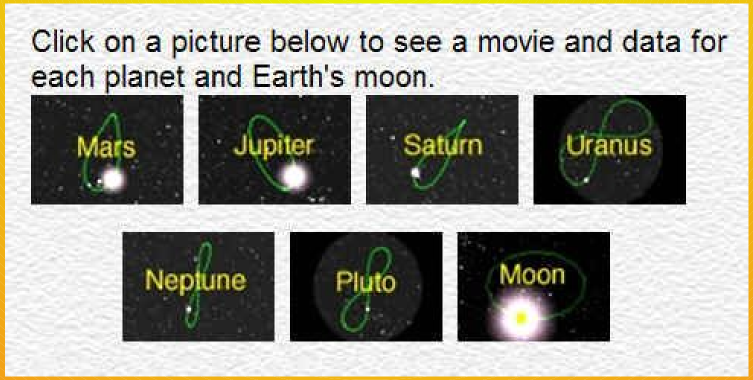
  Positional Astronomy

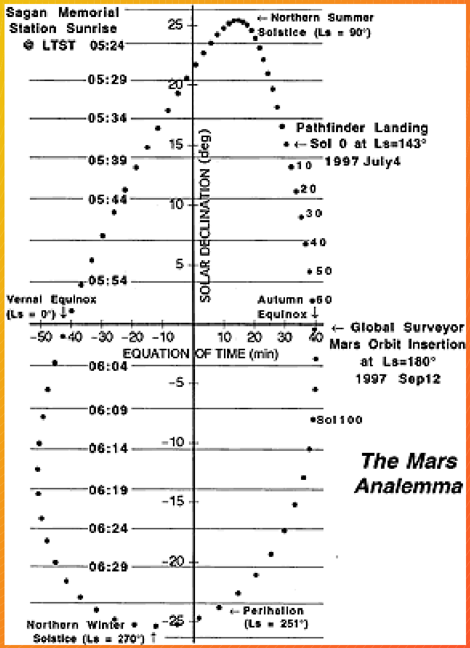


Mars

www.analemma.com

- Other Planets





- Other Systems, e.g. Binary

Summary

- Observing Methods and Examples
- Solar Time
- Daily Movement
- Altitude/Azimuth and Astrolabe
- Finding Direction and Location
- The Analemma
- Sundials
- Sun At Night
- Public Sun Instruments and Art

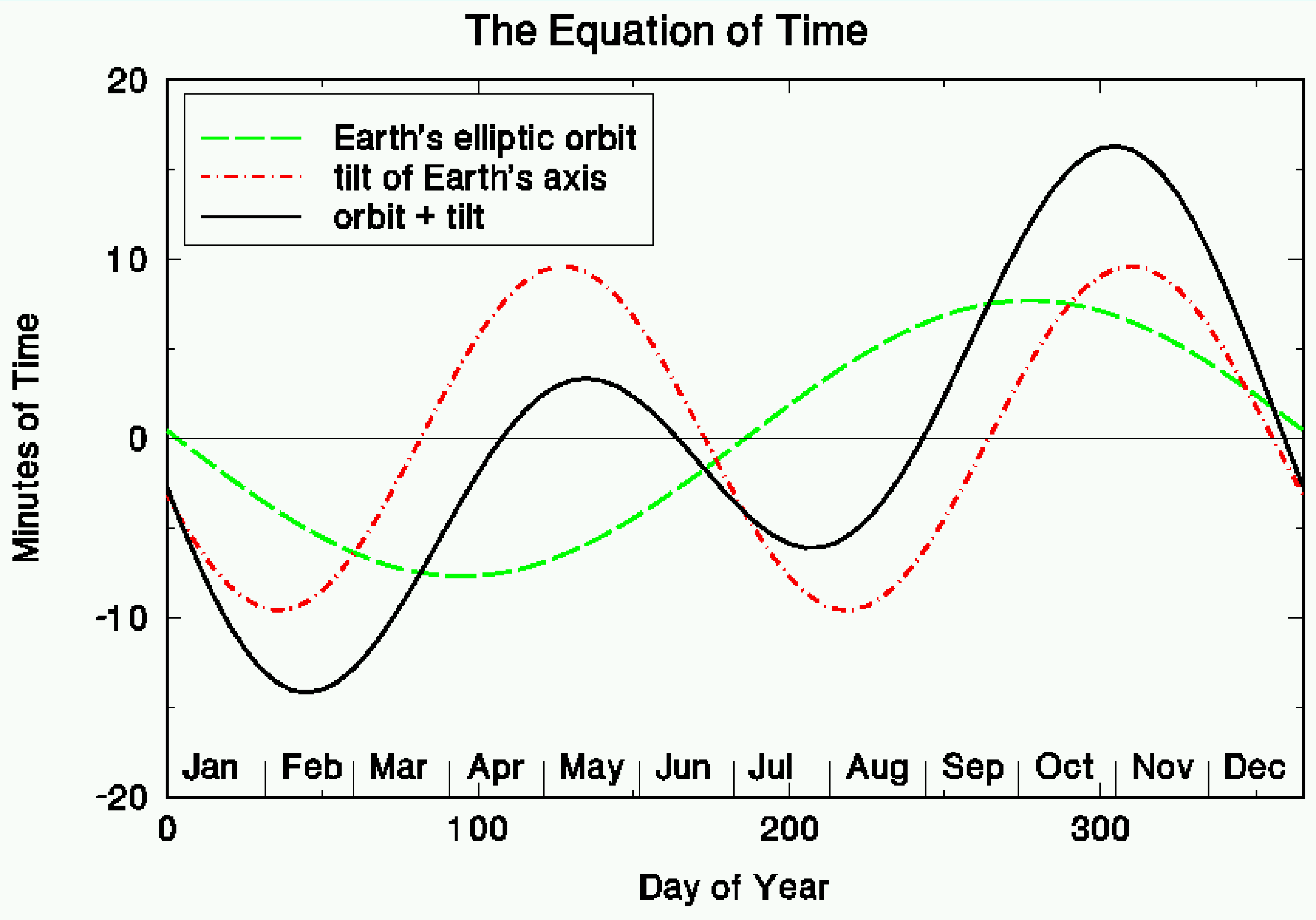
Projects

1. Sun Sight
2. Noon Mark and Solar Time
3. Shadow Stick
4. Analemma
5. Sundial
6. Public Sun Instrument/Art

Conclusion

softwareunderstanding.com/sun

Equation of Time Components



→ **Our Sky**

Rise/Set Angles

Rising/setting angle is (90° – Latitude) due east/west – along celestial equator
Angles are smaller the further N/S one goes