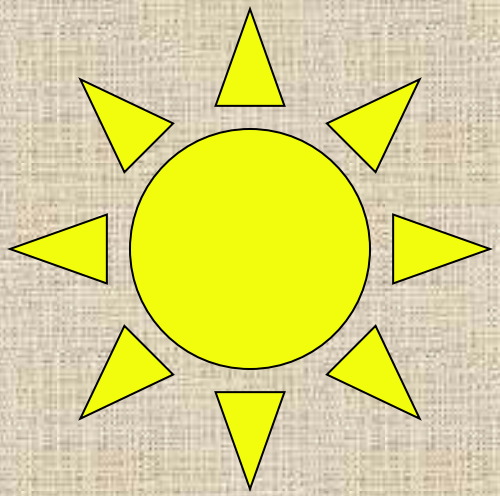
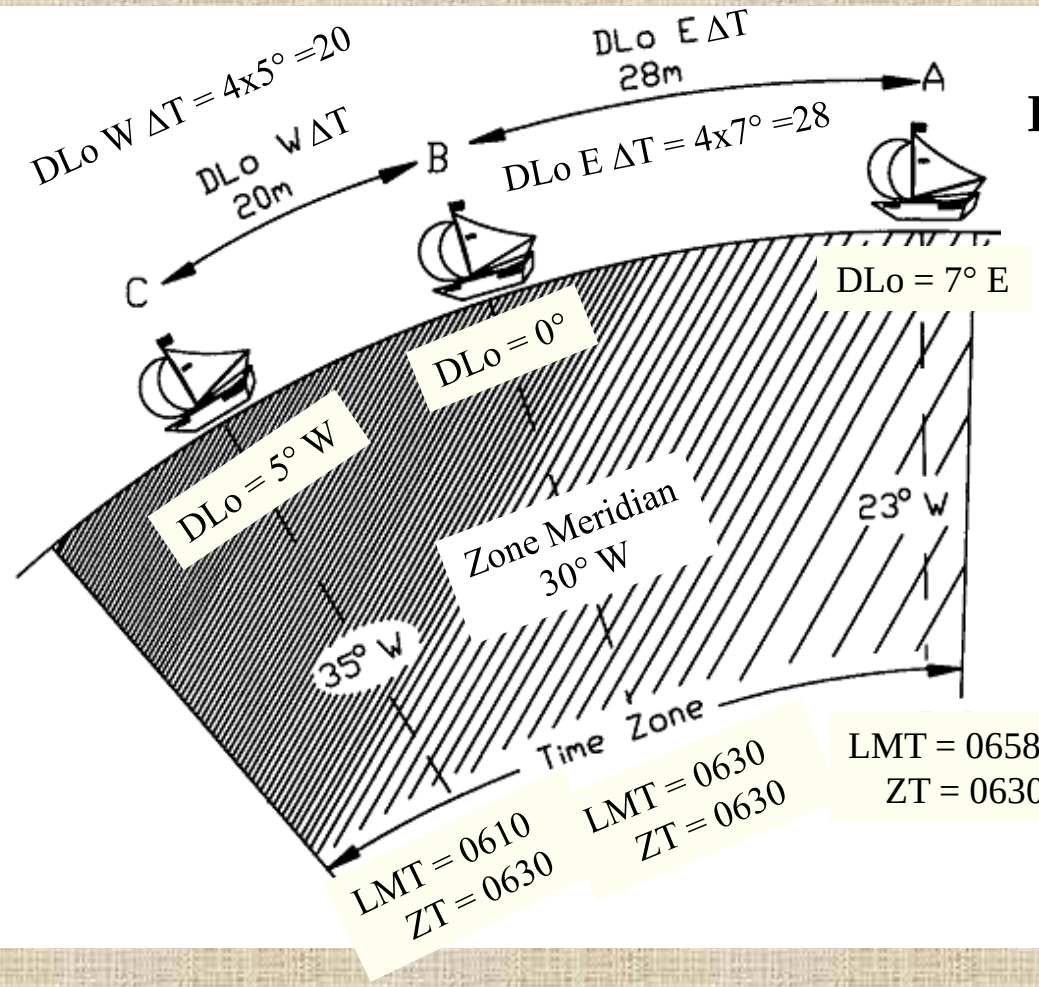
Meridian Transit



Learning Objectives

- Determine Zone Time of Sun's meridian transit using ***Nautical Almanac*** **Mer. Pass.** method
- Determine Zone Time of Sun's meridian transit using ***Nautical Almanac Eqn. of Time*** method
- Determine Zone Time of Sun's meridian transit using **GHA = Observer's Meridian** method
  This method is required for homework & test
- Understand difference between Zone Time (**ZT**) and Local Mean Time (**LMT**)
- Determine latitude from an observation of the Sun at meridian transit

Zone Time (ZT) and Local Mean Time (LMT)



Determining Local Mean Time (LMT) From Zone Time (ZT)

Recall that The Sun moves West at a rate of 15 degrees of Longitude per hour of time or 4 minutes of time per degree of Longitude

LMT = ZT -DLo W
LMT = ZT +DLo E

Meridian Transit of Sun

- **GHA** – defines position of apparent Sun
- Meridian Transit – apparent Sun crosses observer's meridian
- **L**ocal **H**our **A**ngle (**LHA**) = 0° 00.0'

  GHA = Observer's Meridian
- **L**ocal **A**pparent **T**ime (**LAT**) = 12-00-00
- Meridian Transit of Sun is also known as **L**ocal **A**pparent **N**oon (**LAN**)

Mean Sun & Apparent Sun

- **Mean Sun** - an imaginary Sun
  invented for keeping Zone Time

- **Apparent Sun** - the observable Sun
  determines Apparent Time

- Difference is ***Equation of Time***

- Meridian Transit occurs at high noon
  12 hours Local Apparent Time (**LAT**)

A Sun Dial displays Local Apparent Time

Meridian Passage & *Equation of Time*

The *Equation of Time* listed in the *Nautical Almanac* tabulates the difference between the apparent Sun and mean Sun.

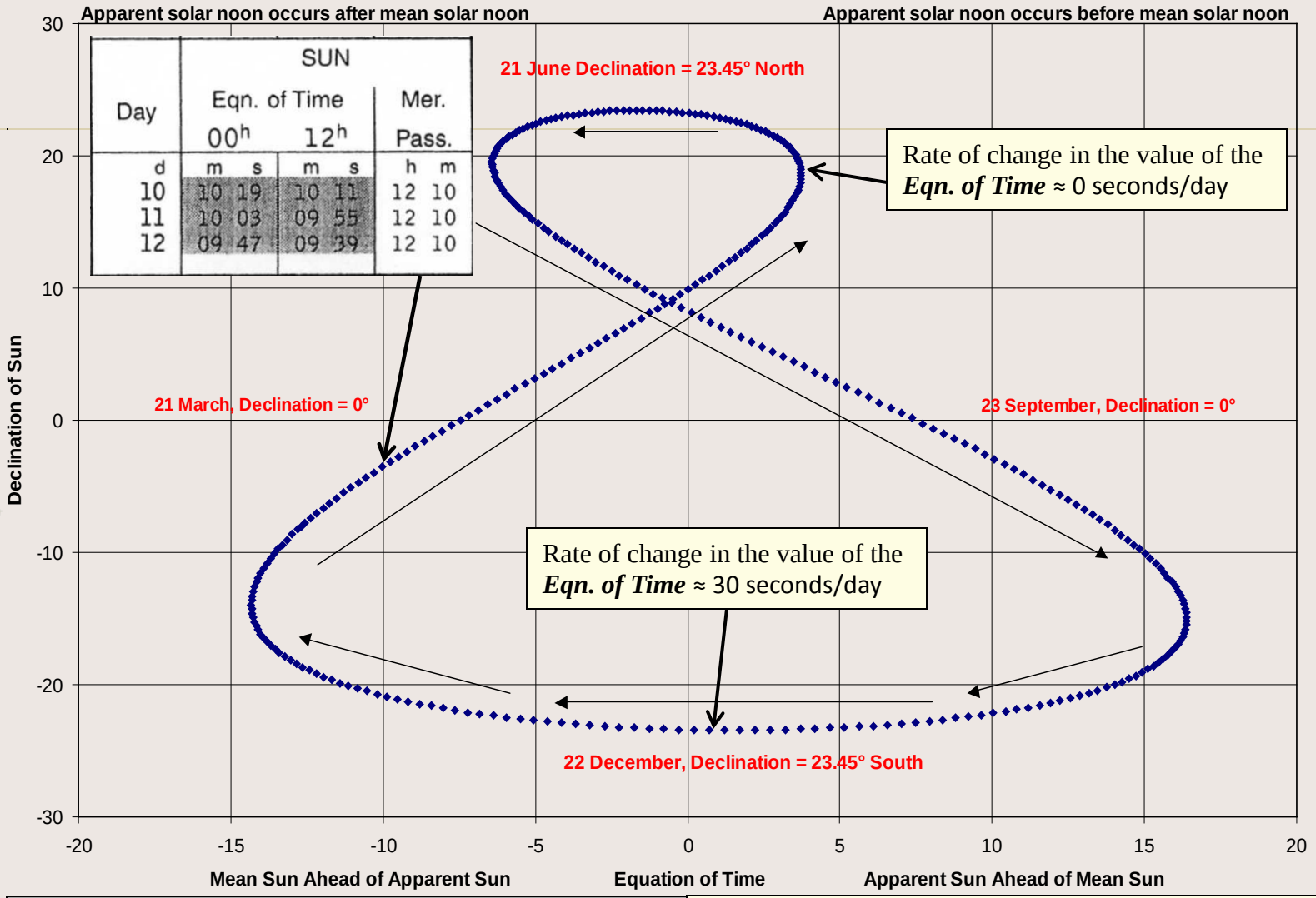
If meridian passage at Greenwich is earlier than 1200 GMT then the apparent Sun is ahead of the mean Sun and the *Equation of Time* is positive and is shown without a shaded background.

If meridian passage at Greenwich is later than 1200 GMT then the mean Sun is ahead of the apparent Sun and the *Equation of Time* is negative and is shown within a gray shaded background.

Day	SUN		
	Eqn. of Time		Mer.
	00^h	12^h	Pass.
d	m s	m s	h m
10	10 19	10 11	12 10
11	10 03	09 55	12 10
12	09 47	09 39	12 10

The time of the Sun's meridian passage listed in the *Nautical Almanac* is the GMT of the Sun's passage over the prime meridian at Greenwich rounded to the nearest whole minute.

Analemma



Day	SUN Eqn. of Time 00h		SUN Eqn. of Time 12h		SUN Mer. Pass.	
d	m	s	m	s	h	m
10	10	19	10	11	12	10
11	10	03	09	55	12	10
12	09	47	09	39	12	10

The Nautical Almanac Values Shown In Gray Box

The Nautical Almanac Values Shown In White Box

Apparent Time

If the apparent Sun is ahead of the mean Sun

then: LAT = LMT + *Eqn. of Time*

LMT = LAT - *Eqn. of Time*

If the mean Sun is ahead of the apparent Sun

then: LAT = LMT – *Eqn. of Time*

LMT = LAT + *Eqn. of Time*

Transit via *Nautical Almanac* Mer. Pass.

On 22 December 2014 you plan on taking a meridian transit sight of the sun from Ediz Hook, L = 48° 08.5' N; Lo = 123º 26.1' W; (ZD +8)

From the *Nautical Almanac* you determine that on 22 December 2014 meridian passage at the Greenwich meridian occurs at 1159 GMT.

Assume† meridian passage at your Zone Meridian of 120º W also occurs at 1159 Zone Time. Your DLo is 3º 26.1' W which equates to 13 minutes 44 seconds. You can now calculate meridian passage at Ediz Hook on 22 December 2014

Zone Time of Meridian Passage @ 120ºW	**11-59-00**
DLo West ΔT	**+ 13-44**
Zone Time of Meridian Passage @ 123º 26.1'W	**12-12-44**

Maximum error less than 30 seconds

Day	Sun *Eqn of Time* 00h		12h		Mer. Pass.	
d	m	s	m	s	h	m
21	02	13	01	58	11	58
→ 22	01	43	01	28	11	59
23	01	13	00	58	11	59

† Accuracy is degraded by rounding time of Mer. Pass. to a whole minute and the change in the value of the ***Eqn. of Time*** between **1200 GMT** & **1200 LAT** at observer's meridian. Accuracy could be improved by using **11:58:32** as mer. Pass. time. (See Analemma)

Transit via *Nautical Almanac Eqn. of Time*

On 22 December 2014 you plan on taking a meridian transit sight of the sun from Ediz Hook, L = 48° 08.5' N; Lo = 123º 26.1' W;(ZD +8)

From the *Nautical Almanac* you determine that on 22 December 2014 *Eqn. of Time* at 1200 GMT is 1 minute 28 seconds. Apparent Sun is ahead of the Mean Sun. Meridian passage at your Zone Meridian will be at 1200 LAT. Since your is Zone Meridian is 120ºW your DLo is 3º 26.1'W which equates to 13 minutes 44 seconds.

Using 01 min 28 seconds as the value of the *Eqn. of Time,* determine meridian passage at Ediz Hook on 22 December 2014

Maximum error† is less than 15 seconds
Accuracy varies through the year from ≈1 to ≈15 seconds, depending on the rate of change in the ***Eqn. of Time*** (See Analemma)

Day	Sun *Eqn. of Time* 00h		12h		Mer. Pass.	
d	m	s	m	s	h	m
21	02	13	01	58	11	58
→ 22	01	43	01	28	11	59
23	01	13	00	58	11	59

Noon LAT	**12-00-00**
Eqn. of Time	**- 01-28**
LMT	**11-58-32**
DLo of 3º 26.1'W ΔT	**+ 13-44**
Zone Time	**12-12-16**

† Accuracy is degraded by the change in the value of the ***Eqn. of Time*** between **1200 GMT** & **1200 LAT** at observer's meridian. (See Analemma)

Determining UT for GHA = LHA

If you are West of Greenwich, select the latest UT hour from the *Nautical Almanac* where GHA is less than your meridian.

If you are East of Greenwich, select the latest UT hour from the *Nautical Almanac* where GHA is less than 360° minus your meridian.

Take difference between your meridian and the above GHA

Go to the *Yellow Pages* and determine the minutes and seconds that correspond to the above difference.

The Time of Meridian Passage is the above UT hour + the minutes and seconds you determined from the *Yellow Pages*.

At Meridian Passage the LHA of the Sun = 0° 0.0′

GHA of the Sun is equal to the observer's meridian

Transit via GHA = Observer's Meridian

On 22 December 2014 you plan on taking a meridian transit sight of the sun from Ediz Hook, L = 48° 08.5' N; Lo = 123º 26.1' W;(ZD +8)

From the *Nautical Almanac* you determine that at UT 2000 the GHA of the Sun will be 120 º 19.4' with a Declination of 23° 25.9'S

Then the Difference between 123º 26.1' and 120 º 19.4' is 03º 06.7'

From the yellow pages we find that 03º 06.7' converted to time is 12 minutes 27 seconds

GHA of the Sun = 120 º 19.4' @	**UT**	**20-00-00**
3º 26.1' converted to time		**+ 12-27**
GHA of the Sun = 120 º 26.1' @	**UT**	**20-12-27**
	ZD	**+8 (rev)**
Zone Time of meridian transit		**12-12-27**

Accuracy ± 1 second

Comparison of Methods

- **The rate of change in the value of the *Eqn. of Time* is at it's maximum value on 22 December (≈30 seconds/day)**
- ***Nautical Almanac* Mer. Pass. method**
  Zone Time of 12-12-44 Hc = 18° 25.61'
- ***Nautical Almanac Eqn. of Time* method**
  Zone Time of 12-12-16 Hc = 18° 25.61'
- **GHA = Observer's Meridian method**
  Zone Time of 12-12-27 Hc = 18° 25.61'
- **For Zone Time of 12-10-45 Hc = 18° 25.55'**

No significant change in Hc over this time period

- **For Zone Time of 12-13-55 Hc = 18° 25.56'**

Skill 1 – Find Time of Transit

On 29 February you plan on taking a meridian transit sight of the sun from Ediz Hook, L = 48° 08.5' N; Lo = 123º 26.1' W; (ZD +8).

Use Excerpts from *Nautical Almanac* supplied with JN Student Manual to determine Zone Time of meridian transit using the three methods shown below:

- ***Nautical Almanac* Mer. Pass. method**
- ***Nautical Almanac Eqn. of Time* method**
- **GHA = Observer's Meridian method**

Also compute Hc for each of the above meridian transit times.

Nautical Almanac Mer. Pass. method

On 29 February you plan on taking a meridian transit sight of the sun from Ediz Hook, L = 48° 08.5' N; Lo 123º 26.1' W; (ZD +8).
Use Excerpts from *Nautical Almanac* supplied with JN course materials to find Zone Time of Transit.

Your DLo is 3º 26.1'W which equates to 13 minutes 44 seconds.

Zone Time of Meridian Passage @ 120ºW	**12-13-00**
DLo West ΔT	**+ 13-44**
Zone Time of Meridian Passage @ 123º 26.1'W	**12-26-44**

LHA	0.00000
Lat	48.14167
Dec	-7.68367

Zn = 180° **Hc = 34° 10.48'**

Day	Sun *Eqn of Time* 00h		12h		Mer. Pass.	
d	m	s	m	s	h	m
27	13	01	12	56	12	13
28	12	51	12	45	12	13
29	12	40	12	34	12	13

Nautical Almanac Eqn. of Time method

On 29 February you plan on taking a meridian transit sight of the sun from Ediz Hook, L = 48° 08.5' N; Lo 123º 26.1' W; (ZD +8).
Use Excerpts from *Nautical Almanac* supplied with JN course materials to find Zone Time of Transit.

***Eqn. of Time* @ 12 hours GMT is 12 min 34 seconds**
The mean sun is ahead of the apparent sun
Your DLo is 3º 26.1'W which equates to 13 minutes 44 seconds.

LHA	0.00000
Lat	48.14167
Dec	-7.68367

Day	Sun *Eqn of Time* 00h		Sun *Eqn of Time* 12h		Mer. Pass.	
d	m	s	m	s	h	m
27	13	01	12	56	12	13
28	12	51	12	45	12	13
29	12	40	12	34	12	13

Noon LAT	**12-00-00**
Eqn. of Time	**+ 12-34**
LMT	**12-12-34**
DLo of 3º 26.1'W ΔT	**+ 13-44**
Zone Time	**12-26-18**

Zn =180° Hc = 34° 10.48'

GHA = Observer's Meridian method

On 29 February you plan on taking a meridian transit sight of the sun from Ediz Hook, L = 48° 08.5' N; Lo 123º 26.1' W; (ZD +8).
Use Excerpts from *Nautical Almanac* supplied with JN course materials to find Zone Time of Transit.

From the *Nautical Almanac* you determine that at UT 2000 the GHA of the Sun will be 116 º 52.5' with a Declination of 07° 41.4'S

Then the Difference between 123º 26.1' and 116 º 52.5' is 06º 33.6'

From the yellow pages we find that 06º 33.6' converted to time is 26 minutes 14 seconds

	UT 20-00-00
06º 33.6' converted to time	**+ 26-14**
	UT 20-26-14
	ZD +8 (rev)
	Zone Time 12-26-14

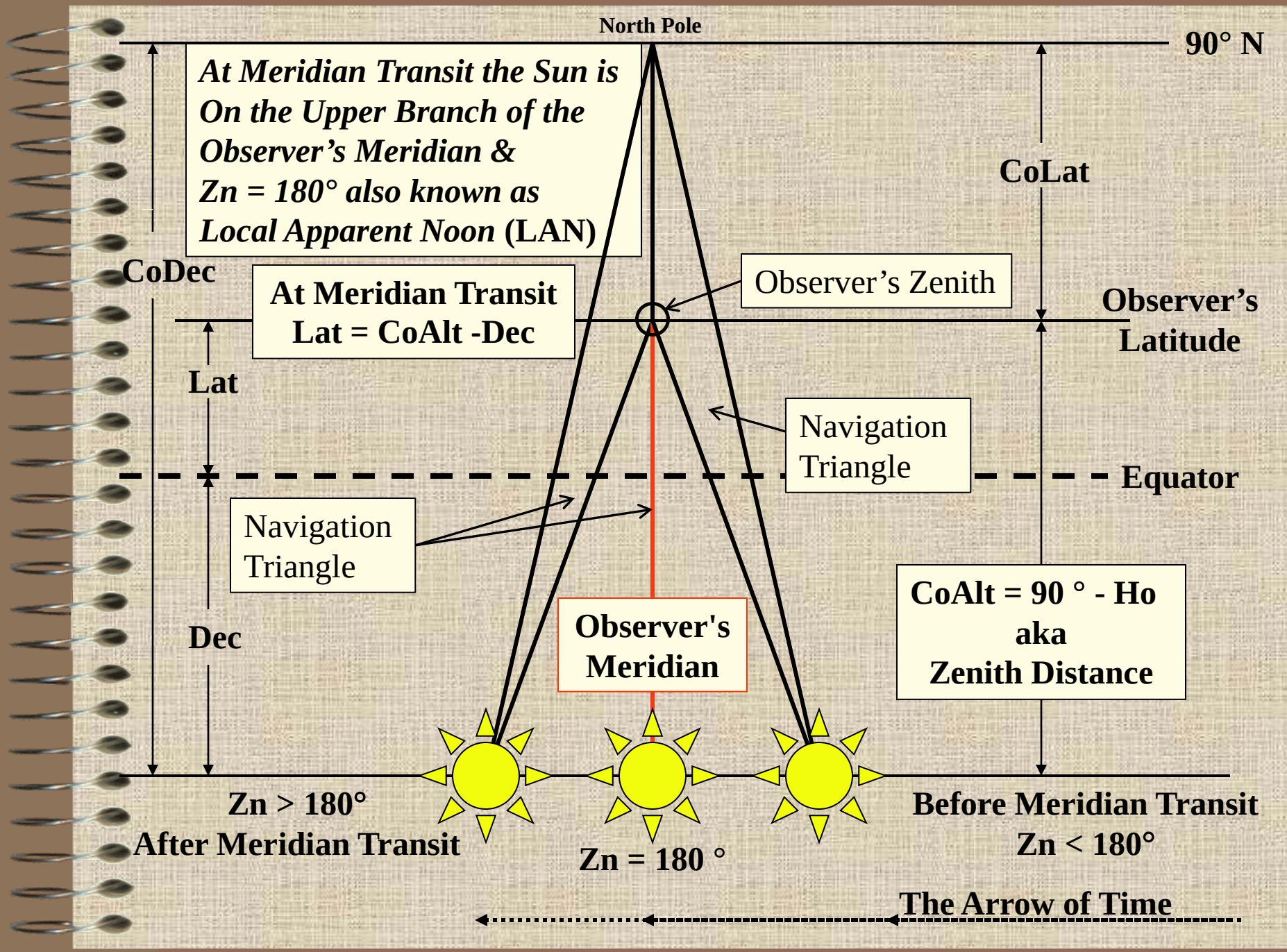
LHA	0.00000
Lat	48.14167
Dec	-7.68367

Zn = 180° **Hc = 34° 10.48'**

Computing Latitude

- Obtain Ho at Time of Transit
- Subtract Ho from 90° to obtain CoAlt
- Name of CoAlt is direction from the body to the observer
- For GMT of the sight, obtain Dec of sun from the *Nautical Almanac*
- Combine CoAlt and Dec to obtain your latitude: Lat = CoAlt ±Dec

If CoAlt & Dec have same name add; If opposite names subtract


North Pole
90° N
At Meridian Transit the Sun is On the Upper Branch of the Observer's Meridian & Zn = 180° also known as Local Apparent Noon (LAN)
CoLat
CoDec
At Meridian Transit
Lat = CoAlt -Dec
Observer's Zenith
Observer's Latitude
Lat
Navigation Triangle
Equator
Navigation Triangle
Observer's Meridian
CoAlt = 90 ° - Ho
aka
Zenith Distance
Dec
Zn > 180°
After Meridian Transit
Zn = 180 °
Before Meridian Transit
Zn < 180°
The Arrow of Time

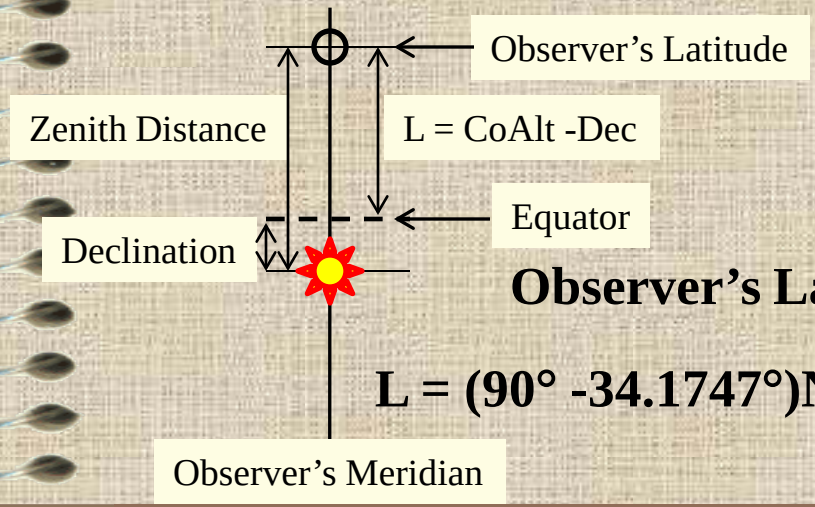
Skill 1 – Solutions Comparison

29 February meridian transit sight of the sun from Ediz Hook,
L 48° 08.5' N Lo123º 26.1' W (ZD +8).

- ***Nautical Almanac* Mer. Pass. Method** **Zone Time 12-26-44**
  Hc = 34° 10.48'

- ***Nautical Almanac Eqn. of Time* method** **Zone Time 12-26-18**
  Hc = 34° 10.48'

- **GHA = Observer's Meridian method** **Zone Time 12-26-14**
  Hc = 34° 10.48'



Declination of Sun 07° 41.0' S = 7.690°

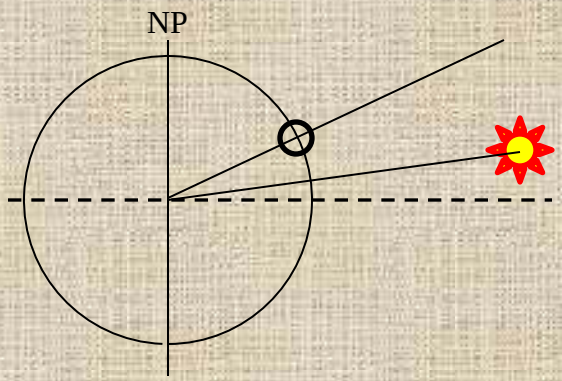
Observer's Latitude = Zenith Distance ± Declination

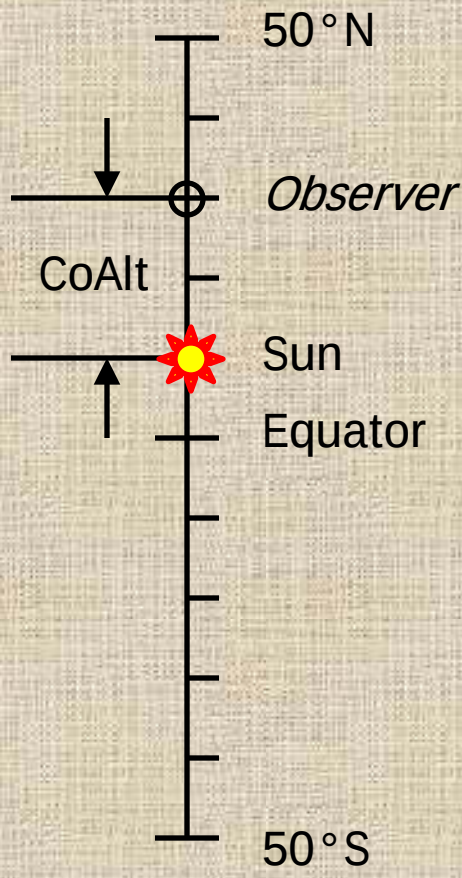
L = (90° -34.1747°)N -7.6833°S = 48.137°N = 48° 08.5' N

Example - Computing Latitude

Observer North of Equator and also North of Sun

Ho = 70°
Zn =180 °
CoAlt = 90° – 70° = 20° N
Dec = 10° N
L = CoAlt ±Dec
L = 20° N +10° N = 30°N

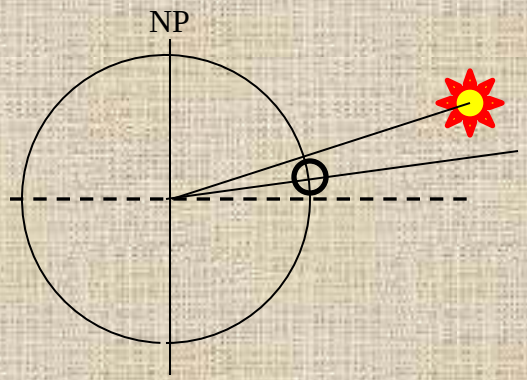


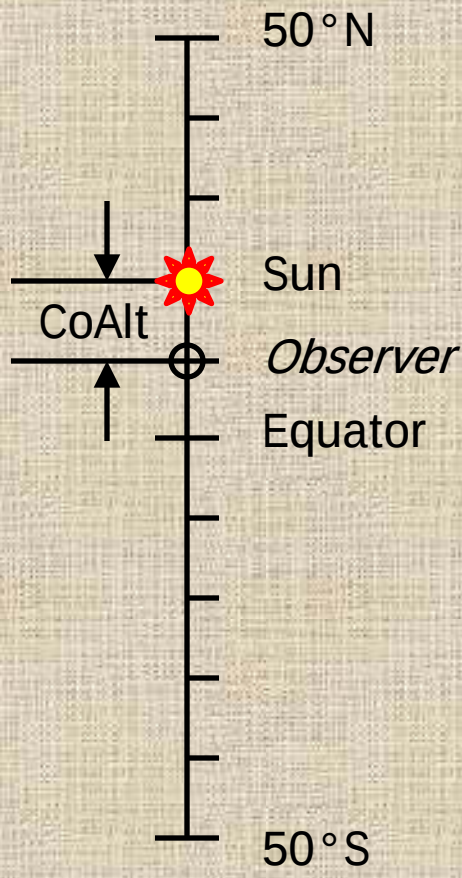


Example - Computing Latitude

Observer North of Equator but South of Sun

Ho = 80°
Zn =360 °
CoAlt = 90° – 80° = 10° S
Dec = 20° N
L = CoAlt ±Dec
L = 10° S – 20° N = 10°N

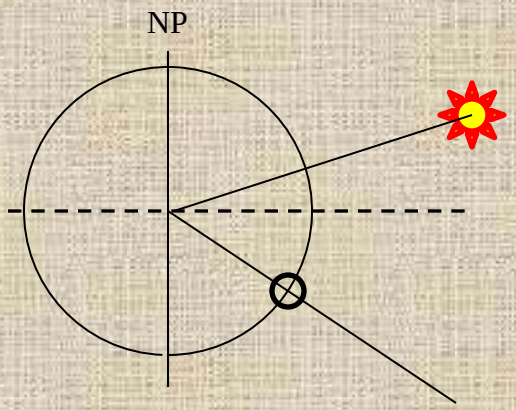


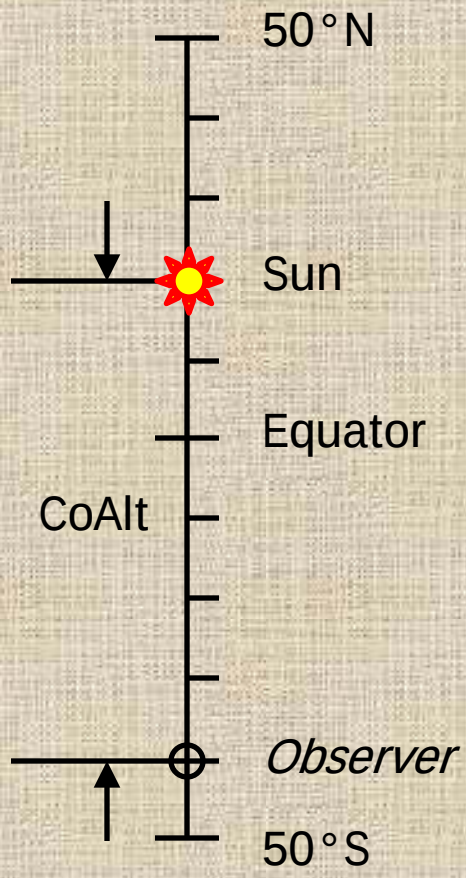


Example - Computing Latitude

Observer South of Equator & also South of Sun

Ho = 30°
Zn =360 °
CoAlt = 90° – 30° = 60° S
Dec = 20° N
L = CoAlt ±Dec
L = 60° S – 20° N = 40°S





LATITUDE BY MERIDIAN TRANSIT

90°	89° 60'
- Ho	___°___'
CoAlt = 90° - Ho	___°___' N / S *
Dec	___°___' N / S
Δ = CoAlt ±Dec	___°___' N / S **
If (Δ > 90°) then Δ = 180° - Δ	___°___' N / S ***
L = Δ	___°___' N / S
DR L	___°___' N / S
a	_____nm

* CoAlt name is same as direction from the body's declination to your DR Latitude

** If CoAlt and Dec have same name, add.

** If CoAlt and Dec have opposite names, subtract.

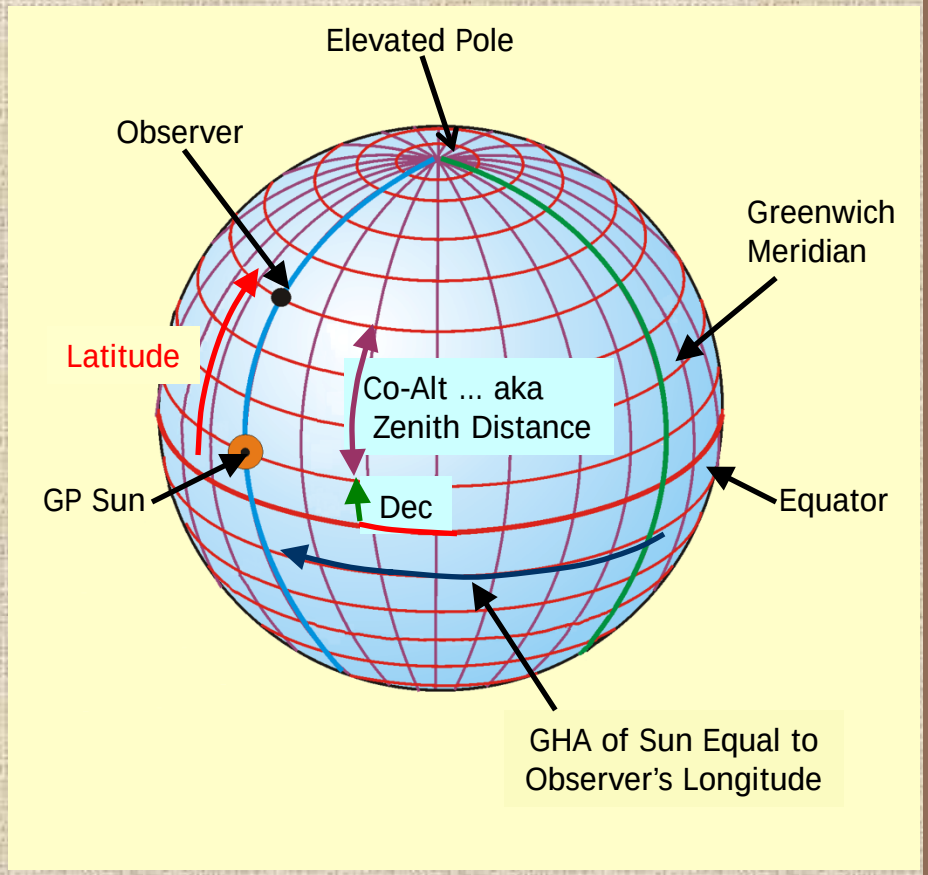
*** If Δ > 90° body is on lower branch of your meridian

Reviewing -- Meridian Transit

Celestial body is on the upper branch of observer's meridian

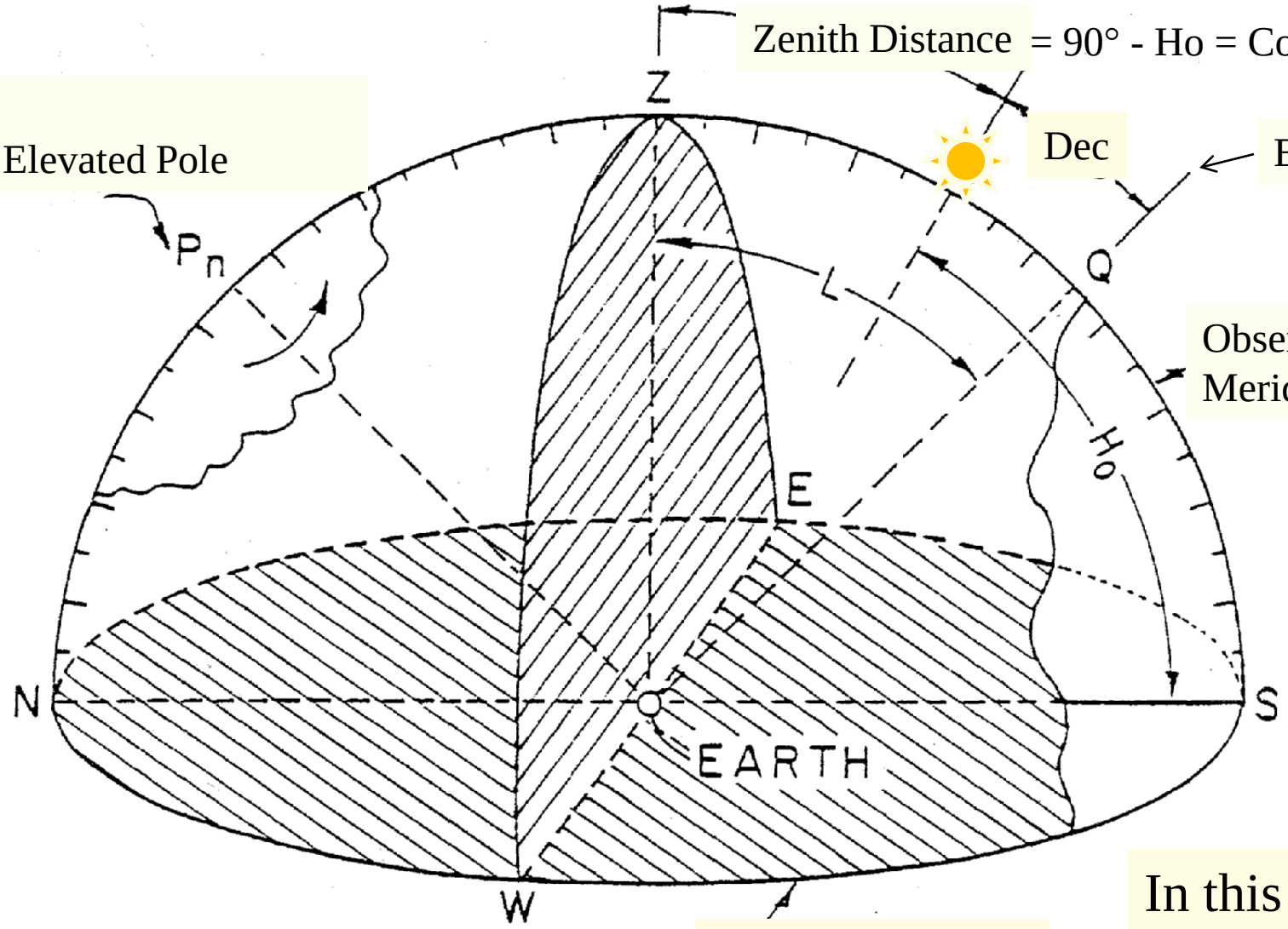
- LHA of Sun = 000° 00.0'
- Sun reaches max. altitude for that date & reference position.
- Azimuth of body is 0° (due north) or (180°) due south of observer's position.
- Navigation triangle collapses to straight line
  - Elevated pole, observer, and GP of body are all on the observer's meridian.
  - Observer's latitude can be found by simple addition or subtraction

Local Apparent Time = 1200



Observer's latitude = Zenith Distance ± Declination of Sun

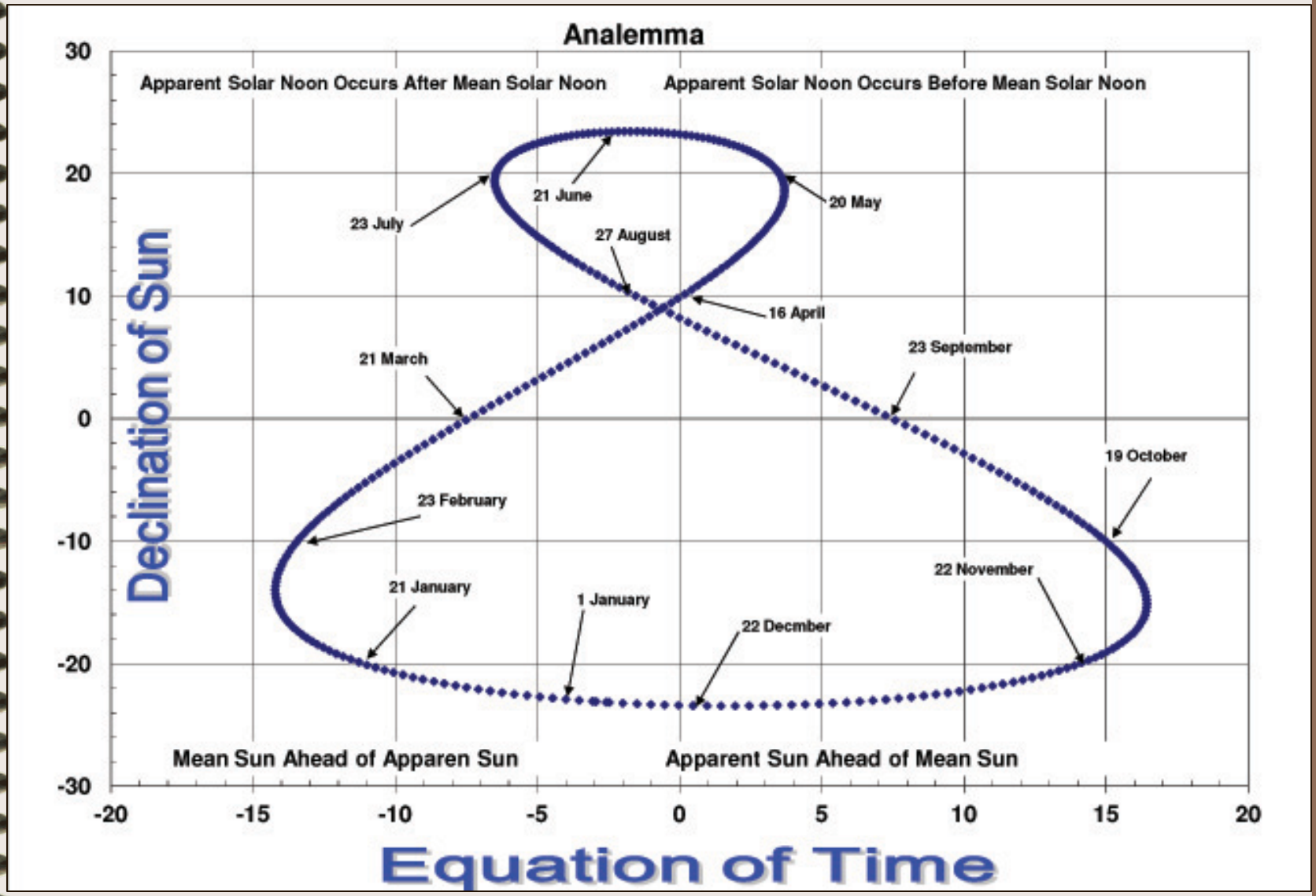
Isometric of Meridian Transit Diagram



In this example
L = CoAlt +Dec

Altitude of Sun at Transit for Year 2003 Location 48° 8.5' N 123° 26.0' W

Date	Sun's Altitude @ Transit	Sun's Altitude @ Transit ± 60 Seconds
15 January	21° 46.54'	21° 46.52'
15 February	29° 15.43'	29° 15.42'
15 March	39° 48.38'	39° 48.37'
15 April	51° 41.97'	51° 41.95'
15 May	61° 27.25'	61° 27.20'
15 June	65° 10.57'	65° 10.52'
15 July	63° 20.93'	63° 20.88'
15 August	55° 50.60'	55° 50.55'
15 September	44° 48.49'	44° 48.44'
15 October	33° 16.31'	33° 16.30'
15 November	23° 19.64'	23° 19.60'
15 December	18° 34.88'	18° 34.86'


Analemma
Apparent Solar Noon Occurs After Mean Solar Noon
Apparent Solar Noon Occurs Before Mean Solar Noon
21 June
20 May
23 July
27 August
16 April
21 March
23 September
19 October
23 February
22 November
21 January
1 January
22 Decmber
Mean Sun Ahead of Apparen Sun
Apparent Sun Ahead of Mean Sun
Declination of Sun
Equation of Time
30
20
10
0
-10
-20
-30
-20
-15
-10
-5
0
5
10
15
20