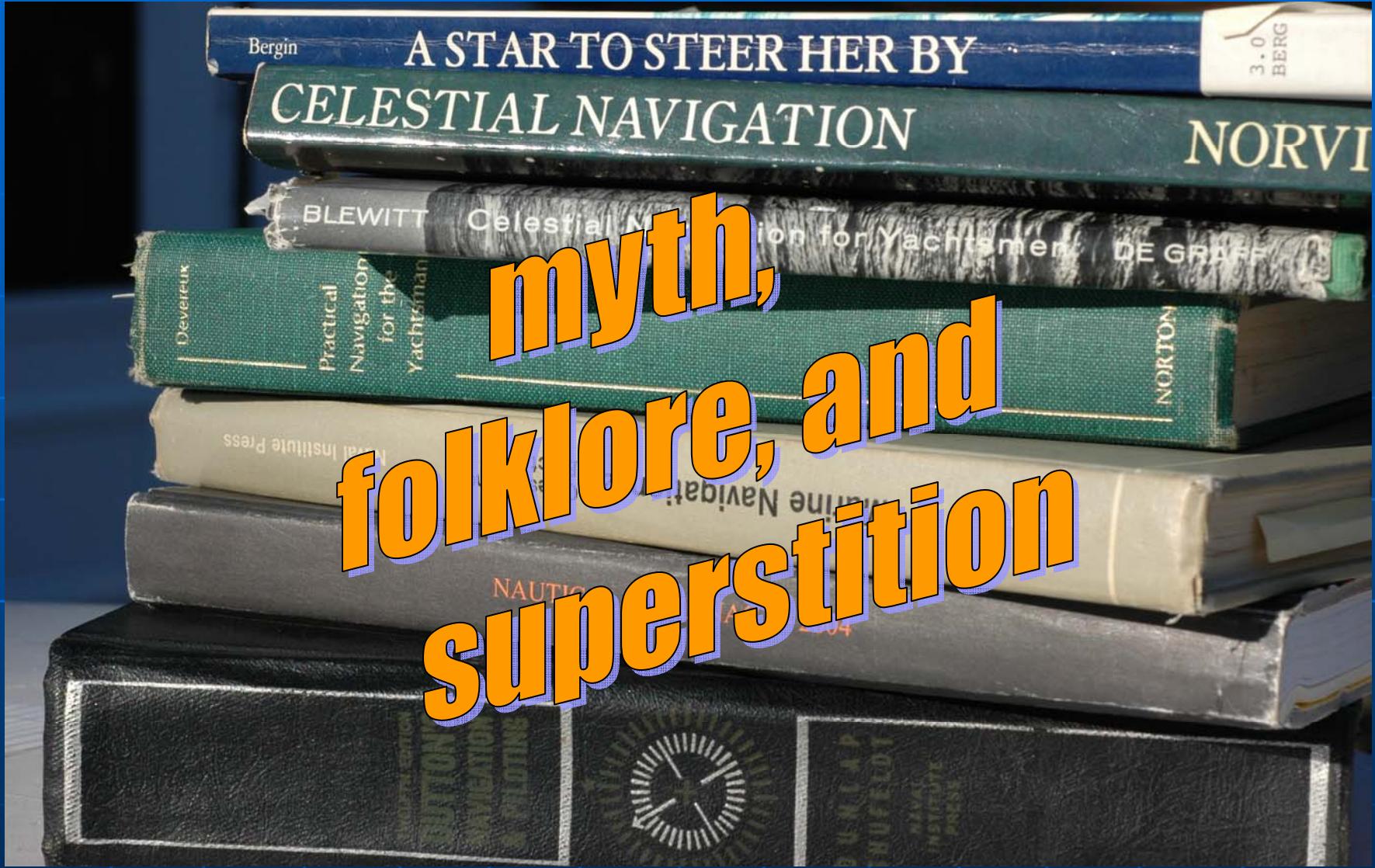


# Celestial Navigation

presented by Ralph Naranjo

**myth,  
folklore, and  
superstition**

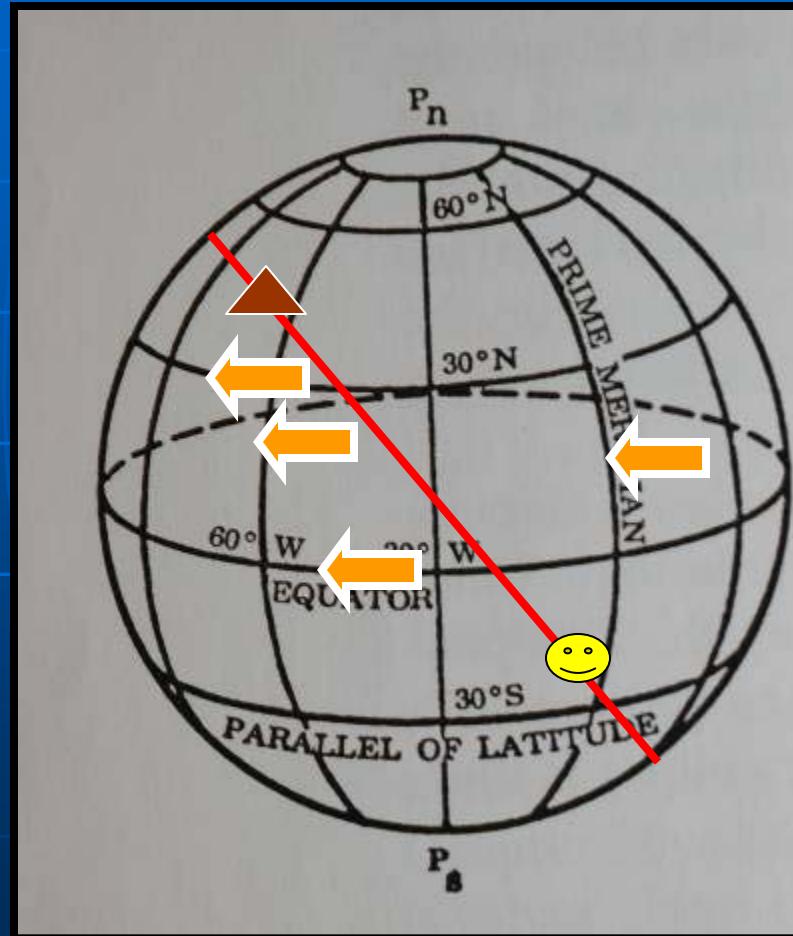


# Session 1

- General theory
- Nautical Almanac
- Sight reduction tables
- Plug and chug forms

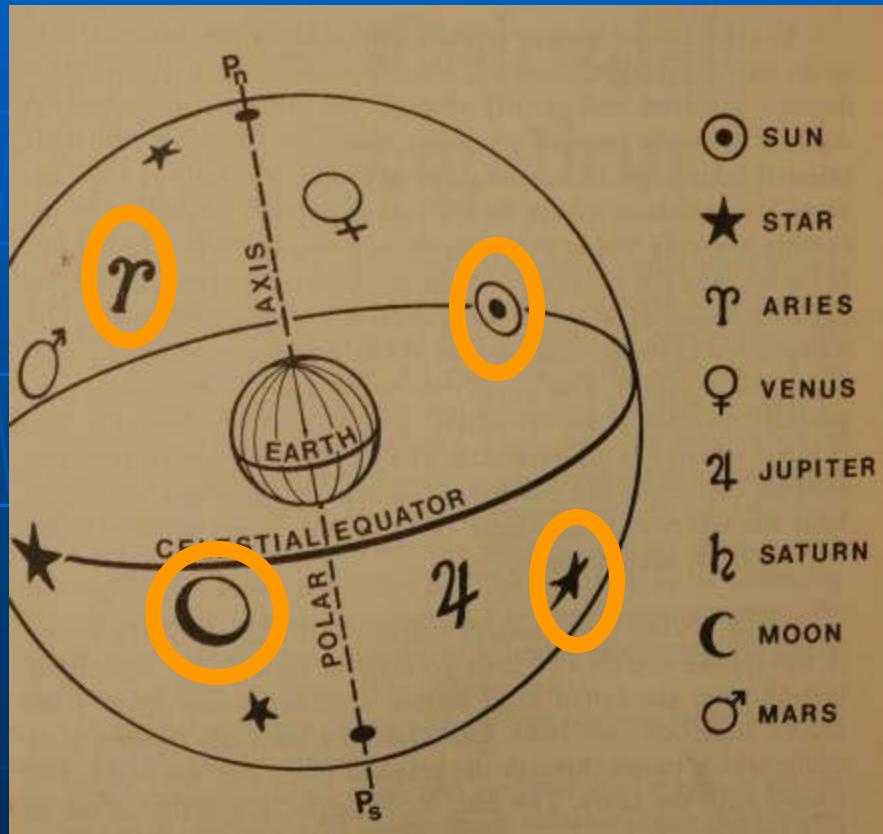


# Circles and spheres



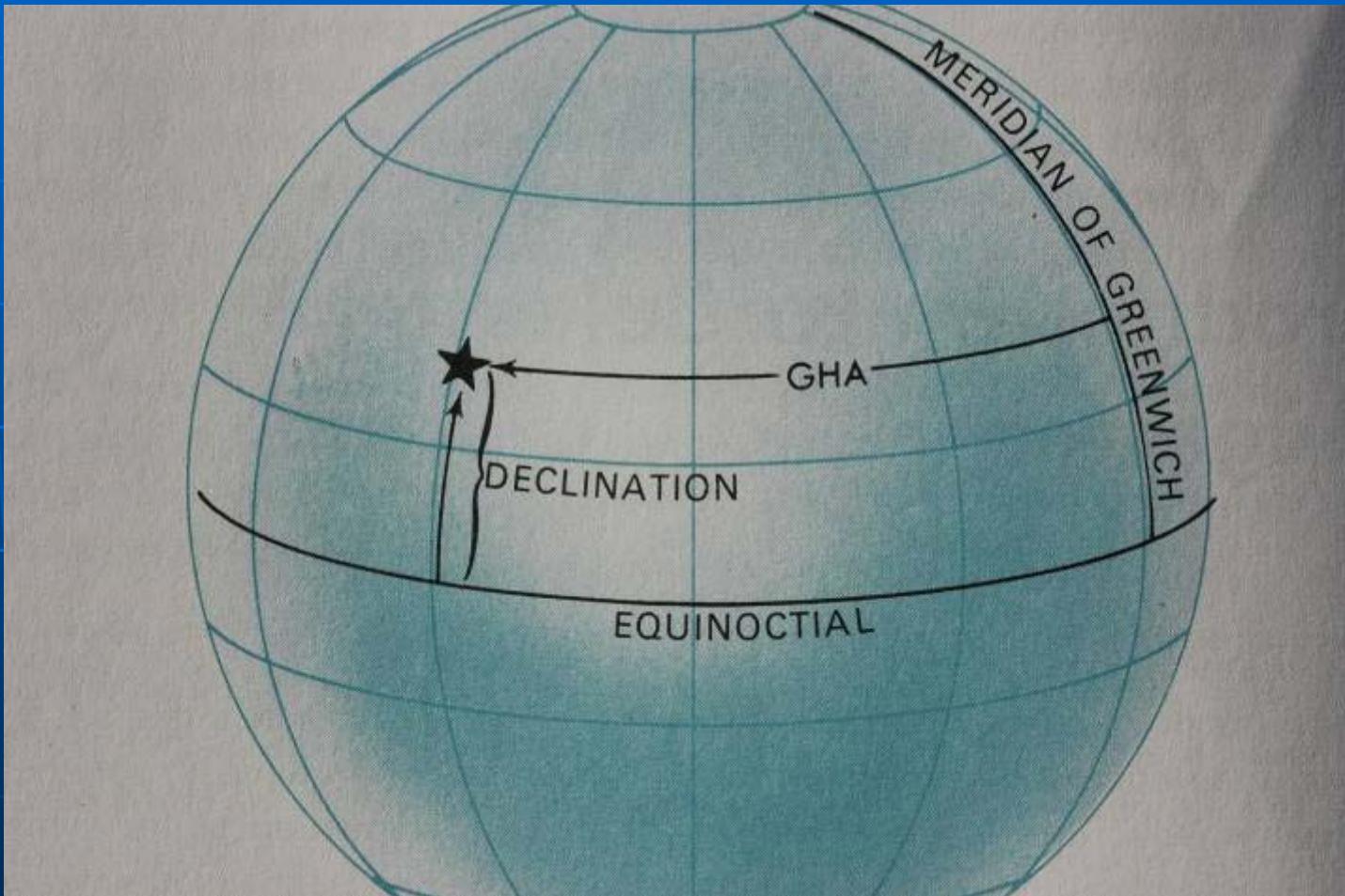
- Great circles
- Longitude
- Latitude
- Equator
- Parallels
- Obliquity of ecliptic

# Celestial sphere

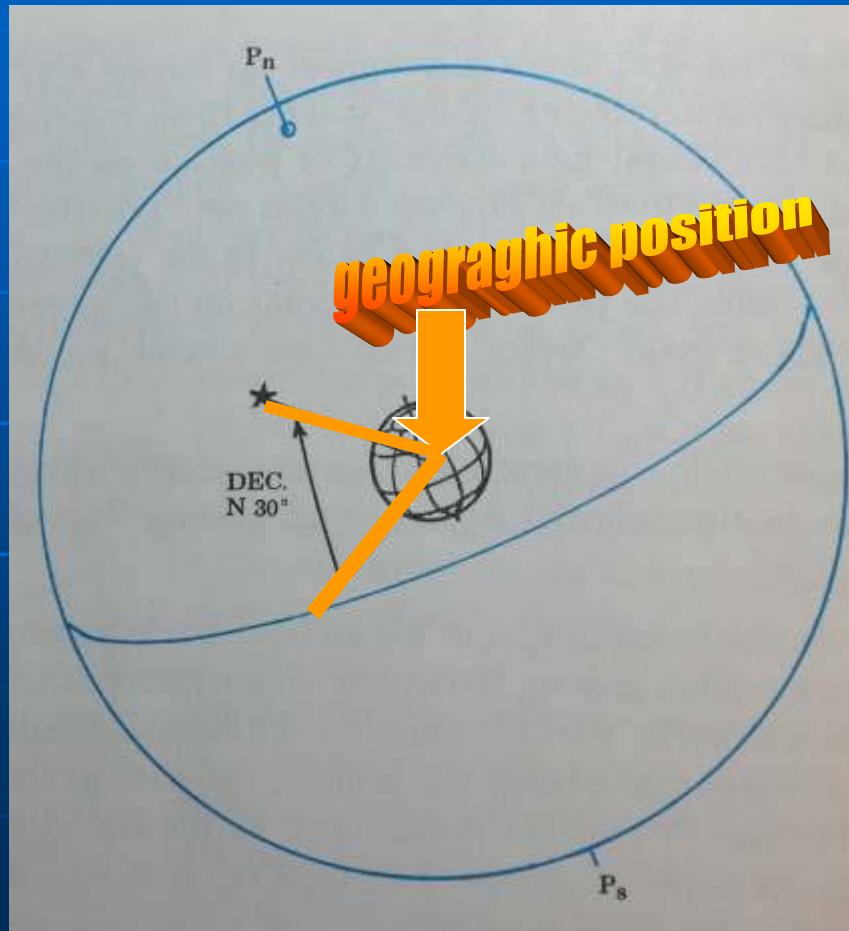


- Alignment
- Latitude & declination
- Longitude & GHA
- Equator and ecliptic

# Coordinates on the Celestial Sphere



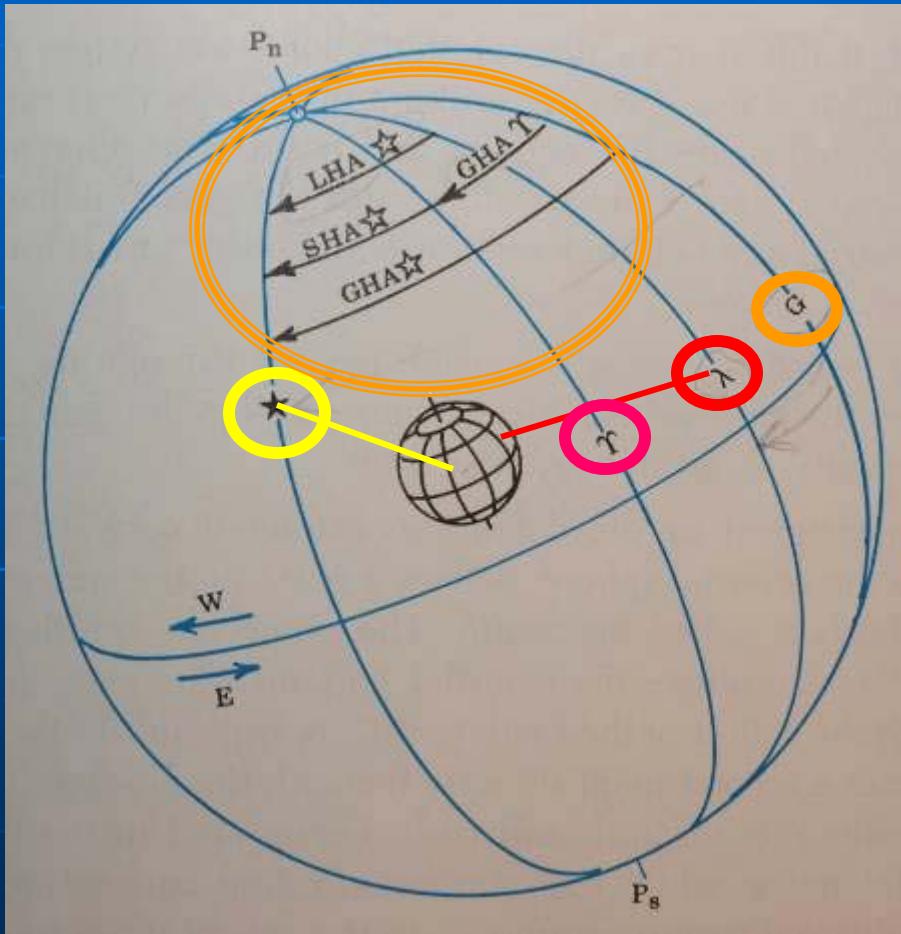
# Relationship of the spheres



- Geographic position
- Dec & GHA
- Lat and Long
- differences

# Establishing location

- Greenwich Hour Angle (GHA)
- Local Hour Angle (LHA)
- GHA Aries
- Sidereal Hour Angle (SHA)



# Arc, time and distance in a great circle context

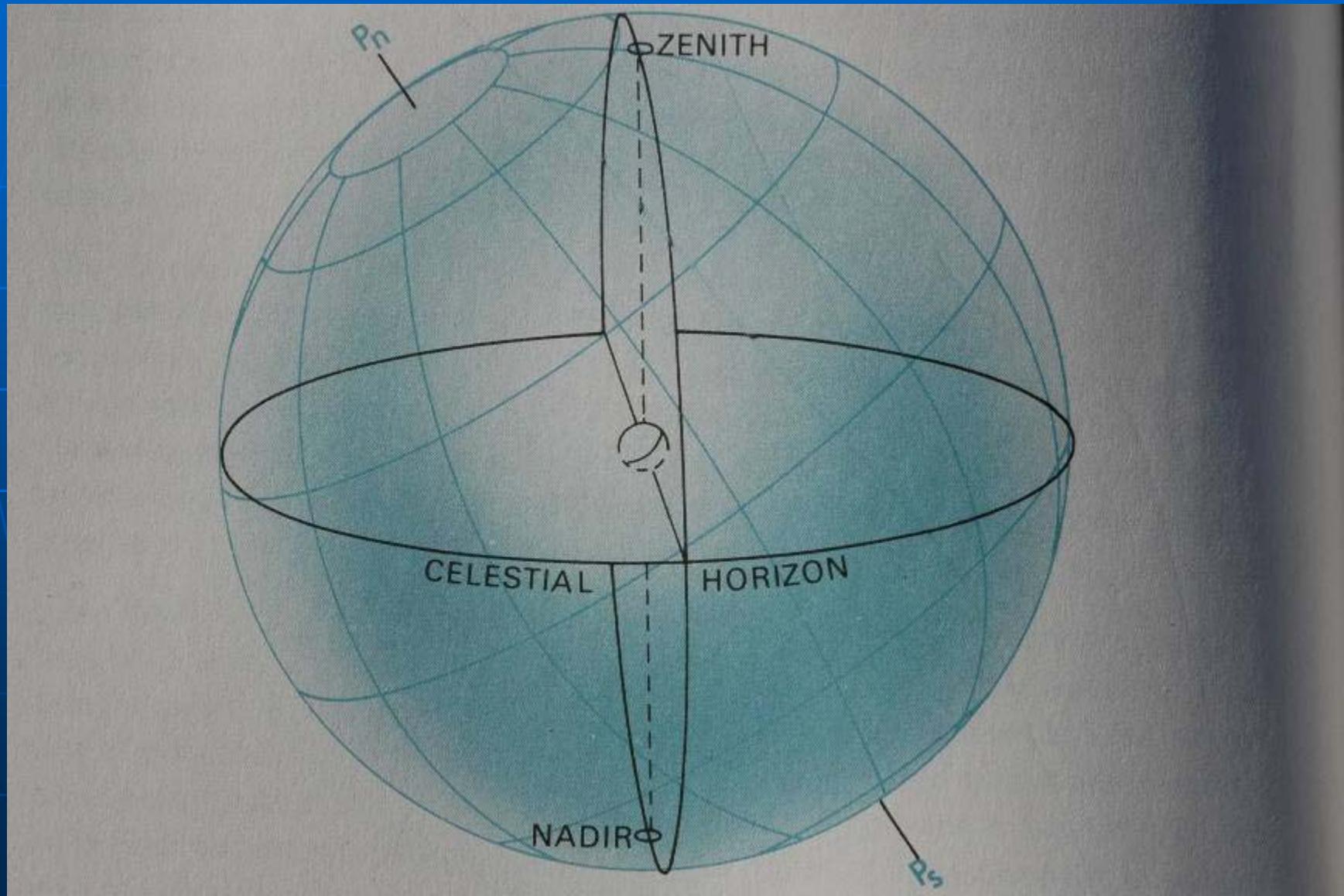
- Earth's circumference - a great circle
- 24hrs = 360 degrees of rotation
- 1 degree = 60 nautical miles
- 360 degrees = 21,600 nautical miles
- 15 degrees = 900 nautical miles = 1 hour (time)
- 1min(arc) = 1 nautical mile = 4 seconds (time)

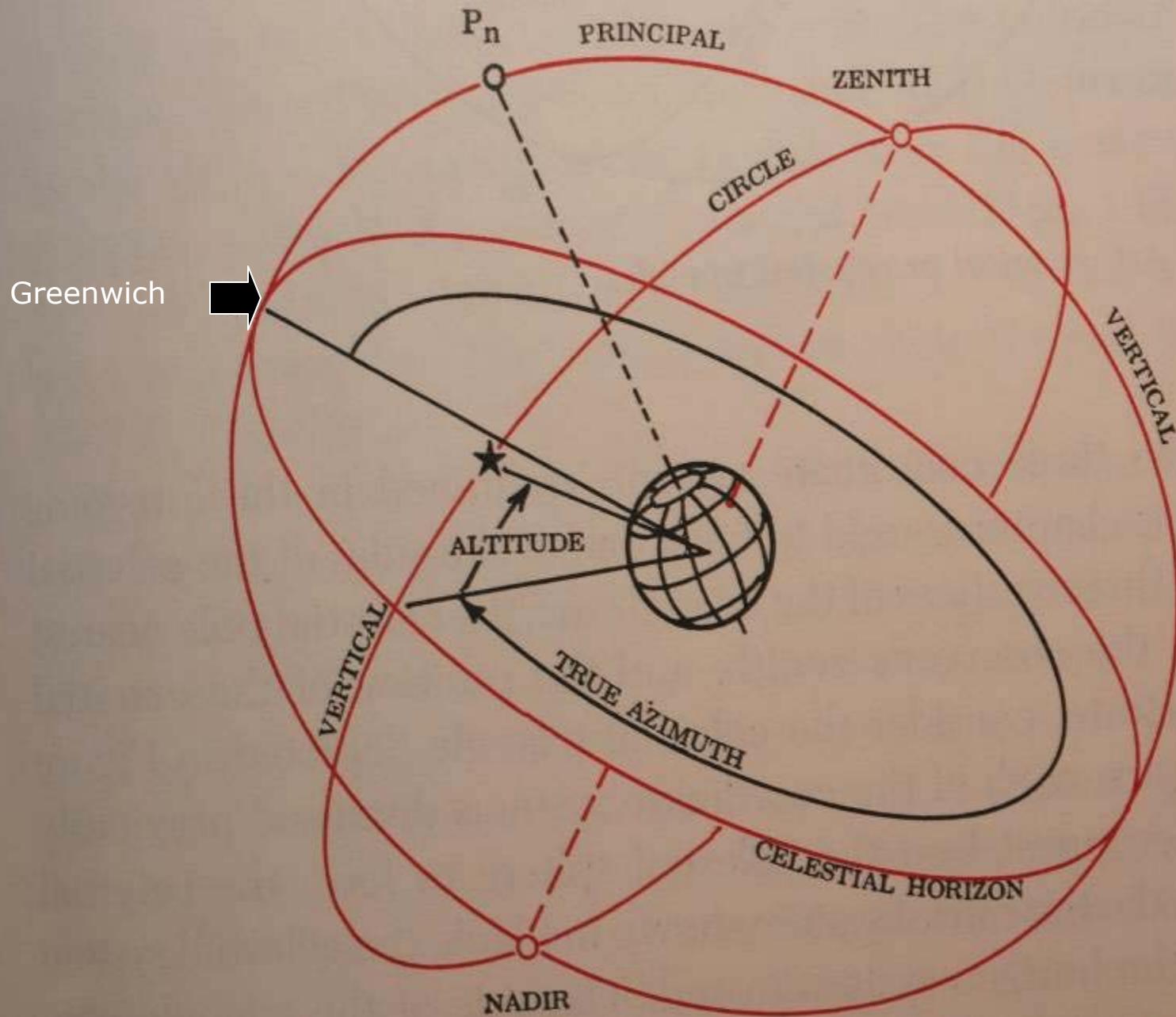
CONVERSION OF ARC TO TIME								
120°-179°		180°-239°		240°-299°		300°-359°		
°	h m	°	h m	°	h m	°	h m	
120	8 00	180	12 00	240	16 00	300	20 00	
121	8 04	181	12 04	241	16 04	301	20 04	
122	8 08	182	12 08	242	16 08	302	20 08	
123	8 12	183	12 12	243	16 12	303	20 12	
124	8 16	184	12 16	244	16 16	304	20 16	
125	8 20	185	12 20	245	16 20	305	20 20	
126	8 24	186	12 24	246	16 24	306	20 24	
127	8 28	187	12 28	247	16 28	307	20 28	
128	8 32	188	12 32	248	16 32	308	20 32	
129	8 36	189	12 36	249	16 36	309	20 36	

# Time

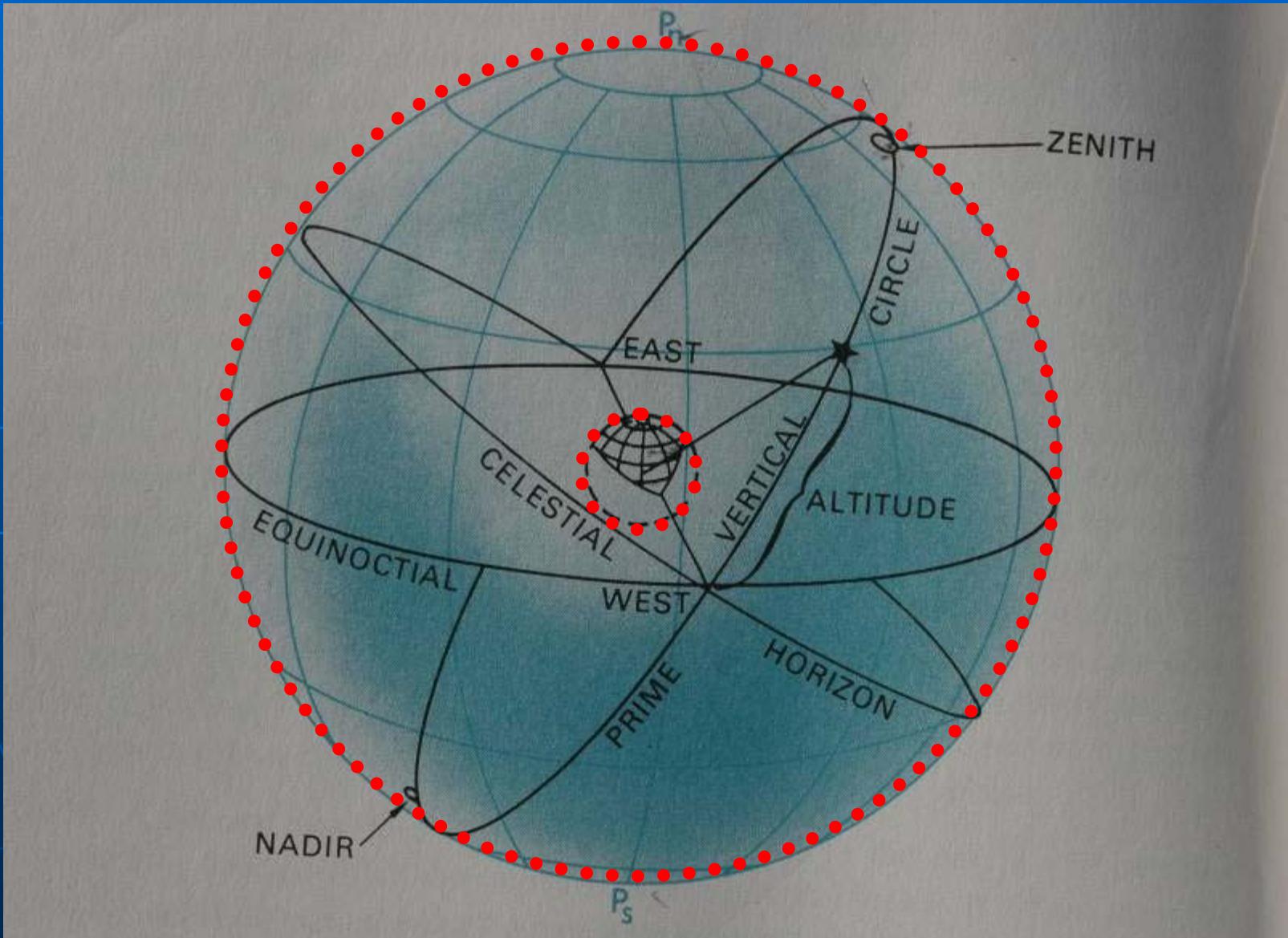
- EST (DST)
- GMT – Zulu – UT
- Zone time
- Sun Time

# The third sphere

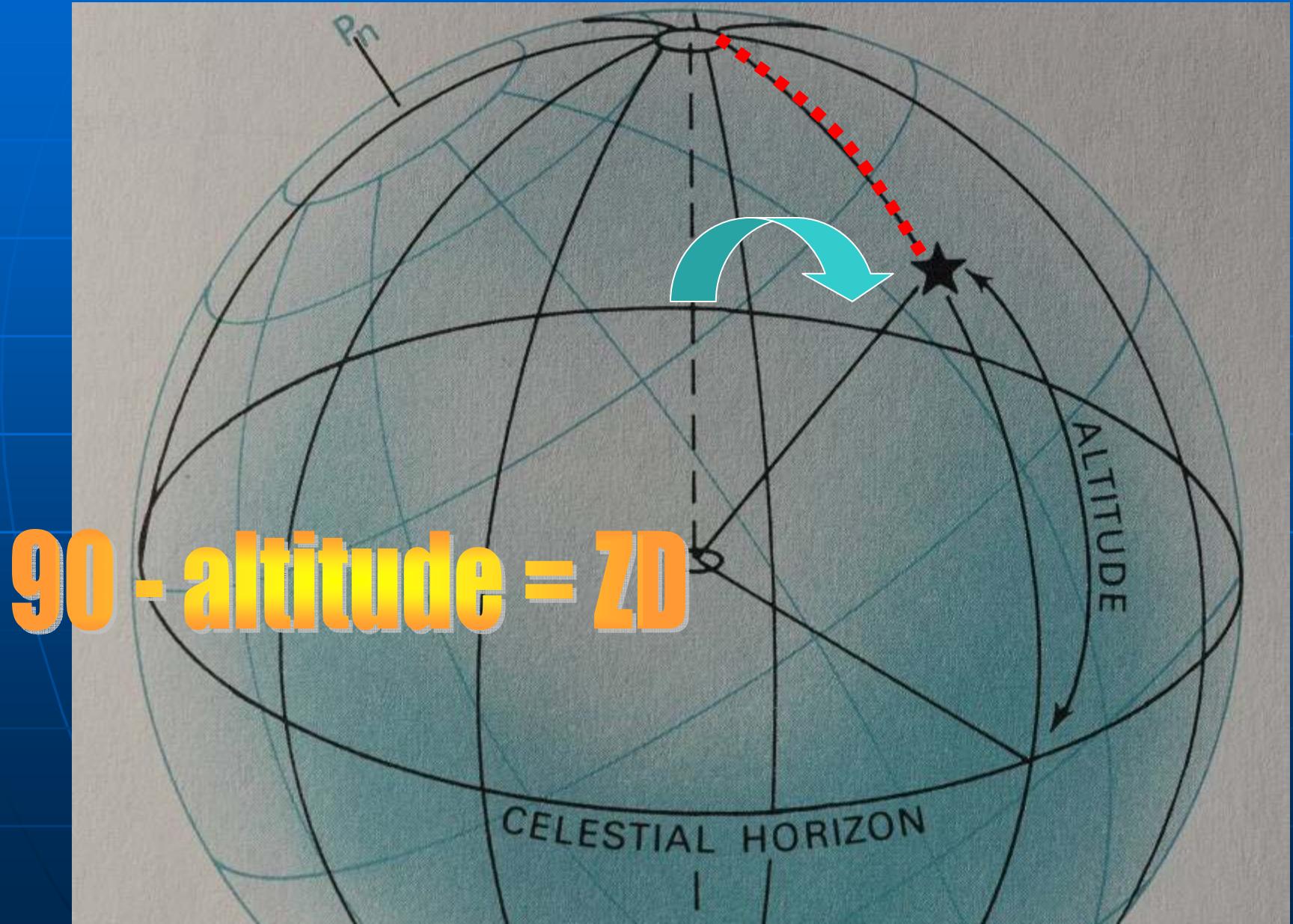




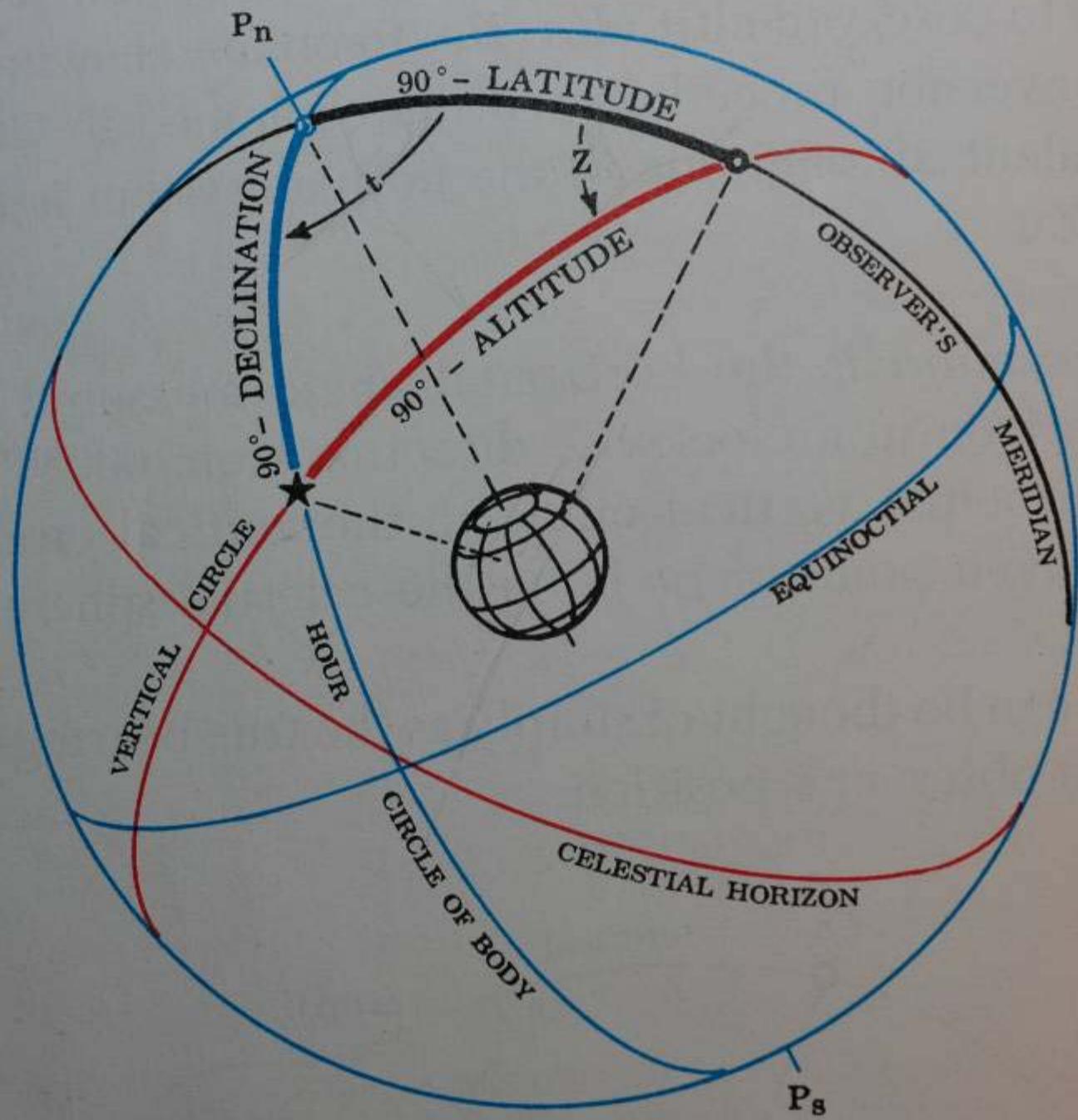
# Three sphere overlay



# Measuring altitude



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e



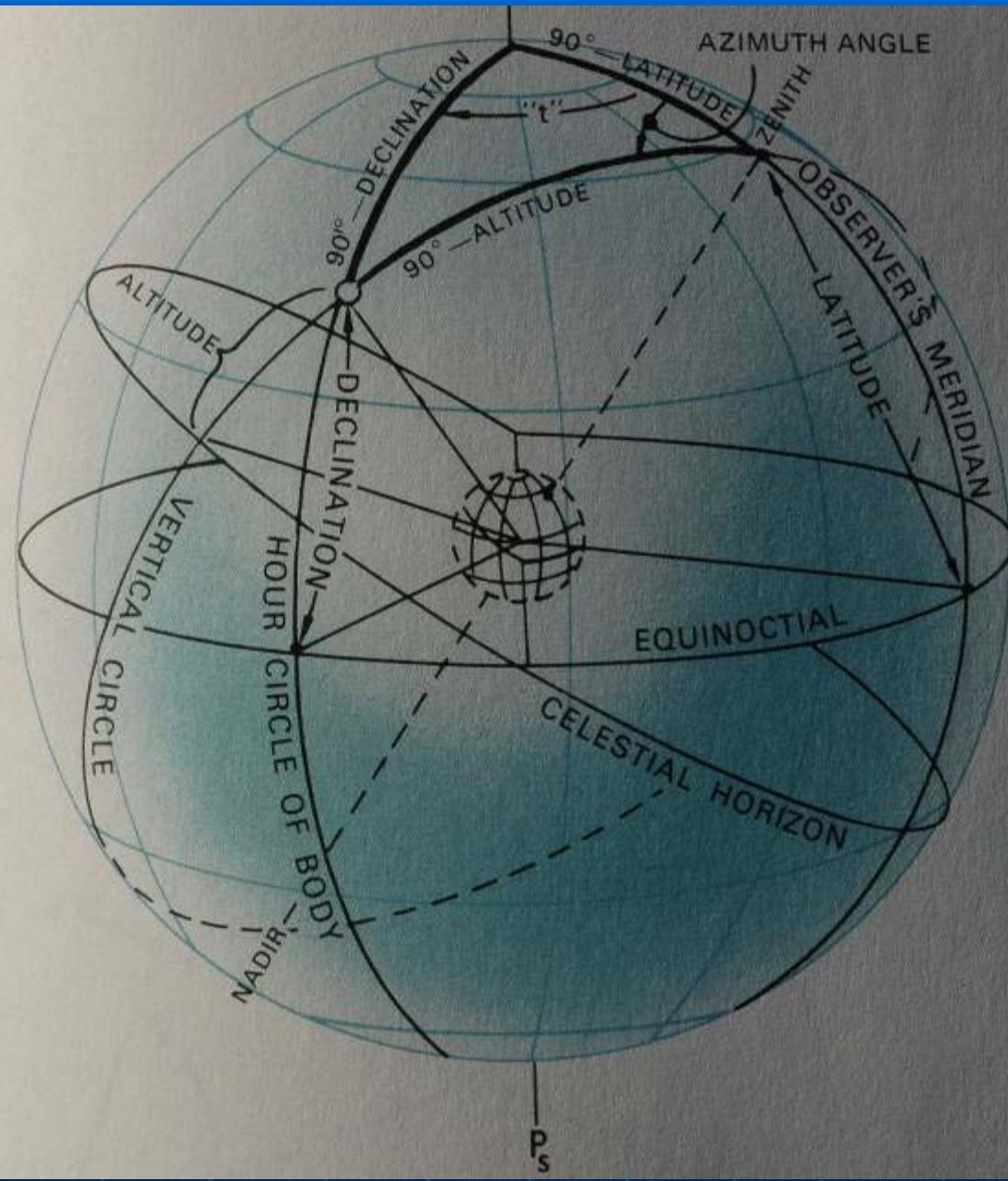
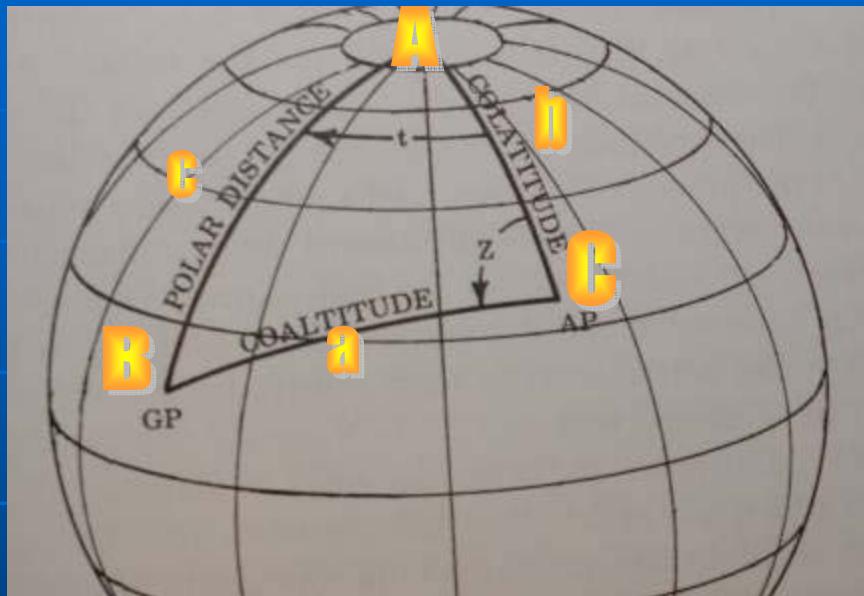


Figure 2005:  
Astronomical or  
celestial triangle.

# Solving the navigational triangle

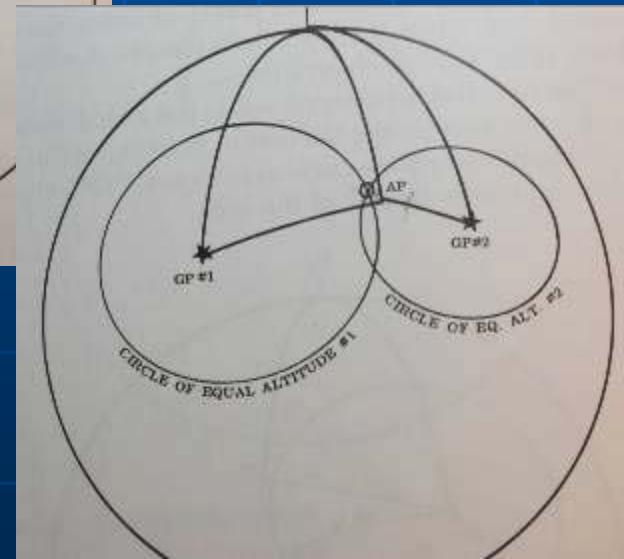
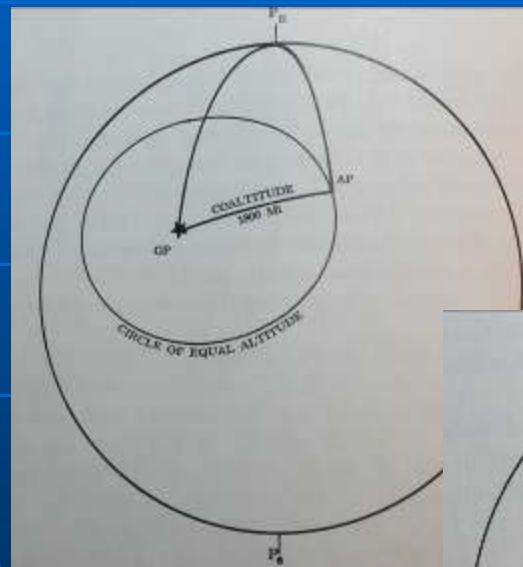
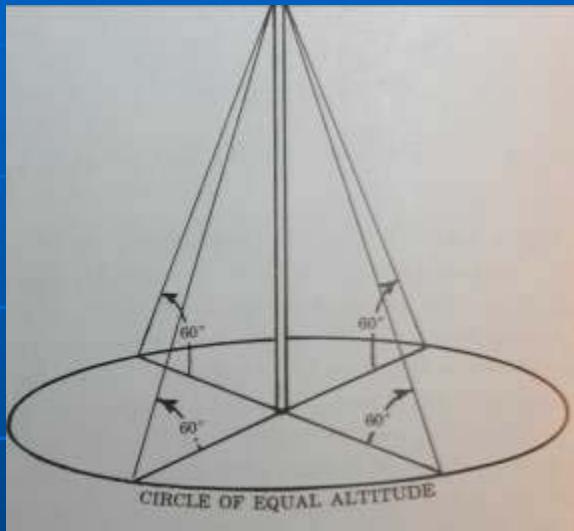


- Spherical trig
- Sight reduction tables
- Calculator
- Computer program

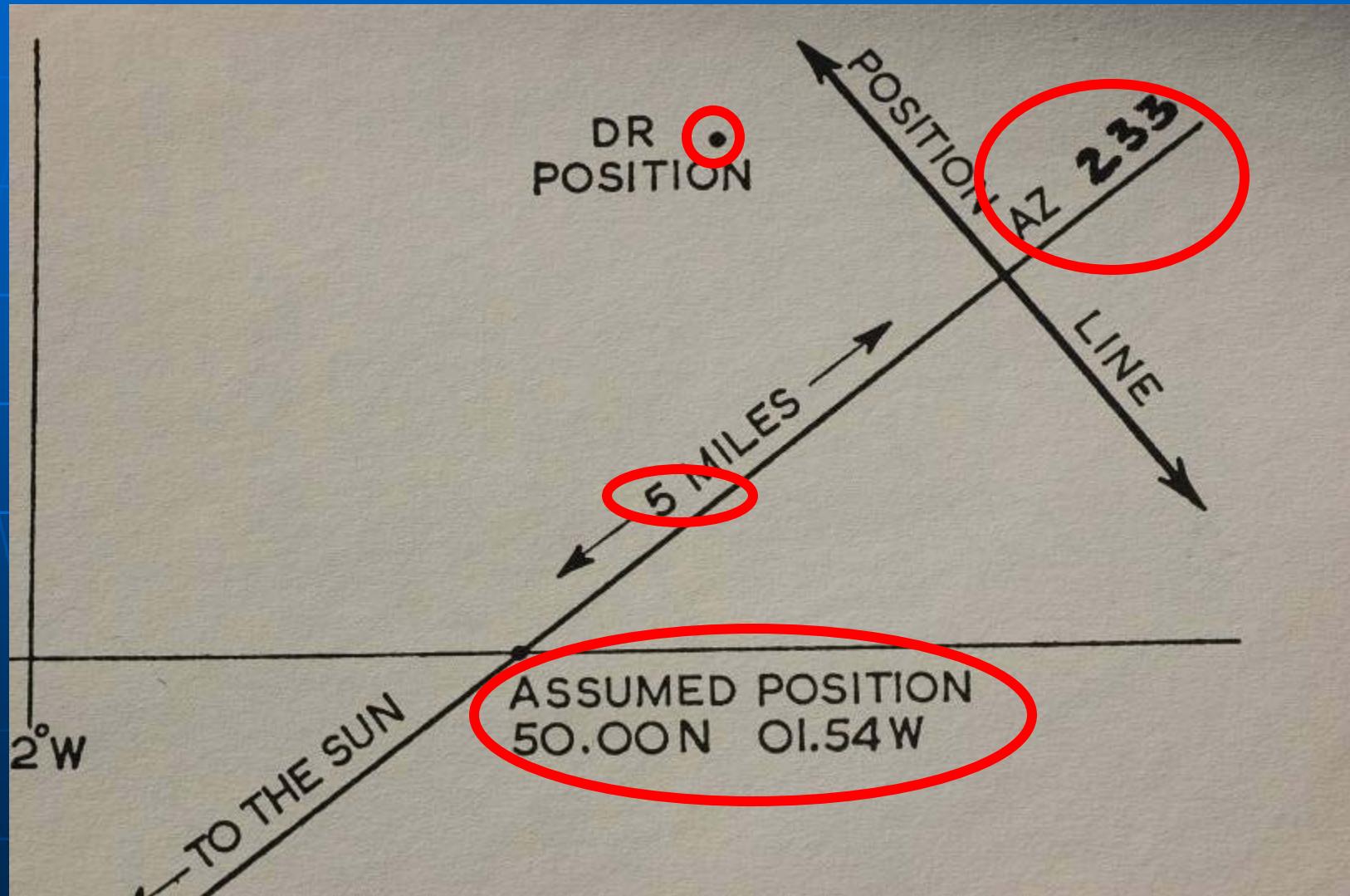
$$\cos a = \cos b \cos c + \sin b \sin c \cos A$$

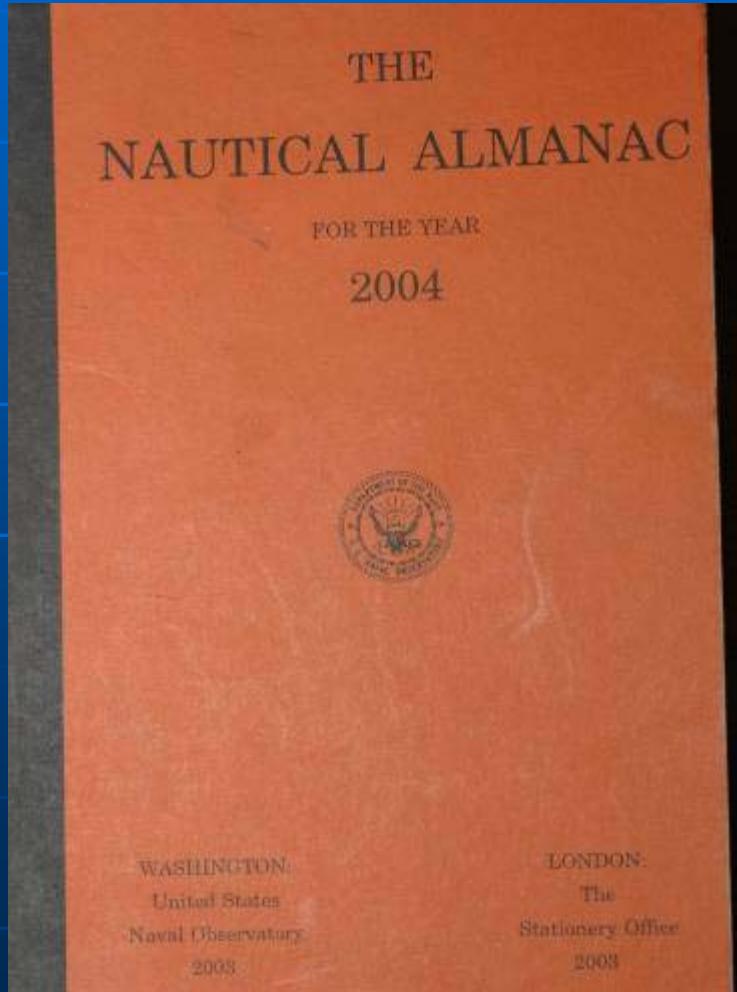
$$\cos C = \frac{\cos c - \cos a \cos b}{\sin a \sin b}$$

# LOP - circle of position - fix



# Plotting a line of position





- Ephemeris
- Layout
- Daily pages
- Corrections
- planets

# Daily pages

2004 AUGUST 25, 26, 27 (WED., THURS., FRI.)

UT	SUN		MOON					Lat.	Twilight		Sunrise	Moonrise		
	GHA	Dec	GHA	v	Dec	d	HP		Naut.	Civil		25	26	27
25 00	179 28.4	N10 42.9	71 31.0	3.4	S27 04.0	3.9	59.6	N 72	////	01 42	03 32	—	—	—
01	194 28.6	42.1	85 53.4	3.4	27 07.9	3.8	59.6	70	////	02 25	03 50	—	—	—
02	209 28.8	41.2	100 15.8	3.3	27 11.7	3.6	59.7	68	////	02 53	04 05	—	—	22 02
03	224 28.9	.. 40.3	114 38.1	3.2	27 15.3	3.4	59.7	66	01 28	03 13	04 16	—	—	20 36
04	239 29.1	39.5	129 00.3	3.2	27 18.7	3.2	59.7	64	02 06	03 30	04 26	—	—	19 58
05	254 29.3	38.6	143 22.5	3.1	27 21.9	3.0	59.7	62	02 32	03 43	04 34	19 47	20 01	19 31
06	269 29.5	N10 37.8	157 44.6	3.0	S27 24.9	2.9	59.7	58	03 07	04 04	04 47	17 51	18 43	19 10
W 07	284 29.6	36.9	172 06.6	3.0	27 27.8	2.6	59.7	56	03 20	04 12	04 53	17 25	18 20	18 53
E 08	299 29.8	36.0	186 28.6	3.0	27 30.4	2.4	59.7	54	03 31	04 20	04 58	17 05	18 01	18 38
E 09	314 30.0	.. 35.2	200 50.6	2.9	27 32.8	2.3	59.8	52	03 41	04 26	05 02	16 47	17 45	18 25
D 10	329 30.1	34.3	215 12.5	2.8	27 35.1	2.0	59.8	50	03 50	04 32	05 06	16 33	17 31	18 14
N 11	344 30.3	33.4	229 34.3	2.8	27 37.1	1.9	59.8	45	04 07	04 44	05 15	16 03	17 03	17 50
E 12	359 30.5	N10 32.6	243 56.1	2.8	S27 39.0	1.6	59.8	N 40	04 20	04 54	05 22	15 39	16 41	17 31
S 13	14 30.7	31.7	258 17.9	2.7	27 40.6	1.5	59.8	35	04 31	05 02	05 28	15 20	16 22	17 15
D 14	29 30.8	30.8	272 39.6	2.7	27 42.1	1.2	59.8	30	04 40	05 09	05 34	15 04	16 06	17 01
A 15	44 31.0	.. 30.0	287 01.3	2.7	27 43.3	1.1	59.8	20	04 54	05 20	05 43	14 36	15 39	16 37
Y 16	59 31.2	29.1	301 23.0	2.6	27 44.4	0.8	59.8	N 10	05 05	05 30	05 51	14 12	15 16	16 16
17	74 31.4	28.2	315 44.6	2.6	27 45.2	0.7	59.8	0	05 13	05 37	05 58	13 50	14 54	15 57
18	89 31.6	N10 27.4	330 06.2	2.6	S27 45.9	0.5	59.9	S 10	05 20	05 44	06 06	13 27	14 32	15 37
19	104 31.7	26.5	344 27.8	2.6	27 46.4	0.2	59.9	20	05 25	05 51	06 13	13 04	14 09	15 16
20	119 31.9	25.6	358 49.4	2.5	27 46.6	0.1	59.9	30	05 30	05 58	06 22	12 36	13 42	14 52
21	134 32.1	.. 24.7	13 10.9	2.5	27 46.7	0.2	59.9	35	05 32	06 01	06 27	12 20	13 26	14 38
22	149 32.3	23.9	27 32.4	2.5	27 46.5	0.3	59.9	40	05 33	06 05	06 32	12 01	13 07	14 21
23	164 32.4	23.0	41 53.9	2.5	27 46.2	0.6	59.9	45	05 35	06 09	06 39	11 38	12 44	14 01

# Handling the yellow pages

INCREMENTS AND CORRECTIONS											
	$v$ or $d$	$v$ or $d$	$v$ or $d$			$m$ 27	SUN PLANETS	ARIES	MOON		
	'	'	'	'	'	s	°	'	°	'	
0·0	0·0	6·0	2·7	12·0	5·3	00	6 45·0	6 46·1	6 26·6	0	
0·1	0·0	6·1	2·7	12·1	5·3	01	6 45·3	6 46·4	6 26·8	0	
0·2	0·1	6·2	2·7	12·2	5·4	02	6 45·5	6 46·6	6 27·0	0	
0·3	0·1	6·3	2·8	12·3	5·4	03	6 45·8	6 46·9	6 27·3	0	
0·4	0·2	6·4	2·8	12·4	5·5	04	6 46·0	6 47·1	6 27·5	0	
0·5	0·2	6·5	2·9	12·5	5·5	05	6 46·3	6 47·4	6 27·7	0	
0·6	0·3	6·6	2·9	12·6	5·6	06	6 46·5	6 47·6	6 28·0	0	
0·7	0·3	6·7	3·0	12·7	5·6	07	6 46·8	6 47·9	6 28·2	0	
0·8	0·4	6·8	3·0	12·8	5·7	08	6 47·0	6 48·1	6 28·5	0	
0·9	0·4	6·9	3·0	12·9	5·7	09	6 47·3	6 48·4	6 28·7	0	
1·0	0·4	7·0	3·1	13·0	5·7	10	6 47·5	6 48·6	6 28·9	1	
						11	6 47·8	6 48·9	6 29·2	1	

- Calculate min and sec value of GHA
- v or d correction

# Semi diameter - - finding the middle

ALTITUDE CORRECTION TABLES 0°-10°—SUN, STARS, PLANETS A3												
APP. AIR	OCT.—MAR.				SUN APR.—SEPT.				STARS, PLANETS			
	Lower Limb	Upper Limb	Lower Limb	Upper Limb	Lower Limb	Upper Limb	Lower Limb	Upper Limb	Lower Limb	Upper Limb	Lower Limb	Upper Limb
0 00	-17.5	-49.8	-17.8	-49.6	-33.8		3 30	+ 3.4 -28.9	+ 3.1 -38.7	-12.9		
0 03	-16.9	-49.2	-17.2	-49.0	-33.2		3 35	+ 3.6 -28.7	+ 3.3 -38.5	-12.7		
0 06	-16.3	-48.6	-16.6	-48.4	-32.6		3 40	+ 3.8 -28.5	+ 3.6 -38.3	-12.5		
0 09	-15.7	-48.0	-16.0	-47.8	-32.0		3 45	+ 4.0 -28.3	+ 3.8 -38.0	-12.3		
0 12	-15.2	-47.5	-15.4	-47.2	-31.4		3 50	+ 4.2 -28.1	+ 4.0 -37.8	-12.1		
0 15	-14.6	-46.9	-14.8	-46.6	-30.6		4 4	+ 4.4 -27.9	+ 4.1 -37.7	-11.9		
0 18	-14.1	-46.4	-14.2	-46.1	-		4 5	+ 4.5 -27.7	+ 4.3 -37.5	-11.7		
0 21	-13.5	-45.8	-13.8	-45.6	-		4 5	+ 4.5 -27.5	+ 4.5 -37.3	-11.5		
0 24	-13.0	-45.3	-13.3	-45.1	-		4 7	+ 4.7 -27.1	+ 4.6 -36.9	-11.4		
0 27	-12.5	-44.8	-12.8	-44.6	-		4 7	+ 4.7 -26.9	+ 4.6 -36.7	-11.2		
0 30	-12.0	-44.3	-12.3	-44.1	-		5 0	+ 5.0 -26.6	+ 4.9 -36.5	-11.0		
0 33	-11.6	-43.9	-11.8	-43.7	-		5 0	+ 5.0 -26.4	+ 4.9 -36.3	-10.9		
0 36	-11.1	-43.4	-11.3	-43.2	-		5 3	+ 5.3 -26.1	+ 5.2 -36.1	-10.7		
0 39	-10.6	-42.9	-10.8	-42.7	-		5 3	+ 5.3 -25.9	+ 5.2 -35.9	-10.5		
0 42	-10.2	-42.5	-10.4	-42.3	-		5 5	+ 5.5 -25.7	+ 5.4 -35.7	-10.3		
0 45	-9.8	-42.1	-10.0	-41.9	-		5 5	+ 5.5 -25.5	+ 5.4 -35.5	-10.1		
0 48	-9.4	-41.7	-9.6	-41.5	-		5 7	+ 5.7 -25.3	+ 5.6 -35.3	-9.9		
0 51	-9.0	-41.3	-9.2	-41.1	-		5 7	+ 5.7 -25.1	+ 5.6 -35.1	-9.7		
0 54	-8.6	-40	-8.8	-39.8	-		6 0	+ 6.0 -24.9	+ 5.9 -34.9	-9.5		
0 57	-8.2	-	-8.4	-			6 0	+ 6.0 -24.7	+ 5.9 -34.7	-9.3		
1 00	-7.8	-	-8.0	-			6 0	+ 6.0 -24.5	+ 5.9 -34.5	-9.1		
1 03	-7.4	-	-7.6	-			6 0	+ 6.0 -24.3	+ 5.9 -34.3	-8.9		
1 06	-7	-	-7.2	-			6 0	+ 6.0 -24.1	+ 5.9 -34.1	-8.7		
1 09	-	-	-6.6	-			6 0	+ 6.0 -23.9	+ 5.9 -33.9	-8.5		
1 12	-	-	-6.2	-			6 0	+ 6.0 -23.7	+ 5.9 -33.7	-8.3		
1 15	-	-	-5.8	-			6 0	+ 6.0 -23.5	+ 5.9 -33.5	-8.1		
1 18	-	-	-5.4	-			6 0	+ 6.0 -23.3	+ 5.9 -33.3	-7.9		
1 21	-	-	-5.0	-			6 0	+ 6.0 -23.1	+ 5.9 -33.1	-7.7		
1 24	-	-	-4.6	-			6 0	+ 6.0 -22.9	+ 5.9 -32.9	-7.5		
1 27	-	-	-4.2	-			6 0	+ 6.0 -22.7	+ 5.9 -32.7	-7.3		
1 30	-	-	-3.8	-			6 0	+ 6.0 -22.5	+ 5.9 -32.5	-7.1		
1 33	-	-	-3.4	-			6 0	+ 6.0 -22.3	+ 5.9 -32.3	-6.9		
1 36	-	-	-3.0	-			6 0	+ 6.0 -22.1	+ 5.9 -32.1	-6.7		
1 39	-	-	-2.6	-			6 0	+ 6.0 -21.9	+ 5.9 -31.9	-6.5		
1 42	-	-	-2.2	-			6 0	+ 6.0 -21.7	+ 5.9 -31.7	-6.3		
1 45	-	-	-1.8	-			6 0	+ 6.0 -21.5	+ 5.9 -31.5	-6.1		
1 48	-	-	-1.4	-			6 0	+ 6.0 -21.3	+ 5.9 -31.3	-5.9		
1 51	-	-	-1.0	-			6 0	+ 6.0 -21.1	+ 5.9 -31.1	-5.7		
1 54	-	-	-0.6	-			6 0	+ 6.0 -20.9	+ 5.9 -30.9	-5.5		
1 57	-	-	-0.2	-			6 0	+ 6.0 -20.7	+ 5.9 -30.7	-5.3		
1 60	-	-	-0.8	-			6 0	+ 6.0 -20.5	+ 5.9 -30.5	-5.1		
1 63	-	-	-0.4	-			6 0	+ 6.0 -20.3	+ 5.9 -30.3	-4.9		
1 66	-	-	-0.0	-			6 0	+ 6.0 -20.1	+ 5.9 -30.1	-4.7		
1 69	-	-	-0.6	-			6 0	+ 6.0 -19.9	+ 5.9 -29.9	-4.5		
1 72	-	-	-0.2	-			6 0	+ 6.0 -19.7	+ 5.9 -29.7	-4.3		
1 75	-	-	-0.8	-			6 0	+ 6.0 -19.5	+ 5.9 -29.5	-4.1		
1 78	-	-	-0.4	-			6 0	+ 6.0 -19.3	+ 5.9 -29.3	-3.9		
1 81	-	-	-0.0	-			6 0	+ 6.0 -19.1	+ 5.9 -29.1	-3.7		
1 84	-	-	-0.6	-			6 0	+ 6.0 -18.9	+ 5.9 -28.9	-3.5		
1 87	-	-	-0.2	-			6 0	+ 6.0 -18.7	+ 5.9 -28.7	-3.3		
1 90	-	-	-0.8	-			6 0	+ 6.0 -18.5	+ 5.9 -28.5	-3.1		
1 93	-	-	-0.4	-			6 0	+ 6.0 -18.3	+ 5.9 -28.3	-2.9		
1 96	-	-	-0.0	-			6 0	+ 6.0 -18.1	+ 5.9 -28.1	-2.7		
1 99	-	-	-0.6	-			6 0	+ 6.0 -17.9	+ 5.9 -27.9	-2.5		
2 02	-	-	-0.2	-			6 0	+ 6.0 -17.7	+ 5.9 -27.7	-2.3		
2 05	-	-	-0.8	-			6 0	+ 6.0 -17.5	+ 5.9 -27.5	-2.1		
2 08	-	-	-0.4	-			6 0	+ 6.0 -17.3	+ 5.9 -27.3	-1.9		
2 11	-	-	-0.0	-			6 0	+ 6.0 -17.1	+ 5.9 -27.1	-1.7		
2 14	-	-	-0.6	-			6 0	+ 6.0 -16.9	+ 5.9 -26.9	-1.5		
2 17	-	-	-0.2	-			6 0	+ 6.0 -16.7	+ 5.9 -26.7	-1.3		
2 20	-	-	-0.8	-			6 0	+ 6.0 -16.5	+ 5.9 -26.5	-1.1		
2 23	-	-	-0.4	-			6 0	+ 6.0 -16.3	+ 5.9 -26.3	-0.9		
2 26	-	-	-0.0	-			6 0	+ 6.0 -16.1	+ 5.9 -26.1	-0.7		
2 29	-	-	-0.6	-			6 0	+ 6.0 -15.9	+ 5.9 -25.9	-0.5		
2 32	-	-	-0.2	-			6 0	+ 6.0 -15.7	+ 5.9 -25.7	-0.3		
2 35	-	-	-0.8	-			6 0	+ 6.0 -15.5	+ 5.9 -25.5	-0.1		
2 38	-	-	-0.4	-			6 0	+ 6.0 -15.3	+ 5.9 -25.3	-0.3		
2 41	-	-	-0.0	-			6 0	+ 6.0 -15.1	+ 5.9 -25.1	-0.1		
2 44	-	-	-0.6	-			6 0	+ 6.0 -14.9	+ 5.9 -24.9	-0.3		
2 47	-	-	-0.2	-			6 0	+ 6.0 -14.7	+ 5.9 -24.7	-0.1		
2 50	-	-	-0.8	-			6 0	+ 6.0 -14.5	+ 5.9 -24.5	-0.3		
2 53	-	-	-0.4	-			6 0	+ 6.0 -14.3	+ 5.9 -24.3	-0.1		
2 56	-	-	-0.0	-			6 0	+ 6.0 -14.1	+ 5.9 -24.1	-0.3		
2 59	-	-	-0.6	-			6 0	+ 6.0 -13.9	+ 5.9 -23.9	-0.1		
2 62	-	-	-0.2	-			6 0	+ 6.0 -13.7	+ 5.9 -23.7	-0.3		
2 65	-	-	-0.8	-			6 0	+ 6.0 -13.5	+ 5.9 -23.5	-0.1		
2 68	-	-	-0.4	-			6 0	+ 6.0 -13.3	+ 5.9 -23.3	-0.3		
2 71	-	-	-0.0	-			6 0	+ 6.0 -13.1	+ 5.9 -23.1	-0.1		
2 74	-	-	-0.6	-			6 0	+ 6.0 -12.9	+ 5.9 -22.9	-0.3		
2 77	-	-	-0.2	-			6 0	+ 6.0 -12.7	+ 5.9 -22.7	-0.1		
2 80	-	-	-0.8	-			6 0	+ 6.0 -12.5	+ 5.9 -22.5	-0.3		
2 83	-	-	-0.4	-			6 0	+ 6.0 -12.3	+ 5.9 -22.3	-0.1		
2 86	-	-	-0.0	-			6 0	+ 6.0 -12.1	+ 5.9 -22.1	-0.3		
2 89	-	-	-0.6	-			6 0	+ 6.0 -11.9	+ 5.9 -21.9	-0.1		
2 92	-	-	-0.2	-			6 0	+ 6.0 -11.7	+ 5.9 -21.7	-0.3		
2 95	-	-	-0.8	-			6 0	+ 6.0 -11.5	+ 5.9 -21.5	-0.1		
2 98	-	-	-0.4	-			6 0	+ 6.0 -11.3	+ 5.9 -21.3	-0.3		
3 01	-	-	-0.0	-			6 0	+ 6.0 -11.1	+ 5.9 -21.1	-0.1		
3 04	-	-	-0.6	-			6 0	+ 6.0 -10.9	+ 5.9 -20.9	-0.3		
3 07	-	-	-0.2	-			6 0	+ 6.0 -10.7	+ 5.9 -20.7	-0.1		
3 10	-	-	-0.8	-			6 0	+ 6.0 -10.5	+ 5.9 -20.5	-0.3		
3 13	-	-	-0.4	-			6 0	+ 6.0 -10.3	+ 5.9 -20.3	-0.1		
3 16	-	-	-0.0	-			6 0	+ 6.0 -10.1	+ 5.9 -20.1	-0.3		
3 19	-	-	-0.6	-			6 0	+ 6.0 -9.9	+ 5.9 -19.9	-0.1		
3 22	-	-	-0.2	-			6 0	+ 6.0 -9.7	+ 5.9 -19.7	-0.3		
3 25	-	-	-0.8	-			6 0	+ 6.0 -9.5	+ 5.9 -19.5	-0.1		
3 28	-	-	-0.4	-			6 0	+ 6.0 -9.3	+ 5.9 -19.3	-0.3		
3 31	-	-	-0.0	-			6 0	+ 6.0 -9.1	+ 5.9 -19.1	-0.1		
3 34	-	-	-0.6	-			6 0	+ 6.0 -8.9	+ 5.9 -18.9	-0.3		
3 37	-	-	-0.2	-			6 0	+ 6.0 -8.7	+ 5.9 -18.7	-0.1		
3 40	-	-	-0.8	-			6 0	+ 6.0 -8.5	+ 5.9 -18.5	-0.3		
3 43	-	-	-0.4	-			6 0	+ 6.0 -8.3	+ 5.9 -18.3	-0.1		
3 46	-	-	-0.0	-			6 0	+ 6.0 -8.1	+ 5.9 -18.1	-0.3		
3 49	-	-	-0.6	-			6 0	+ 6.0 -7.9	+ 5.9 -17.9	-0.1		
3 52	-	-	-0.2	-			6 0	+ 6.0 -7.7	+ 5.9 -17.7	-0.3		
3 55	-	-	-0.8	-			6 0	+ 6.0 -7.5	+ 5.9 -17.5	-0.1		
3 58	-	-	-0.4	-			6 0	+ 6.0 -7.3	+ 5.9 -17.3	-0.3		
3 61	-	-	-0.0	-			6 0	+ 6.0 -7.1	+ 5.9 -17.1	-0.1		
3 64	-	-	-0.6	-			6 0	+ 6.0 -6.9	+ 5.9 -16.9	-0.3		
3 67	-	-	-0.2	-			6 0	+ 6.0 -6.7	+ 5.9 -16.7	-0.1		
3 70	-	-	-0.8	-			6 0	+ 6.0 -6.5	+ 5.9 -16.5	-0.3		
3 73	-	-	-0.4	-			6 0	+ 6.0 -6.3	+ 5.9 -16.3	-0.1		
3 76	-	-	-0.0	-			6 0	+ 6.0 -6.1	+ 5.9 -16.1	-0.3		
3 79	-	-	-0.6	-			6 0	+ 6.0 -5.9	+ 5.9 -15.9	-0.1		
3 82	-	-	-0.2	-			6 0	+ 6.0 -5.7	+ 5.9 -15.7	-0.3		
3 85	-	-	-0.8	-			6 0	+ 6.0 -5.5	+ 5.9 -15.5	-0.1		
3 88	-	-	-0.4	-			6 0	+ 6.0 -5.3	+ 5.9 -15.3	-0.3		
3 91	-	-	-0.0	-			6 0	+ 6.0 -5.1	+ 5.9 -15.1	-0.1		
3 94	-	-	-0.6	-			6 0	+ 6.0 -4.9	+ 5.9 -14.9	-0.3		
3 97	-	-	-0.2	-			6 0	+ 6.0 -4.7	+ 5.9 -14.7	-0.1		
4 00	-	-	-0.8	-			6 0	+ 6.0 -4.5	+ 5.9 -14.5	-0.3		
4 03	-	-	-0.4	-			6 0	+ 6.0 -4.3	+ 5.9 -14.3	-0.1		
4 06	-	-	-0.0	-			6 0	+ 6.0				

App. Alt.	Lower Limb		Upper Limb		Lower Limb	Upper Limb	STARS PLANETS
	Lower	Upper	Limb	Limb			
0° 00'	-17.5	-49.8	-17.8	-49.6	-33.8		
0° 03'	16.9	49.2	17.2	49.0	33.2		
0° 06'	16.3	48.6	16.6	48.4	32.6		
0° 09'	15.7	48.0	16.0	47.8	32.0		
0° 12'	15.2	47.5	15.4	47.2	31.5		
0° 15'	14.6	46.9	14.8	46.6	30.		
0° 18'	-14.1	-46.4	-14.3	-46.1			
0° 21'	13.5	45.8	13.8	45.6			
0° 24'	13.0	45.3	13.3	45.1			
0° 27'	12.5	44.8	12.8	44.6			
0° 30'	12.0	44.3	12.3	44.			
0° 33'	11.6	43.9	11.8				
0° 36'	-11.1	-43.4	-11.3				
0° 39'	10.6	42.9	10.				

# Time and arc

## CONVERSION OF ARC TO TIME

120° - 179°		180° - 239°		240° - 299°		300° - 359°		
°	h m	h m	h m	h m	h m	h m	h m	°
120	8 00	180	12 00	240	16 00	300	20 00	0
121	8 04	181	12 04	241	16 04	301	20 04	1
122	8 08	182	12 08	242	16 08	302	20 08	2
123	8 12	183	12 12	243	16 12	303	20 12	3
124	8 16	184	12 16	244	16 16	304	20 16	4
125	8 20	185	12 20	245	16 20	305	20 20	5
126	8 24	186	12 24	246	16 24	306	20 24	6
127	8 28	187	12 28	247	16 28	307	20 28	7
128	8 32	188	12 32	248	16 32	308	20 32	8
129	8 36	189	12 36	249	16 36	309	20 36	9

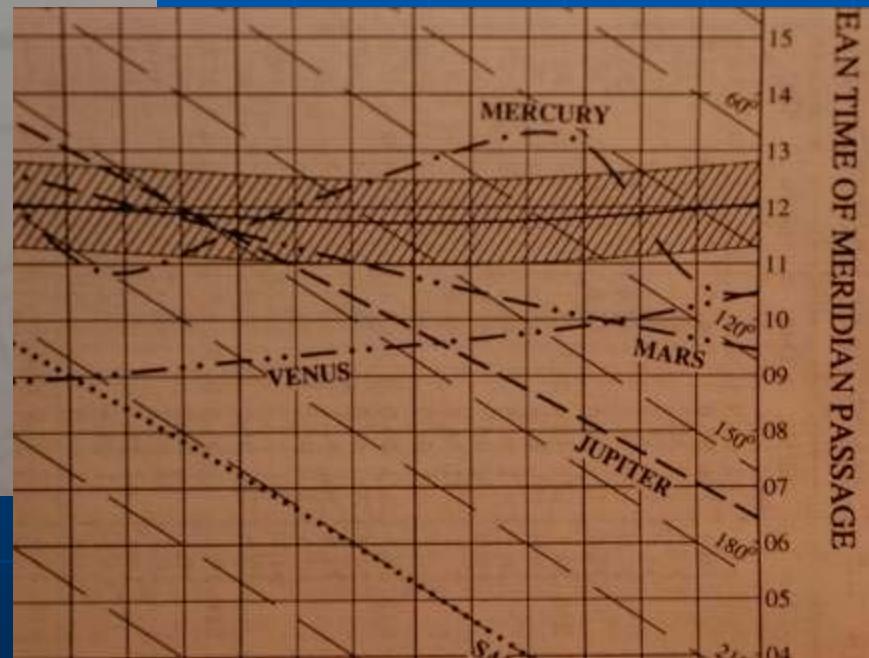
# Moon and planets

8

## PLANET NOTES,

### VISIBILITY OF PLANETS

VENUS is a brilliant object in the evening sky from the beginning of the year until early June when it becomes too close to the Sun for observation. In mid-June it reappears in the morning sky where it stays until the end of the year. Venus is in conjunction with Saturn on September 1, with Jupiter on November 4, with Mars on December 5 and with Mercury on December 29. Venus transits the Sun's disk on June 8 from  $05^{\text{h}} 14^{\text{m}}$  to  $11^{\text{h}} 26^{\text{m}}$ ; the event is visible from Alaska, Australasia except New Zealand, Alaska, Asia, Indian Ocean, Africa, Europe, Greenland, South America except the southern part, North America except the western part.



# Sight Reduction Table

- HO 229
- HO 249

292	51 19	074	50 59	120	64 19	167	16 09	221	20 08	280	28 00	313	38 09
293	32 07	074	51 22	121	64 30	169	15 36	222	19 19	281	27 23	313	37 53
294	32 55	075	52 04	122	64 38	172	15 03	223	18 31	281	26 47	313	37 37
295	33 43	075	52 46	123	64 44	174	14 29	223	17 42	282	26 11	314	37 21
296	34 31	076	53 28	124	64 48	176	13 54	224	16 53	282	25 35	314	37 05
297	35 19	076	54 08	126	64 50	179	13 20	225	16 05	283	24 59	314	36 48
298	36 07	077	54 48	127	64 50	181	12 44	225	15 16	283	24 23	314	36 32
299	36 56	077	55 28	128	64 48	183	12 09	226	14 28	284	23 48	315	36 16
	*Mirfak		Alpheratz		*FOMALHAUT		ALTAIR		Rasalhague		*Alphecca		Koo
300	13 41	038	37 44	077	13 49	141	64 45	186	50 38	246	33 12	282	35 59
301	14 12	039	38 33	078	14 20	142	64 39	188	49 52	247	32 24	282	35 43
302	14 43	039	39 22	078	14 50	143	64 31	190	49 07	248	31 35	283	35 27
303	15 14	040	40 10	079	15 20	144	64 21	192	48 20	249	30 47	283	35 10
304	15 46	040	40 59	079	15 50	144	64 09	195	47 34				
305	16 18	040	41 48	079	16 18	145	63 56	197	46 47				
306	16 51	041	42 37	080	16 47	146	63 40	199	46 00				
307	17 23	041	43 26	080	17 14	147	63 23	201	45 13				
308	17 56	041	44 15	081	17 41	147	63 05	203	44 26				
309	18 29	042	45 04	081	18 08	148	62 44	205	43 38				
310	19 02	042	45 53	082	18 34	149	62 22	207	42 50				
311	19 35	042	46 43	082	18 59	150	61 59	209	42 02				
312	20 09	043	47 32	083	19 24	151	61 34	211	41 14				
313	20 43	043	48 21	083	19 48	151	61 07	213	40 25				
314	21 17	043	49 11	083	20 12	152	60 39	215	39 37				
	*Mirfak		Hamal		Diphda		*FOMALHAUT		ALTAIR				
315	21 51	044	22 27	077	15 41	195	60 20	216					

SIGHT REDUCTION TABLES  
FOR

AIR NAVIGATION

LATITUDES  $0^{\circ}$ – $40^{\circ}$

DECLINATIONS  $0^{\circ}$ – $29^{\circ}$



PUB. NO. 249

VOL. 1

SIGHT REDUCTION TABLES

FOR  
AIR NAVIGATION  
(SELECTED STARS)

EPOCH 1990.0

# NAVIGATION WORKBOOK

	DATE/DR POSIT
Body	
IC	
Dip (Ht ____')	
Sum	
hs	
ha	
Alt Corr	
Add'l	
H.P. ( )	
Corr to ha	
Ho (Obs Alt)	

Date

DR Lat

DR  $\lambda$

Obs Time

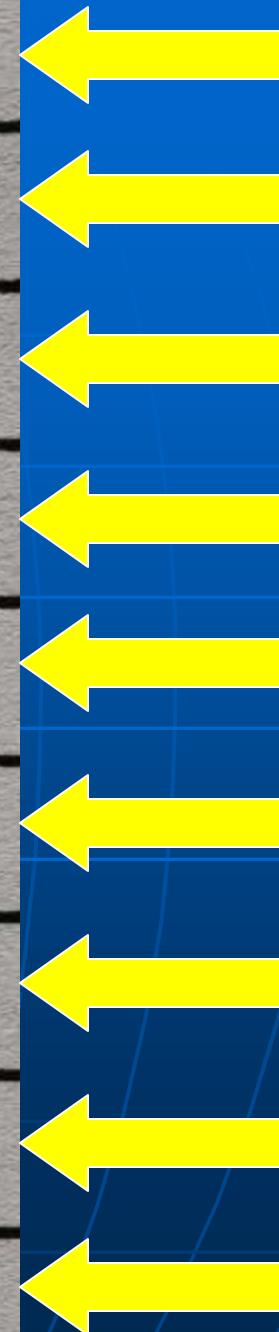
WE (S+, F-)

ZT

ZD (W+, E-)

GMT

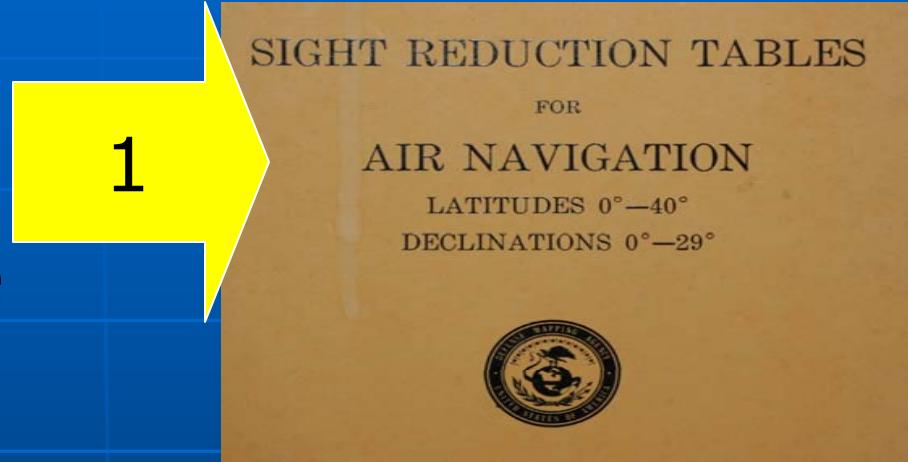
Date (GMT)



Tab GHA)	v	
GHA Incr'mt		
SHA or v Corr		
Total GHA		
$\pm 360^\circ$ if needed		
a $\lambda$ (+E,-W)		
LHA		
Tab Dec	d	
d Corr (+ or -)		
True Dec		

# Entering sight reduction tables

- LHA
- Declination
- Assumed latitude



Azimuth  
Intercept



Hc (tabulated altitude)  
Z (Azimuth angle)

# Plug and chug

1. Name of Body
2. Limb (Upper/  
Lower)
3. Date (G)
  
4. Watch Time (G)
  
5. Watch Error  
(+ if slow – if fast)
  
6. GMT (six  
digits)
  
7. DR Latitude  
(N/S)
  
8. DR Longitude  
(E/W)

Sun		
Lower		
5 JUNE 83		
Hrs	Min	Sec
11	31	21
-	-	-
Dec	Mins	Tenths
44	03	N
64	21	W

# Sextant Corrections —general

9. Sextant  
Reading (Hs)

10. Instrument  
Corr. (+ or -)

11. Index Cor-  
rection (- or -)

12. Dip Correction  
for ~~10~~ feet -)

13. Total (Items 9-12)  
is Apparent  
Altitude (Ha).

Deg	Mins	Tenths
29	46	6
		-
		-1
	-3	1
29	43	5

#### **14. Altitude Correction (+ or -)**

**15. Venus, Mars**  
only, add'l correction (+ or -)

16. Moon only, Corr.  
for daily page HP: \_\_\_\_\_ (+)

17. Moon only, if  
upper limb - 30'

**18. Non-Standard  
conditions only,  
add'l Corr.**

**19. Total (Items  
13-18) is Observed  
Altitude ( $H_o$ )**

DAILY PAGES

20. GHA of body,  
whole hours

● "v" value, planets      "v"  
moon, + unless  
shown otherwise



YELLOW PAGES

21. Increments, (+)  
minutes and secs.,  
from sun planets or  
moon column.

22. Moon, planets,  
"v" correction for "v"  
value above, use  
same sign

23. Total GHA.  
(items 20-21 & 22)  
● if over 360°  
subtract 360°

Deg      Mins      Tenths

Deg	Mins	Tenths
345	25	2

7	50	3

	-	

353	15	5
-----	----	---

# Declination—From Nautical Almanac

## DAILY PAGES

24. Declination,  
whole hour. (N/S)

- "d" value, (+ if Dec. increasing, - if Dec. decreasing)

## YELLOW PAGES

25. "d" correction  
for "d" value above,  
use same sign

26. Total Decli-  
nation (items 24-25)  
(N/S)

"d"  
**+0.3**

Deg	Mins	Tenths	
22	30	5	N
+2			
22	30	7	N

# Session II

- Sextant
- Noon sight
- Sun sights
- Stars, planets, moon

