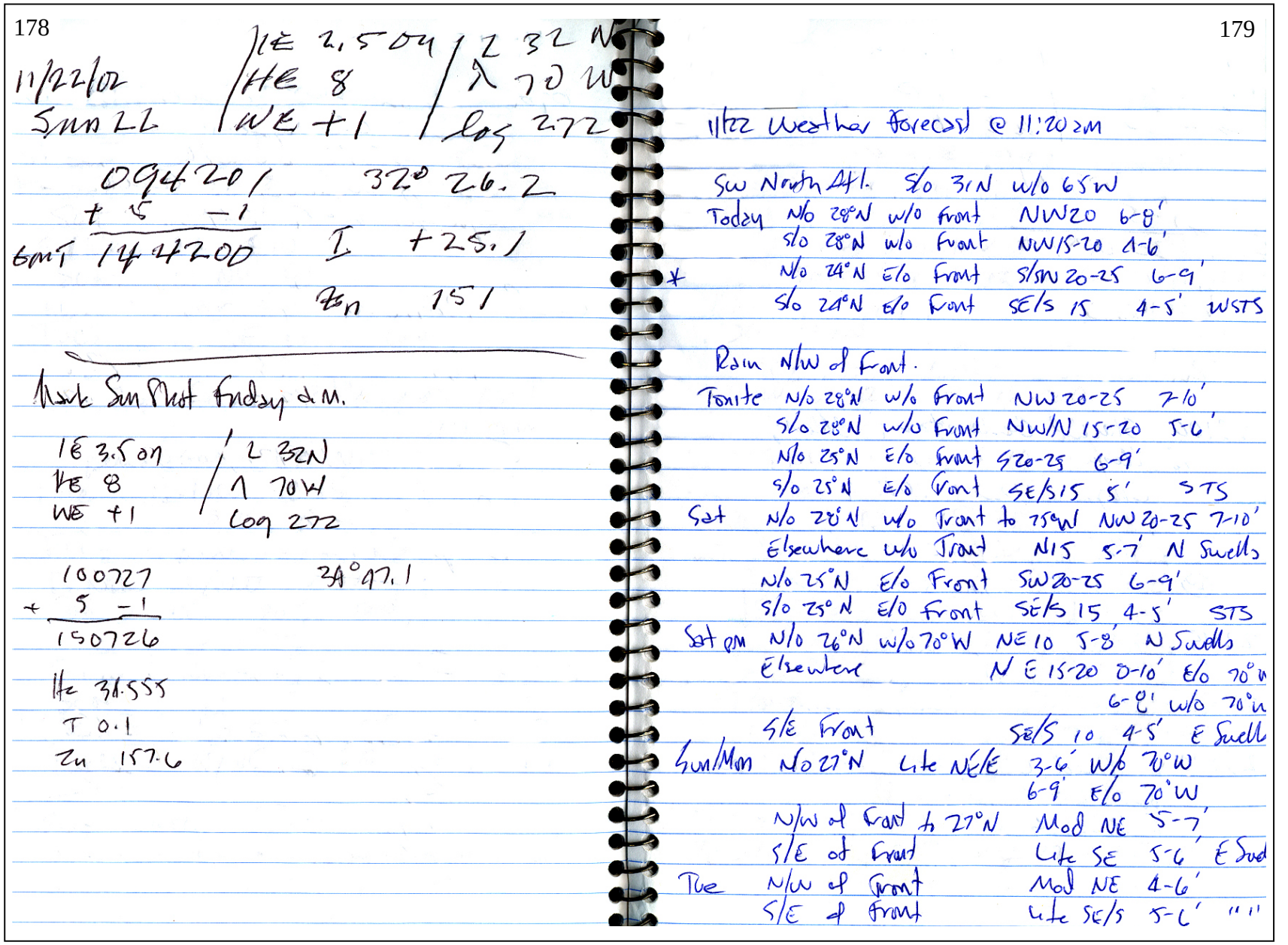


Figure 3-5: Narrative page from a Deck Logbook.

Date: 11/22/02 FRI

Time	Course	Distance	Wind Dir	Wind Speed	Wave Dir	Wave Height	Barometer MB	Sea Wtr Temp
01	165	210	210	6-7	SSE	3-4	1018	76.8*
02	162	216	210	10-12	SSE	3-4	1017	—
03	160	222	210	10	SSE	3-4	1017	—
04	165	229	208	10	SE	3-4	1017	—
05	155	237	210	20	SW	4	1017	—
06	150	244	210	18	SW	4	1017	—
07	145	251	200	20	SW	4	1017	—
08	145	259	200	20	SW	4	1017	—
09	150	267	205	20	SW	6	1017	—
10	155	274	205	15	SW	5	1017.5	—
11	155	281	205	17	SW	5-6	1017	—
12	165	290	205	20	SW	5	1016	—
13	155	299	215	15-20	SW	4	1016	—
14	153	307	215	15-20	SW	4	1016	—
15	155	315	210	20	SW	4	1015.5	—
16	155	323	210	20	SW	4	1016	—
17	155	328	210	18	SW	4	1016	—
18	155	337	210	20	SW	4	1016	—
19	155	344	210	18	SW	4	1016	—
20	155	350	210	20	SW	3	1016	—
21	155	358	210	20	SW	3	1016	—
22	155	365	210	22	SW	4	1016	—
23	145	369	230	25	SW	5	1016	—
24	140	374	235	30	SW	5	1016	—

Time	Clouds %	Clouds Type	Volts #1	Volts #2	Volts #3	Bilge Strokes	Boat Check	Navigator
01	45	Cu Ci	12.3	12.3	12.8	—	MJ	163-12=1
02	60	Cu/Ci	12.3	12.4	12.8	—	MJ	D-27
03	30	Ci Cu	12.2	12.3	12.8	—	MJ	
04	40	Ci Cu	12.0	12.3	12.8	—	MJ	
05	50	St, Cu	12.2	12.2	12.8	—	TT	149-12=
06	40	St Ci	12	12.4	12.8	—	SA	137
07	50	Cu Ci	12.2	12.3	12.8	—	TT	
08	40	Cu Ci	12.2	12.3	12.8	—	SA	3
09	75	Cu/Ci	13.6	13.6	13.6	—	LT	C-156
10	70	Cu/Ci	12.7	12.8	12.8	9	CB	12 144
11	70	Cu/Ci	12.6	12.7	12.8	—	LT	D-31
12	70	Cu/Ci	12.6	12.7	12.9	—	LT	
13	60	Cu/Ci	12.7	12.7	12.9	—	MJ	C-143
14	70	Cu/Ci	12.5	12.6	12.8	—	CB	D-35
15	70	Cu/Ci	12.5	12.6	12.9	—	MJ	
16	85	Cu/Ci	12.4	12.4	12.8	—	MJ	
17	90	Cu/Ci	12.2	12.4	12.8	—	SA	155-12
18	100	St	12.3	12.4	12.8		TT	133
19	100	St Cu	12.2	12.4	12.8	—	SA	
20	100	St Cu	12.0	12.2	13.0	—	SA	2
21	100	Cu Str.	12.1	12.2	12.8	—	LT	C-149
22	100	Cu/Str	12.0	12.2	12.8	—	LT	-12 137
23	100	Cu	13.8	13.8	13.8	—	LT	
24	100	Cu (RAIN)	12.6	12.8	13.0	—	CB	D-24

Figure 3-6: Tabular page from a Deck Logbook.

- ***Definitions***
  - *A meter = one ten-millionth of the distance from Equator to Pole*
  - *A nautical miles = one minute of latitude*
- ***Therefore*** *the distance from Equator to Pole*

  = 90 degrees x 60 minutes = 5400 minutes of latitude

  = 5400 nautical miles
- ***And*** *10,000,000 meters = 5400 nm*

  10,000,000 ÷ 5400 = 1851.9 meters per nm

  and 1851.9 x 3.281 feet per meter = 6076 feet per nm

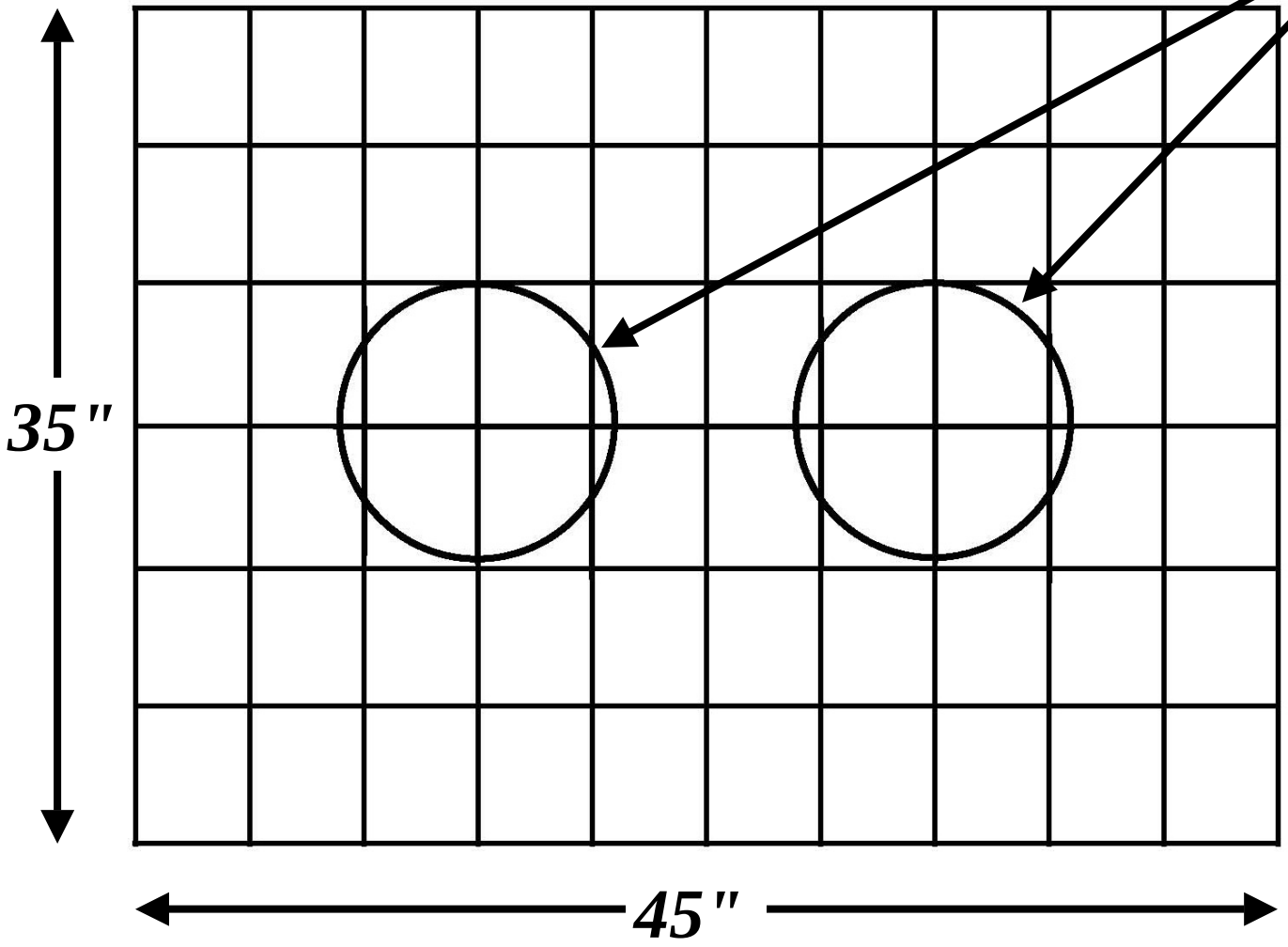
Nautical Mile = 6076 feet

Statute Mile = 5280 feet

$$\frac{6076}{5280} = 1.15$$

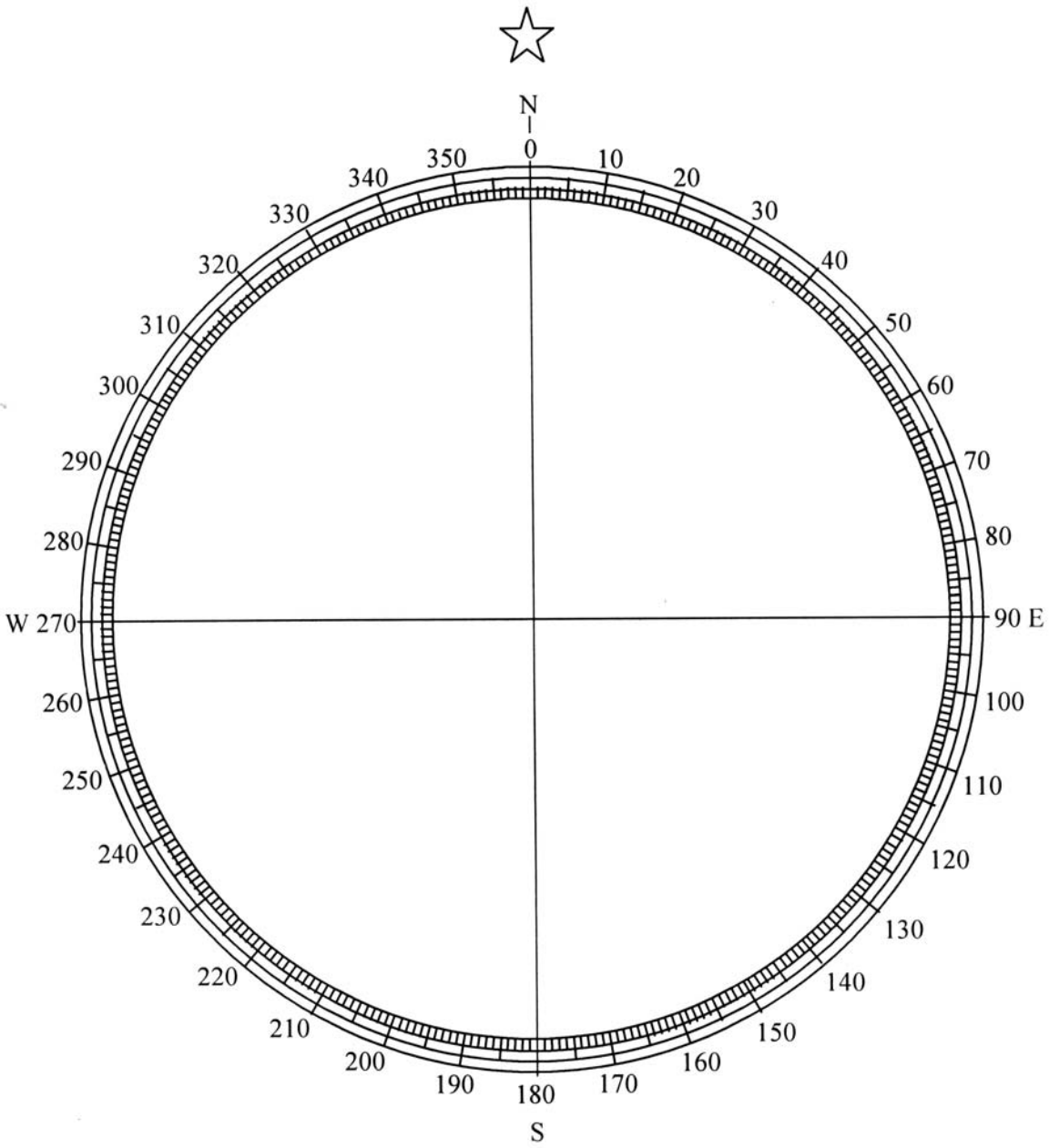
Nautical Mile is 15% longer than a Statute Mile

Typical Plotting Sheet

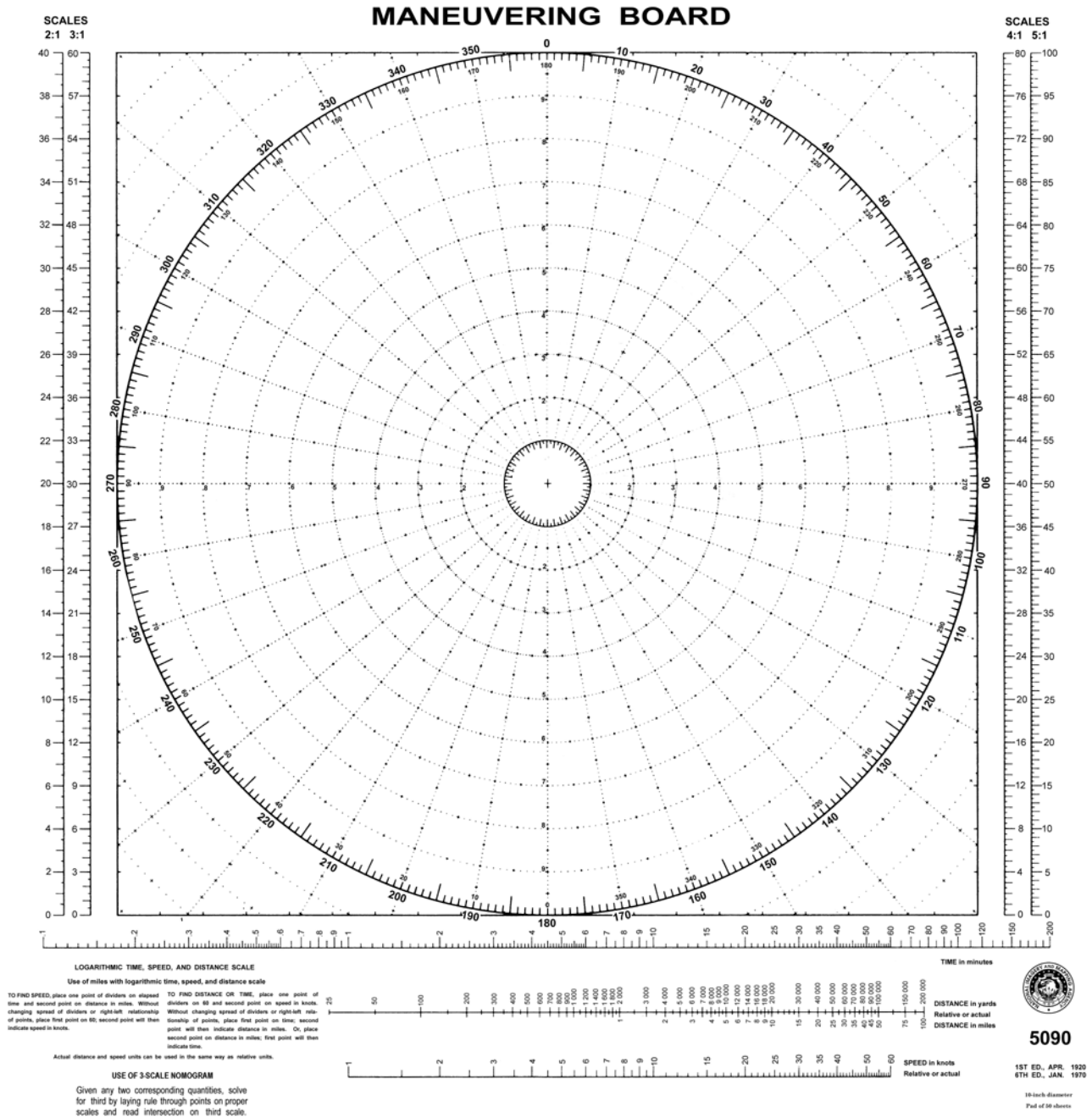


True Compass Rose

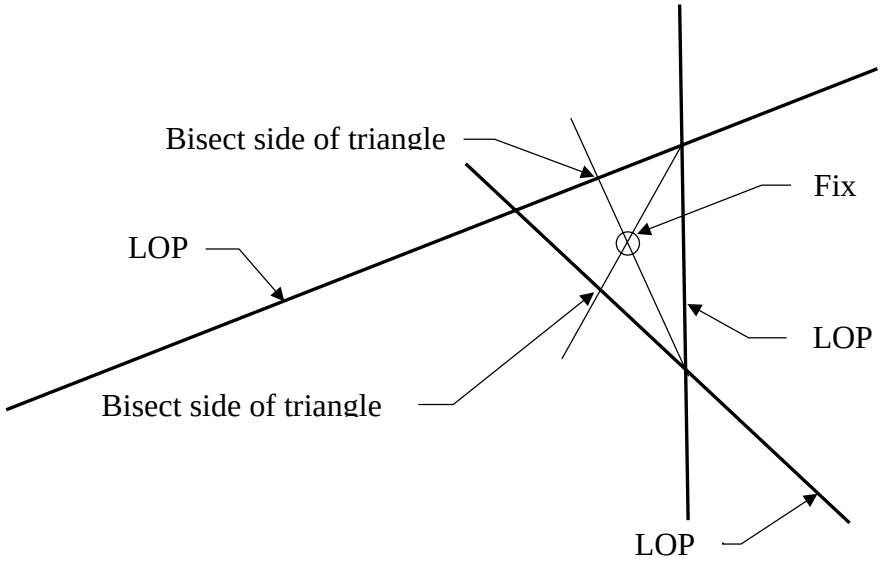
- Minutes of angle are printed in both directions
- Latitude degrees are pre-printed
- Longitude degrees are not printed

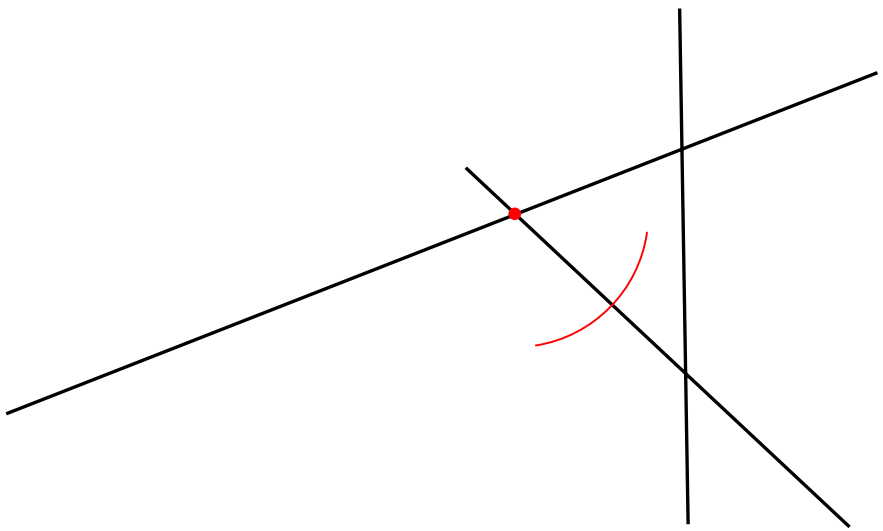


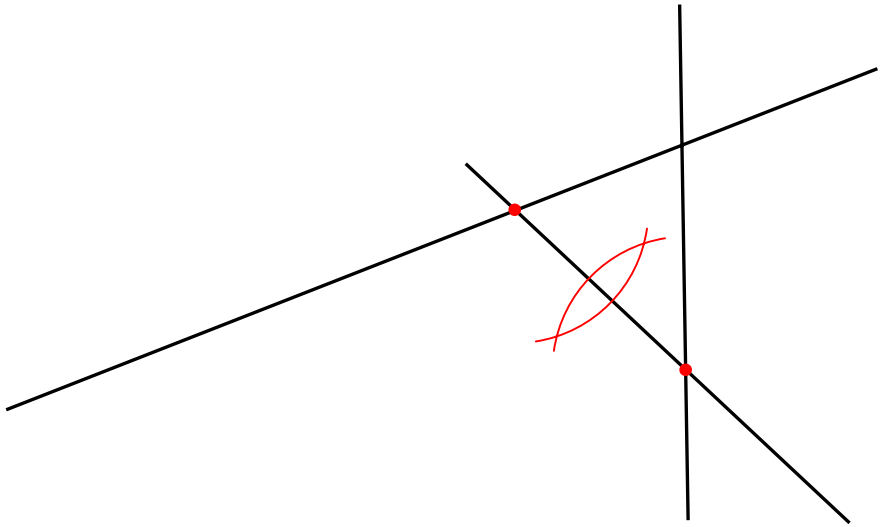
- ***True Rose on Ocean Charts***

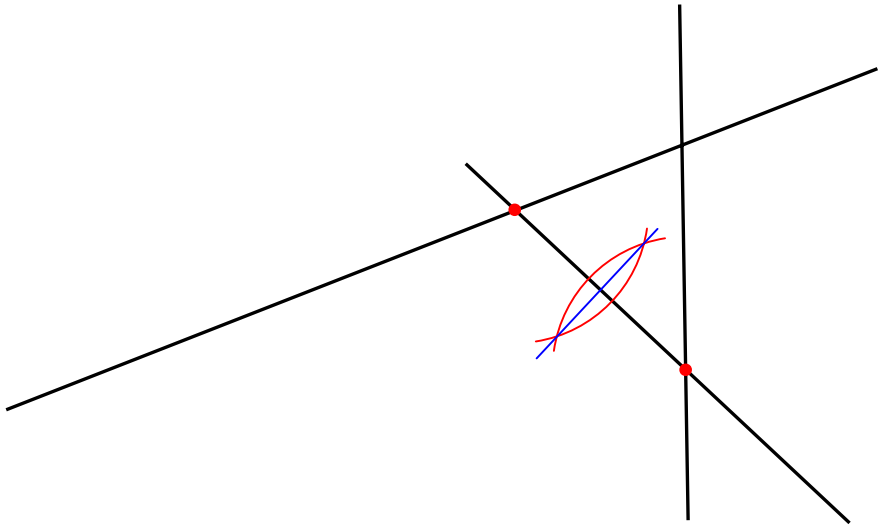


Scale: Speed :1;
Distance :1 thousands of yds.


Bisect side of triangle
Fix
LOP
LOP
Bisect side of triangle
LOP







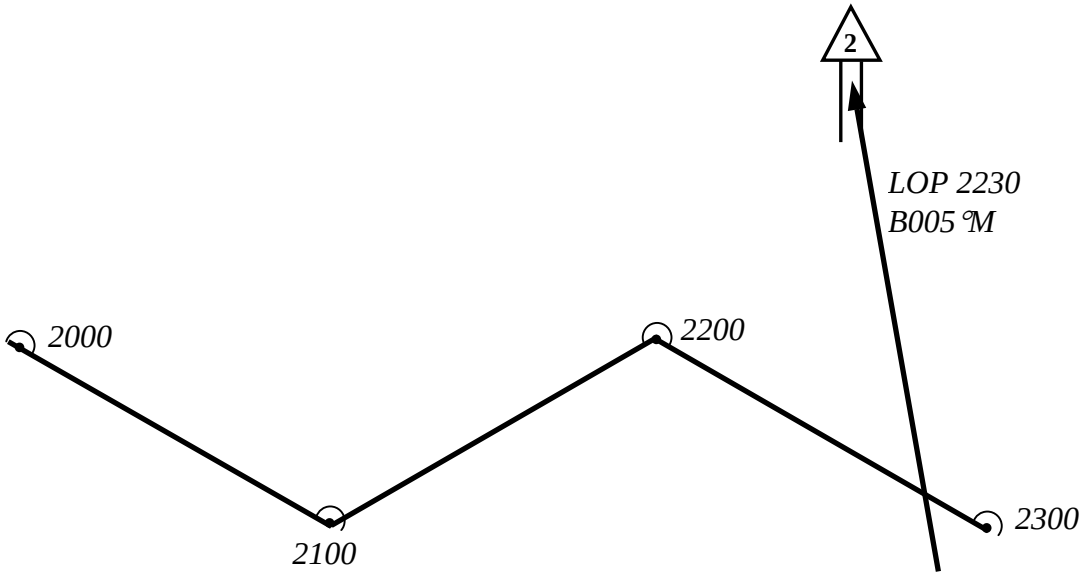


Figure 1-9: Estimated Position for DR + one LOP.

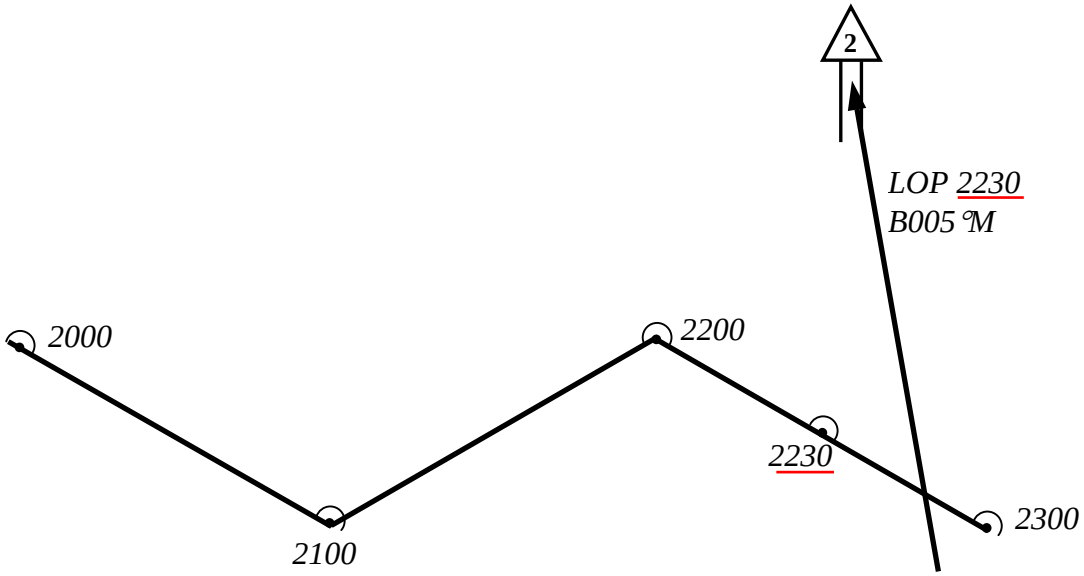


Figure 1-9: Estimated Position for DR + one LOP.

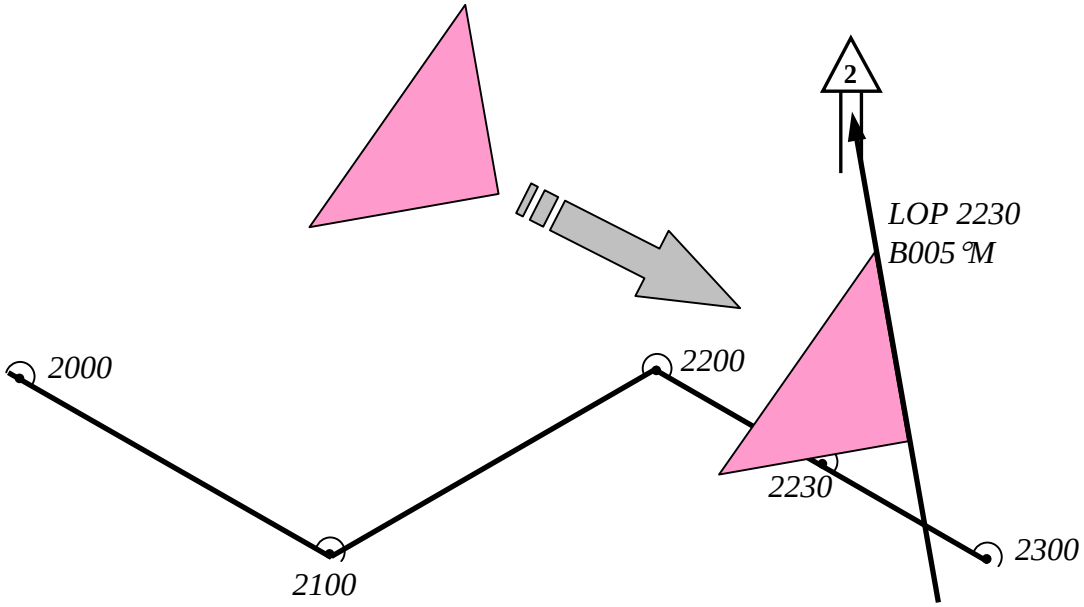


Figure 1-9: Estimated Position for DR + one LOP.

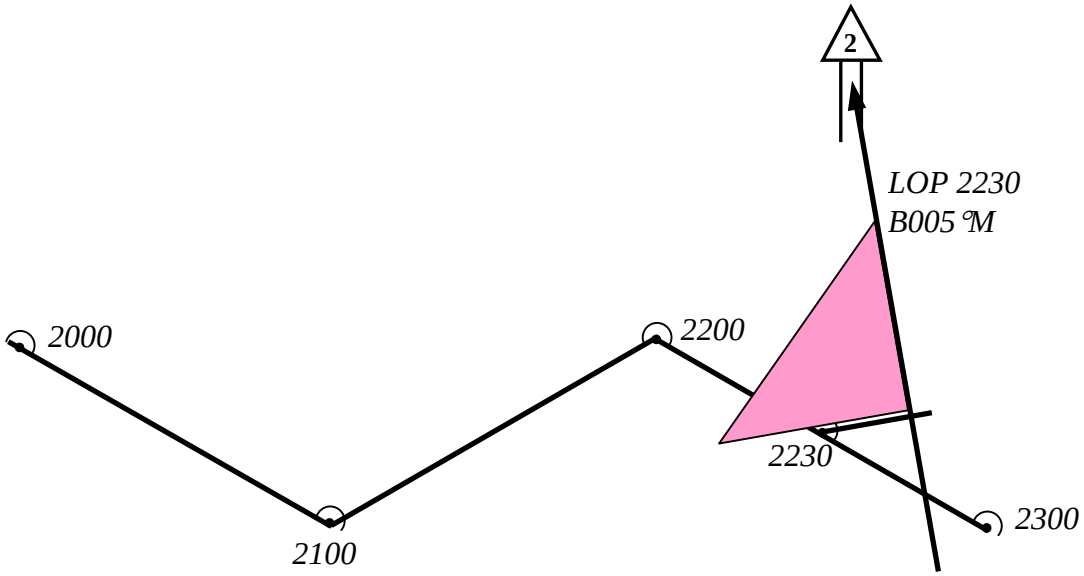


Figure 1-9: Estimated Position for DR + one LOP.

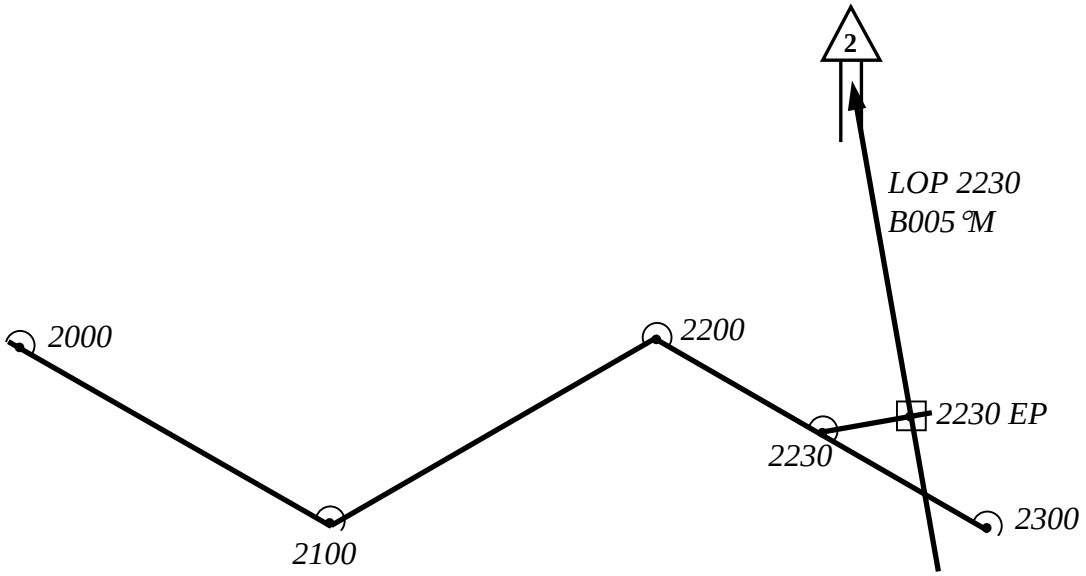
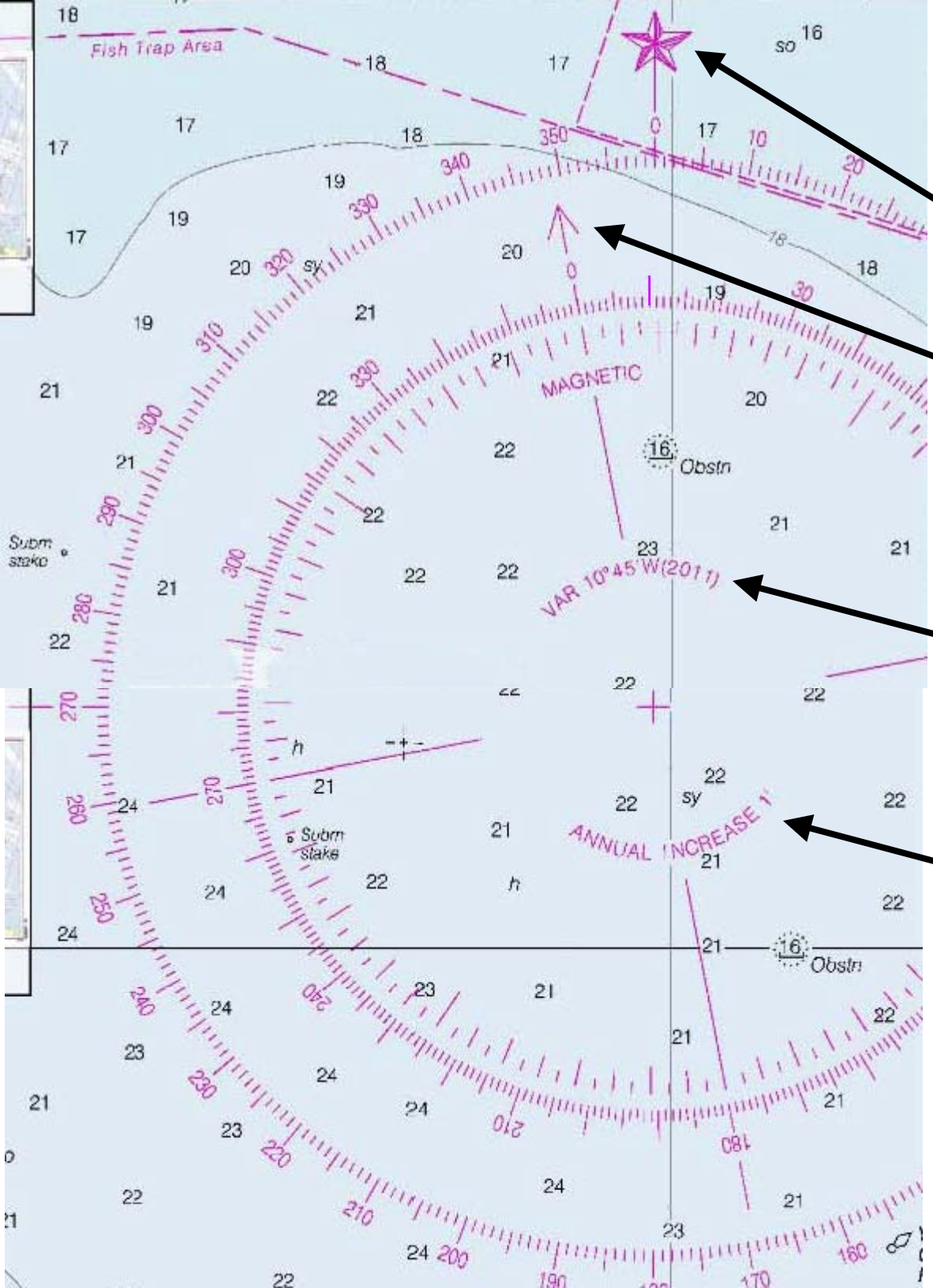


Figure 1-9: Estimated Position for DR + one LOP.



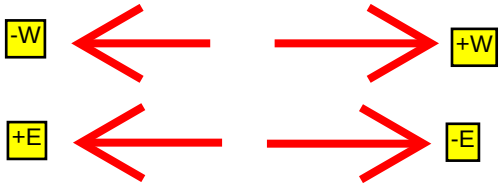
Coastal Chart

True North

Magnetic North

West Magnetic Variation

Annual Change



Complete the following table:

T	V	M	D	C
090	3E	087	1W	088
	14E	157	2W	
324		318		315
	11W		4E	005
358	8W			355
222		227	6W	
	9E	355		002
002	4E		7W	

Interpolation

While on a boat heading of 200°psc, you shoot a bearing of 240°psc on a lighthouse. Variation is 13E. Convert this bearing to °T in order to plot it on the chart.

Do not use this Deviation Table for PE or HW

Heading °M	Deviation	Heading °psc
358	2W	000
041	4W	045
089	1W	090
138	3E	135
185	5E	180
227	2E	225
270	0	270
314	1W	315

200°psc

Interpolate Deviation from the table as follows:

	Dev		psc	
x	5E		180	
	?	3	200	45
	2E		225	

20

$$\frac{x}{3} = \frac{20}{45}$$

$x = 3 * 20/45 = 60/45 = 1.33$

Deviation for heading of 200°psc
= ?
= 5E – x
= 5E – 1.33E
= 3.67E
= 4E rounded

T	V	M	D	C
257	13E	244	4E	240

Bearing

New question: Let's assume that you've plotted a Track of 162°T on the chart that you want to sail on. Variation is 11E. Assuming no wind leeway or current, what course do you tell the helmsman to steer on the ship's compass to remain on this Track?

In order to enter the Deviation Table, you need to convert the Track of 162°T to °M:

T	V	M	D	C	
162	11E	151			Track

Use the 151°M Track to find Deviation:

151°M

Heading °M	Deviation	Heading °psc
358	2W	000
041	4W	045
089	1W	090
138	3E	135
185	5E	180
227	2E	225
270	0	270
314	1W	315

Interpolate Deviation from the table as follows:

M		Dev
138		3E
151		**?**
185		5E

13 / 47 x 2

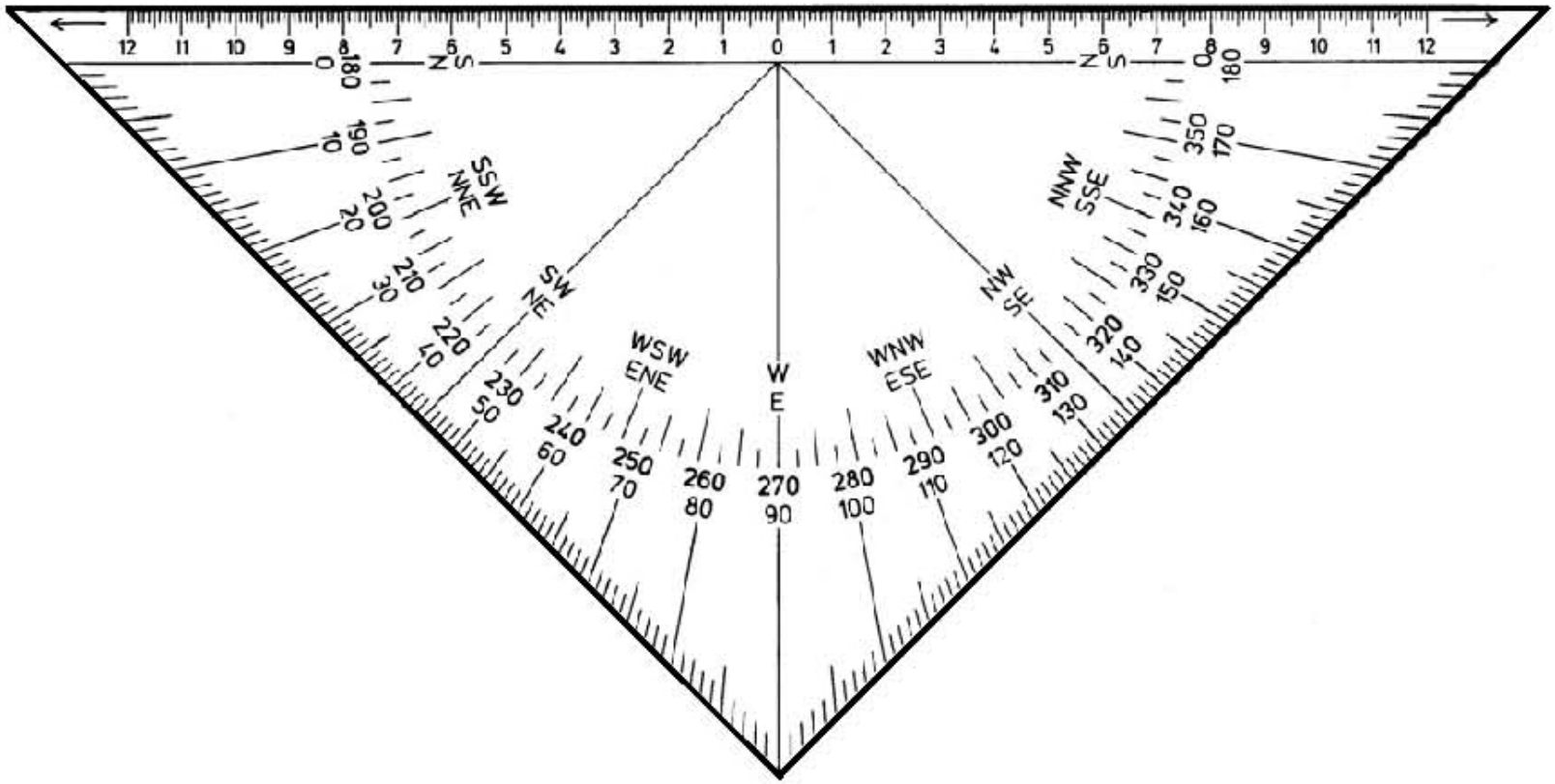
$$\frac{13}{47} = \frac{x}{2}$$

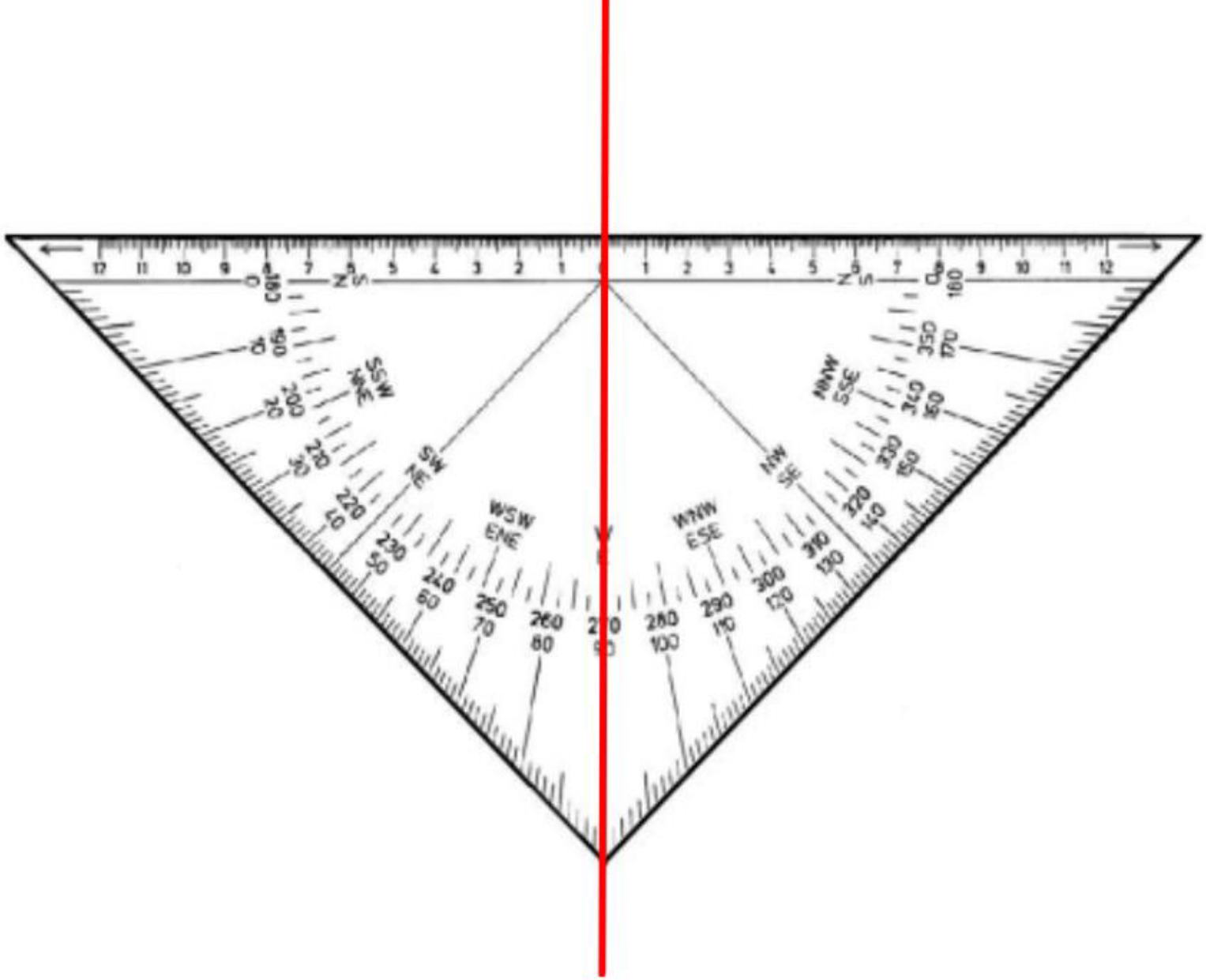
$x = 2 * 13/47 = 26/47 = 0.55$

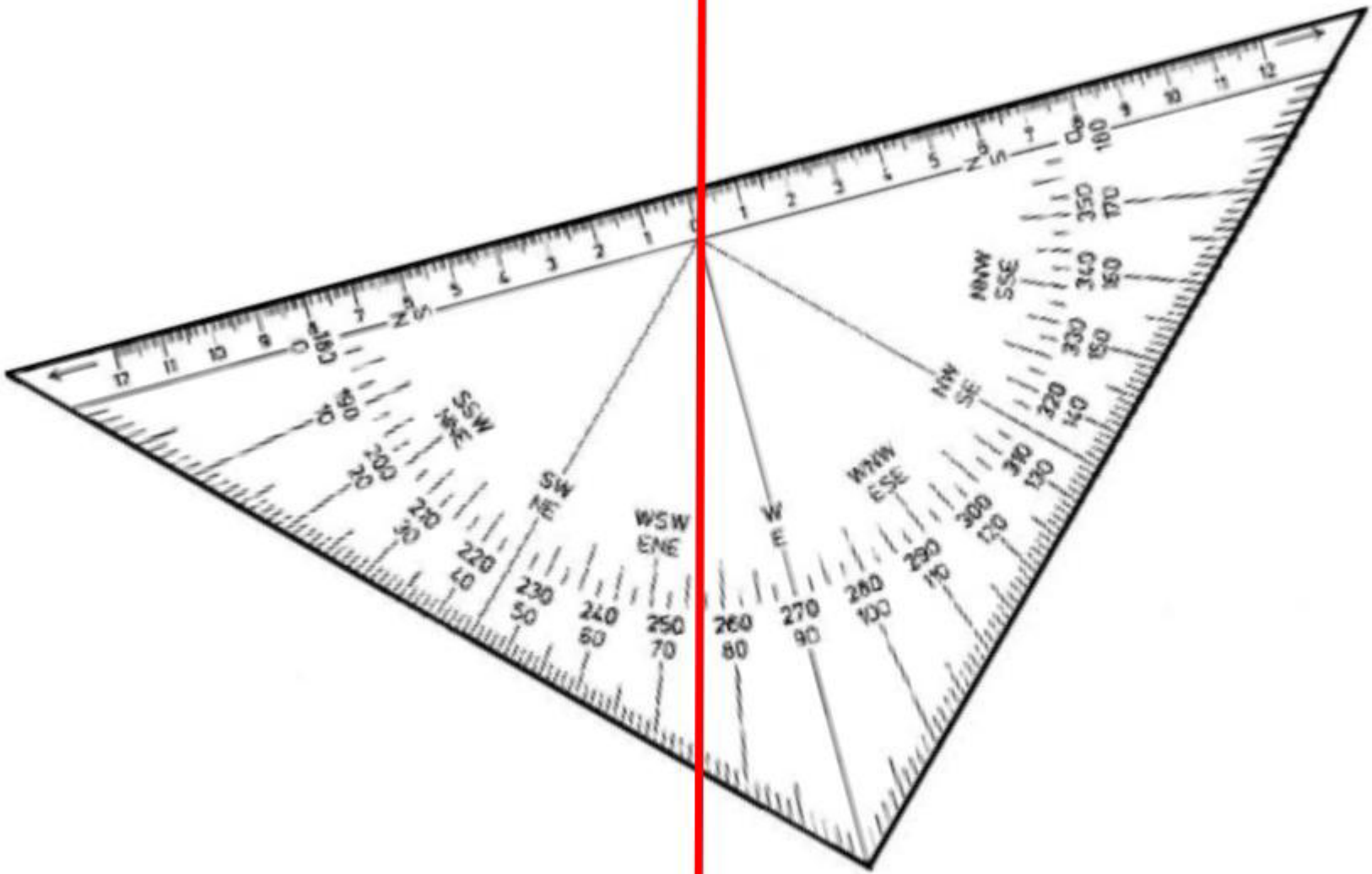
Deviation for heading of 151M
= **?**
= 3E + 0.55
= 3.55E
= 4E rounded

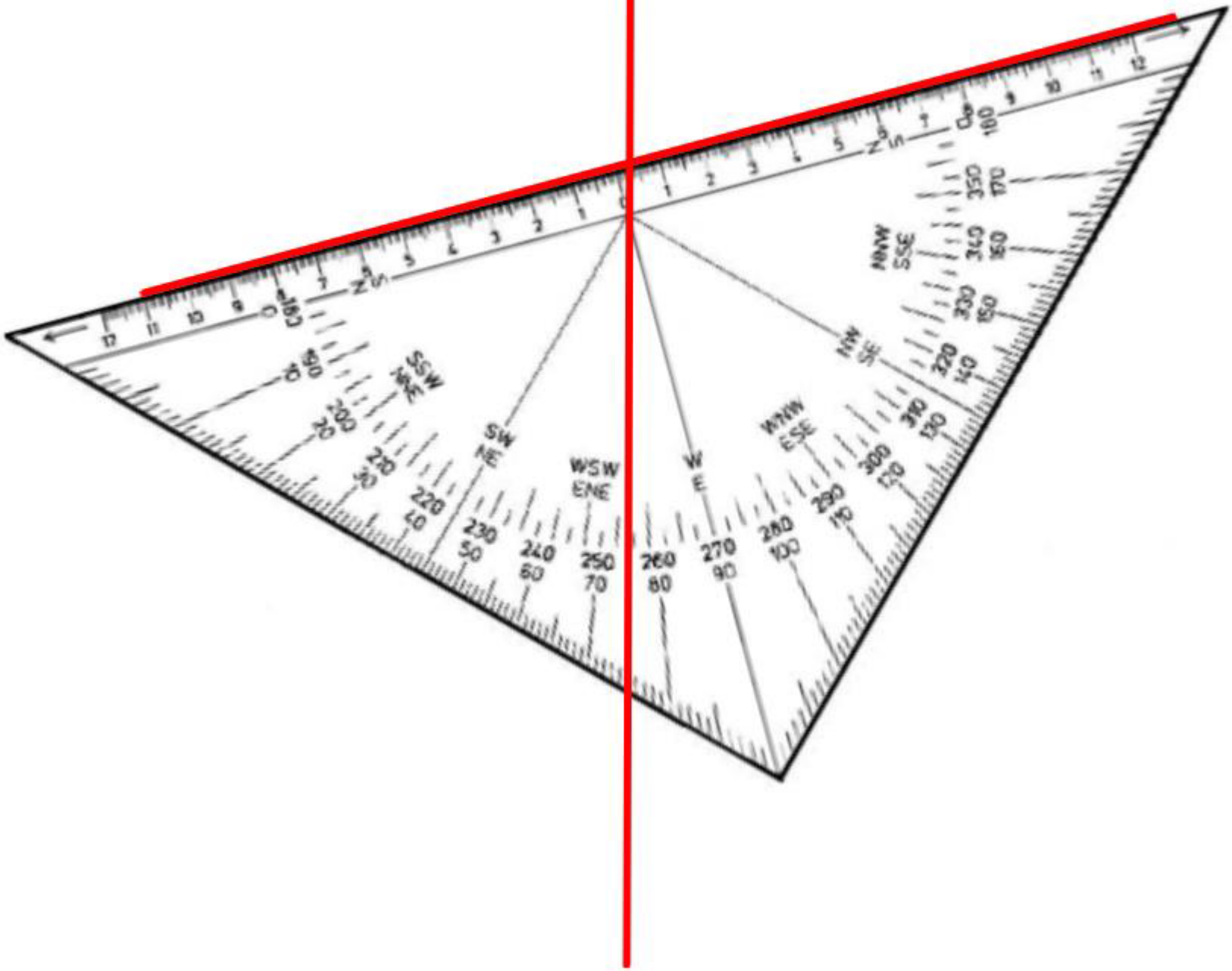
T	V	M	D	C	
162	11E	151	4E	147	Track

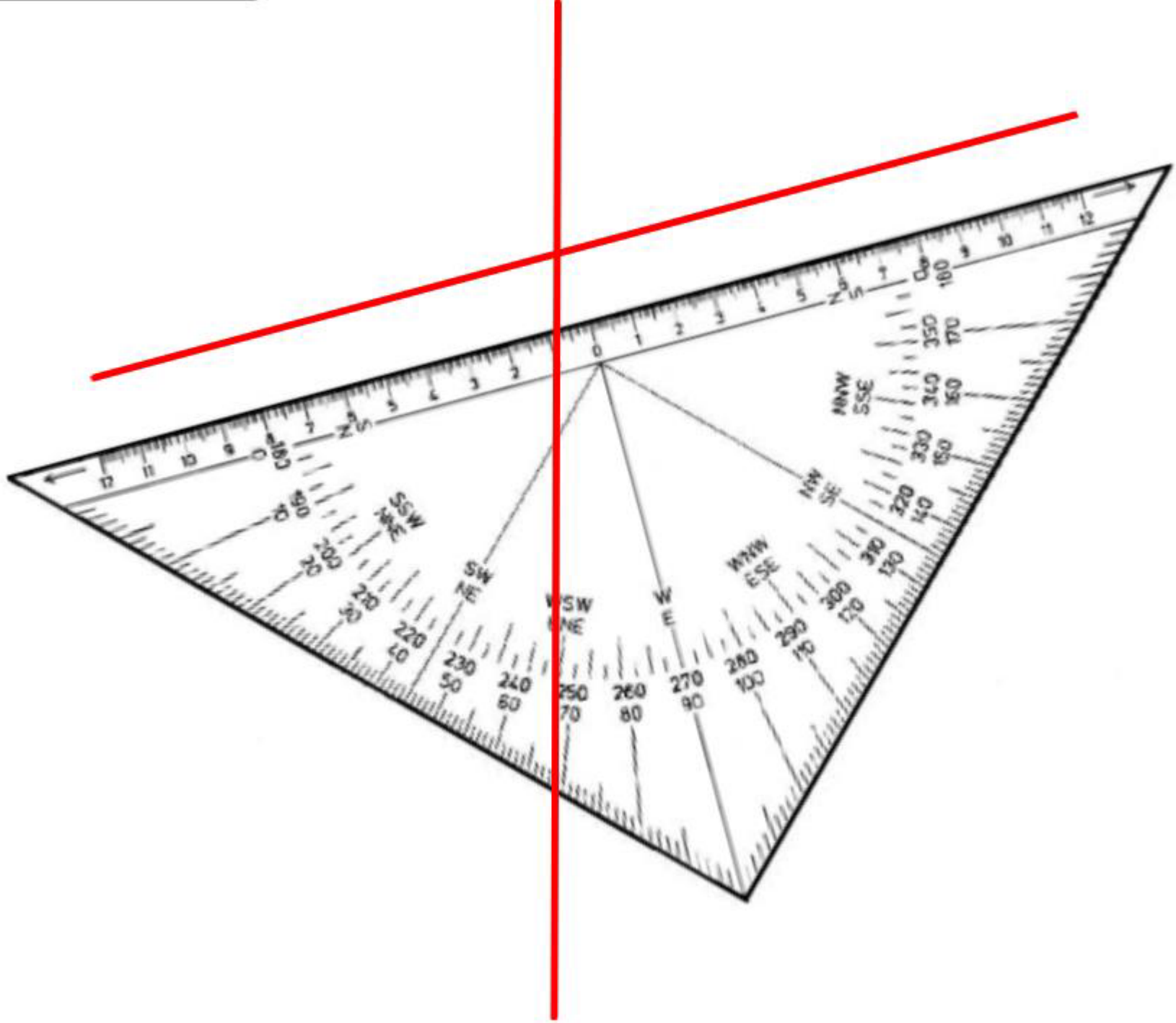
Drawing a Line at an Angle


12 11 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10 11 12
N S
N S
0 180
10 190
20 200
30 210
40 220
50 230
60 240
70 250
80 260
90 270
100 280
110 290
120 300
130 310
140 320
150 330
160 340
170 350
180 0
SSW NNE
SW NE
WSW ENE
W E
WNW ESE
NW SE
NNW SSE


SSW
NNE
SW
NE
WSW
ENE
W
WNW
ESE
NW
SE
NNW
SSE


SSW
NNE
SW
NE
WSW
ENE
W
E
WNW
ESE
NW
SE
NNW
SSE
N
S
0
180
10
190
20
200
30
210
40
220
50
230
60
240
70
250
80
260
90
270
100
280
110
290
120
300
130
310
140
320
150
330
160
340
170
350
180
10
20
30
40
50
60
70
80
90
100
110
120


SW
NE
WSW
ENE
W
E
WNW
ESE
NW
SE
NNW
SSE
SSW
NNE
S
N
180
0
210
30
220
40
230
50
240
60
250
70
260
80
270
90
280
100
290
110
300
120
310
130
320
140
330
150
340
160
350
170
10
190
20
200


0
1
2
3
4
5
6
7
8
9
10
11
12
NNW
SSE
NW
SE
NNW
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W
E
WSW
ENE
SW
NE
SSW
NNE
350
170
340
160
330
150
320
140
310
130
300
120
290
110
280
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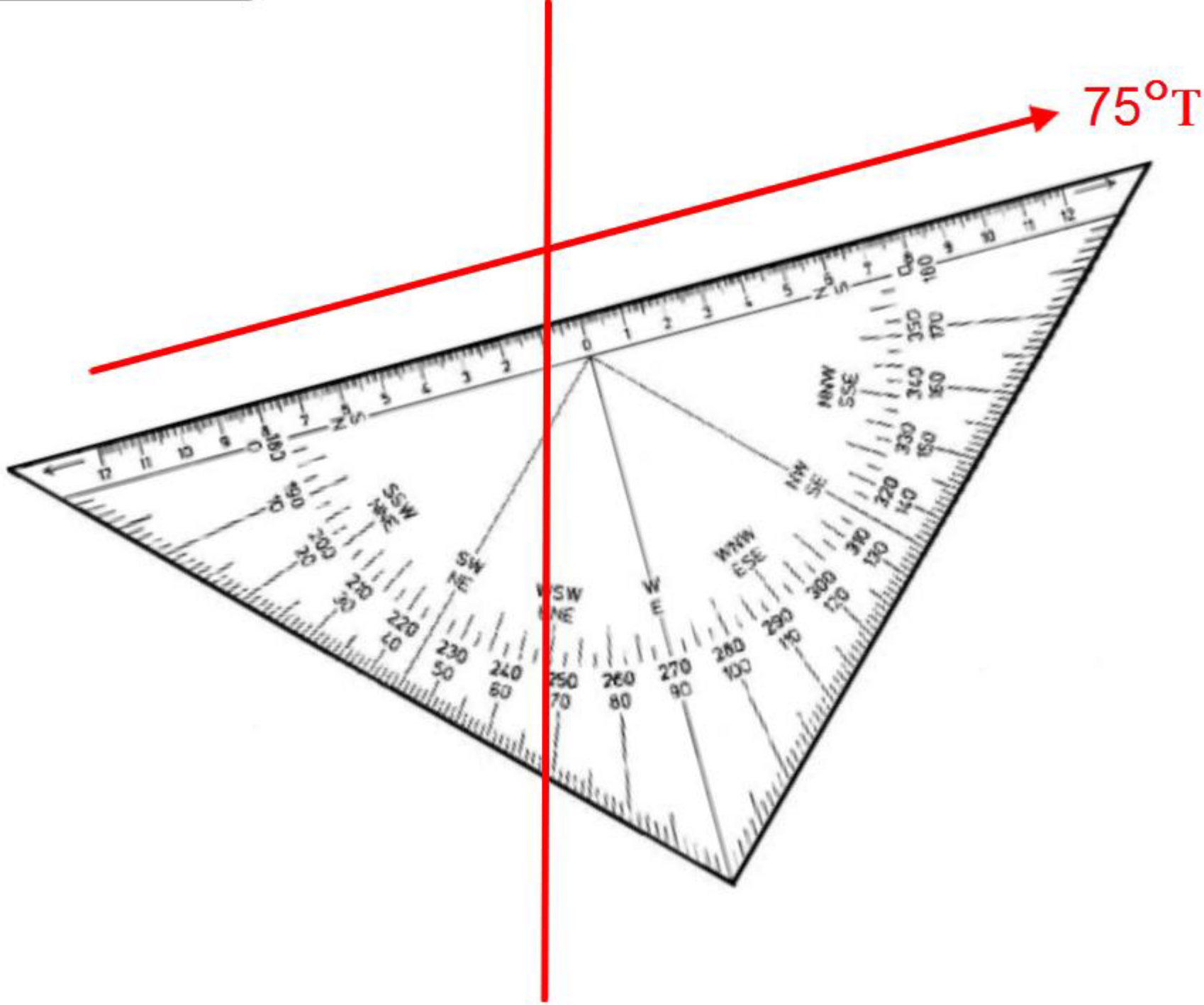
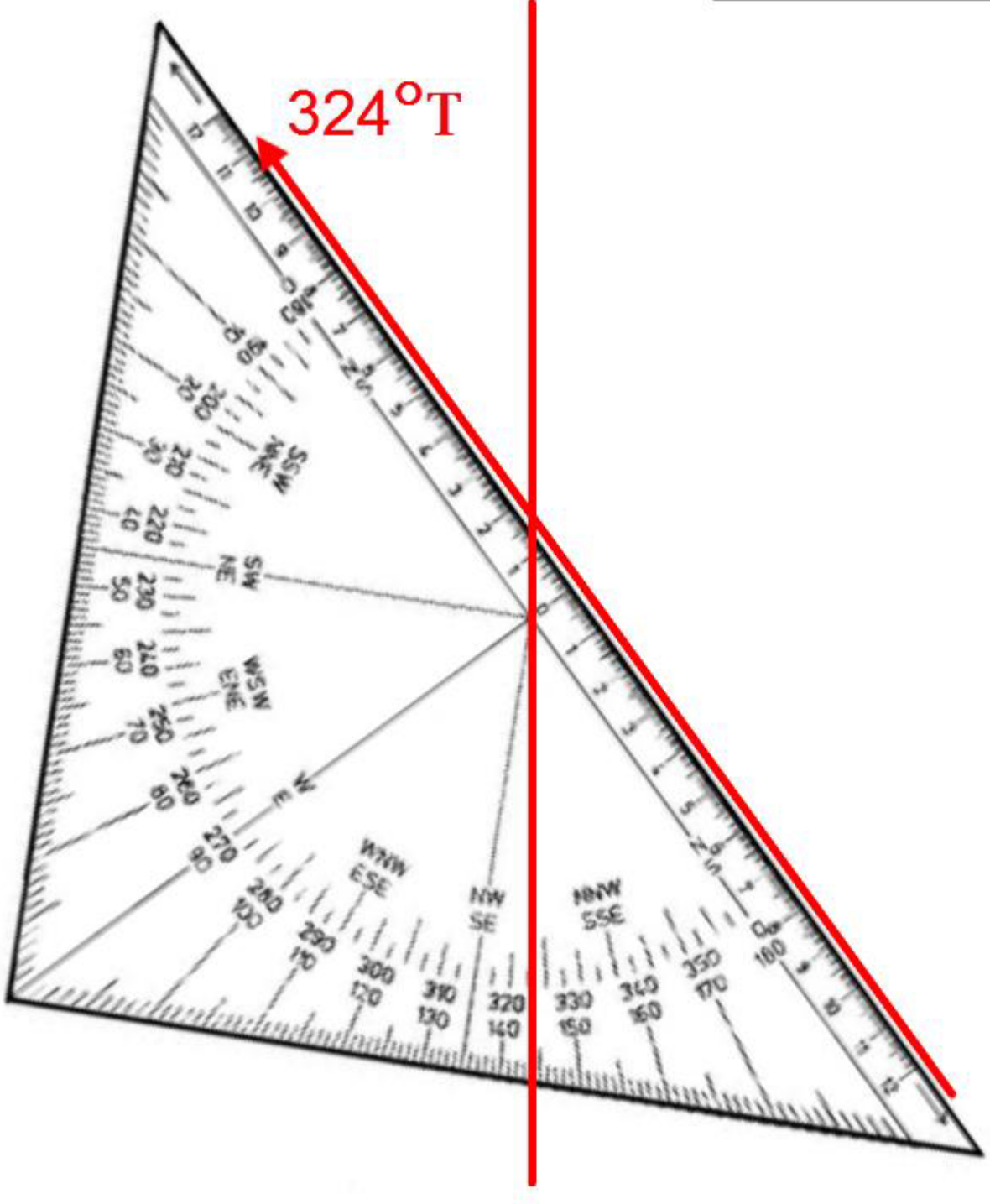
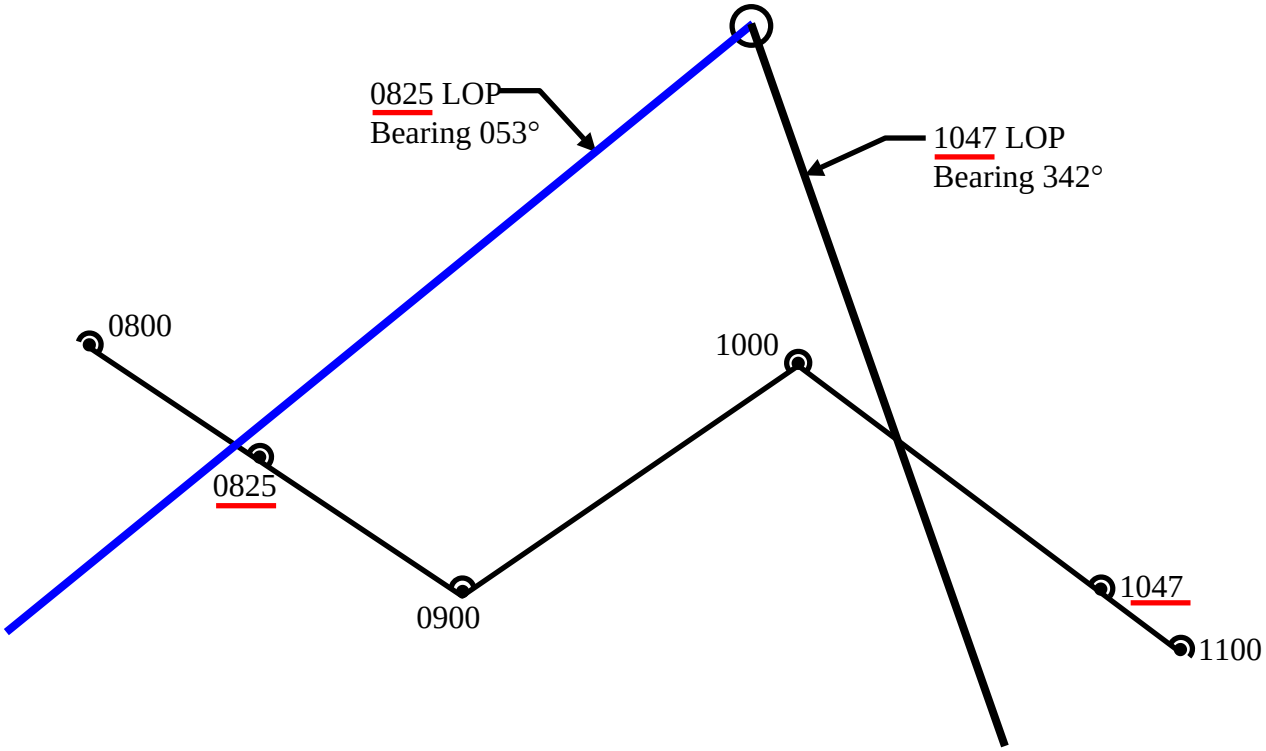
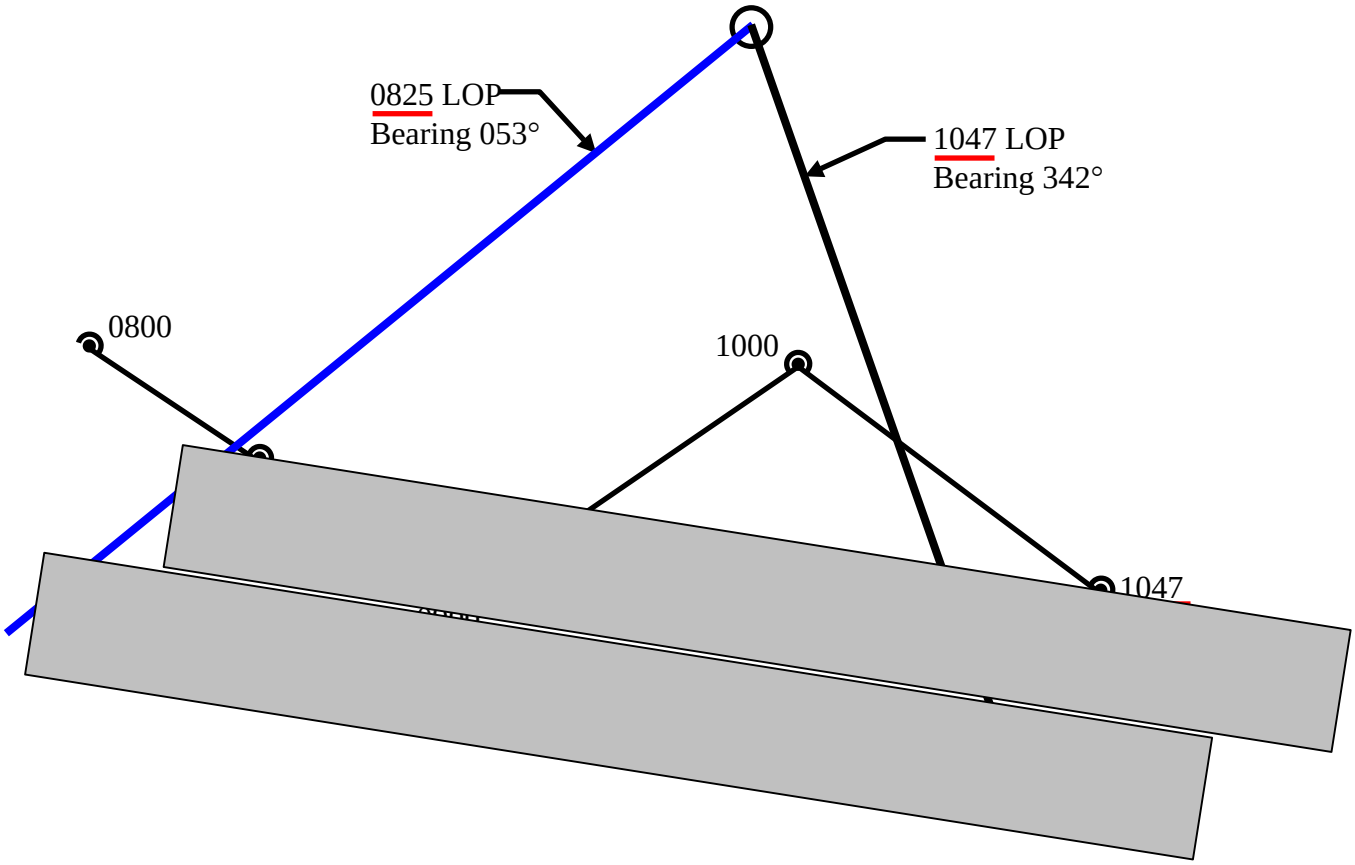
220
40
210
30
200
20
190
10
180
0


75°T

Measuring the Angle of a Line


324°T
NW
SE
NNW
SSE
WNW
ESE
NE
SW
ENE
WSW
SSW
NNE


0825 LOP
Bearing 053°
1047 LOP
Bearing 342°
0800
0825
0900
1000
1047
1100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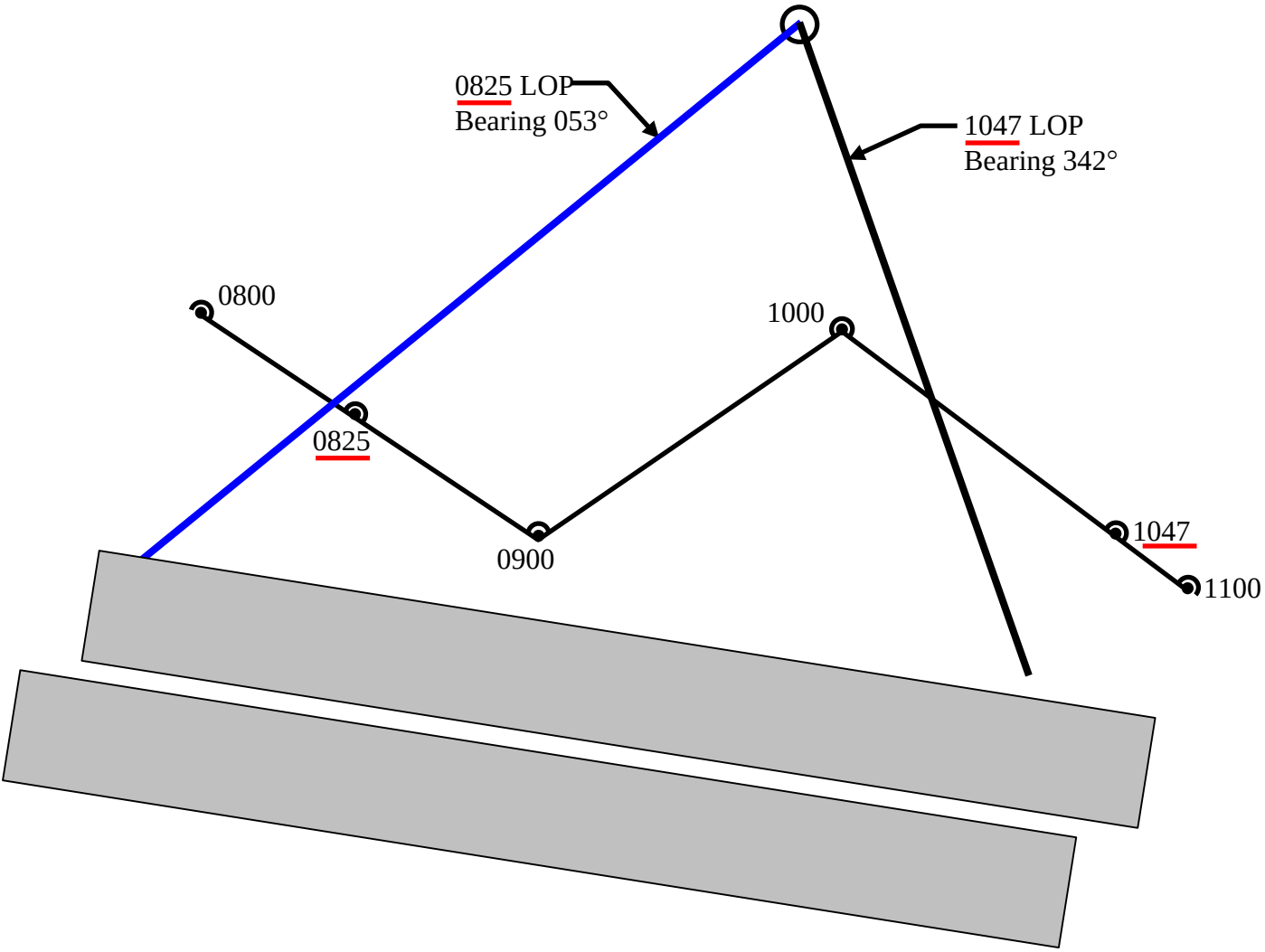
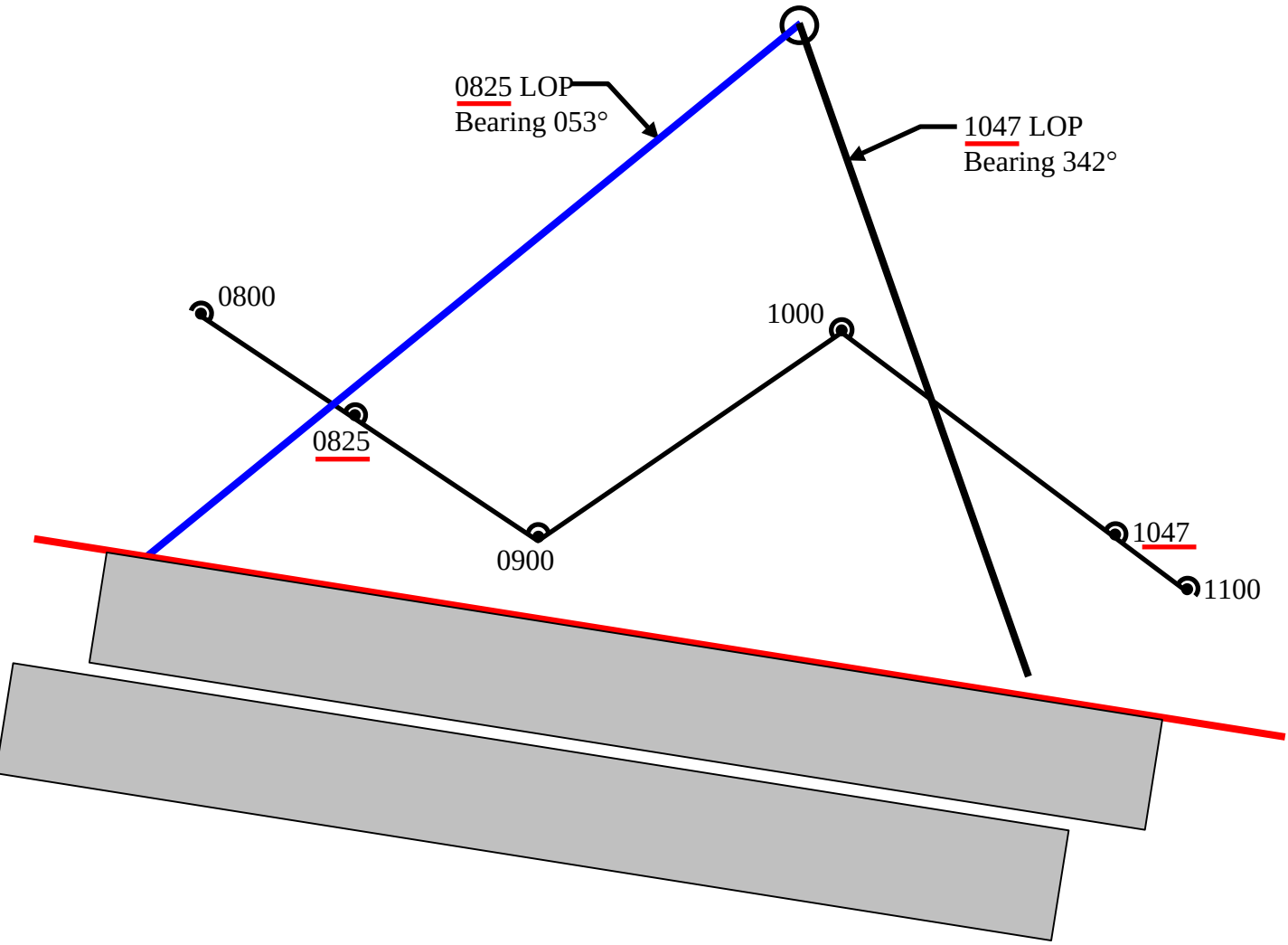
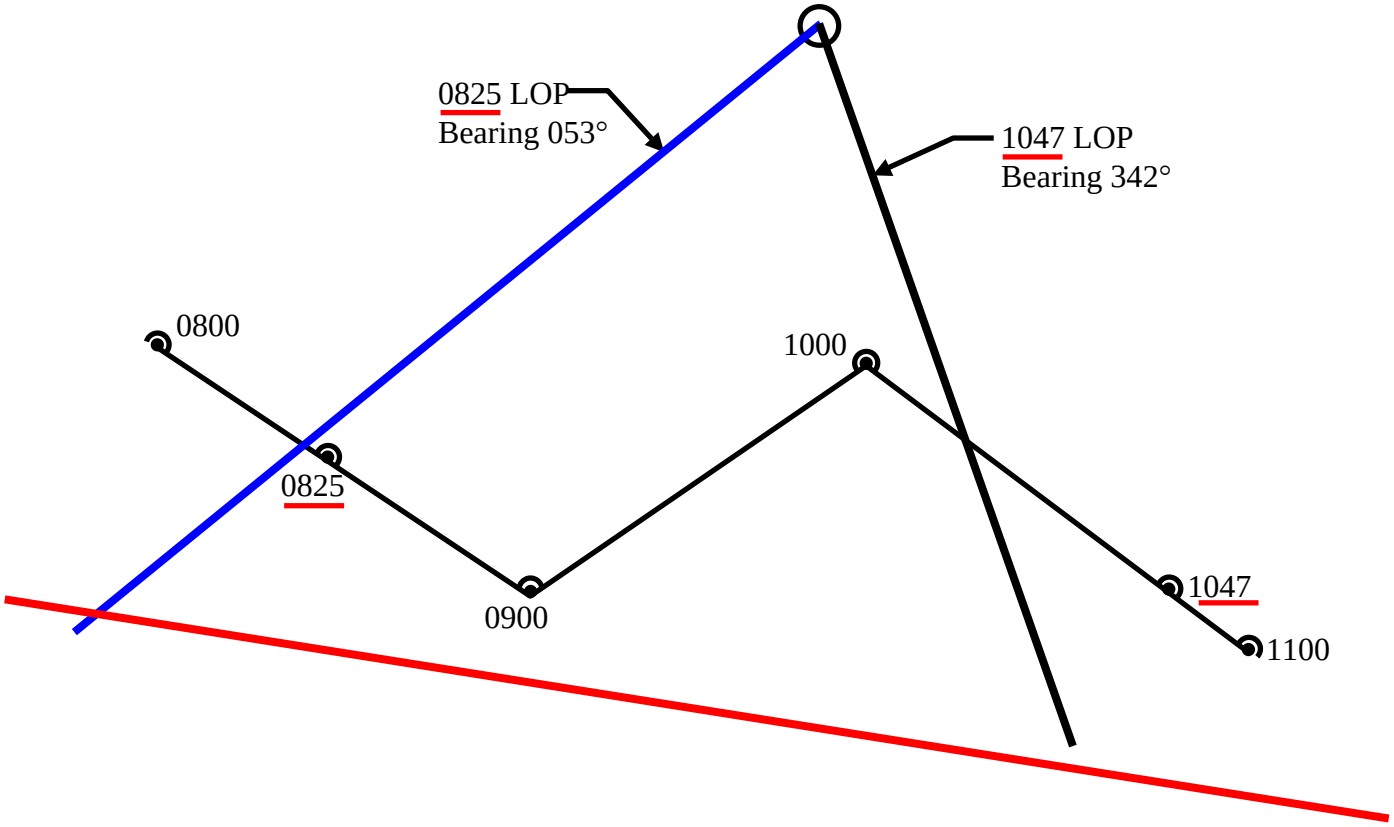
Bearing 053°
1047 LOP
Bearing 342°
0800
1000
1047


0825 LOP
Bearing 053°
1047 LOP
Bearing 342°
0800
0825
0900
1000
1047
1100


0825 LOP
Bearing 053°
1047 LOP
Bearing 342°
0800
1000
0825
0900
1047
1100


0825 LOP
Bearing 053°
1047 LOP
Bearing 342°
0800
0825
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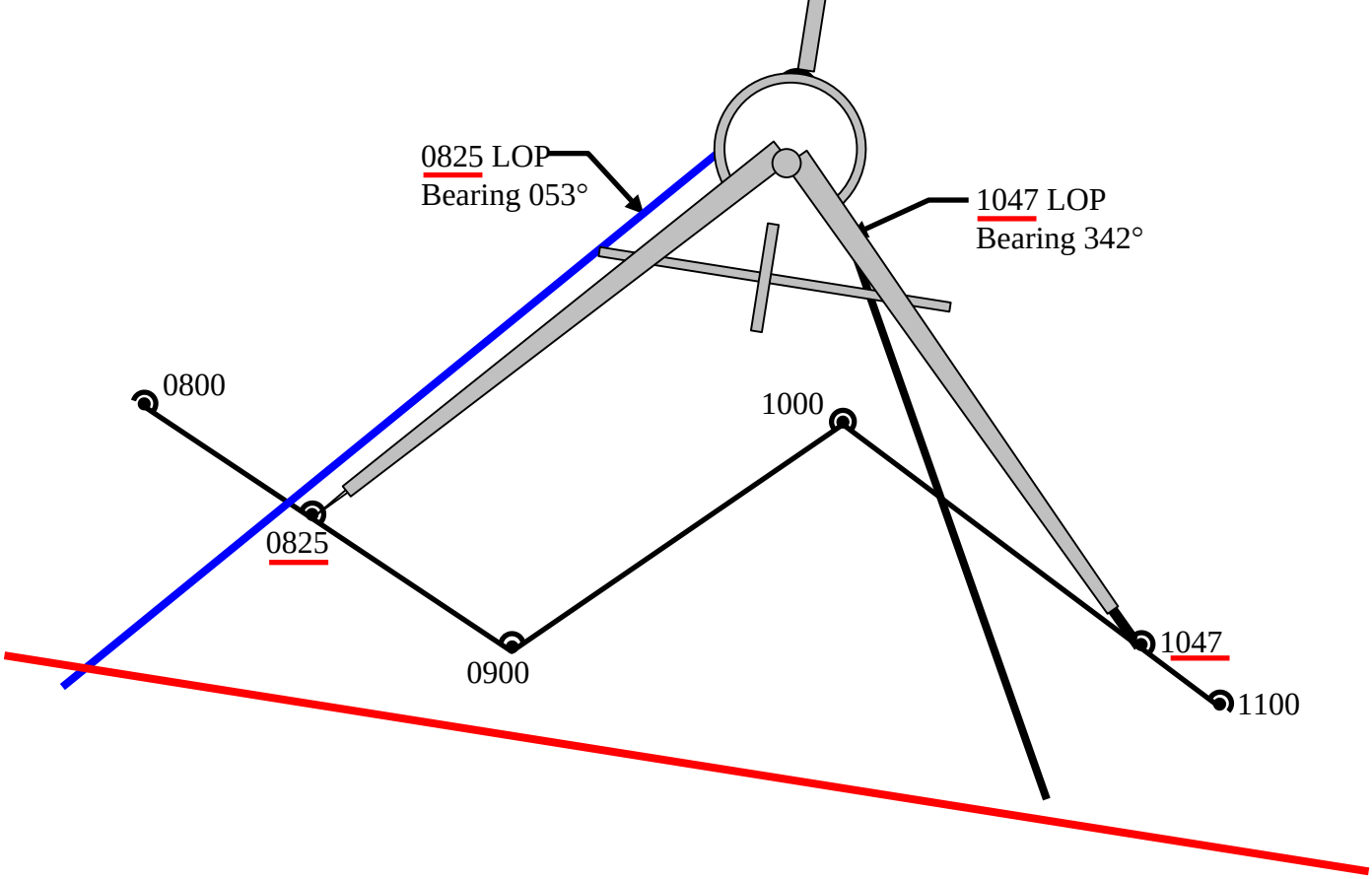
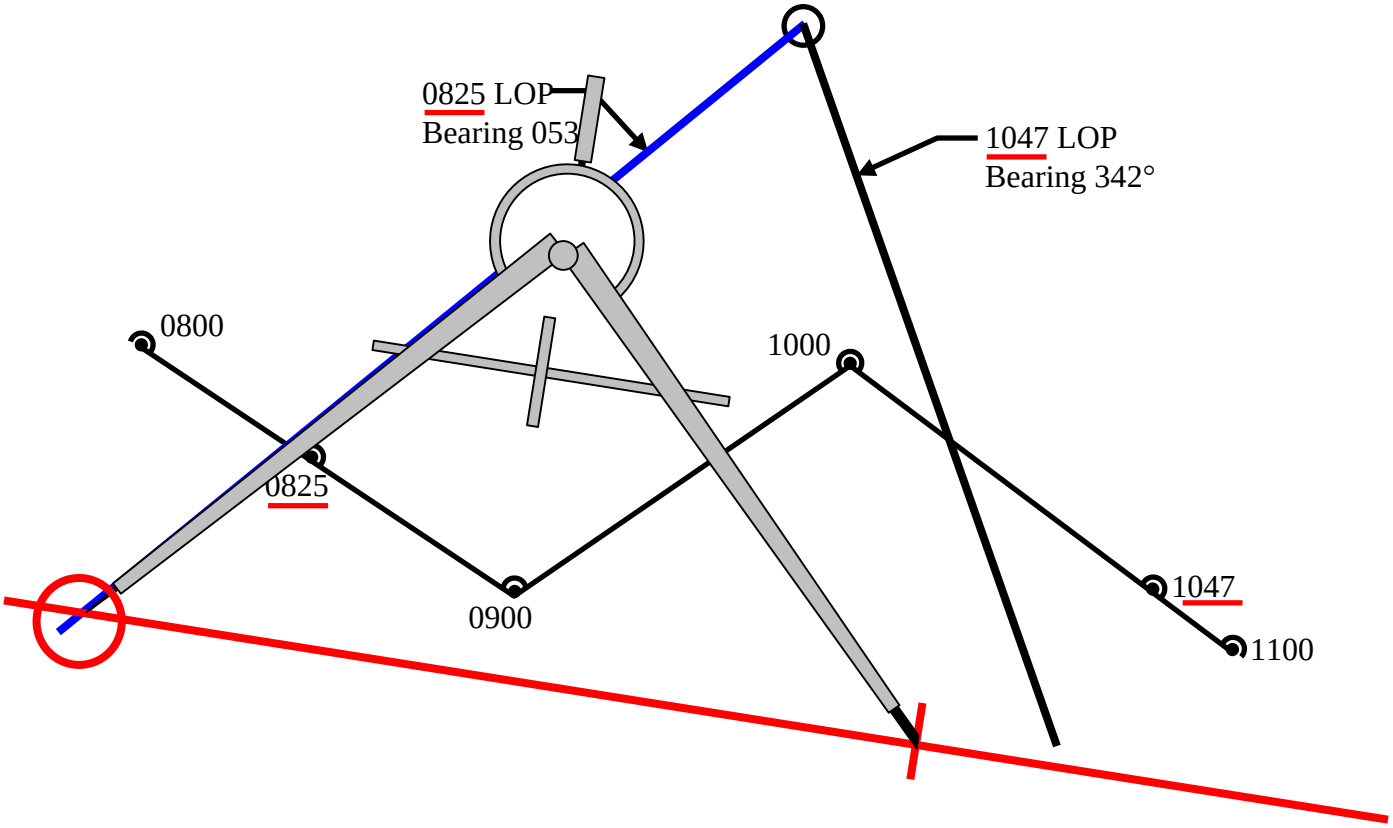
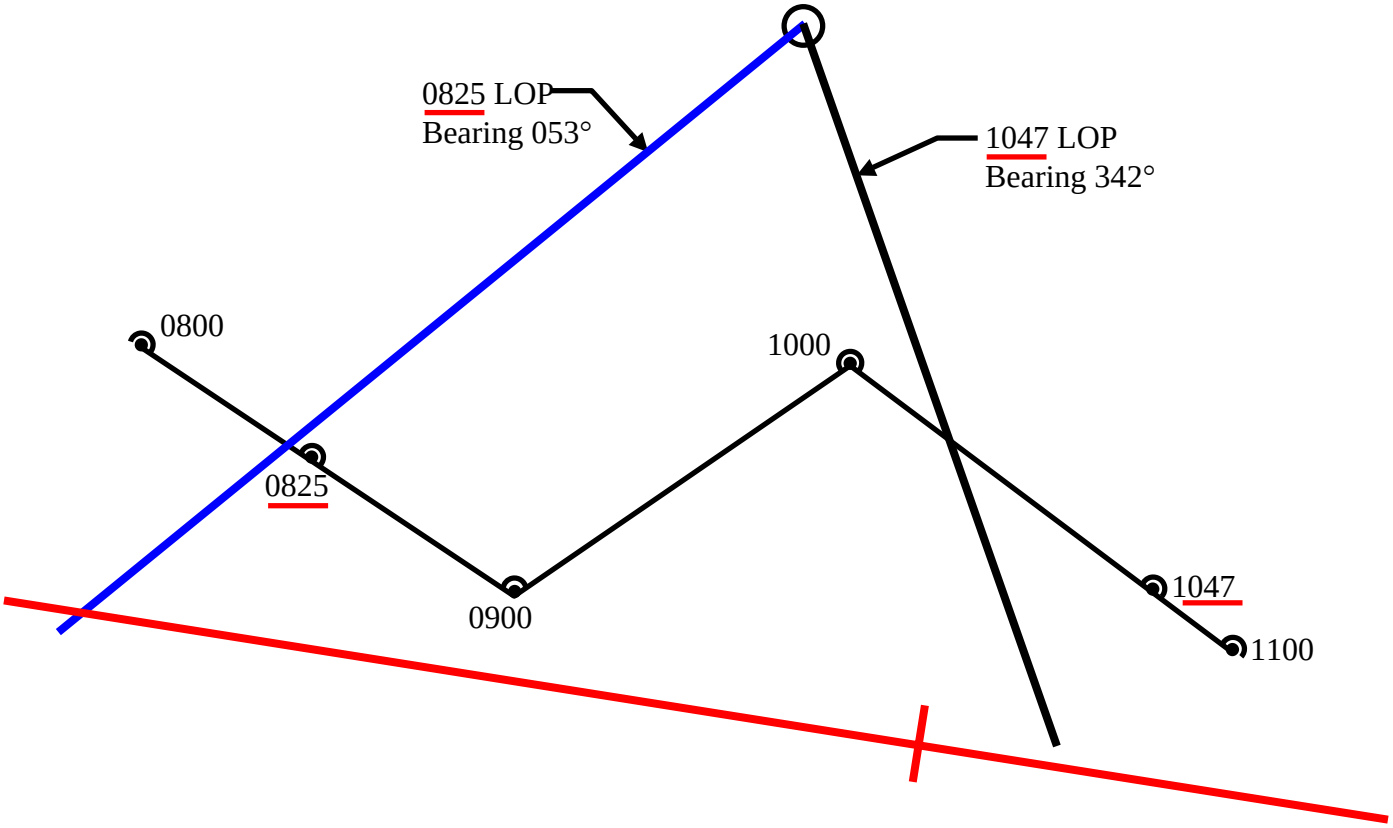
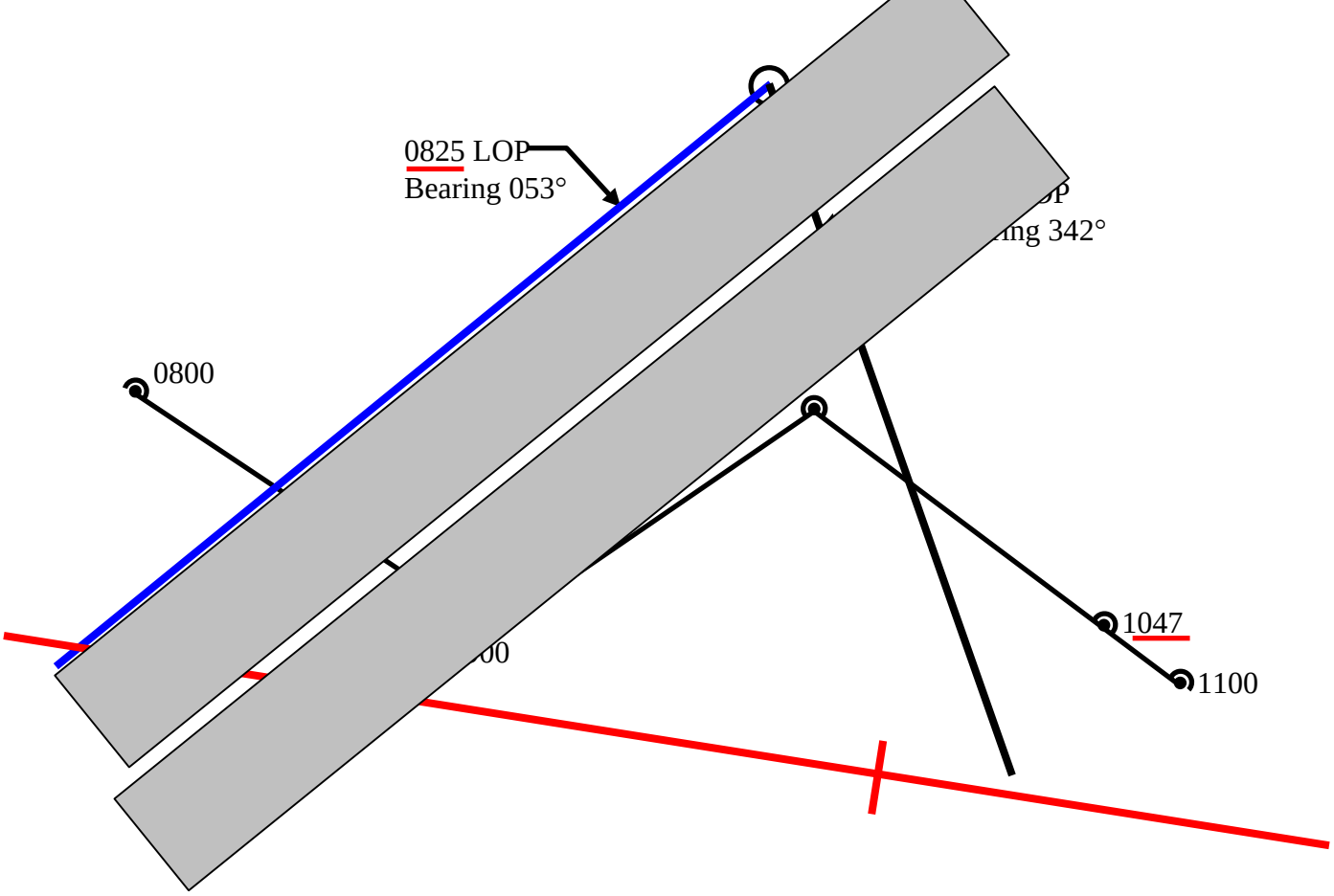
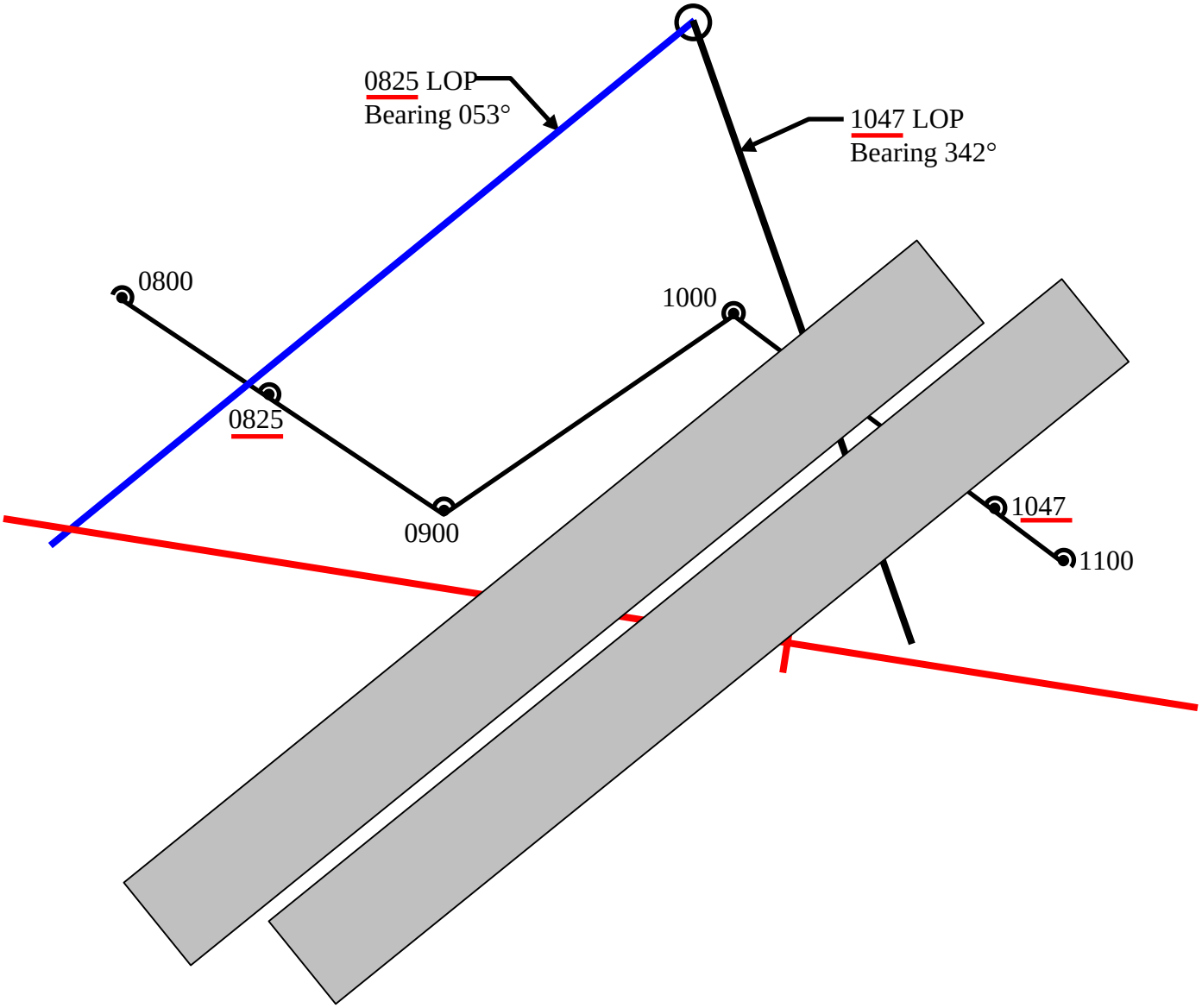
1000
1047
1100

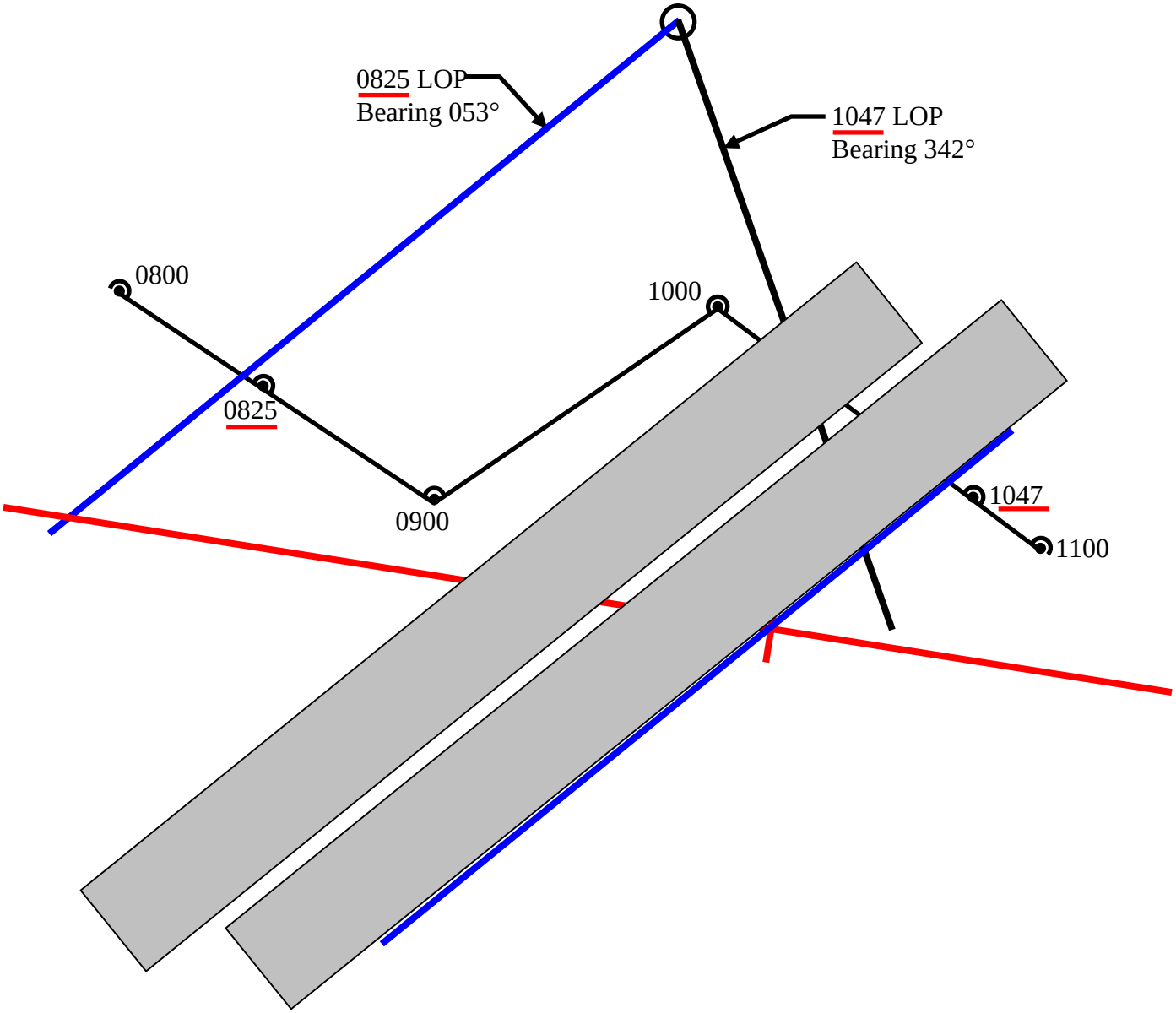

0825 LOP
Bearing 053°
1047 LOP
Bearing 342°
0800
0825
0900
1000
1047
1100

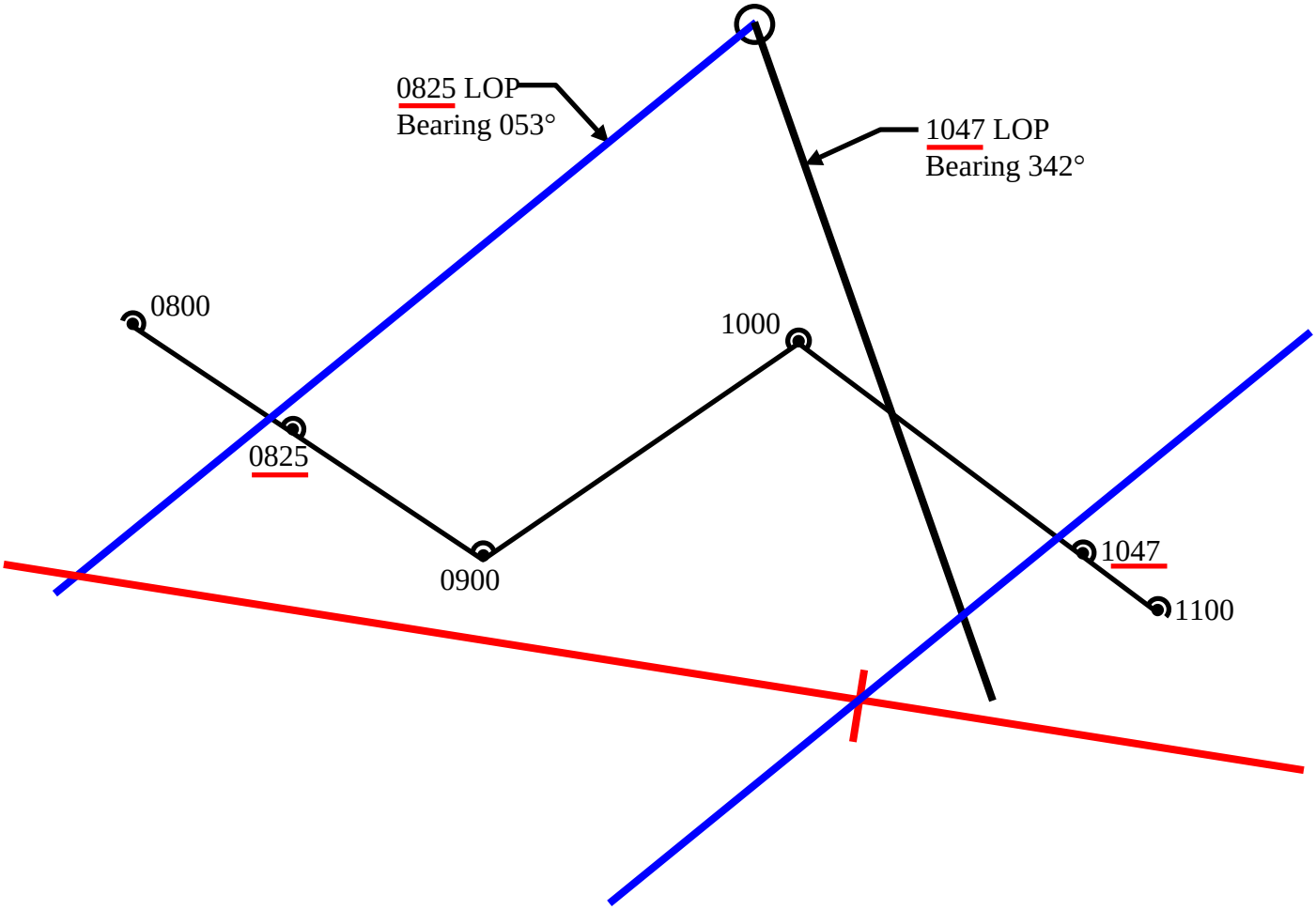

0825 LOP
Bearing 053
1047 LOP
Bearing 342°
0800
1000
0825
0900
1047
1100

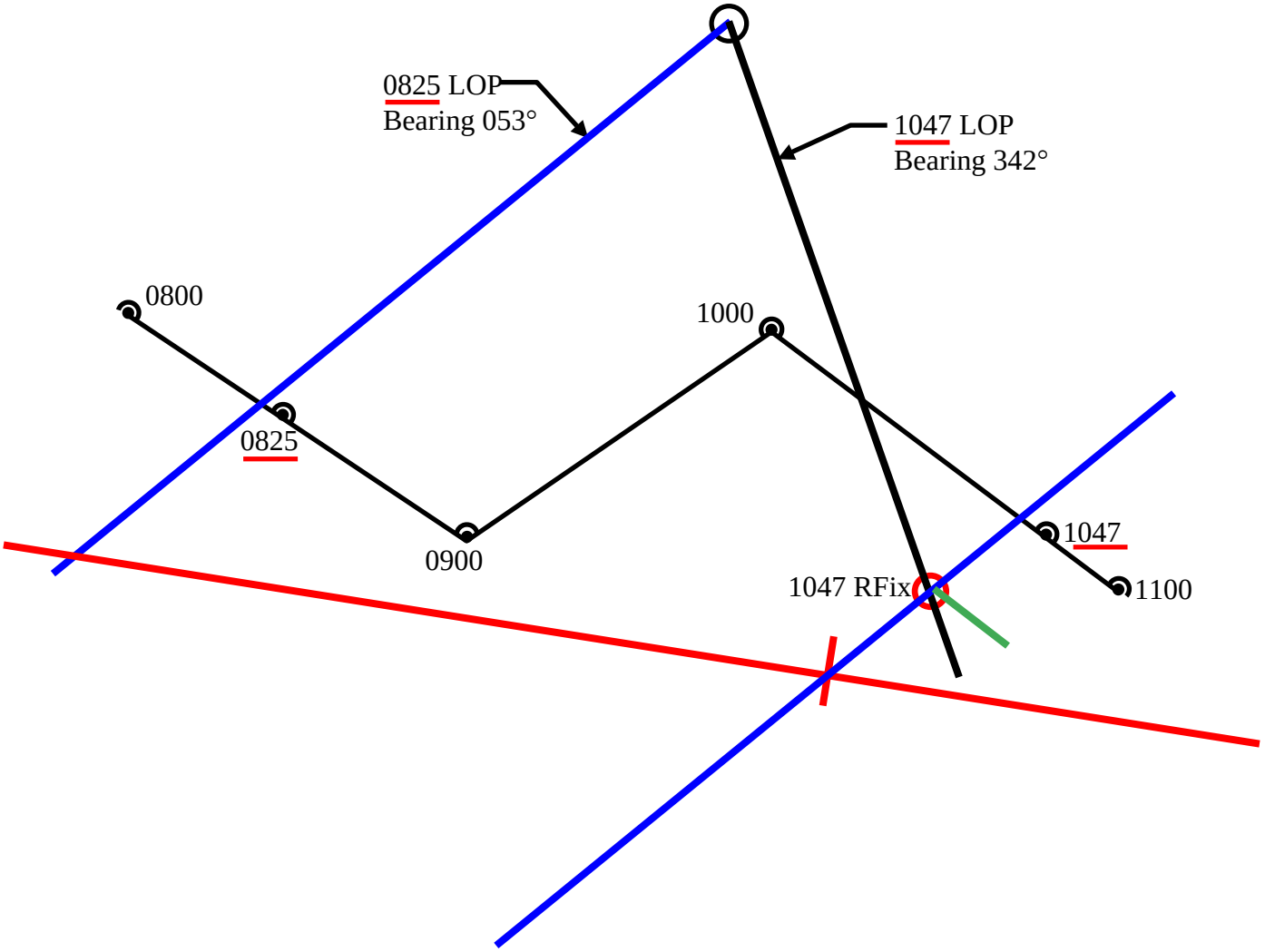

0825 LOP
Bearing 053°
1047 LOP
Bearing 342°
0800
0825
0900
1000
1047
1100


0825 LOP
Bearing 053°
ing 342°
0800
1047
1100


0825 LOP
Bearing 053°
1047 LOP
Bearing 342°
0800
1000
0825
0900
1047
1100

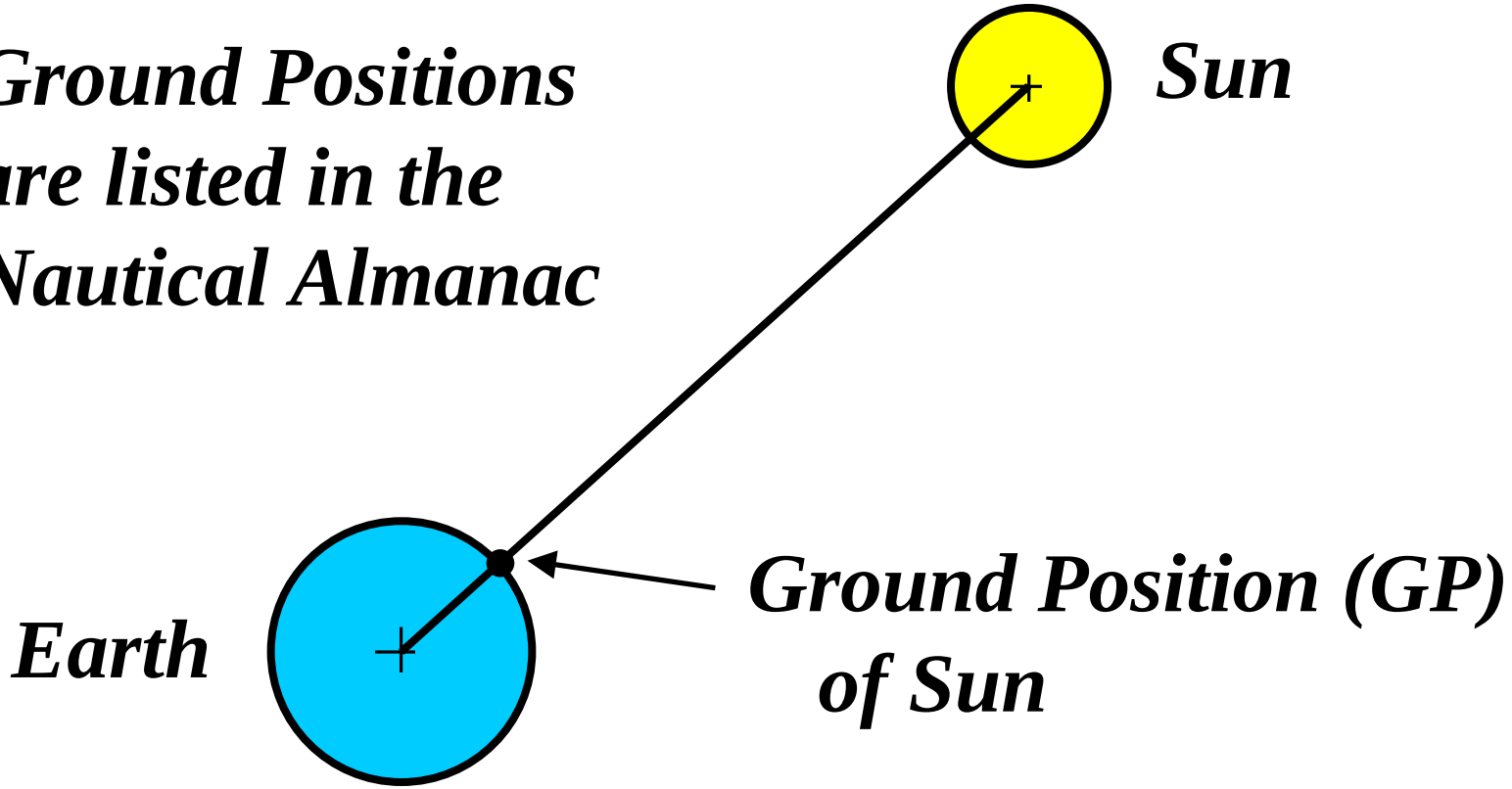

0825 LOP
Bearing 053°
1047 LOP
Bearing 342°
0800
1000
0825
0900
1047
1100


0825 LOP
Bearing 053°
1047 LOP
Bearing 342°
0800
0825
0900
1000
1047
1100


0825 LOP
Bearing 053°
1047 LOP
Bearing 342°
0800
0825
0900
1000
1047
1047 RFix
1100

Celestial Geometry

- *Ground Positions are listed in the Nautical Almanac*



THE NAUTICAL ALMANAC

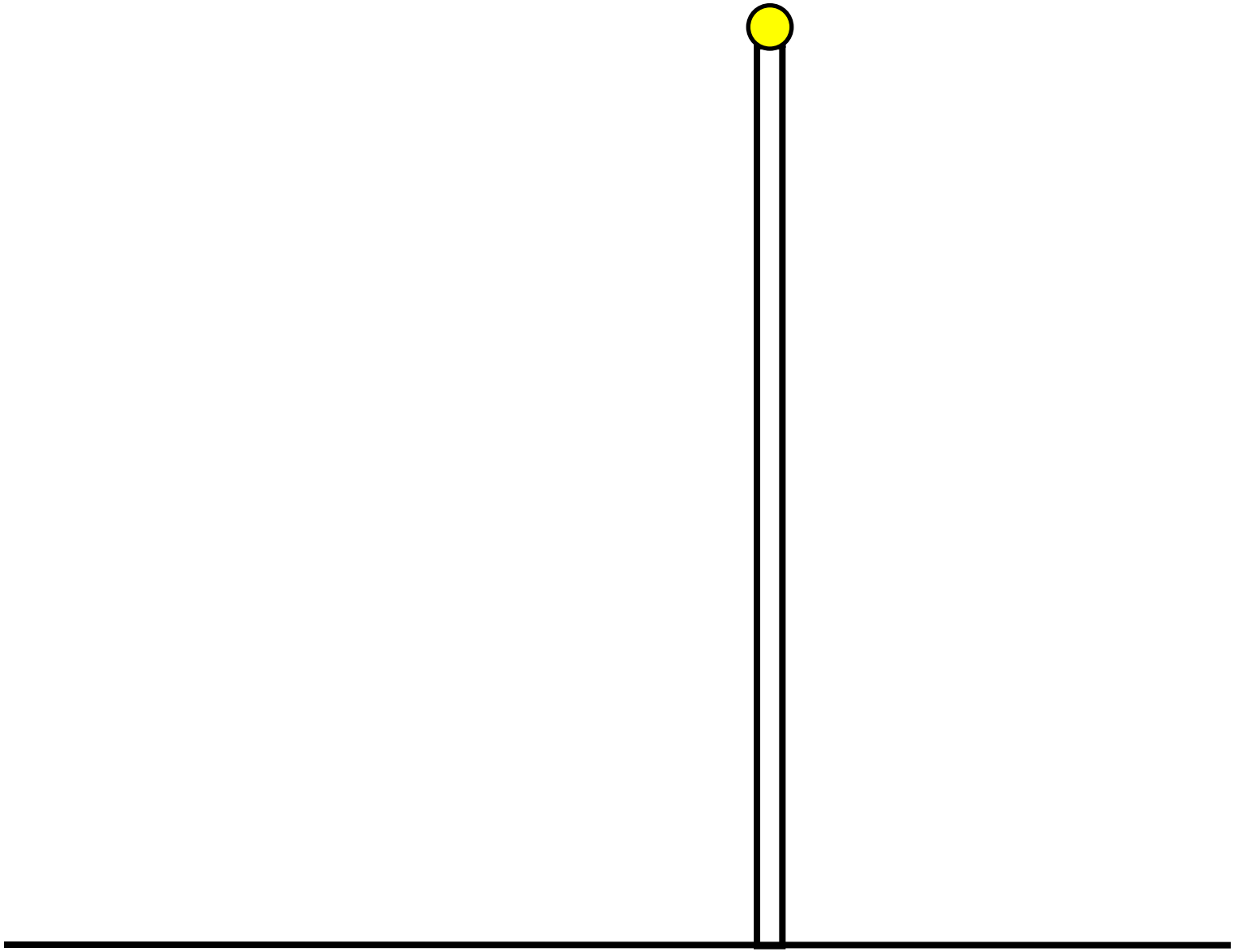
FOR THE YEAR

2014

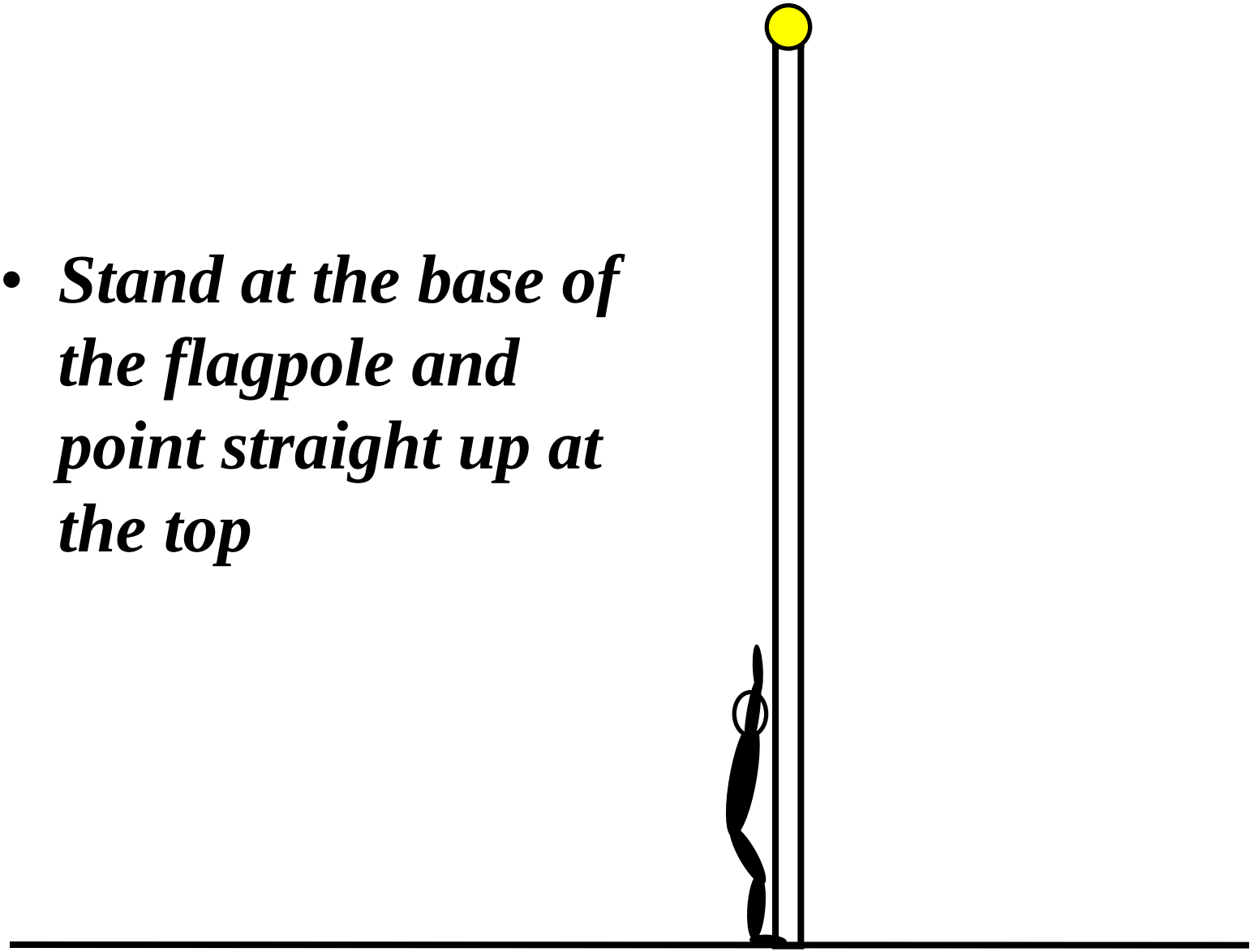
WASHINGTON:
United States
Naval Observatory
2013

TAUNTON:
The United Kingdom
Hydrographic Office
2013

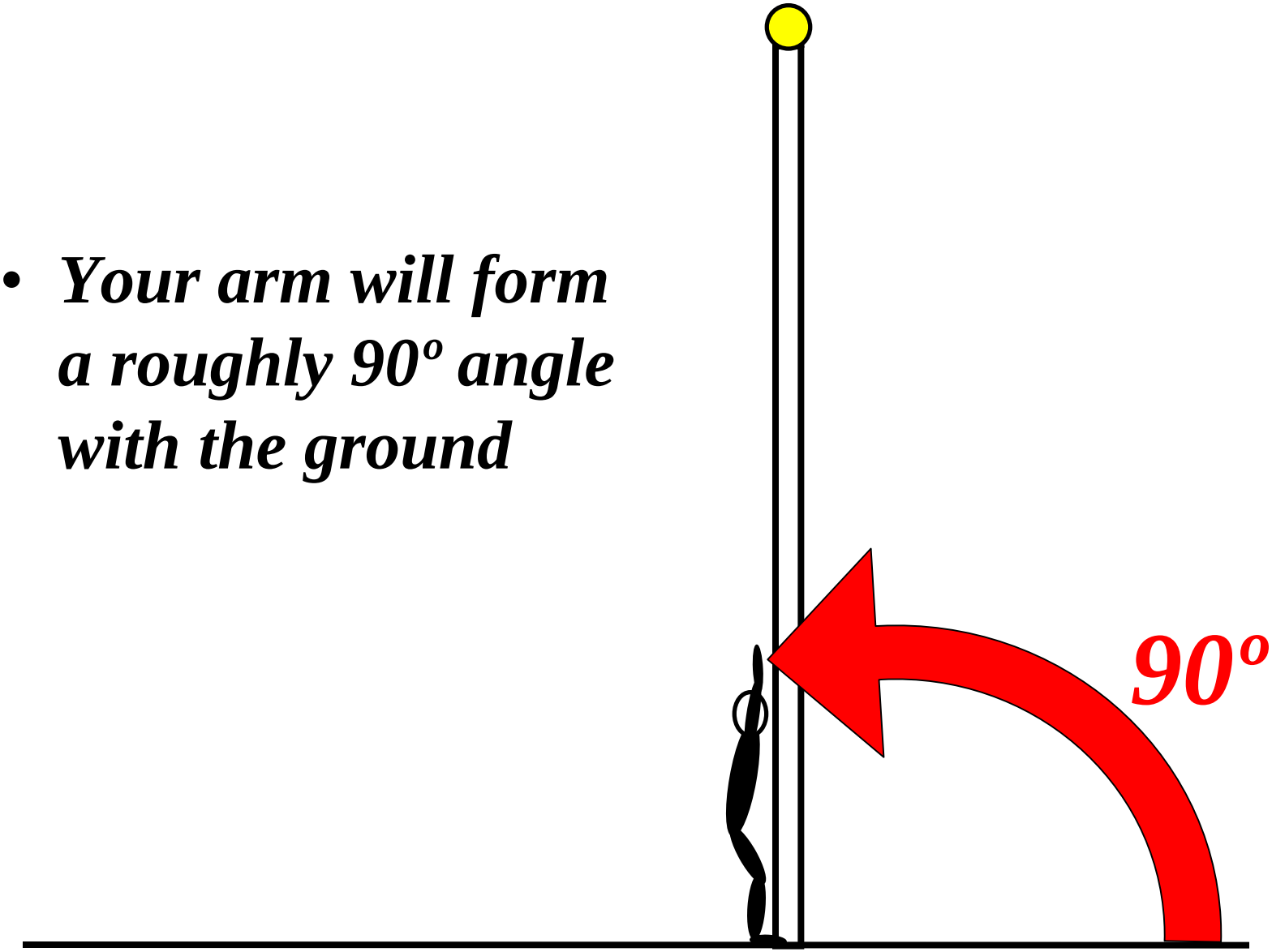
NSN 7642016155074
NGA Ref No. NAUTALMANAC14
ED. NO 000



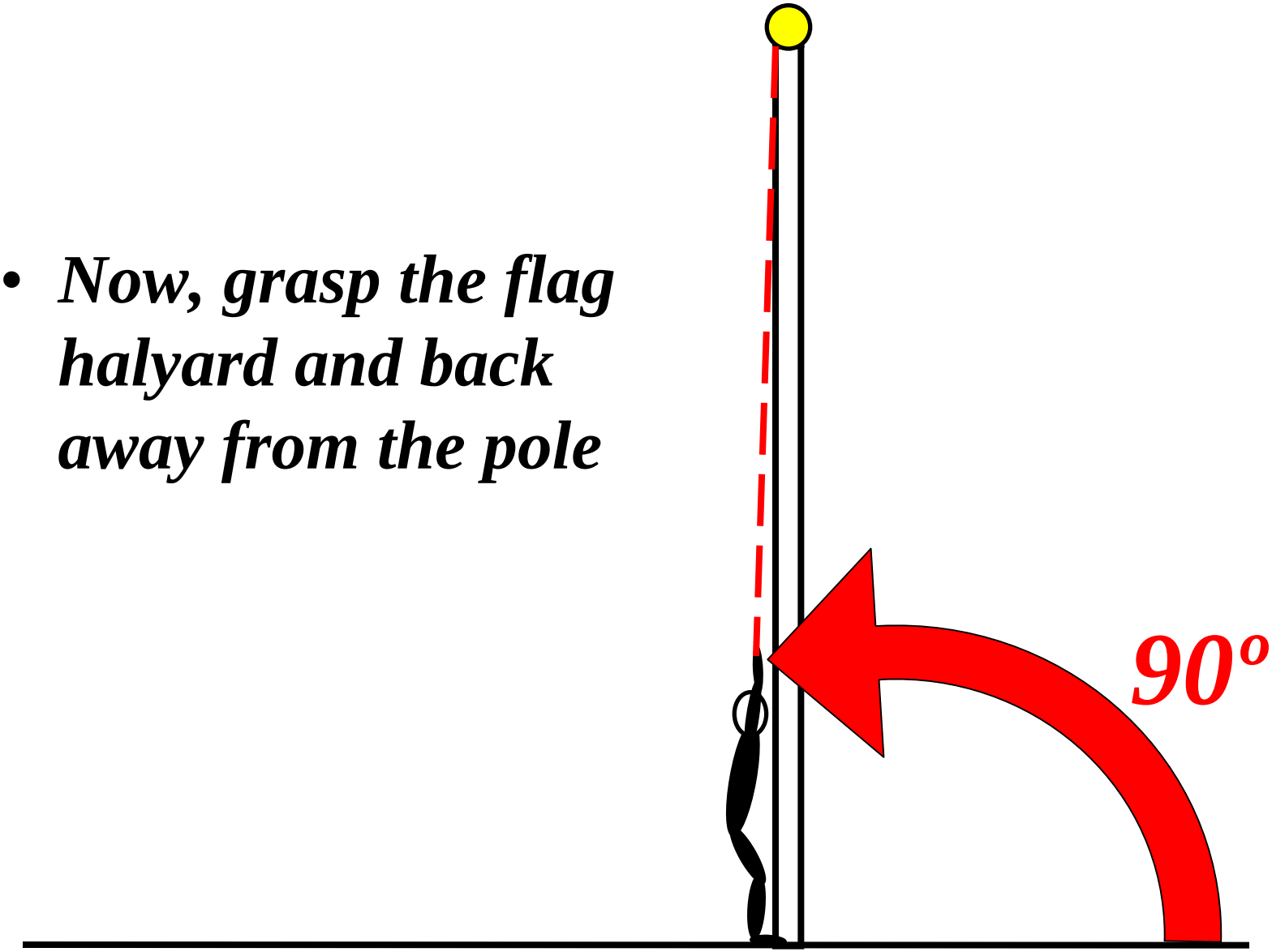
- ***Stand at the base of the flagpole and point straight up at the top***

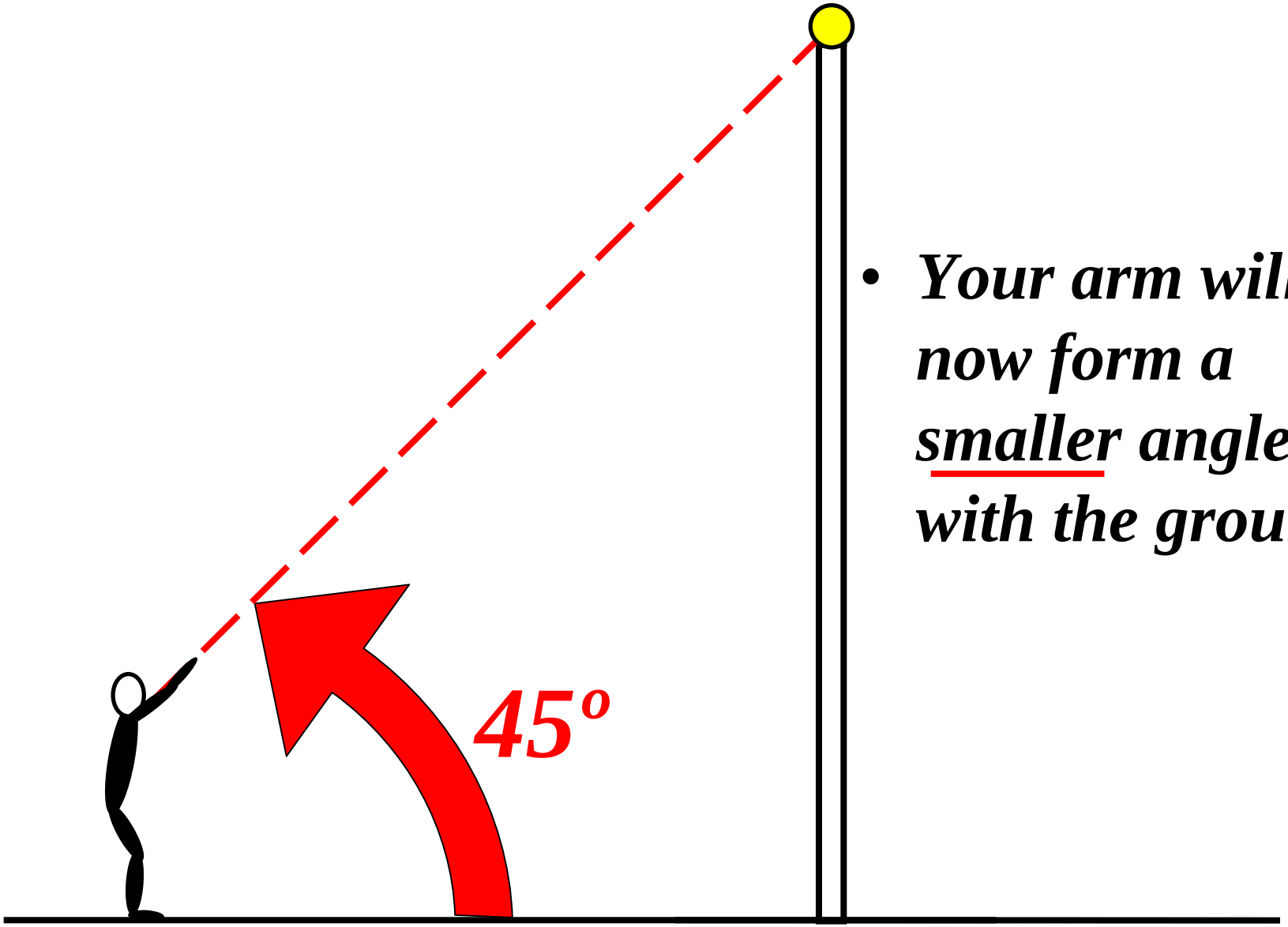


- ***Your arm will form a roughly 90º angle with the ground***



- ***Now, grasp the flag halyard and back away from the pole***

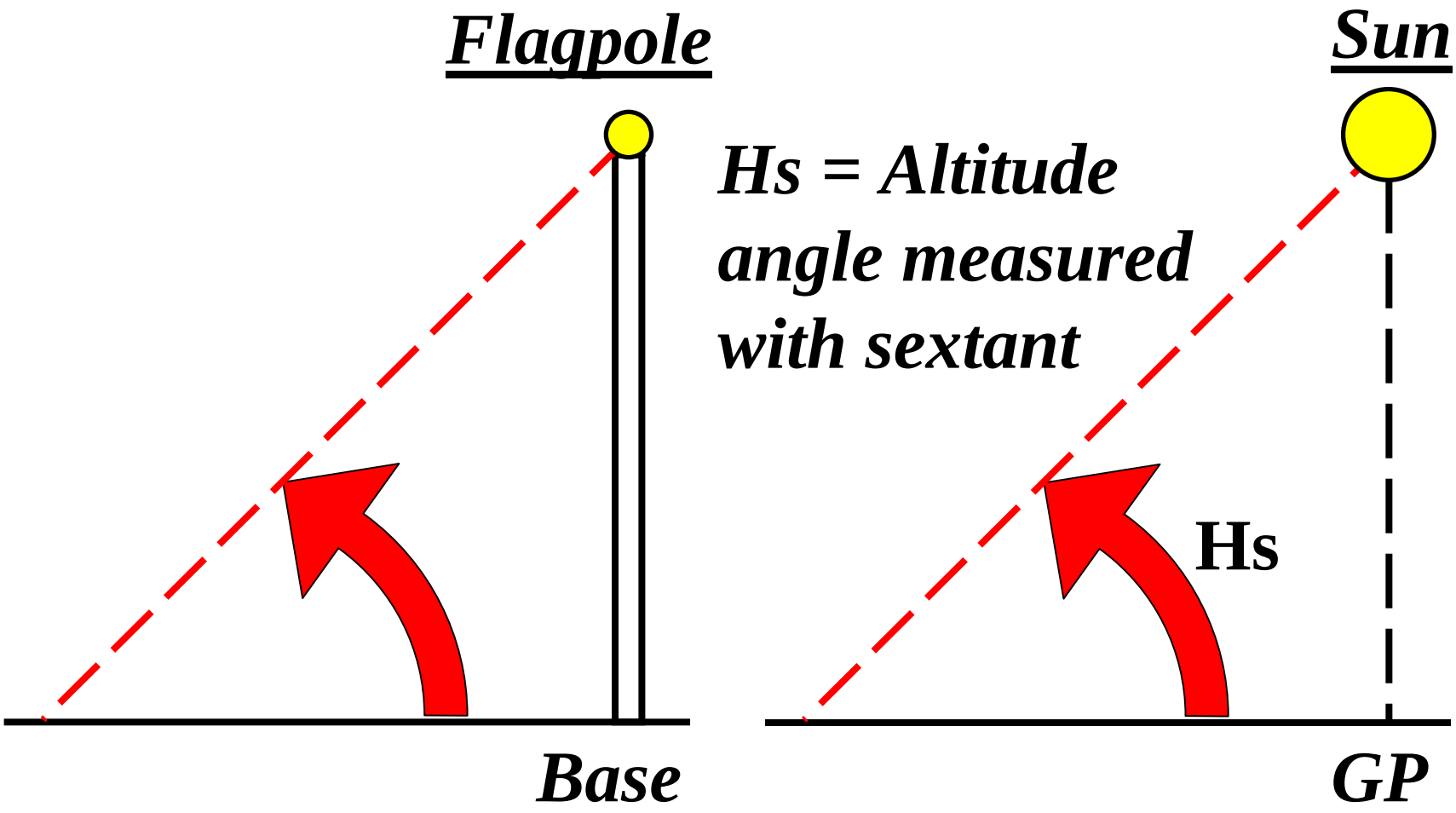




- ***Your arm will now form a <u>smaller</u> angle with the ground***

General Rule

- ***Large angels are close to the flagpole***
- ***Small angles are farther away***


Flagpole
Sun
Hs = Altitude angle measured with sextant
Hs
Base
GP

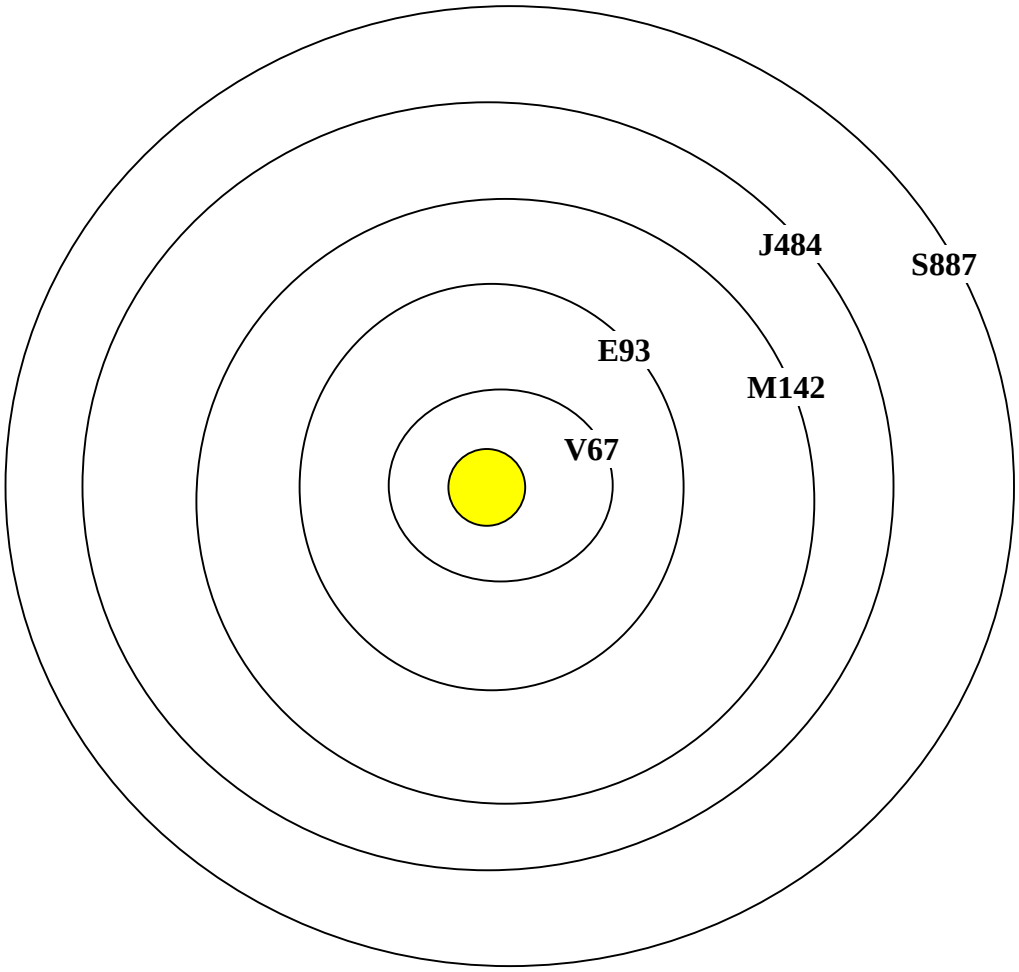
Ocean Navigation

- ***Our objective is to combine DR navigation with measurements of the Sun's Altitude Angle (Hs) into a meaningful ocean navigation process***

- ***Also applies to Moon, Planets and selected Stars***

Planet Approximate Distances to Sun

(Millions of Miles)

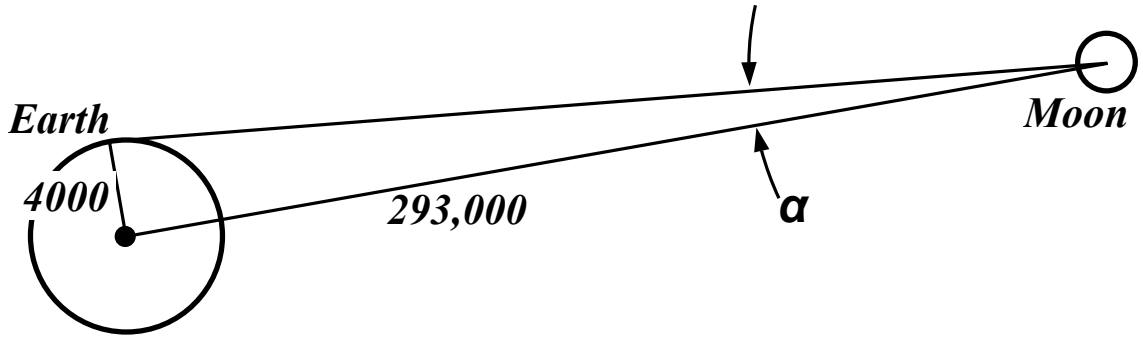


Distances- Millions of Miles

Earth-Venus	***26 to 160***
Earth- Mars	***49 to 235***
Earth-Jupiter	***391 to 577***
Earth-Saturn	***794 to 980***
Earth-Moon	***0.293***

Closer Bodies

(Non-Parallel Light Rays)



Moon: $\tan \alpha_M = \dfrac{4{,}000}{293{,}000} = 0.0136$

$\alpha_M = 0.78^o = 47 \text{ minutes}$

Sun: $\tan \alpha_S = \dfrac{4{,}000}{93 \times 10^6} = 0.000043$

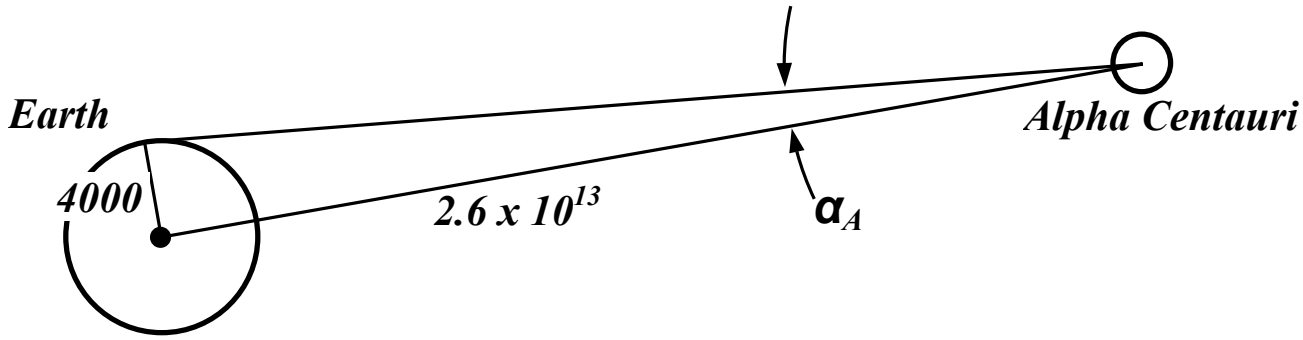
$\alpha_S = 0.0024^o = 0.15 \text{ minutes}$

Parallax for Venus & Mars also

Distant Bodies

Alpha Centauri- The nearest star

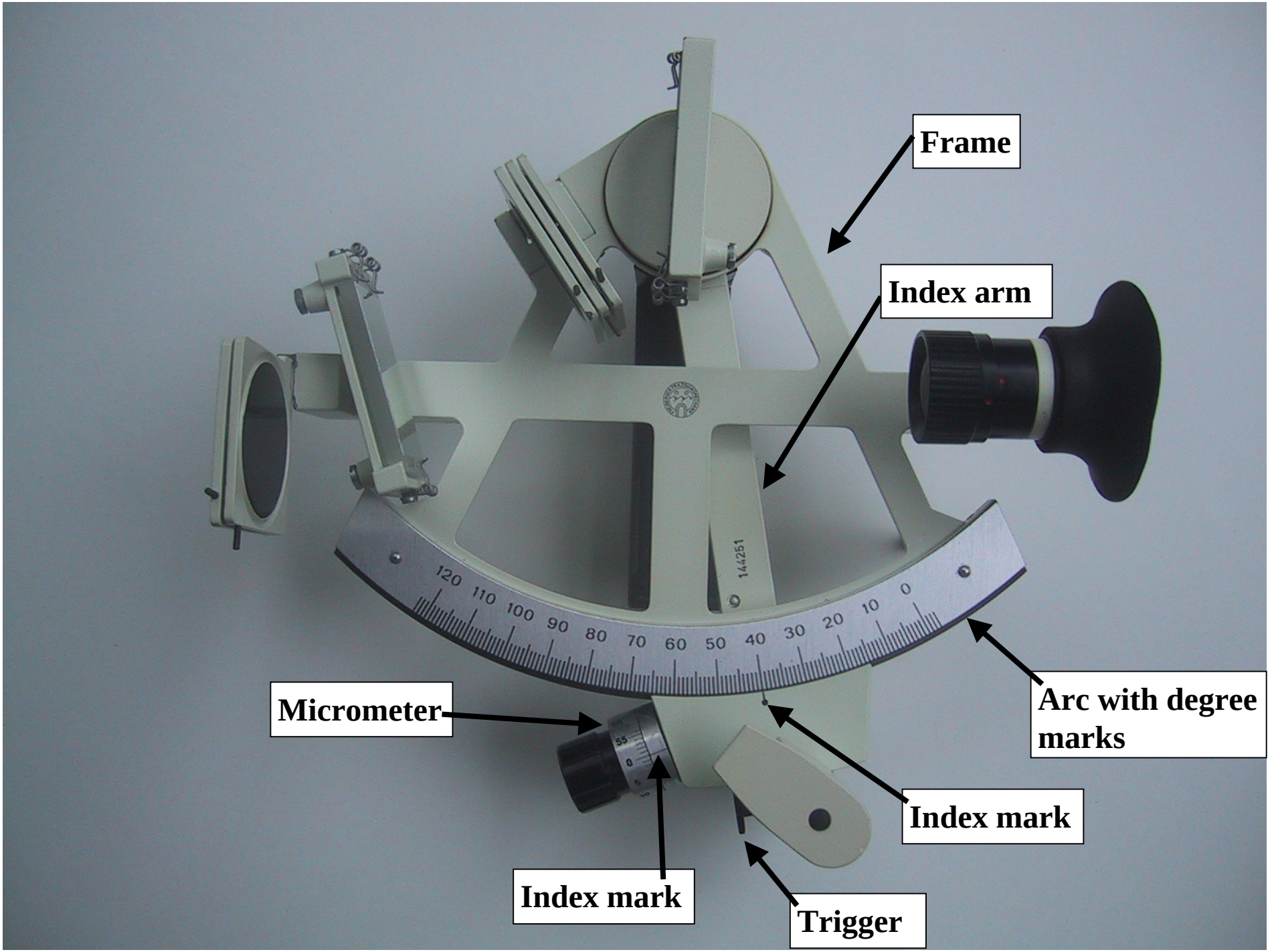
4.5	***Light years distant***
365	***Days per year***
24	***Hours per day***
60	***Minutes per hour***
60	***Seconds per minute***
186,000	***Miles per second***
2.6×10^{13}	***Miles form Earth***

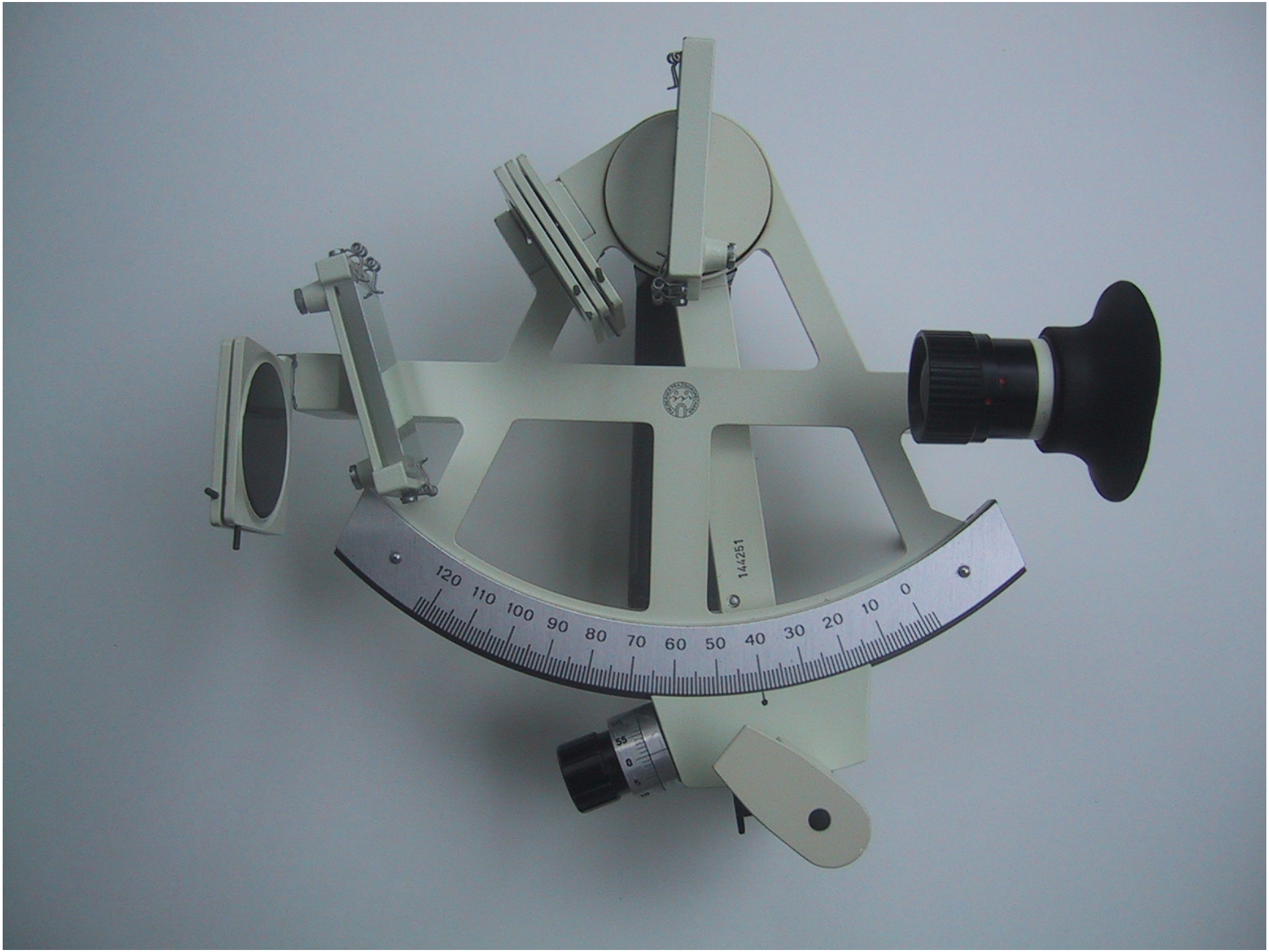


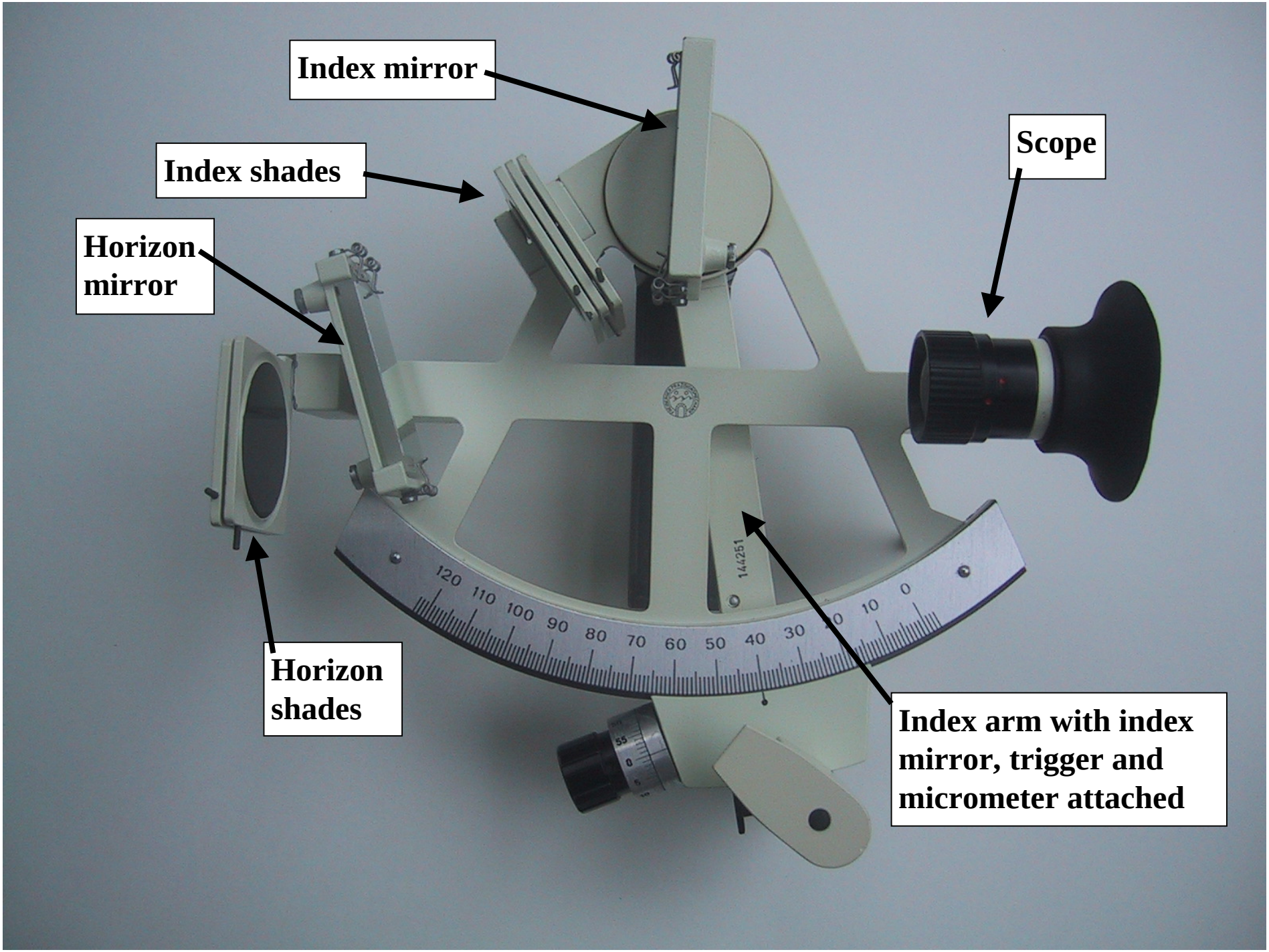
$$\tan \alpha_A = \frac{4{,}000}{2.6 \times 10^{13}} = 1.5 \times 10^{-10}$$

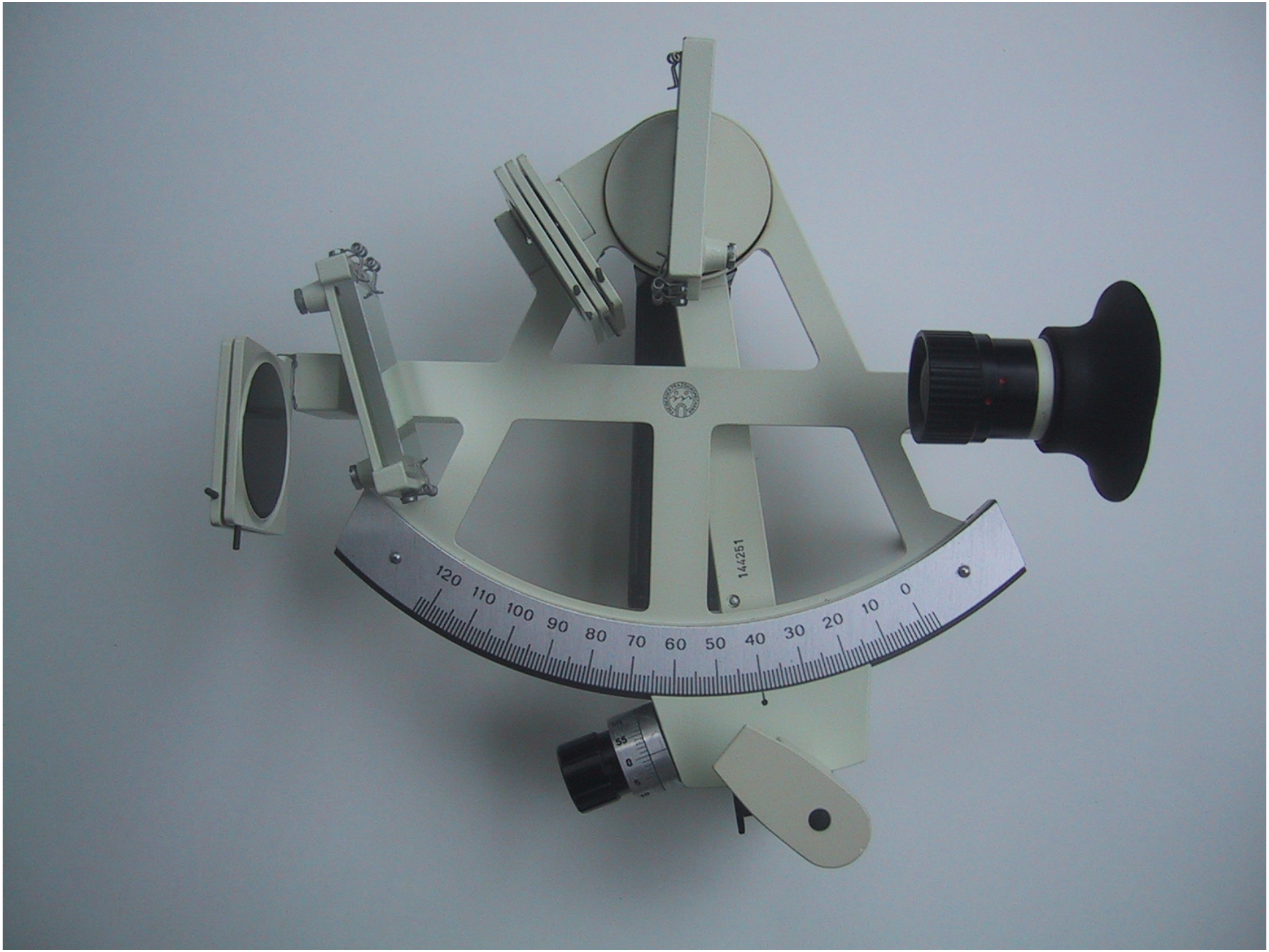
α_A = ***A Billionth of a degree***

Therefore, essentially parallel light rays


Frame
Index arm
Micrometer
Arc with degree marks
Index mark
Index mark
Trigger
144251
120 110 100 90 80 70 60 50 40 30 20 10 0


120 110 100 90 80 70 60 50 40 30 20 10 0
144251


Index mirror
Index shades
Horizon mirror
Horizon shades
Scope
Index arm with index mirror, trigger and micrometer attached
120 110 100 90 80 70 60 50 40 30 10 0
144251


120 110 100 90 80 70 60 50 40 30 20 10 0
144251

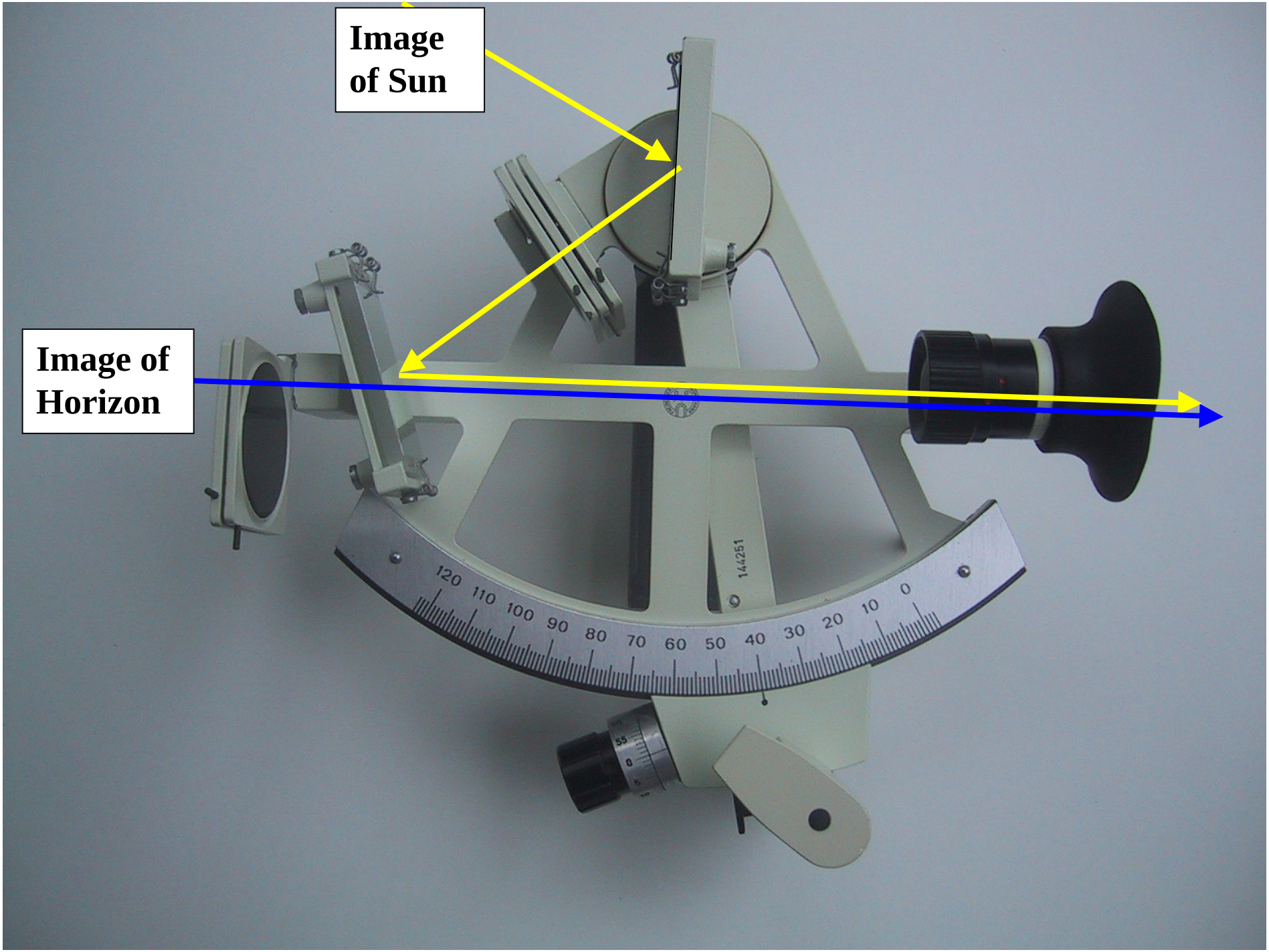
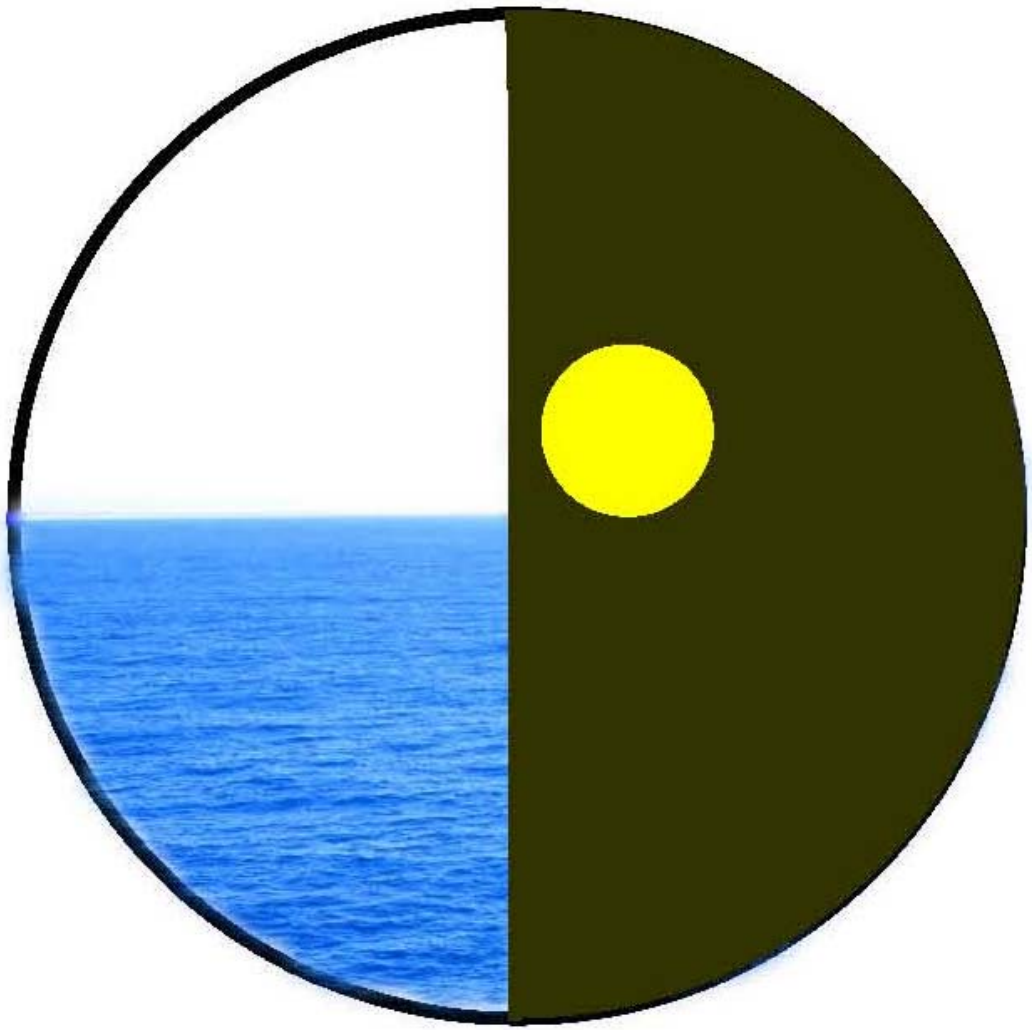


Image of Sun
Image of Horizon
120 110 100 90 80 70 60 50 40 30 20 10 0
144251



Split Horizon Mirror

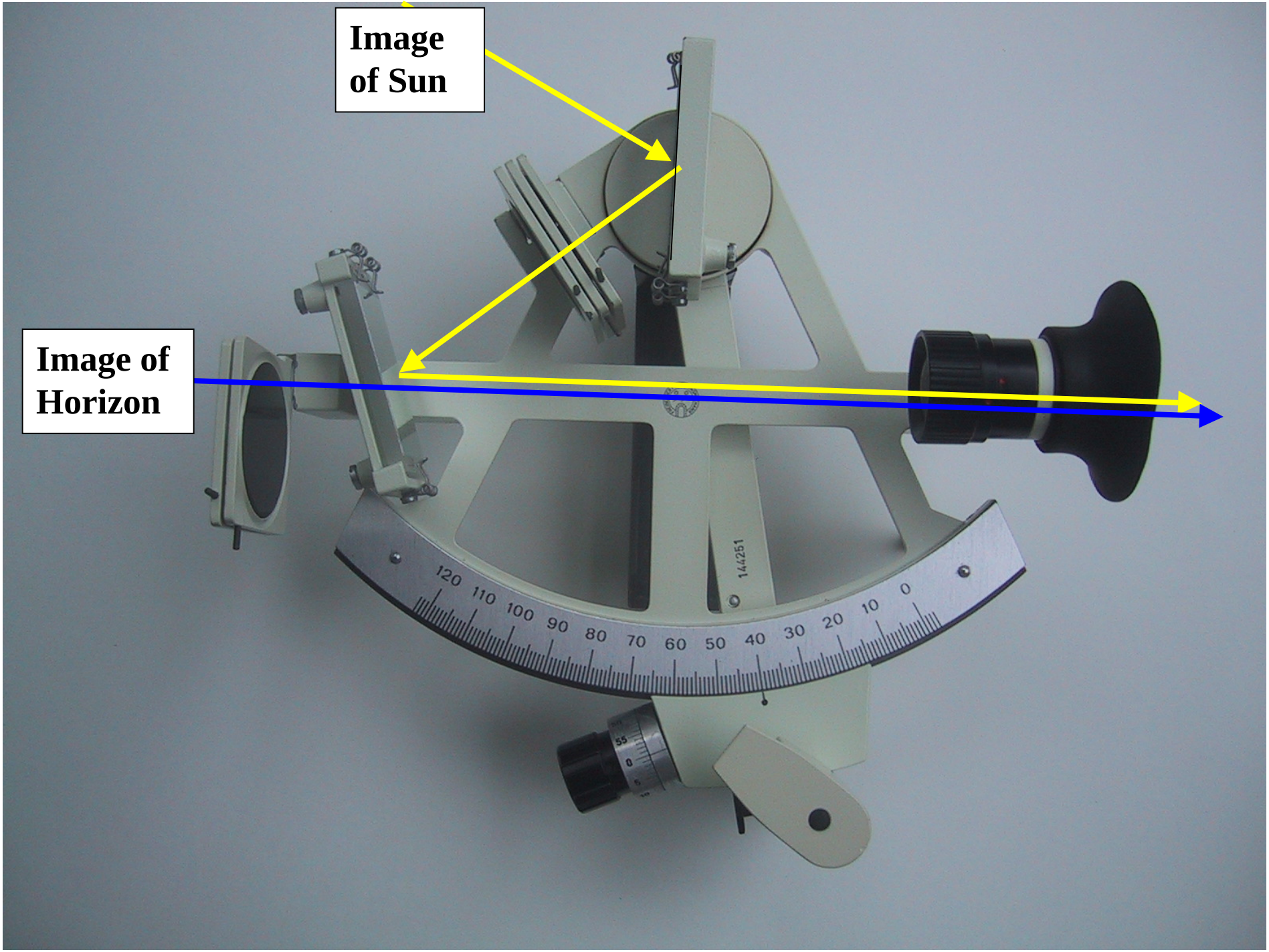
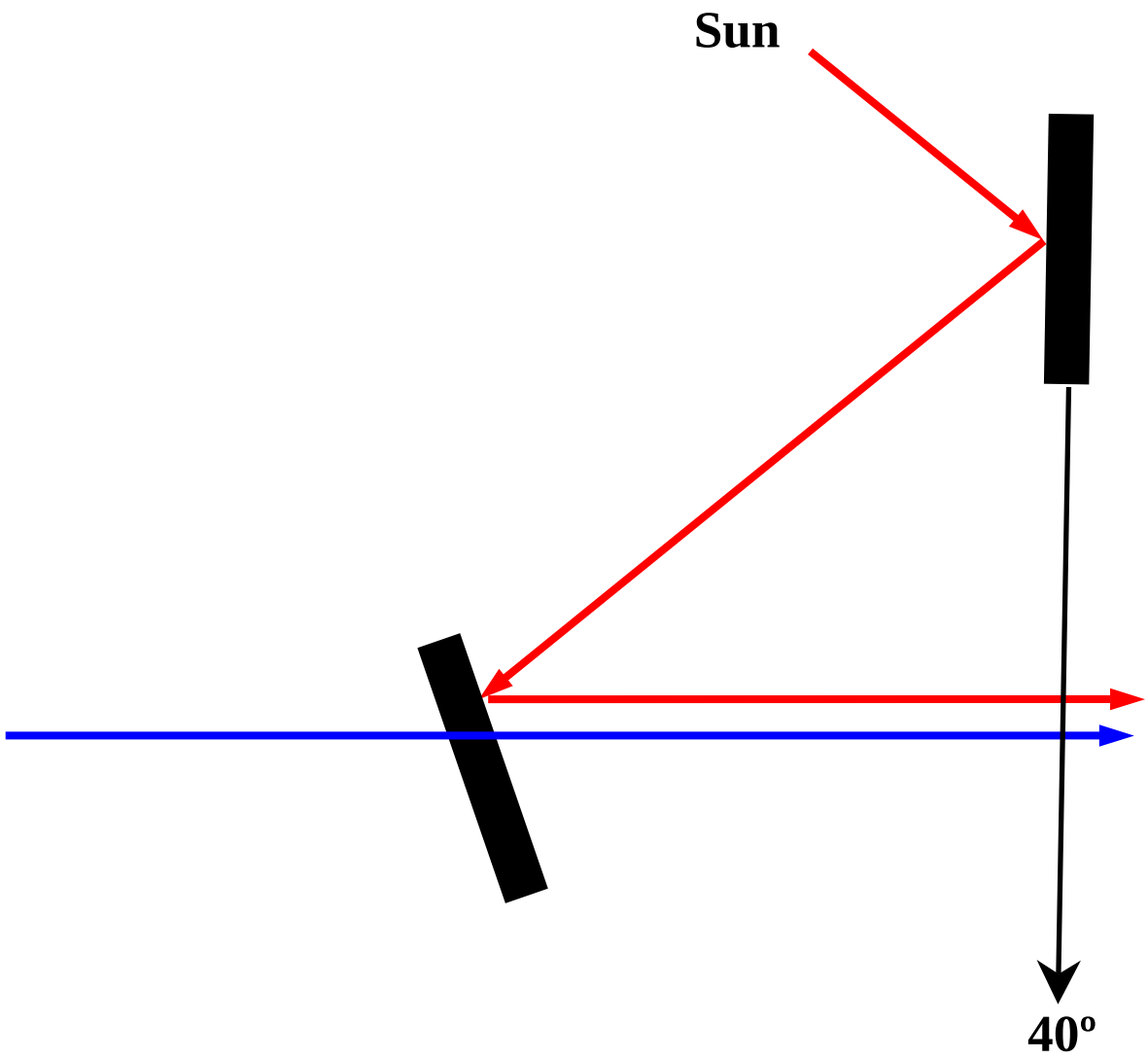
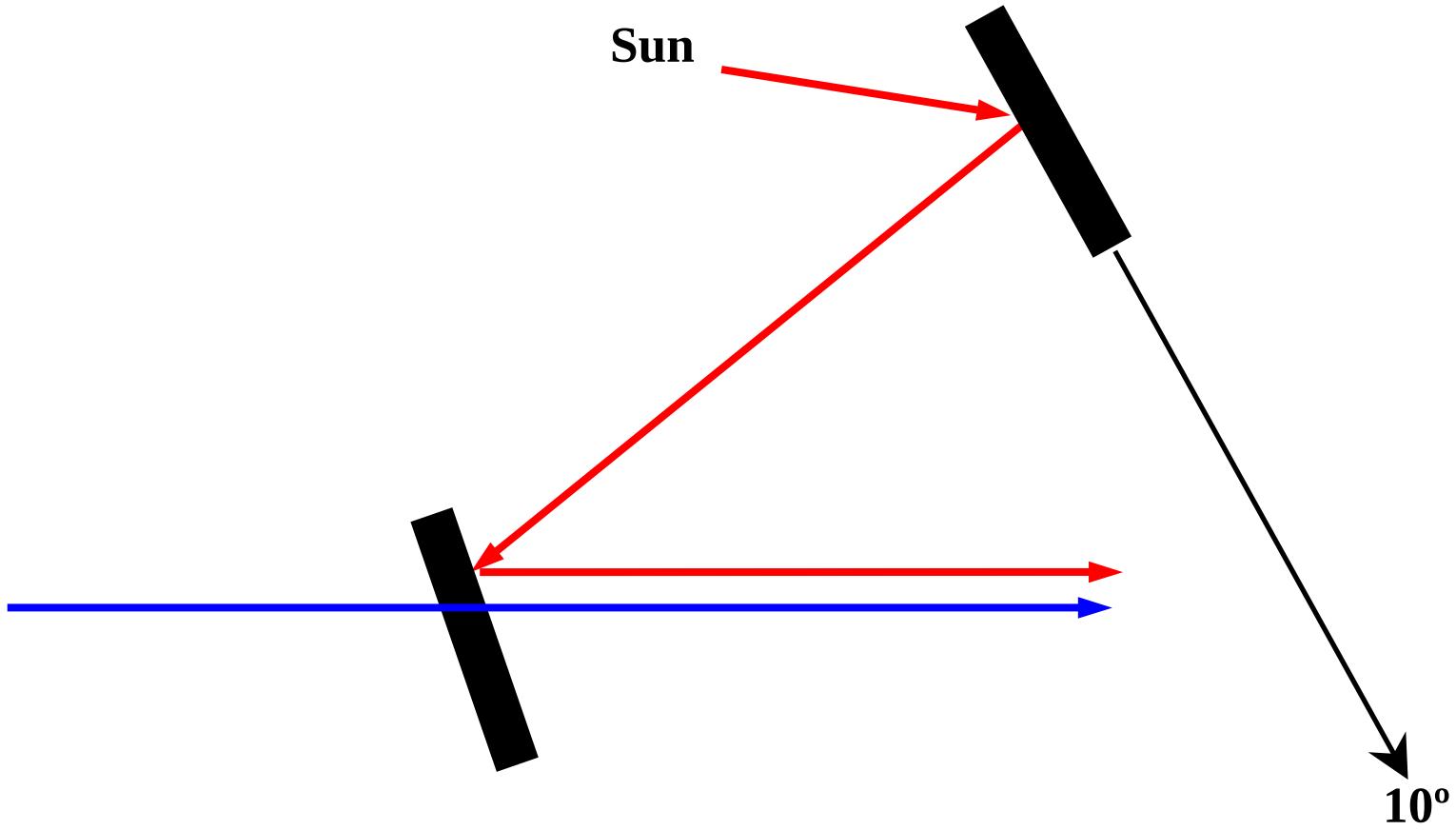
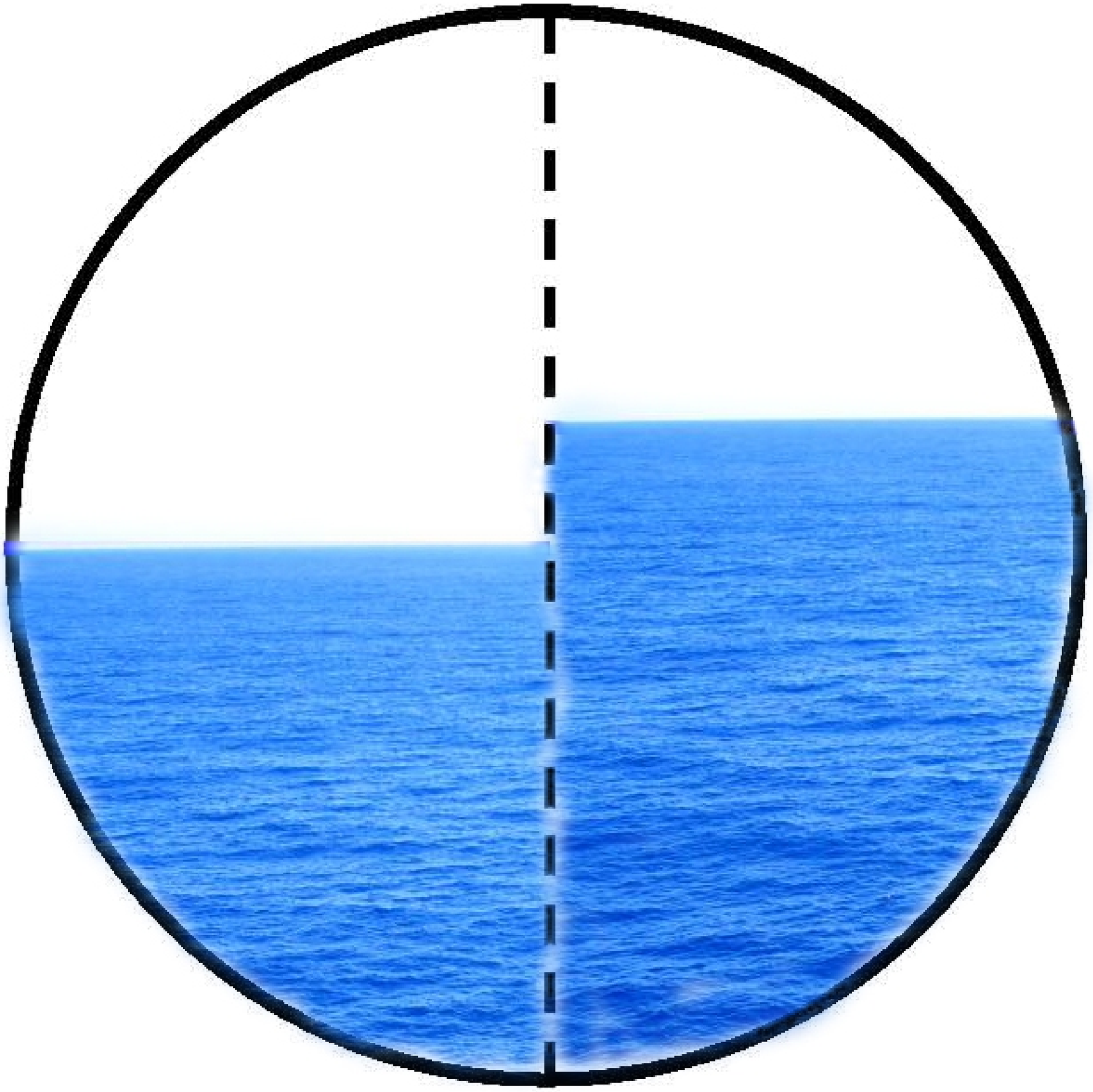
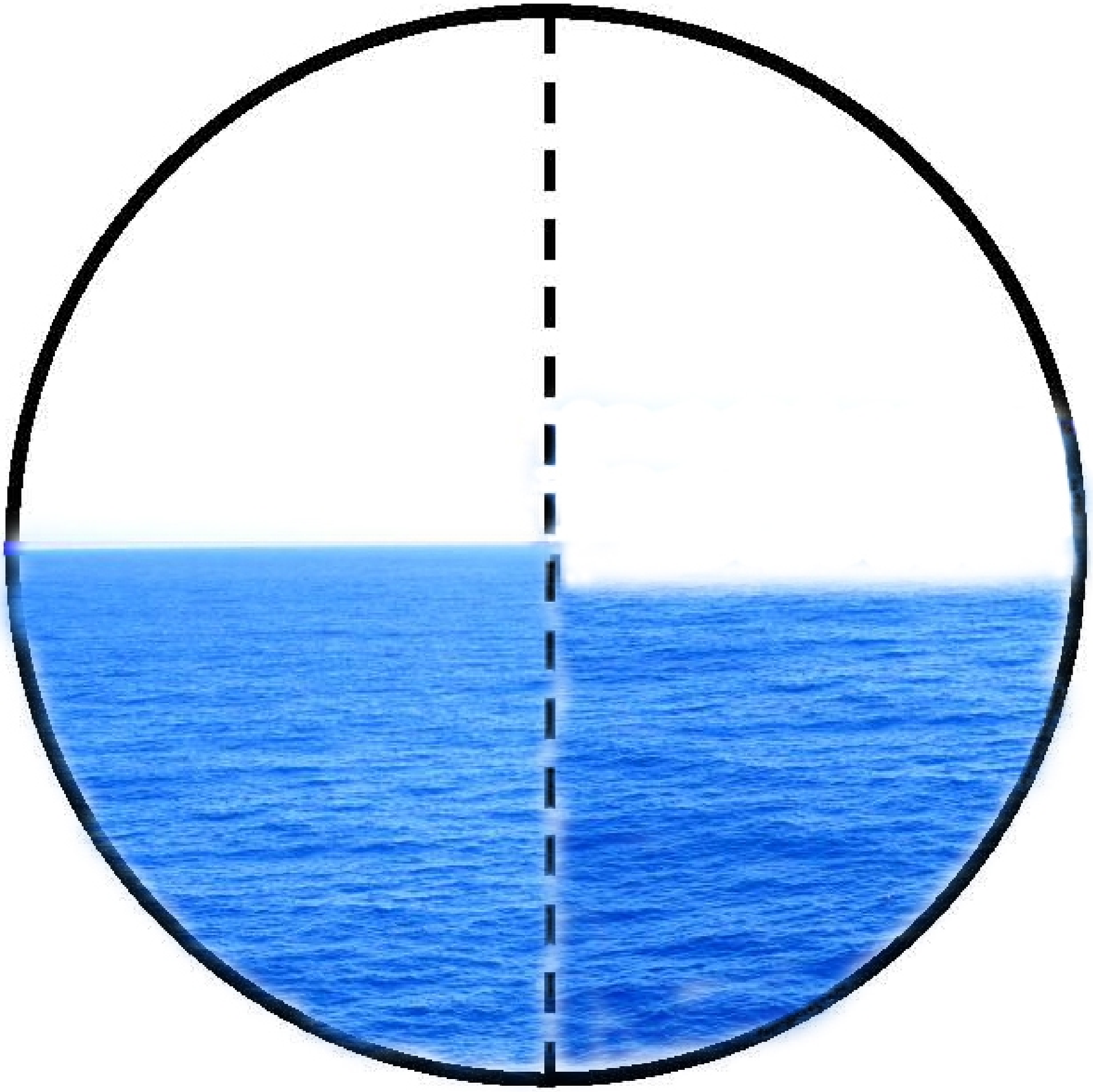


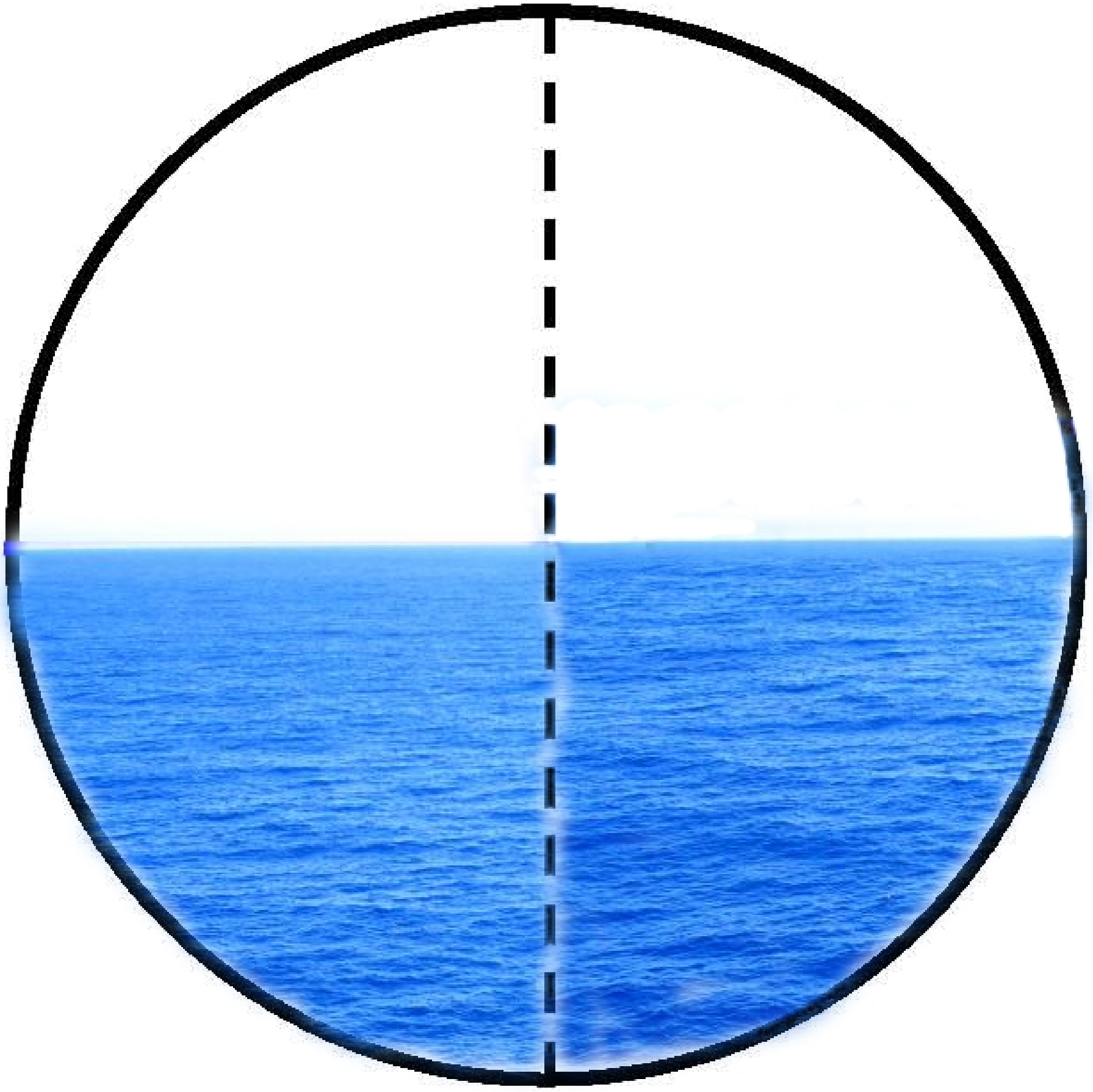
Image of Sun
Image of Horizon
120 110 100 90 80 70 60 50 40 30 20 10 0
144251

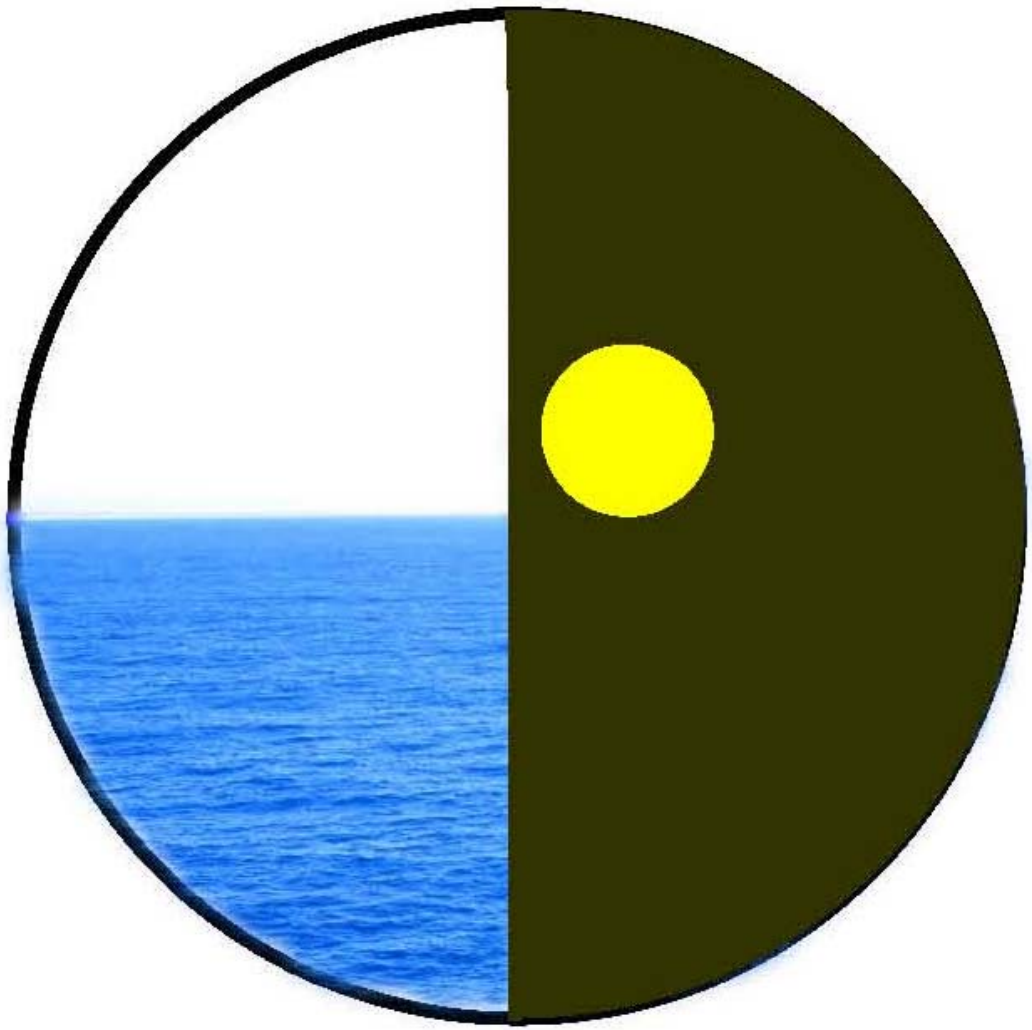

Sun
40º


Sun
10º









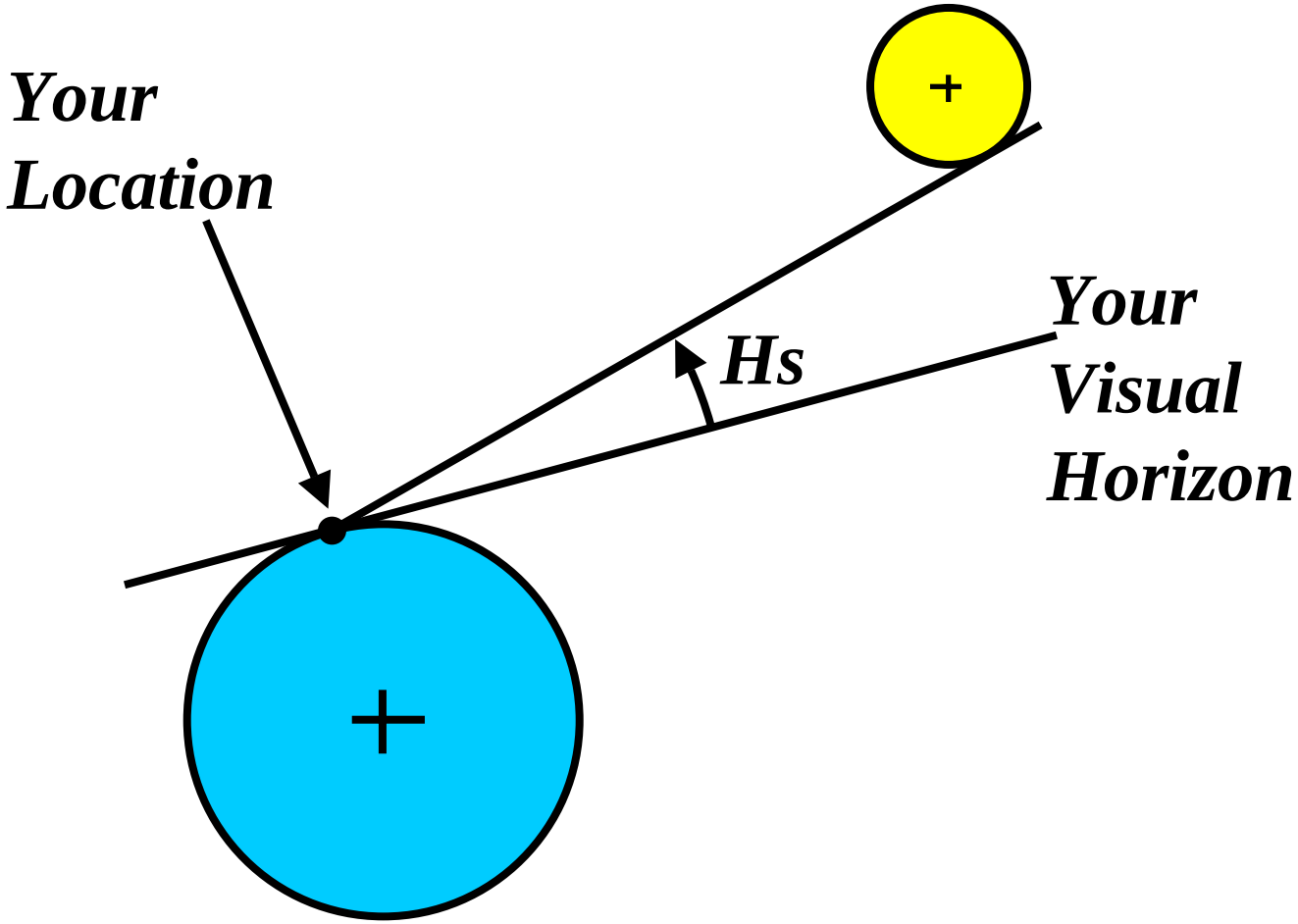
Split Horizon Mirror

Limb of Sun or Moon

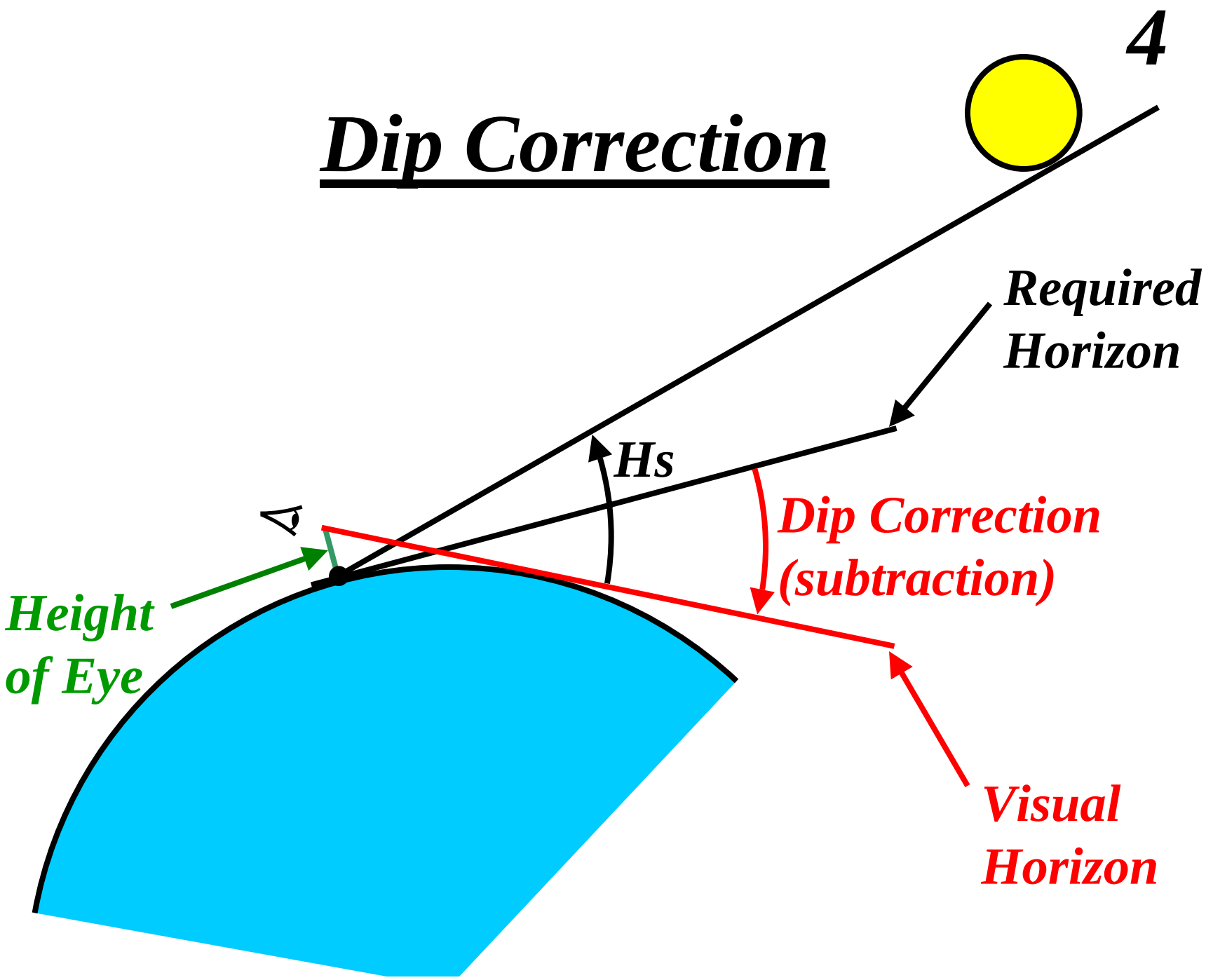
Lower Limb shot

Upper Limb shot

Sextant Altitude of Sun (Hs)



Dip Correction



GHA Increments Calculation

hms = hours, minutes, seconds of time
º and ' = degrees and minutes of angle

- **Earth rotates 15^{o} per hour with respect to the Sun**
- **For Sample Problem #4, calculate GHA for $28^{m}38^{s}$**
- **Convert minutes/seconds to decimal minutes:**

$$28^{m}38^{s} = 28^{m} + \frac{38^{s}}{60^{s/m}} = 28.633^{m}$$

- **In 28.633^{m} the Sun's GHA increases:**

$$15^{o/h} \times \frac{28.633^{m}}{60^{m/h}} = 7.158^{o}$$

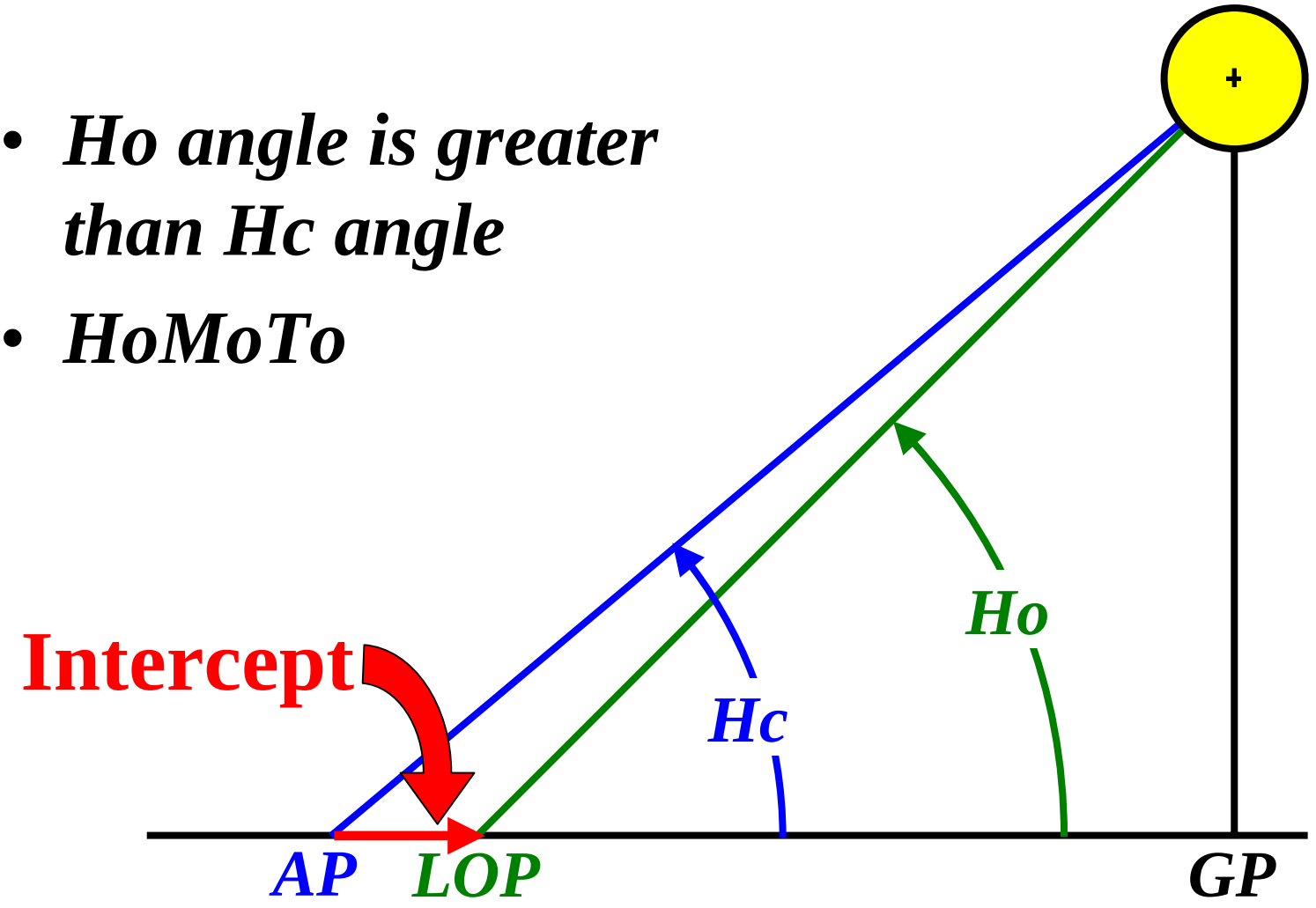
$$= 7^{o} + 0.158^{o} \times 60^{'/o}$$

$$= 7^{o} + 09.5'$$

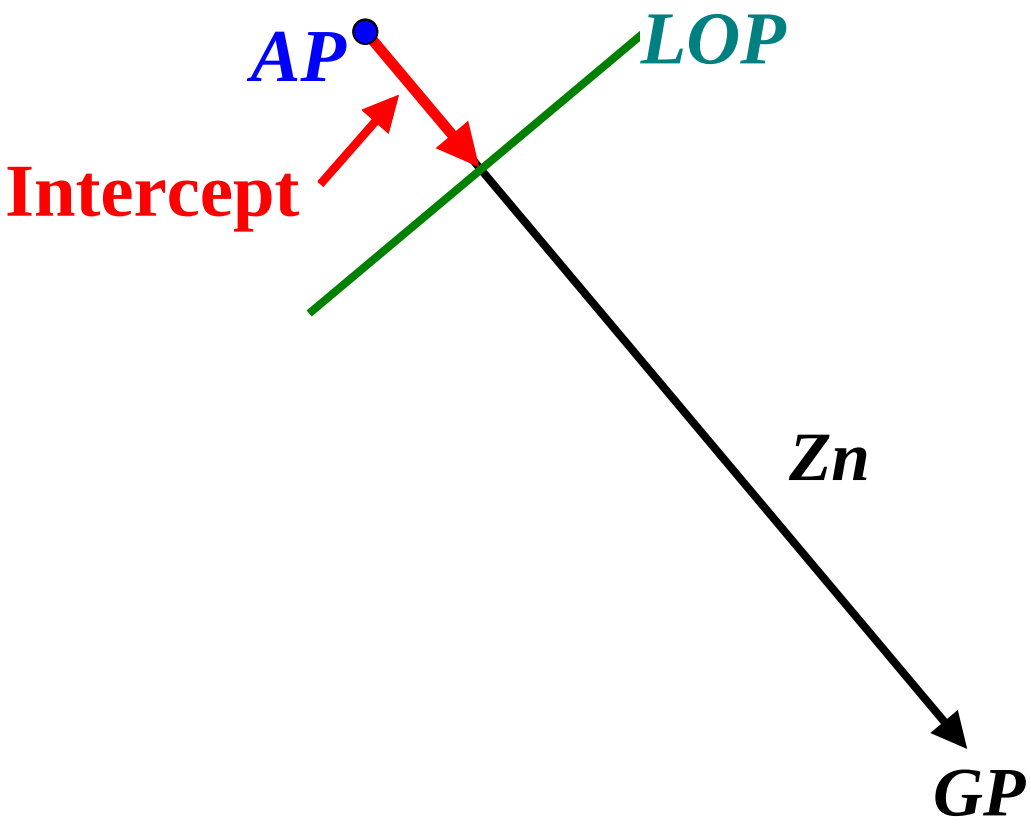
$$= 7^{o}09.5'$$

Plot Intercept Toward GP

- *Ho angle is greater than Hc angle*
- *HoMoTo*

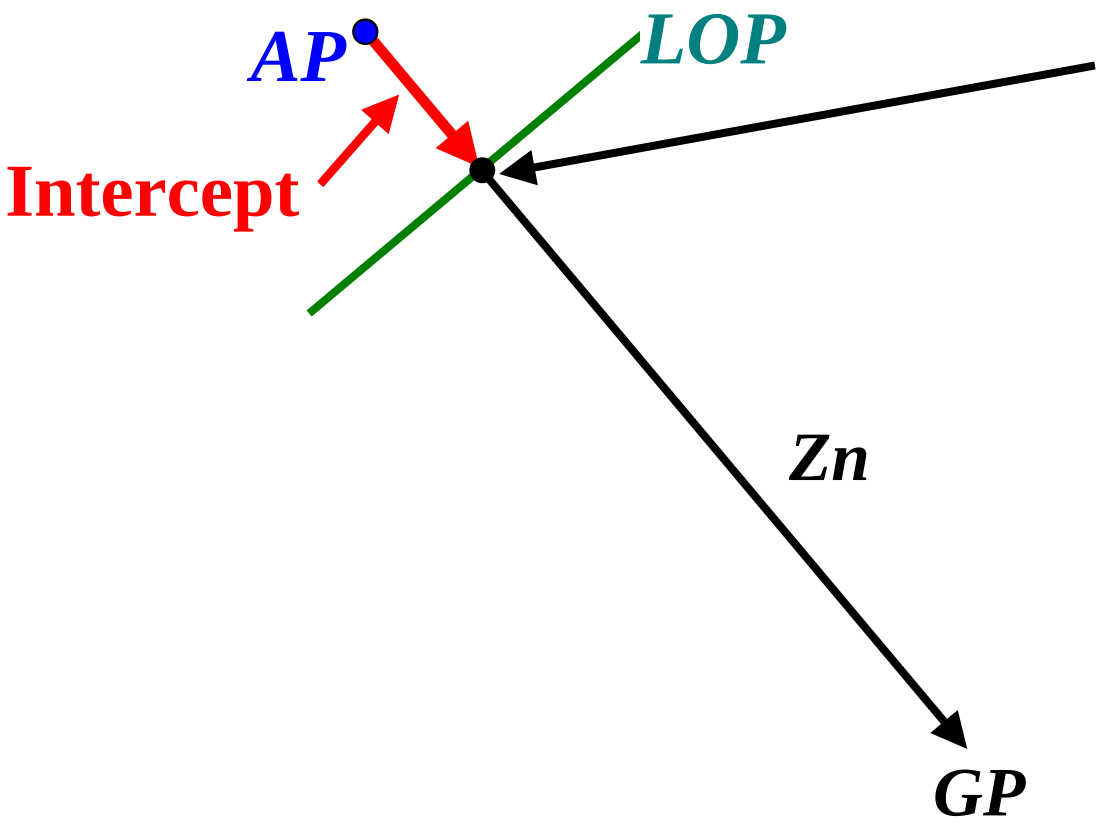


Plot LOP



- ***Draw the LOP line through the Intercept arrow point at <u>right angles</u> to the Zn***

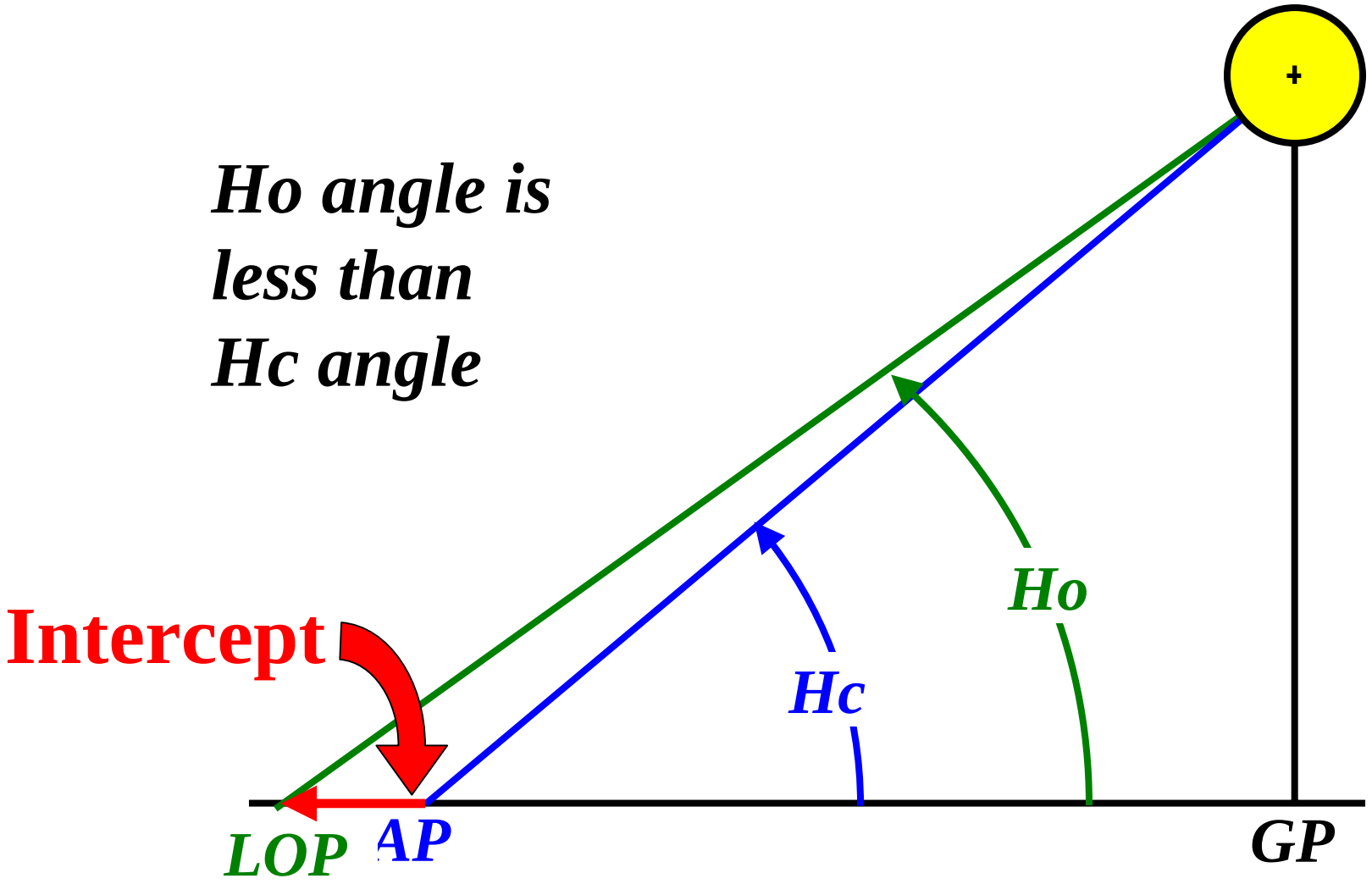
By the Way



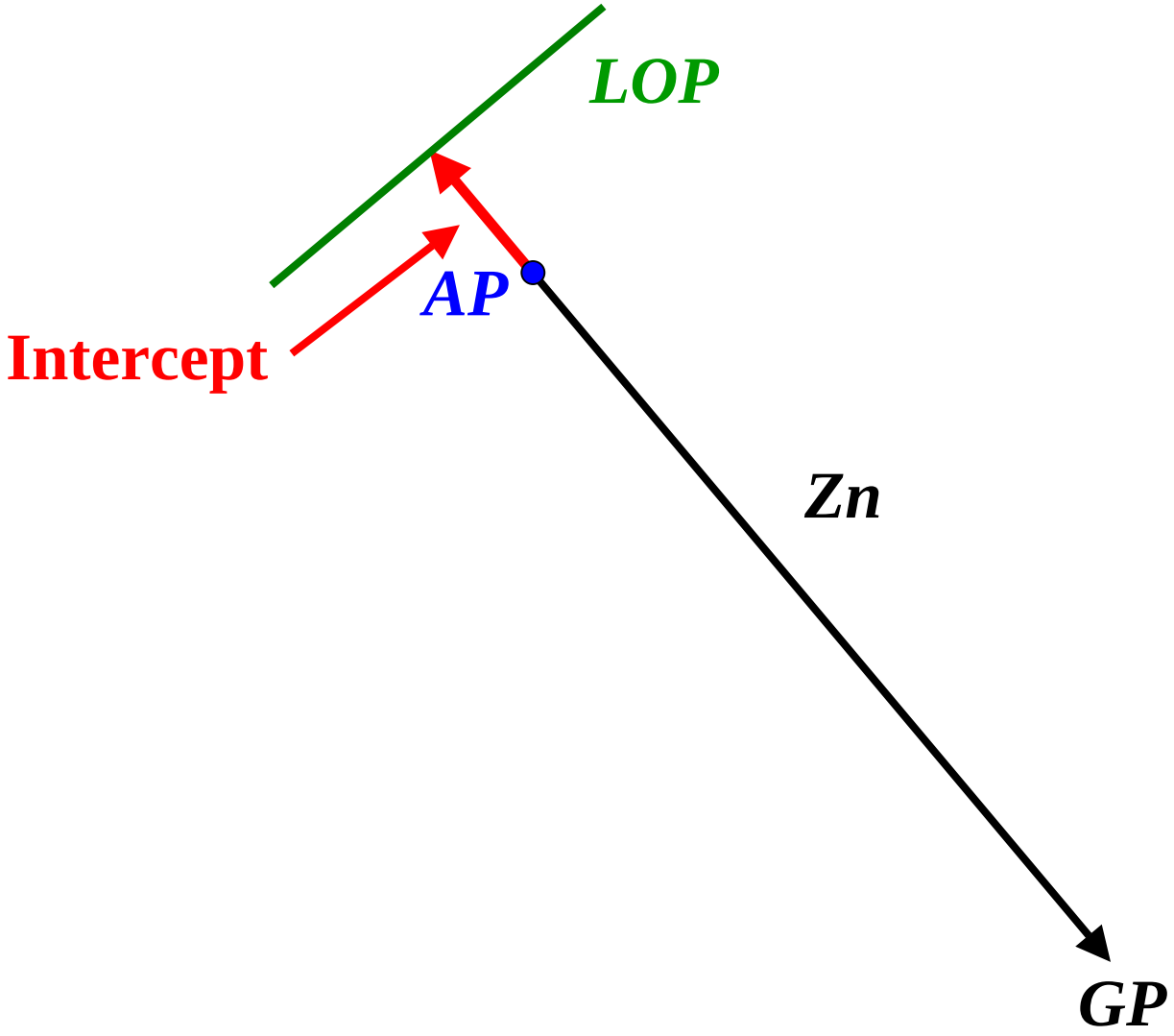
- ***You are <u>not</u> at this point because it's location is based on the Assumed Position***
- ***Assumed Position is arbitrary or based on the DR, which by definition is inaccurate***

Intercept Plotted Away from GP

Ho angle is less than Hc angle



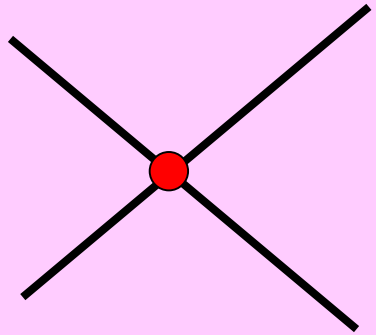
Intercept Plotted Away from GP



See YT Video
Celestial Navigation at Sea

Position Fix

- ***A Position Fix requires at least two LOPs from two different celestial shots***



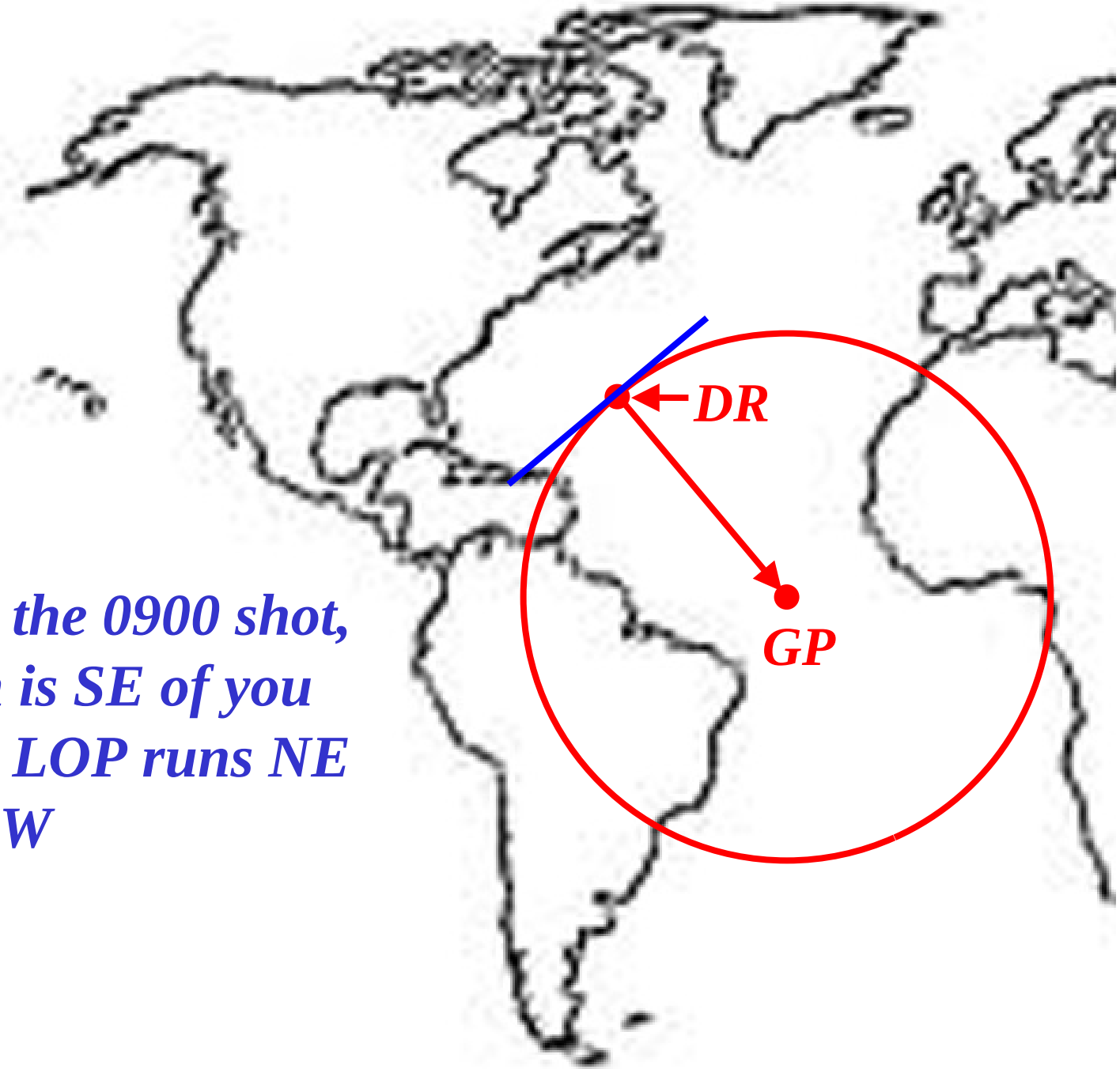
Obtain Two Celestial Shots

- ***Either by shooting two celestial bodies at about the same time for a Fix:***
  - ***Such as Sun & Moon in daylight***
  - ***Two stars or planets at twilight***
- ***Or, shoot the Sun twice at different times for a Running Fix:***
  - ***Shots separated by about 4 hours***

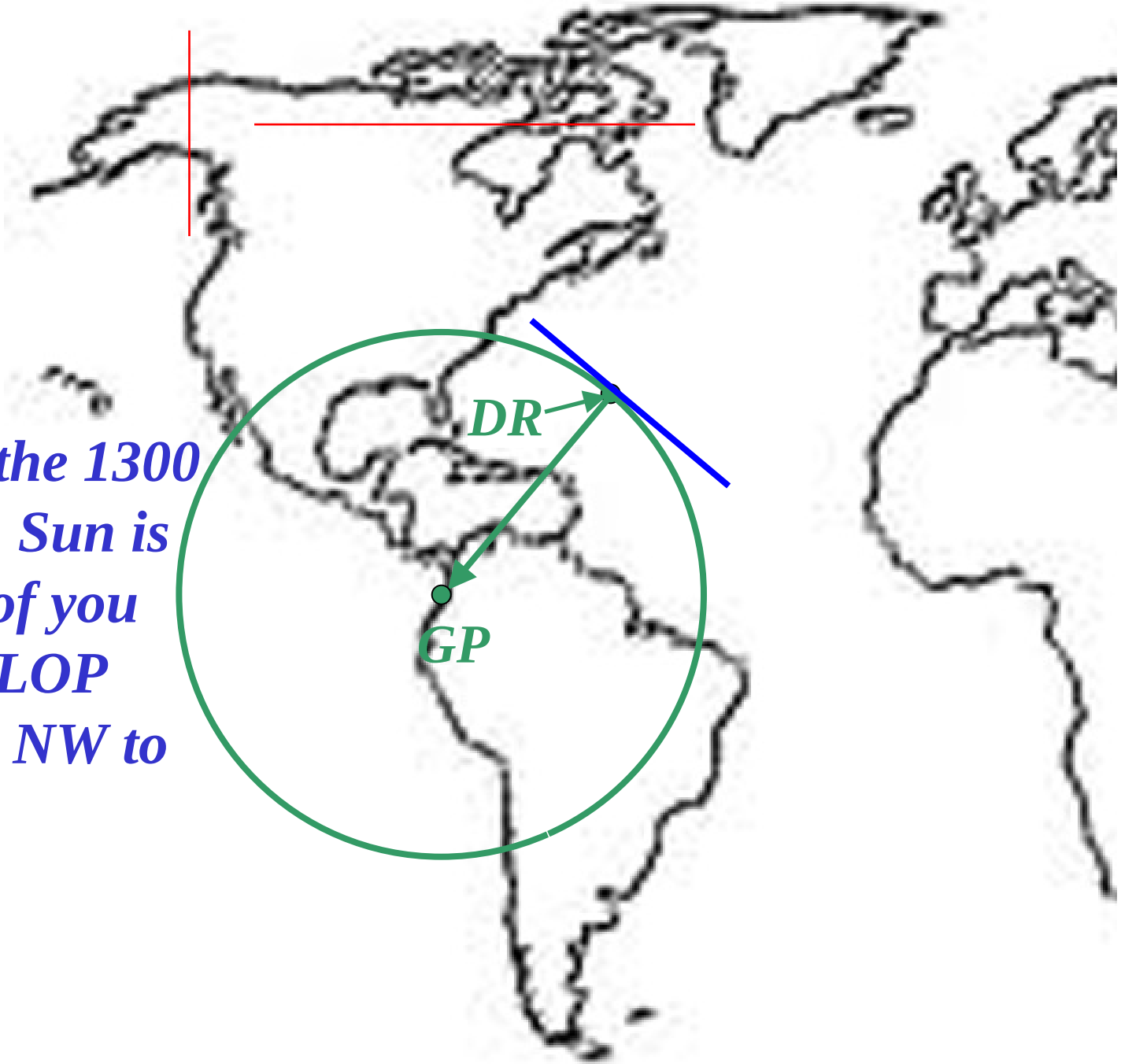
Running Fix

- ***Example: Shoot Sun at 0900 and 1300***
- ***If you are in Northern Hemisphere, and Sun is south of you:***
  - ***0900 shot will give a roughly NE to SW LOP***
  - ***1300 shot will give a roughly SE to NW LOP***
  - ***Times will vary with latitude and season***
- ***Running Fix procedure allows combining these two LOPs***

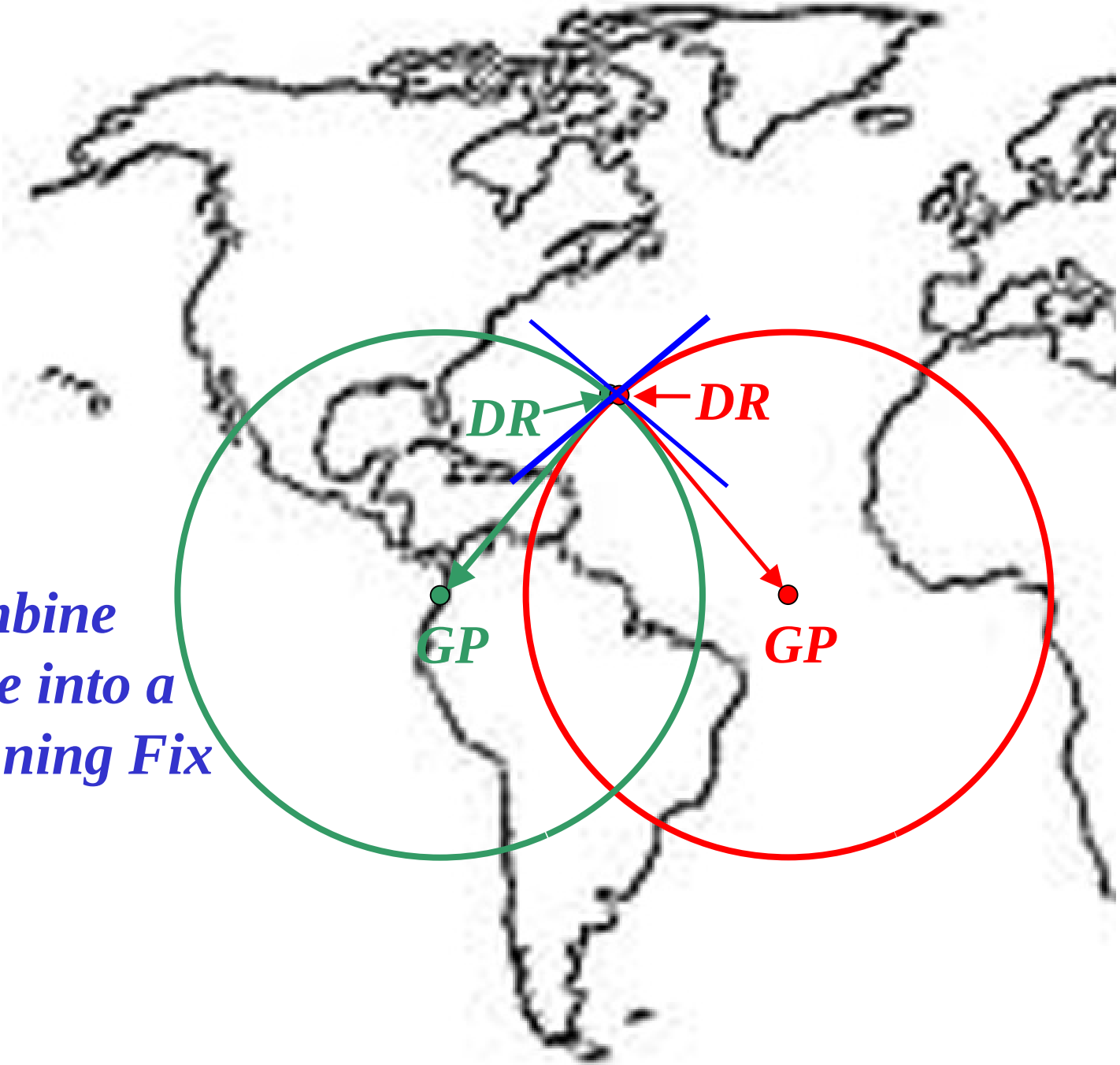
- ***For the 0900 shot, Sun is SE of you and LOP runs NE to SW***



- ***For the 1300 shot, Sun is SW of you and LOP runs NW to SE***



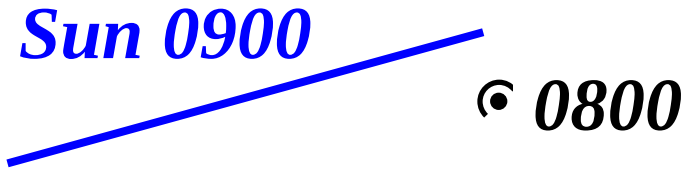
- ***Combine these into a Running Fix***



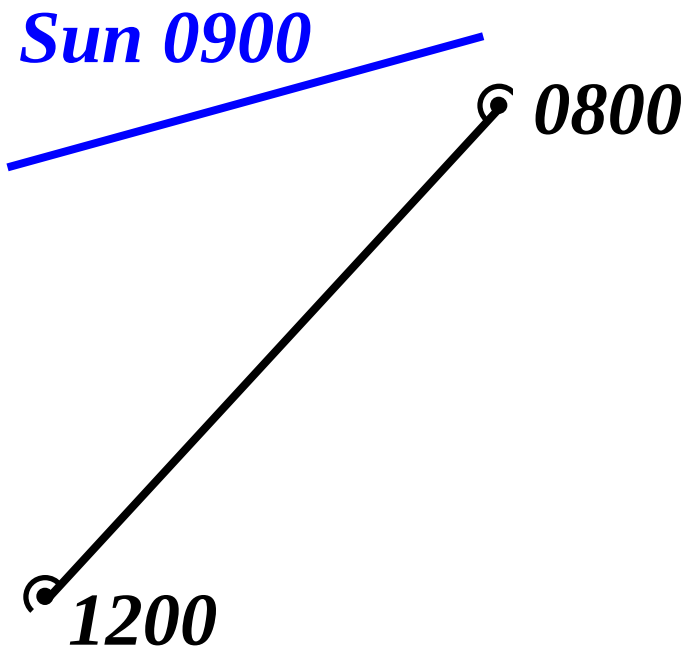
Plot 0800 DR Position

0800

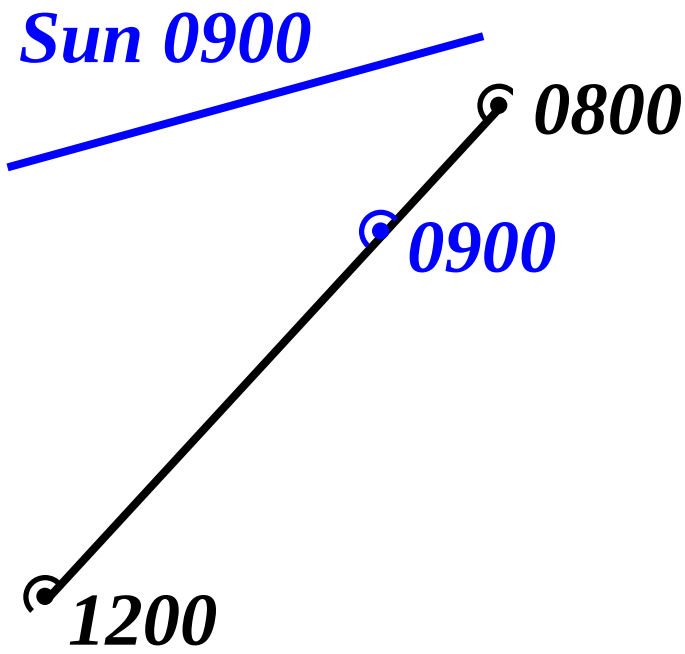
Plot 0900 Shot



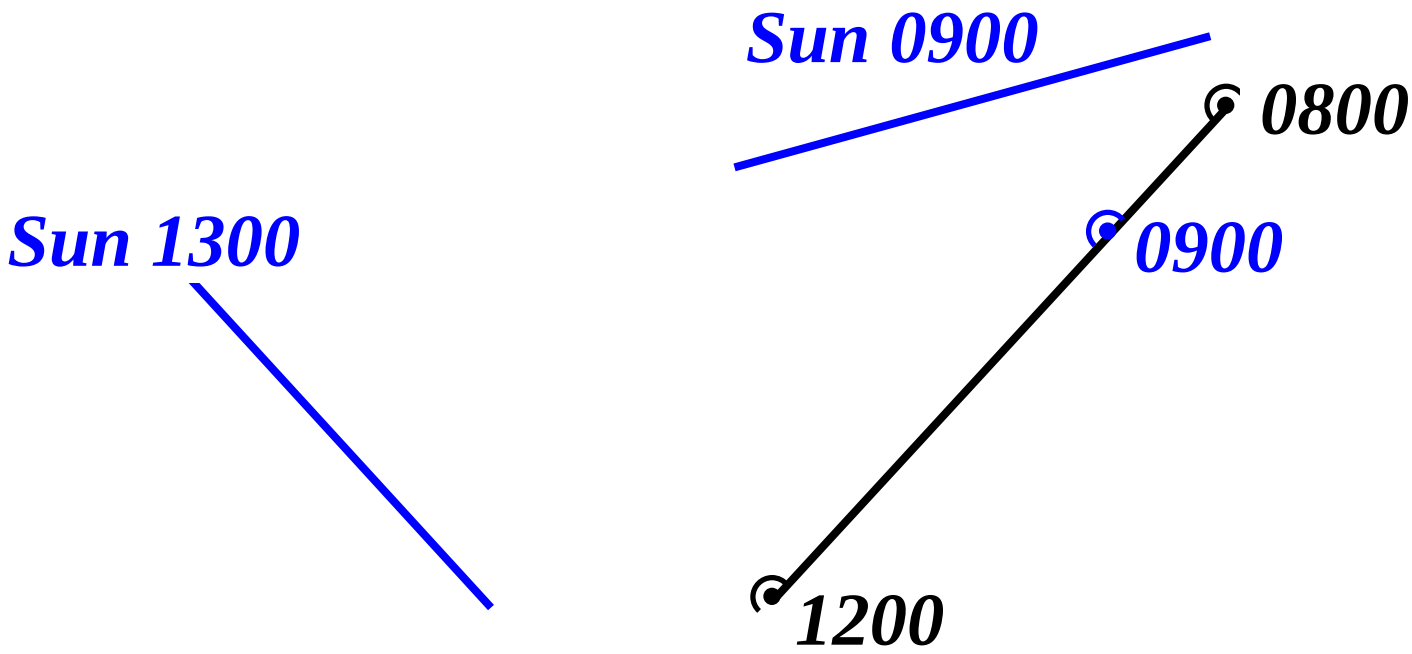
Plot 0800-1200 DR



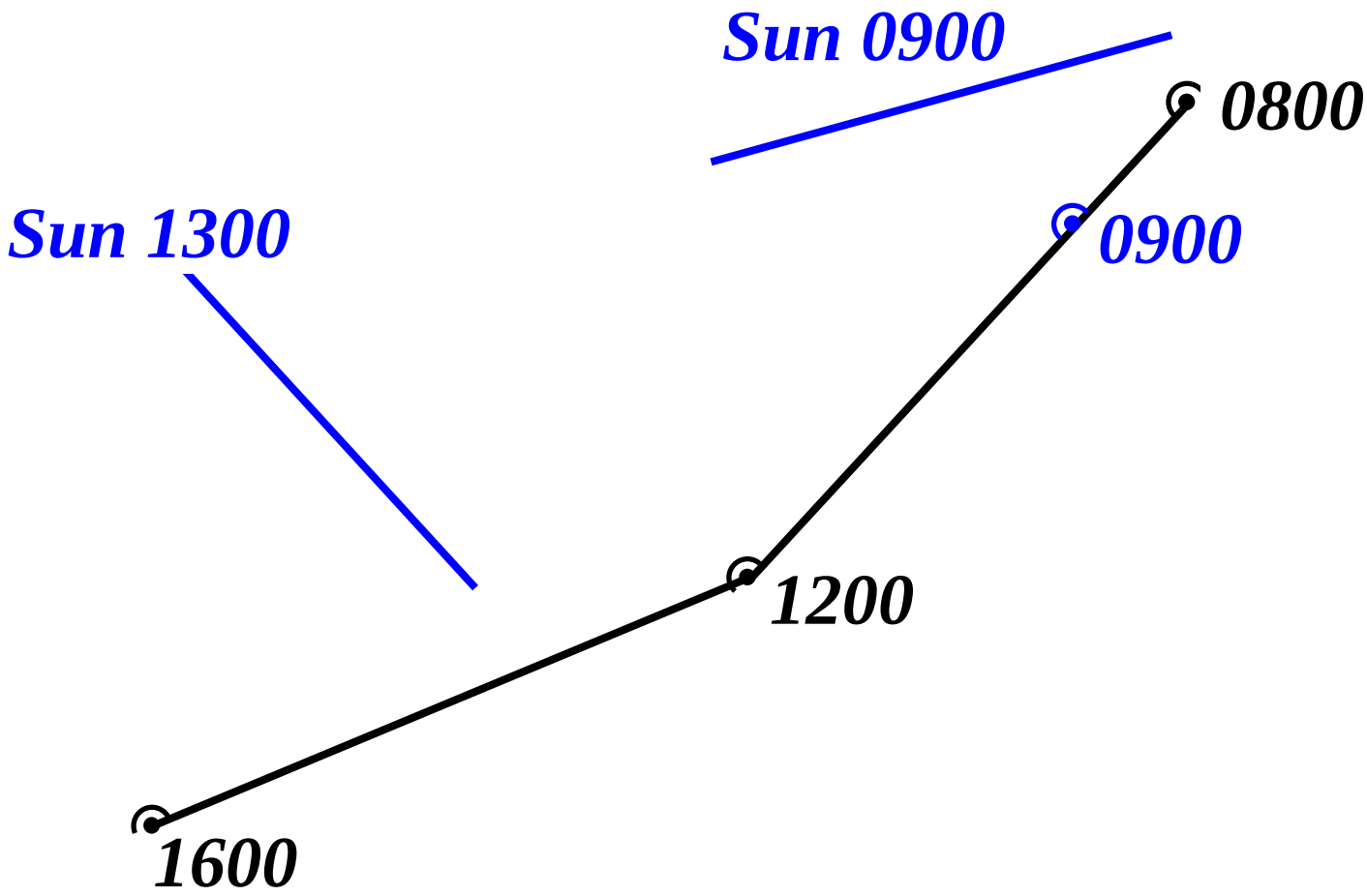
Mark 0900 DR Point



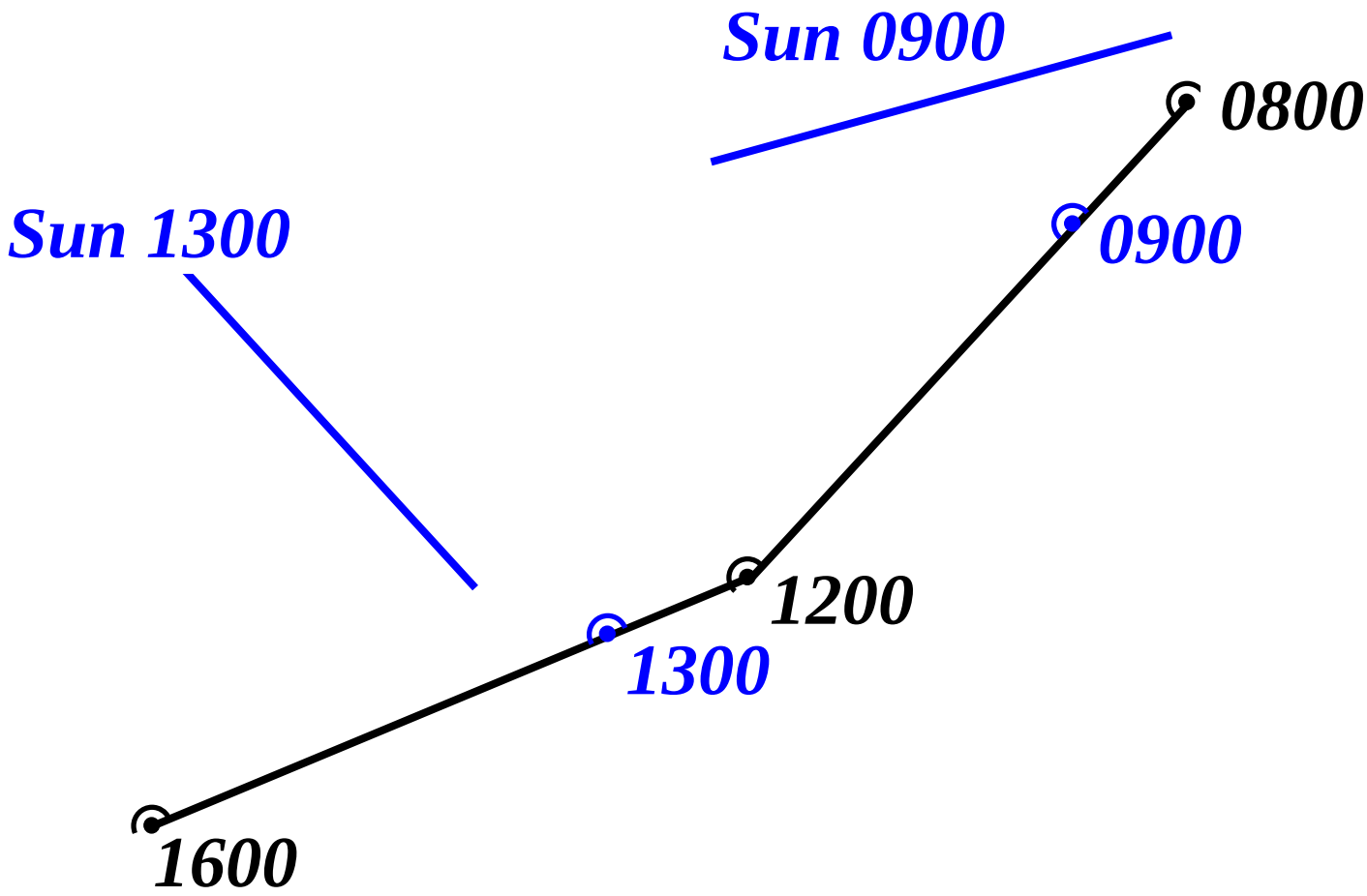
Plot 1300 Shot



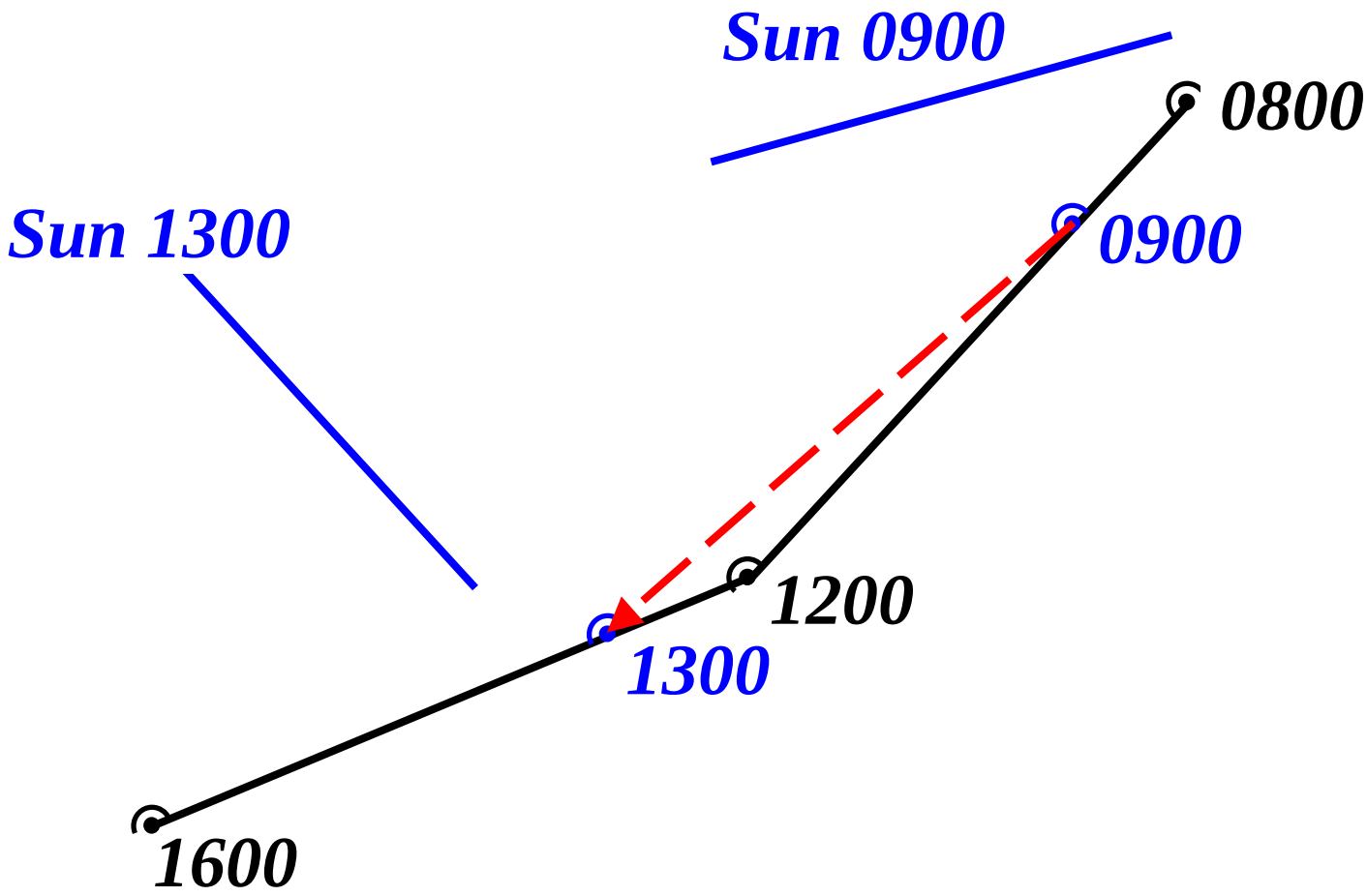
Plot 1200-1600 DR



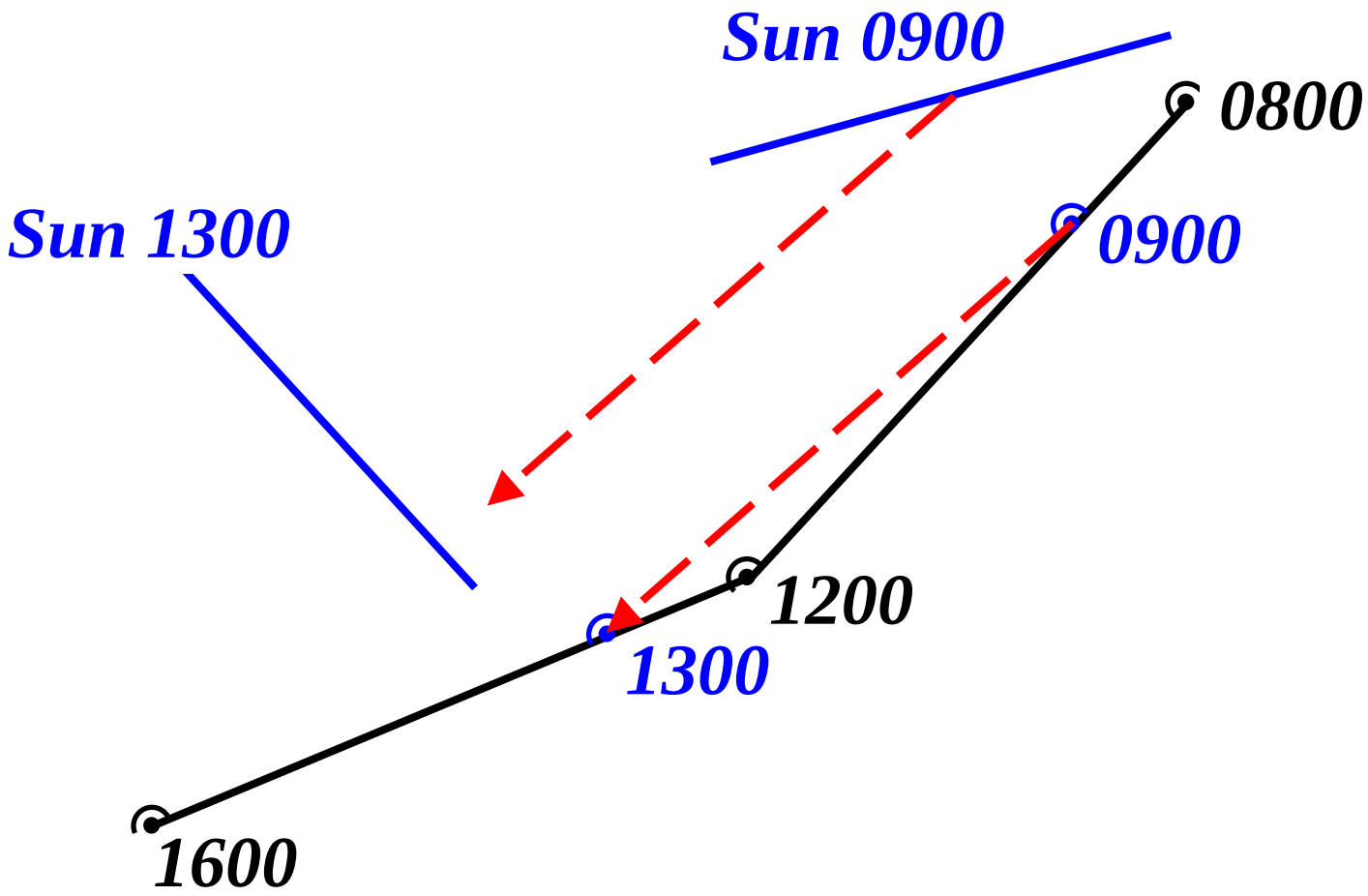
Mark 1300 DR Point



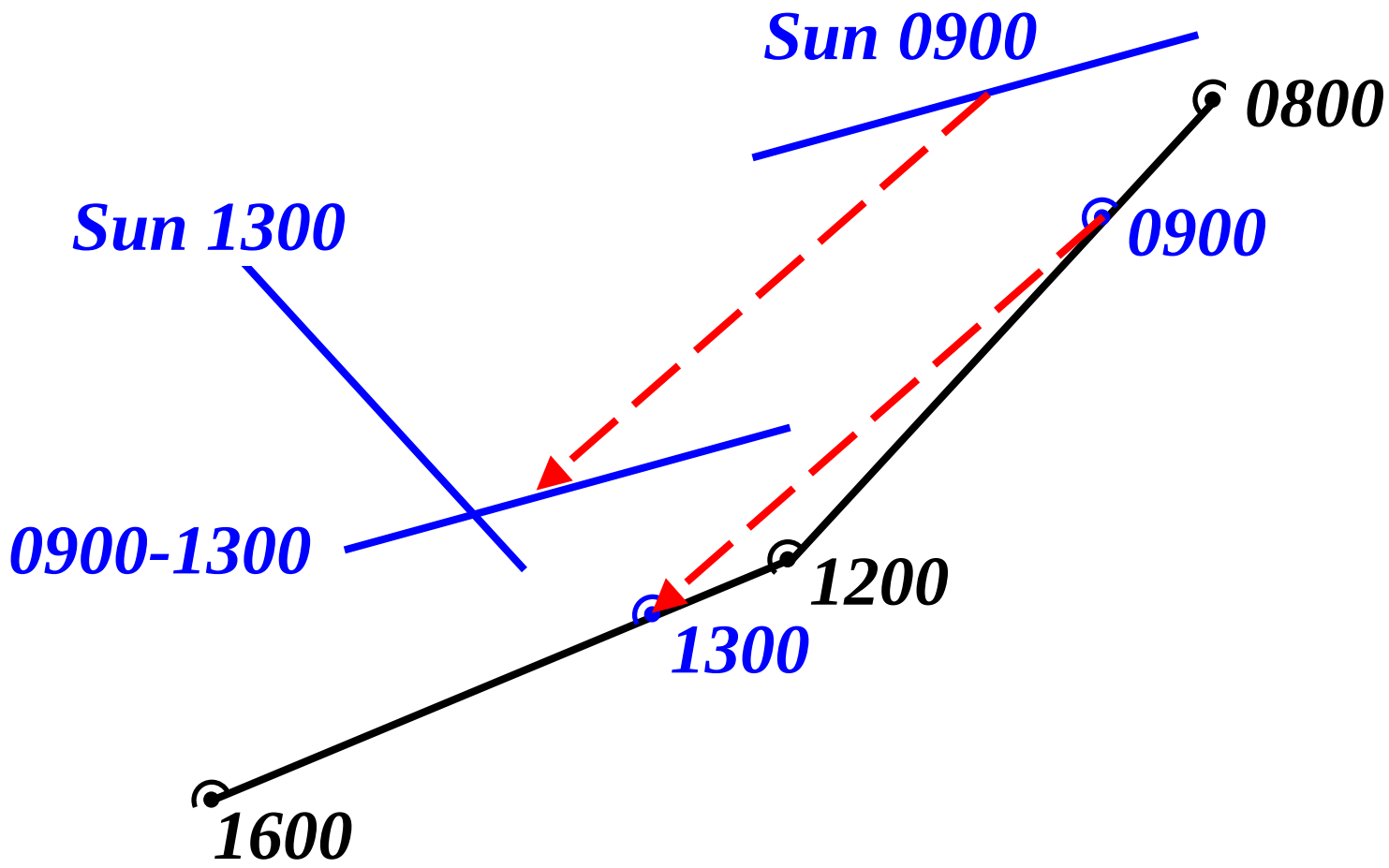
Measure Average Course



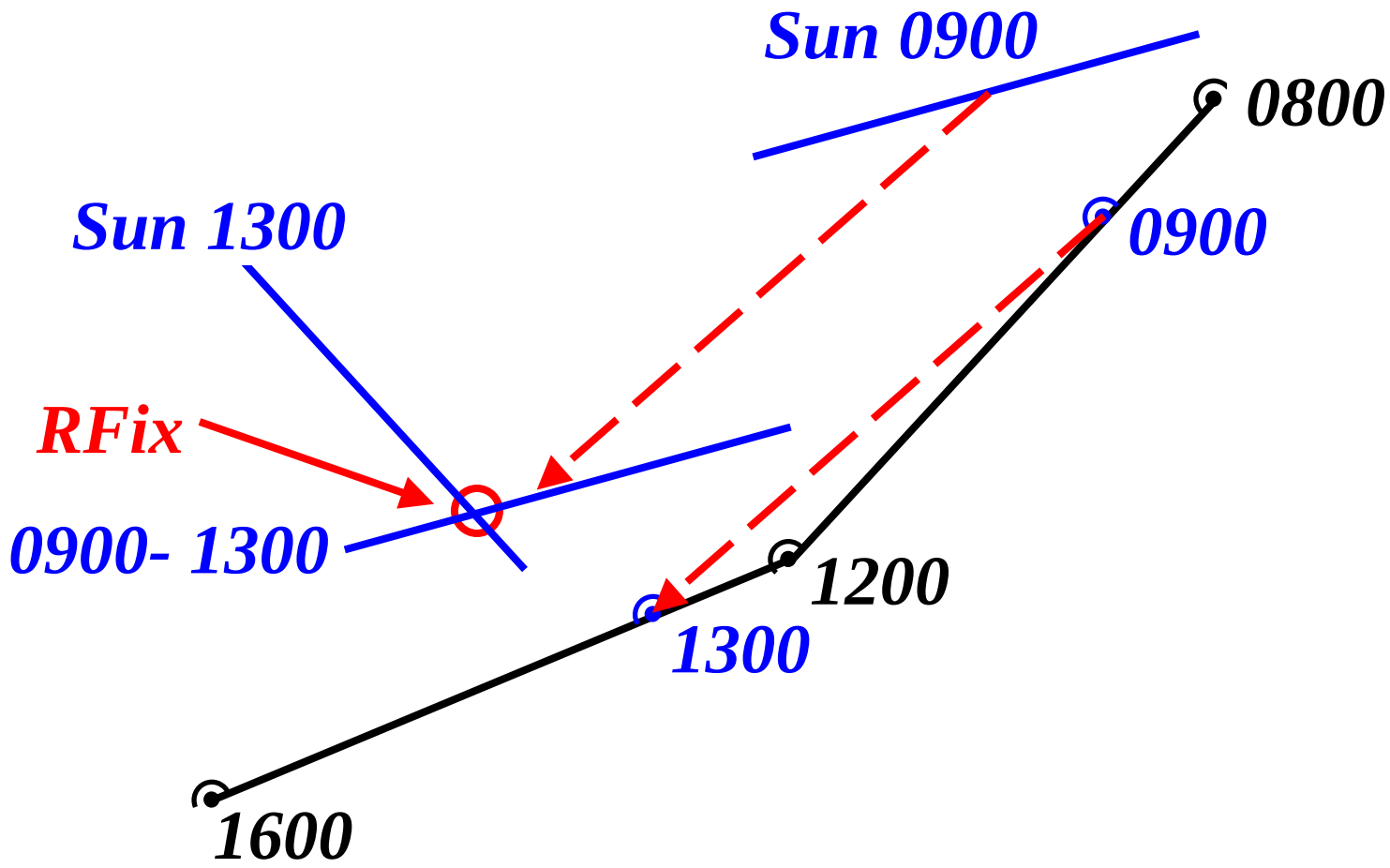
Transfer Average Course Line



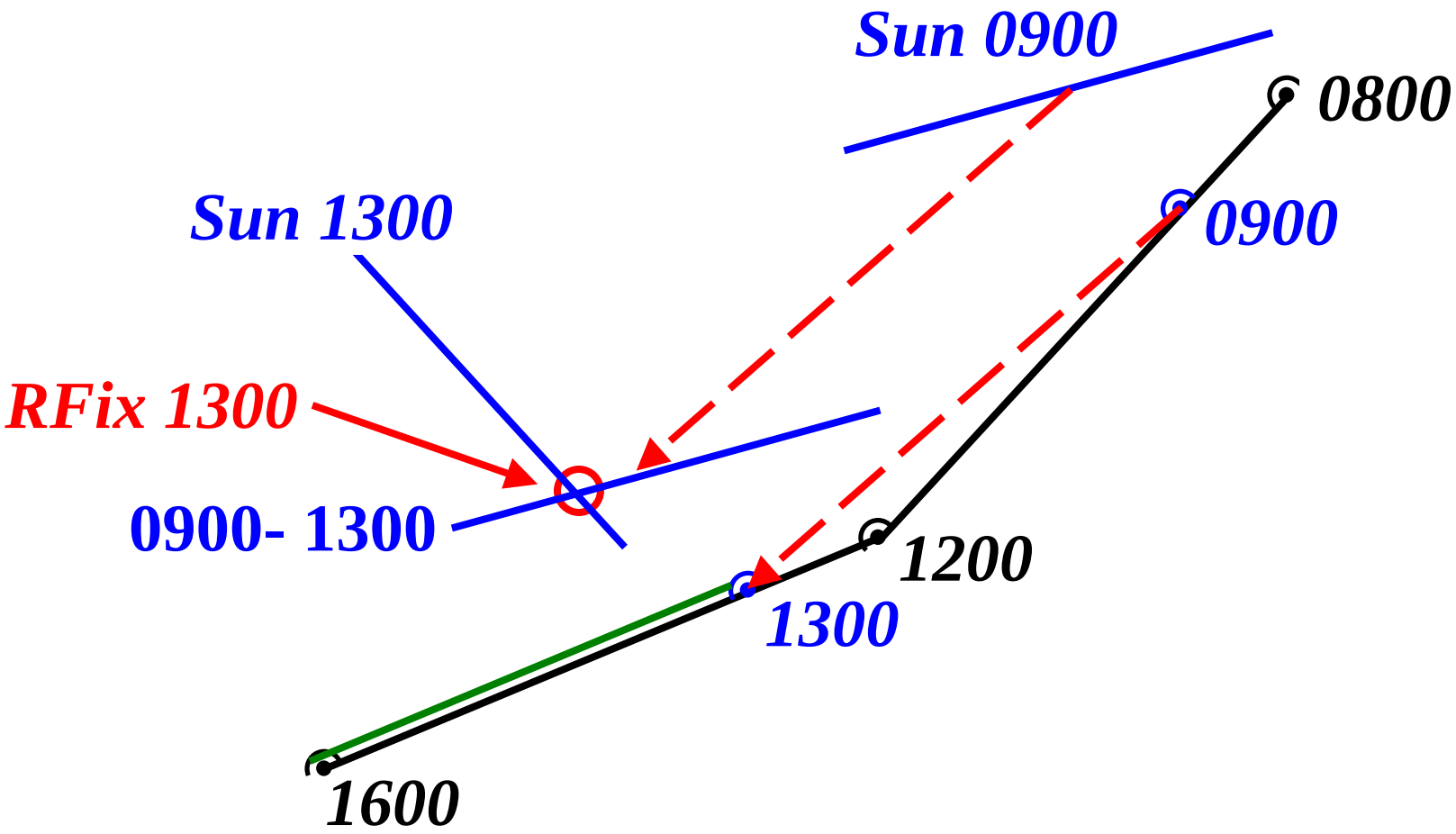
Advanced 0900 LOP to 1300



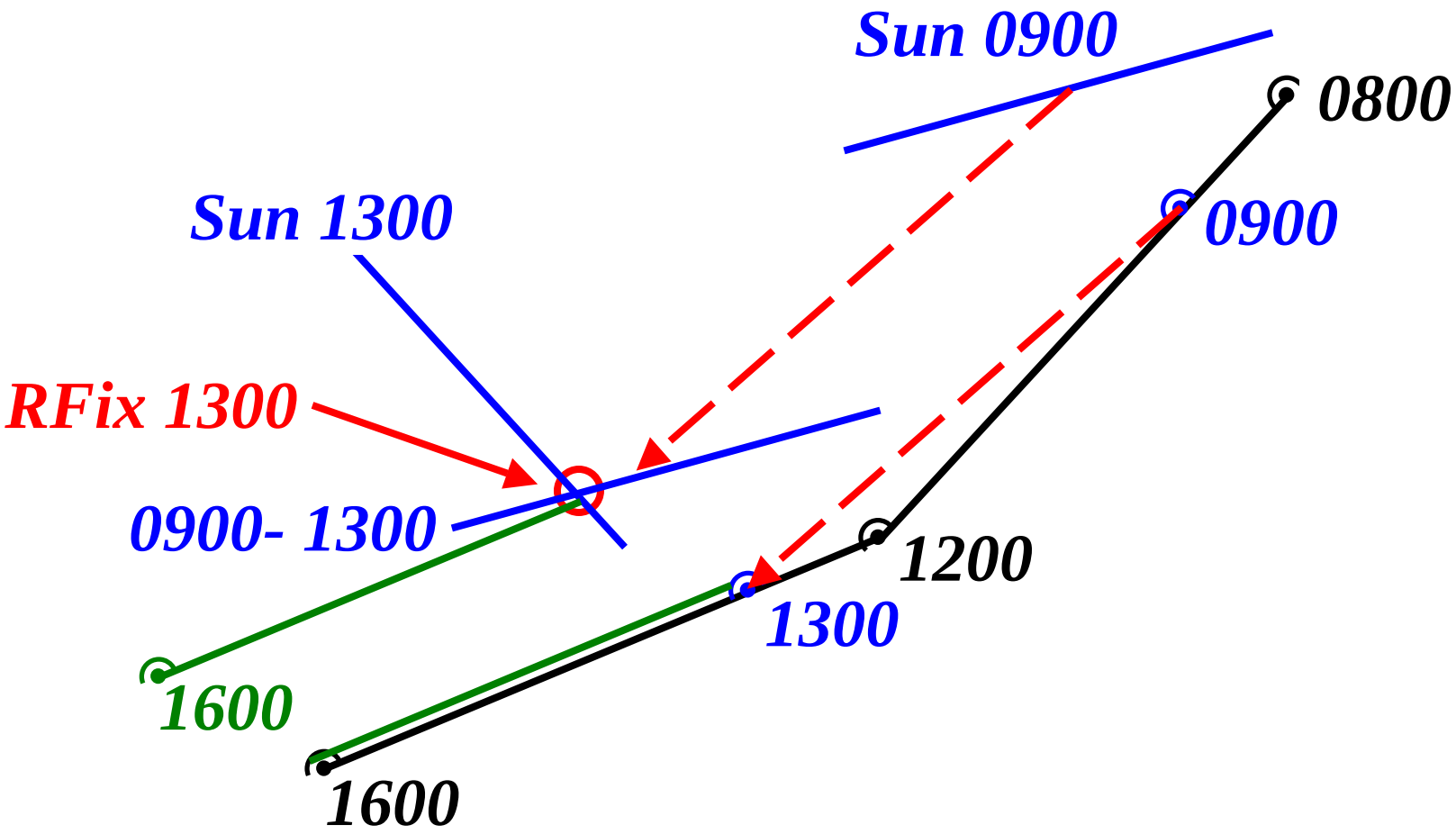
Mark Running Fix



Measure DR Continuation

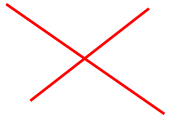


Plot New DR to 1600



Daily Fix

- ***Get at least one Fix or Running Fix each day and restart your DR there***
- ***On occasion, due to cloudy skies, it may be several days without a celestial shot***
  - ***Maintaining a good DR plot in these situations is essential***



I want to measure the distance from the street to the tree, but an obstruction is in the way preventing me from directly making that measurement

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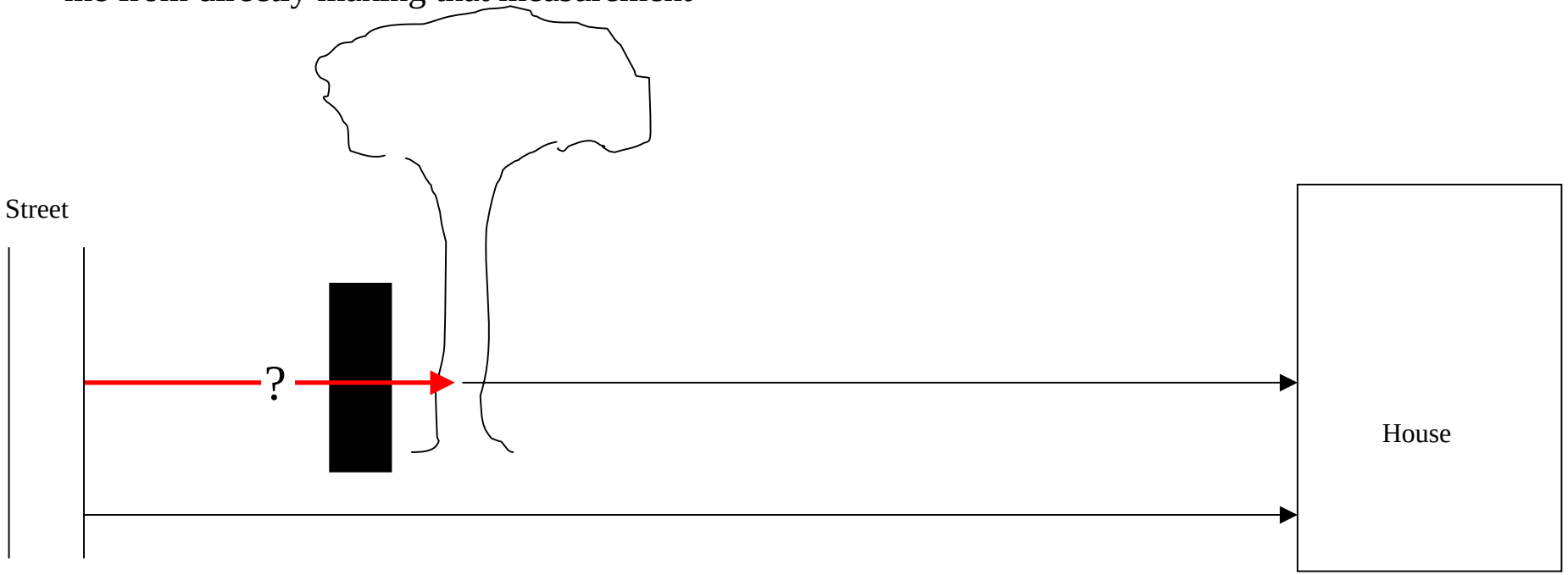
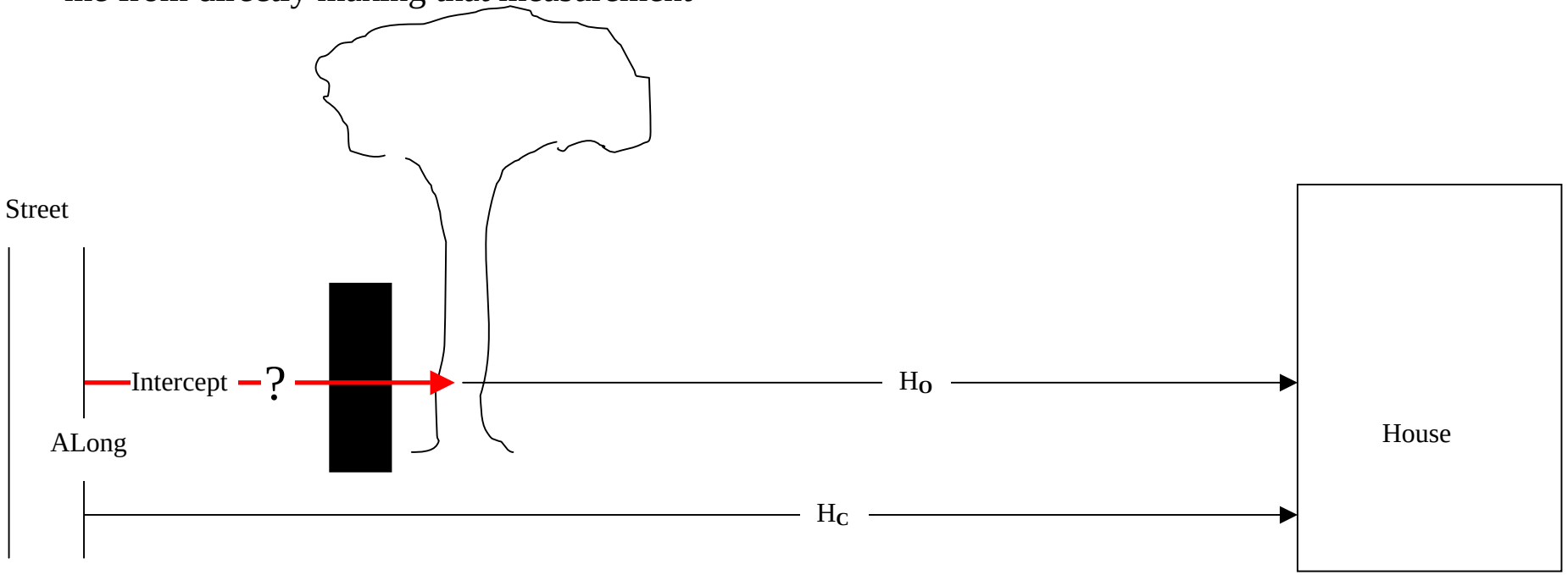


But, I can measure the distance from the street to the house

And I can measure the distance from the tree to the house

So the difference between these two measurements is the distance from the street to the tree

I want to measure the distance from the street to the tree, but an obstruction is in the way preventing me from directly making that measurement



Street curb equates to ALong

Street to House equates to H_C

Tree to House equates to H_O

Intercept $= H_C - H_O$