

Celestial Navigation

with the *Sight Reduction Tables from Pub. No. 249*

Table of Contents

GLOSSARY	v
REFRESHER	xi
INTRODUCTION	3
Chapter 1: Concepts of Celestial Navigation	5
1.1 Traditional Coastal Navigation	5
1.2 Celestial Navigation	5
1.3 Determining the Geographic Position of a Celestial Body	6
1.4 Plotting the Circles of Position around the GP	7
1.5 The Marcq Saint Hilaire Solution	8
1.6 Sight Reduction Tables	8
1.7 Angle at the Center of the Earth	9
1.8 Calculation of the length of a segment of Great Circle	9
1.9 Navigation by latitude and the problem of longitudes	10
Chapter 2: Measure of the Sun's Altitude: Ho	11
2.1 Principle of the Sextant	11
2.2 Index Error	12
2.3 Dip	13
2.4 Main Correction	14
2.5 Correction from Lower Limb (or Upper Limb) to the Center of the Sun	15
2.6 Correction for Refraction	17
2.7 Correction for Parallax	18
2.8 Summary: Constituents of the Main Correction (approximate values)	20
2.9 Examples showing all corrections: Index Error, Dip, and Main Correction	21
2.10 Exercises: Sextant Corrections	22
2.11 Adjustment of the Sextant Mirrors	23
2.12 Taking a Sight on the Sun with a Sextant	25

Chapter 3: Measure of the Times of Sights: UTC	27
3.1 The Harrison Chronometers	27
3.2 Definition of the day and second : True and Mean Suns	28
3.3 Coordinated Universal Time (UTC)	28
3.4 Local Meridian Time	28
3.5 Time Zones	29
3.6 Meridian Crossing of the Sun: The Equation of Time	29
3.7 Conversion between angles of revolution of celestial objects around the earth and changes in time	31
3.8 Exercises: Conversion between Arcs (angles) and Time	34
3.9 Time Correction on the Boat Chronometer	36
 Chapter 4: Sun Coordinates in the Almanac	 37
4.1 Sun Declination: Variations during the year	37
4.2 Greenwich Hour Angle	39
4.3 Interpolation of the sun's GHA and Dec for minutes and seconds of time	41
4.4 Exercises: GHA and Dec from the Almanac for the Sun	45
 Chapter 5: Local Hour Angle	 47
5.1 Boat with a West Longitude	47
5.2 Boat with an East Longitude	48
5.3 Exercises: Local Hour Angle	48
 Chapter 6: Latitude by Noon Sight	 49
6.1 Calculation of Latitude, given the Sun Altitude and Declination	49
6.2 Plotting the Sun Trajectory in order to measure the Sun Altitude at Noon	51
6.3 Exercises	51
6.4 Review Exercise: Traditional plotting method, before Marcq Saint Hilaire	53
 Chapter 7: Approximate Longitude from a Noon Sight	 57
7.1 Example 1: West Longitude	58
7.2 Example 2: East Longitude	59
7.3 Accuracy of Longitude Estimates from a Noon Sight	59
 Chapter 8: Approximate Latitude from Polaris	 61

Chapter 9: Sight Reduction Tables	63
9.1 Bearing of the Sun Z_n from the Azimuth Angle	65
9.2 Resolution of the Spherical Triangle: Z and Z_n from the Sight Reduction Tables	67
9.3 The Marcq Saint Hilaire Method: Calculation of the Intercept	72
9.4 Exercises: <i>Sight Reduction Tables</i> ; H_c , Z , and Z_n	81
9.5 Other Sight Reductions Tables	83
Chapter 10: Using Work Forms	87
10.1 Form for Latitude by Noon Sight	87
10.2 Form for LOPs from Morning or Afternoon Sun Sights	90
Chapter 11: Plotting	93
11.1 Construction of a Plotting Chart for the sailing region	93
11.2 Example 1: Plotting of an LOP from an Afternoon Sun Sight; Advancing the Morning LOP	96
11.3 Exercises: A day's work at sea	99
Chapter 12: Twilight Times	109
12.1 Interpolation of times for the Latitude of the Boat	111
12.2 Example	111
12.3 Exercises	113
Chapter 13: Sights With the Moon	117
13.1 Corrections Specific to the Moon	117
13.2 Exercise: Sight on the Moon	122
Chapter 14: Sights With the Planets	127
14.1 Modifications Specific to Planets	127
14.2 Example 1: GHA and Declination for Mars	129
14.3 Exercise: LOPs with Planets	133
Chapter 15: Sights With the Stars	137
15.1 The First Point of Aries	137
15.2 Declination, Sidereal Hour Angle, and Greenwich Hour Angle of the Navigation Stars	138
15.3 Example	139
15.4 Exercise: LOPs with Stars	144

Chapter 16: Exact Latitude from Polaris	153
16.1 Example: Exact Latitude from Polaris	153
16.2 True North from Polaris	155
16.3 Exercise: Latitude from Polaris	155
Chapter 17: Pre-selection of Planets and Stars	157
17.1 Pre-selection of Planets	157
17.2 Pre-selection of Stars	160
Chapter 18: Review Exercises.	163
18.1 Exercise 1: LOP from Two Morning-twilight Planets	163
18.2 Exercise 2: LOPs with Morning Sun, Noon Sight, and Afternoon Sun	169
18.3 Exercise 3: LOPs with the Moon (morning-twilight) and Morning Sun	177
18.4 Exercise 4: LOPs with Three Morning-twilight Stars	183
18.5 Exercise 5: LOPs with Evening Sun, Moon, and Polaris	192
Chapter 19: Main Constellations, and Other Uses of the Sextant	201
19.1 Maps of some of the Main Constellations	201
19.2 Use of the Sextant to Determine Compass Deviation ($H_c > 10^\circ$)	203
19.3 Use of the Sextant to determine Compass Deviation ($H_c < 10^\circ$)	206
19.4 Circle of Position from a landmark of known height: Vertical Sights	210
19.5 Circle of Position from two (or three) landmarks: Horizontal Sights	212
Chapter 20: Use of electronic hand-held calculators	213
20.1 Formula for H_c , and use of the calculator	213
20.2 Formula for Z , and use of the calculator	215
20.3 Dedicated calculators for Celestial Navigation	216
Appendix 1: Sight Reduction Work Forms.	A1-1
Appendix 2: Almanac Tables	A2-1
Appendix 3: Sight Reduction Tables	A3-1
Appendix 4: Pre-Selected Stars	A4-1
Appendix 5: Other Sight Reduction Tables	A5-1
Index	I-1