YVAN VAN DEN BOGAERT **INTRODUCTION TO CELESTIAL NAVIGATION** www.loxodrome.org

# **TABLE OF CONTENTS**

## FOREWORD

### THE FUNDAMENTALS

|   | General description                                | 1  |  |
|---|--|----|--|
|   | Estimation of the position                         | 2  |  |
|   | Geometrical approach of Hc and Zn                  | 3  |  |
|   | General geometrical definitions and properties     | 4  |  |
|   | The earth projection of a celestial body           | 8  |  |
|   | The navigation triangle                            | 9  |  |
|   | The Azimuth of a celestial body                    | 12 |  |
|   | The position circle                                | 13 |  |
|   | The measured and the real height above the horizon | 14 |  |
|   | Plotting Zn and $\Delta h$ on a chart              | 17 |  |
| THE CO-ORDINATE SYSTEMS AND FORMULARIES |  |    |  |
|   | The Terrestrial Co-ordinate system                 | 2  |  |
|   | The Equatorial Co-ordinate system                  | 4  |  |
|   | General formulas for spherical triangles           | 5  |  |
|   | Formulas for the navigation triangle               | 6  |  |
|   | The sign convention                                | 7  |  |
|   | Special configurations of the navigation triangle  | 10 |  |
| ASTRONOM                                | Y  |    |  |
|   | The heliocentric universe                          | 2  |  |
|   | The motions of the earth                           | 3  |  |
|   | Difference between Solar and Sidereal time         | 5  |  |
|   | The geometry of the terrestrial Orbit              | 6  |  |
|   | The declination of the sun                         | 7  |  |

www.loxodrome.org/ Introduction to Celestial Navigation

| ,          | The geocentric universe                       | 10 |
|------------|---|----|
| ,<br>-     | The star charts                               | 13 |
| ,<br>-     | The apparent motion of the sun                | 16 |
| ,<br>-     | The time zones and the date change line       | 18 |
| CHARTS AND | TRACKS  |    |
|            | The Mercator chart                            | 2  |
|            | Orthodromy                                    | 7  |
|            | The Gnomonic chart                            | 11 |
| NUMERICAL  | EXAMPLES                                      |    |
|            | PROBLEM 1                                     | 2  |
|            | PROBLEM 2                                     | 11 |
|            | PROBLEM 3 Pagel Method                        | 16 |
|            | PROBLEM 4 Distance and course calculation     | 21 |
|            | PROBLEM 5 with HO249 tables                   | 22 |
| TABLES     |   |    |
| Appendix   |   |    |
|            | Plane trigonometry                            | 1  |
|            | Plane geometry                                | 3  |
|            | Vectors                                       | 4  |
|            | Vectorial derivation of astronavigal Formulas | 6  |

Formulas for rectangular sperical triangles

9

# Bibliography



www.loxodrome.org/ Introduction to Celestial Navigation

#### FOREWORD

This course is meant for anyone who asks himself how can anyone finds out where he is when the horizon forms a circle of 360° degrees around him.

We will try to give him some tools and explain how these tools operate. The calculation methods will be explained as being part of a general system, so mathematical developments and astronavigal explanations will be given only where they are needed to contribute to general understanding.

The author assumes that the reader has elementary knowledge of trigonometry and space geometry, of which a brief recapitulation is given in the appendix.

We are confident that the understanding of this course will increase your selfconfidence at sea and that you will be able to face any critical situation without being the slave of your GPS.

The Author



www.loxodrome.org/ Introduction to Celestial Navigation