

Contents

Part I	11
1 BASIC KNOWLEDGE OF THE EARTH	19
1.1 Shape and size of the Earth	19
1.1.1 The Earth as Geoid	20
1.1.2 The Earth as Rotational Ellipsoid	20
1.1.3 The Earth as a sphere	24
1.2 Geographic coordinate system	25
1.2.1 Basic terms	25
1.2.2 Latitude and longitude	27
1.2.3 Latitude and longitude difference	29
1.2.4 Geographic coordinates on the ellipsoid	31
1.2.5 Geocentric coordinates and their relationship with the geographic coordinates on the ellipsoid	31
1.3 Units for maritime measurements	33
1.4 Navigation deviation	35
1.5 The main radii of the Earth ellipsoid	36
1.6 Flat rectangular coordinates of the Earth ellipsoid	37
1.7 Calculation examples	40
1.8 Check questions	45
2 DIRECTIONS ON THE EARTH SURFACE	47
2.1 Basic lines and planes on the Earth's surface	47
2.1.1 The perpendicular	47
2.1.2 Apparent horizon	48
2.1.3 Cardinal and intercardinal directions on the observer's horizon plane	48

2.1.4	The observer's horizon division systems	50
2.1.5	Ship's course and true bearing; heading angle	51
2.1.6	The horizon; distances from the horizon	56
2.2	Visibility range of navigational marks	58
2.2.1	The geographic visibility range (the geometric range) . .	59
2.2.2	Optical visibility range	61
2.3	Calculation examples	64
2.4	Check up questions	68
3	DETERMINATION OF DIRECTION AT SEA	69
3.1	Compasses and their general characteristics	69
3.2	Determination of direction by gyrocompass	70
3.3	Magnetism of the Earth	71
3.3.1	Magnetic variation	74
3.3.2	Magnetic variation updating on maritime charts . . .	76
3.3.3	Magnetic heading and bearing	82
3.4	Magnetic compass deviation	83
3.4.1	Deviation dependency on ship's heading changes . . .	84
3.4.2	Compass heading and bearing	86
3.5	Deviation identification methods	87
3.5.1	Ways and means of compass deviation identification .	88
3.5.2	Identification of deviation with regards to a range of leading lights	89
3.5.3	Deviation identification by means of a single leading object	91
3.5.4	Identification of deviation on circulation	92
3.5.5	Identification of steering gear compass deviation by comparison with readings of the primary compass .	93
3.5.6	Identification of magnetic compass deviations by comparison with gyrocompass readings	94
3.5.7	Magnetic compass deviation table and graph	94
3.6	Identification of gyrocompass correction	95
3.7	Heading and bearing changes	96
3.7.1	Heading changes	97
3.7.2	Bearing changes	98
3.7.3	Bearing values on various headings	99

3.7.4	Correlations among heading values, heading angle and bearing values	100
3.8	Calculation examples	101
3.9	Check questions	107
4	SHIP SPEED AND ROUTE	109
4.1	Ship speed	109
4.2	Speed definitions	110
4.3	Speed through water v_w and speed over ground v_d	111
4.3.1	English equivalents in speed terminology	111
4.4	Characteristics of ship's logs	112
4.4.1	Hydromechanic log	112
4.4.2	Hydrodynamic (pressure) log	113
4.4.3	Inductive (electronic) log	114
4.4.4	Doppler log – hydroacoustic	114
4.4.5	Geoelectromagnetic log	116
4.4.6	Inertial log	116
4.4.7	Correction coefficient and percent correction of the log .	116
4.5	Ship speed determination methods	118
4.5.1	The Dutchman's log method	119
4.5.2	The propeller method	119
4.6	Calculation examples	121
4.7	Check questions	122
5	NAUTICAL CHARTS	125
5.1	Nautical charts in the navigational information system	125
5.1.1	General knowledge on cartographic projection methods	127
5.1.2	Azimuthal projection	130
5.1.3	Cylindrical projection (on cylinder side)	132
5.1.4	Conical projection (on cone side)	133
5.1.5	Conventional projection	133
5.1.6	Distortions in cartographic projections	134
5.2	Chart scale	140
5.3	Chart accuracy	141
5.4	Classification of nautical charts	142
5.5	Mercator's cartographic projection	143
5.5.1	Requirements for navigational charts	143

5.5.2	Rhumb line	143
5.5.3	Calculation of the zoomed latitude in Mercator's cartographic graticules	148
5.5.4	Calculation of Mercator's cartographic grid	152
5.5.5	A simplified plotting method of cartographic grid in Mercator's projection	158
5.6	Using navigational charts in Mercator's projection	160
5.6.1	Navigational tools	160
5.6.2	Reading position (point) coordinates from the chart . .	162
5.6.3	Plotting of position (point) coordinates onto a chart . .	162
5.6.4	Measurement of distance between two positions on a chart	163
5.6.5	Plotting of heading line on the chart and of the true bearing from designated position	165
5.6.6	Measurement of straight line direction, plotted on a nautical chart	166
5.6.7	Position transfer from one chart to another	166
5.7	Gnomonic and stereographic projection	166
5.7.1	Correlation between azimuthal and geographic coordinates on the sphere	167
5.7.2	Theory of perspective azimuthal projections	168
5.7.3	Gnomonic projection	170
5.7.4	Stereographic projection	175
5.7.5	The use of maps in gnomonic projection	176
5.8	The contents of navigational nautical charts	181
5.9	Electronic navigational charts	183
5.10	Calculation examples	185
5.11	Check questions	186
6	SPECIFICATION OF A SHIP'S MANOEUVRING CHARACTERISTICS	189
6.1	A Ship's manoeuvring characteristics	189
6.1.1	Manoeuvrability parameters	191
6.1.2	Ship stopping parameters	193
6.2	Legal acts normalising the principles of defining ship manoeuvring characteristics	194

6.2.1	Standardised programme of trials and tests of newly built ships	194
6.2.2	IMO's recommendations with regards to manoeuvring data	197
6.3	Ship manoeuvring affecting factors	204
6.3.1	Ship speed changing factors	204
6.3.2	Ship turning circle affecting factors	210
6.3.3	Factors affecting ship stopping	211
6.4	Requirements for manoeuvring sites (measure lines)	212
6.4.1	Leading sign	213
6.5	Ship preparation to determine manoeuvring characteristics . .	215
6.5.1	General principles of measurement line observation . . .	215
6.5.2	Hydrological and meteorological conditions	216
6.5.3	Determination of the observation onset time point . . .	216
6.5.4	Ship's heading direction at the transit line	216
6.5.5	Transit line length	218
6.5.6	The number of transits	220
6.5.7	Ship turns on the measurement line	221
6.5.8	Ship steering	223
6.6	The principles of speed measurement on the measurement line	224
6.7	The principle of ship circulation measurements	226
6.8	The principle of ship stopping measurements	227
6.9	Determination of ship manoeuvring characteristics with a navigational radar	230
6.9.1	Ship speed determination	230
6.9.2	Determination of turning elements	232
6.9.3	Determination of ship stopping elements	233
6.10	Check questions	234
	SYMBOLS AND ABBREVIATIONS	235
	BIBLIOGRAPHY	239