

Contents

Foreword	xi
Acknowledgments	xiii
Part 1	
The Solar System Chapters 1–6	1
1 The Solar System	3
1.1 Introduction	3
1.2 The Basic Measurements and Their Interpretation	4
2 The Sun	13
2.1 The Sun's Appearance	13
2.2 The Sun's Atmosphere	14
2.3 Sunspots	15
2.4 Radio Output from the Sun	22
2.5 The Sun as an Emitter of X-Rays and Cosmic Rays	22
2.6 The Solar Neutrino Problem	22
2.7 The Solar Wind	23
2.8 Solar Disk Phenomena: Practical Exercises	23
3 The Earth and its Moon	29
3.1 The Earth as a Planet	29
3.2 The Earth's Form	30
3.3 The Earth's Interior	30
3.4 The Earth's Magnetic Field	31
3.5 The Earth's Atmosphere	31
3.6 Solar-Terrestrial Relationships	33
3.7 The Moon's Physical Nature	34
4 The Earth-Moon System	41
4.1 The Phases of the Moon	41
4.2 The Retardation of the Moon's Transit	43
4.3 The Moon's Orbit	44
4.4 The Moon's Librations	45
4.5 The Tides	46
4.6 The Moon's Orbit: Practical Projects	48
5 Eclipses	54
5.1 Introduction	54
5.2 Types of Eclipses	55
5.3 The Eclipse Year	56
5.4 The Saros	57
5.5 Duration of a Total Lunar Eclipse	58
5.6 The Ecliptic Limits	60

5.7	Megalithic Man's Lunar Observatories	61
5.8	The Value of Eclipses	65
6	Members of the Solar System	66
6.1	Mercury	66
6.2	Venus	69
6.3	The Earth	72
6.4	Mars	72
6.5	The Asteroids	81
6.6	Jupiter	83
6.7	Saturn	89
6.8	Uranus	98
6.9	Neptune	99
6.10	Pluto	100
6.11	Comets	102
6.12	Meteors	104
6.13	Zodiacal Light	105
6.14	The Age and Origin of the Solar System	106
	Problems: Part 1	113
	Part 1: Further Study	115
 Part 2		
Astrophysics Chapters 7–14		117
7	The Stars: Observational Data	119
7.1	Introduction	119
7.2	Absolute Magnitude	121
7.3	Stellar Luminosity	122
7.4	The Hertzsprung–Russell (HR) Diagram	123
7.5	Binary Stars	126
7.6	The Mass–Luminosity Relation	138
7.7	The Spectral Sequence	138
7.8	Spectroscopic Parallax	141
7.9	The Complete HR Diagram and Yerkes Classification	142
7.10	The Radius of a Pulsating Star: Practical Exercise	143
7.11	Postscript	147
	Problems: Chapter 7	148
8	Stellar Atmospheres	150
8.1	Introduction	150
8.2	Temperature	150
8.3	Chemical Composition	151
8.4	The Photo-Absorption Cross-Section of an Atom	152
8.5	Model Stellar Atmospheres	152
8.6	Saha's Equation	154
8.7	Measured Abundances of Normal Stellar Atmospheres	157
8.8	Densities in Stellar Atmospheres	157
8.9	Spectrum Classification	158
9	Stellar Interiors	160
9.1	Introduction	160
9.2	Stellar Data	160
9.3	Stellar Models	161

9.4	The Effect of Temperature on the Mean Molecular Weight	165
9.5	The Stability of Hydrostatic Equilibrium	166
9.6	The Method of Energy Transport	167
9.7	The Main Sequence	168
9.8	Early Stages in the Life of a Star	169
9.9	The Source of Stellar Energy	171
9.10	Einstein's Mass–Energy Relation	171
9.11	The Fusion of Hydrogen into Helium	172
9.12	Stellar Evolution after Arrival on the Main Sequence	173
9.13	The Ages of Star Clusters	174
9.14	Application to Real Clusters of Stars	175
9.15	The Later Stages of Stellar Evolution	178
	Problems: Chapter 9	179
10	Stellar Motions	180
10.1	Introduction	180
10.2	The Transverse and Radial Velocities of a Star	180
10.3	The Components of Proper Motion	181
10.4	Measurement of the Transverse and Radial Speeds of a Star	181
10.5	The Velocity of a Star Relative to the Sun	182
10.6	The Convergent Point of a Galactic or Open Cluster	184
10.7	The Parallaxes of the Stars in an Open Cluster	185
10.8	The Solar Motion	186
10.9	The Distribution of Stellar Velocities	187
10.10	The Solar Speed	190
10.11	Secular Parallaxes	190
10.12	The Convergence of an Open Cluster: Graphical Exercise	191
	Problems: Chapter 10	193
11	Stellar Populations: Observational Evidence	194
11.1	Introduction	194
11.2	Stellar Clusters	194
11.3	Kinematic Behaviour	195
11.4	Spectral Differences	196
11.5	Initial Composition	196
11.6	Conclusion	196
12	Stars with Special Properties	198
12.1	Introduction	198
12.2	Variable Stars	198
12.3	Wolf–Rayet Stars	206
12.4	Stars with Extended Atmospheres	207
12.5	Fast-Rotating Stars	208
12.6	Magnetic Variables	209
	Problems: Chapter 12	209
13	Nebulae	211
13.1	Introduction	211
13.2	Diffuse Nebulae	211
13.3	Interstellar Absorption	216
13.4	Planetary Nebulae	218
13.5	Supernova Remnants	219

14 Celestial Objects Observed Outside the Optical Spectrum	221
14.1 Introduction	221
14.2 Galactic Radio Radiation	221
14.3 Extragalactic Radio Sources	224
14.4 Quasars	225
14.5 Pulsars	227
14.6 X-Ray Astronomy	229
14.7 Black Holes	230
14.8 Infra-Red Objects	231
 Part 3	
Galactic Structure and Cosmology Chapters 15–18	233
15 The Galaxy	235
15.1 Introduction	235
15.2 The Milky Way	235
15.3 Review of Methods of Measuring Distances	237
15.4 Galactic Co-ordinates	238
15.5 Distribution of Objects in the Galaxy	239
15.6 Galactic Rotation	239
15.7 The Mass of the Galaxy	242
15.8 The Spiral Arms of the Galaxy	242
15.9 Stellar Populations	244
15.10 The Origin and Evolution of the Galaxy	244
15.11 Galactic Co-ordinates: Graphical Exercise	246
15.12 Galactic Structure: Exercise Using 21 cm Line Data	246
Problem: Chapter 15	249
16 The Extragalactic Universe	250
16.1 Introduction	250
16.2 Catalogues of Galaxies	250
16.3 Types of Galaxies	250
16.4 Hubble's Classification of Galaxies	253
16.5 The Distances of Galaxies	254
16.6 The Sizes of Galaxies	257
16.7 The Masses of Galaxies	258
16.8 The Distribution of Galaxies	259
16.9 The Spectra of Galaxies	259
16.10 The Ages of Galaxies	261
17 Cosmology	263
17.1 Introduction	263
17.2 Observational Data in Cosmology	266
17.3 The Cosmological Principle	267
17.4 The Velocity of Light	267
17.5 Einstein's Theories of Relativity	270
17.6 The Einstein Universe	271
17.7 The Steady-State Universe	273
17.8 Observational Tests	274
18 Cosmogony	276
18.1 Introduction	276
18.2 The Origin of the Universe	276
18.3 The Origin of the Galaxies	276
18.4 The Origin of the Elements	276

18.5	Life and the Universe	277
18.6	The Astronomical Facts of Life	278
18.7	Life As We Know It	279
18.8	Suitable Planets for Life	279
18.9	The Origin of Life	280
18.10	The Search for Extra-Terrestrial Life	281
	Problems: Parts 2 and 3	285

Appendix: Astronomical and Related Constants	286
---	-----

Bibliography	288
---------------------	-----

Answers to Problems	290
----------------------------	-----

Index	292
--------------	-----