

Valerio Faraoni

Exercises in Environmental Physics

Contents

Dedication	v
Preface	xi
Acknowledgments	xv
1. MATHEMATICAL METHODS	1
1.1 Complex numbers	2
1.2 Functions of a single variable	6
1.2.1 Differentiation	6
1.2.2 Integration	10
1.2.3 Maxima, minima, and graphs	14
1.3 Ordinary differential equations	24
1.3.1 Solution methods	24
1.3.2 Qualitative analysis	33
1.4 Functions of two or more variables	37
1.4.1 Differentiation	37
1.4.2 Integration	40
1.5 Vector calculus	45
1.6 Partial differential equations	56
1.7 Tensors	69
1.8 Dimensional analysis	73
2. PLANET EARTH IN SPACE	81
2.1 Astronomy	82
2.2 Planet Earth	87

3. OCEAN AND ATMOSPHERIC PHYSICS	103
3.1 The blue planet	104
3.2 Oceanic circulation	107
3.3 Ocean waves	115
3.4 General features of the atmosphere	122
3.5 Temperature and pressure	128
3.6 Atmospheric circulation	130
3.7 Precipitation	132
4. ELECTROMAGNETIC RADIATION AND RADIOACTIVITY	139
4.1 The electromagnetic spectrum	140
4.2 Blackbody radiation	142
4.3 Propagation of electromagnetic radiation	147
4.4 Greenhouse effect	156
4.5 Electromagnetic radiation and human health	161
4.6 Environmental spectroscopy	164
4.6.1 Quantum mechanics	165
4.6.2 Vibrational and rotational levels of molecules	169
4.7 Radioactivity	173
5. ENERGY AND THE ENVIRONMENT	183
5.1 Mechanical energy	184
5.1.1 Storage and transport	184
5.1.2 Transportation and vehicles	189
5.1.3 Eolic energy	190
5.2 Heat transfer	196
5.3 Thermodynamics	214
5.4 Electricity	219
6. FLUID MECHANICS	223
6.1 Liquids	223
6.1.1 Fluid statics	224
6.1.2 Capillarity and surface tension	231
6.1.3 Fluid dynamics	235
6.2 Gases	244

7. EVAPOTRANSPIRATION, SOILS, AND HYDROLOGY	251
7.1 Phase transitions, hygrometry, and evapotranspiration	252
7.2 Soil physics	262
7.3 Groundwater hydrology	276
8. POLLUTION	287
8.1 Transport equations	288
8.2 Water pollution	296
8.3 Air pollution	307
APPENDICES	315
A Physical constants	315
B Mathematical identities	319
C Differential operators in various coordinate systems	321
REFERENCES	323
INDEX	327