

Contents

Preface	vii
1 $F = ma$	1
1.1 Prelude to Newton's <i>Principia</i>	1
1.2 Equal Area in Equal Time	5
1.3 The Law of Gravity	9
1.4 Exercises	16
1.5 Reprise with Calculus	18
1.6 Exercises	26
2 Vector Algebra	29
2.1 Basic Notions	29
2.2 The Dot Product	34
2.3 The Cross Product	39
2.4 Using Vector Algebra	46
2.5 Exercises	50
3 Celestial Mechanics	53
3.1 The Calculus of Curves	53
3.2 Exercises	65
3.3 Orbital Mechanics	66
3.4 Exercises	75
4 Differential Forms	77
4.1 Some History	77
4.2 Differential 1-Forms	79
4.3 Exercises	86
4.4 Constant Differential 2-Forms	89
4.5 Exercises	96
4.6 Constant Differential k -Forms	99
4.7 Prospects	105
4.8 Exercises	107

5	Line Integrals, Multiple Integrals	111
5.1	The Riemann Integral	111
5.2	Line Integrals	113
5.3	Exercises	119
5.4	Multiple Integrals	120
5.5	Using Multiple Integrals	131
5.6	Exercises	134
6	Linear Transformations	139
6.1	Basic Notions	139
6.2	Determinants	146
6.3	History and Comments	157
6.4	Exercises	158
6.5	Invertibility	163
6.6	Exercises	169
7	Differential Calculus	171
7.1	Limits	171
7.2	Exercises	178
7.3	Directional Derivatives	181
7.4	The Derivative	187
7.5	Exercises	197
7.6	The Chain Rule	201
7.7	Using the Gradient	205
7.8	Exercises	207
8	Integration by Pullback	211
8.1	Change of Variables	211
8.2	Interlude with Lagrange	213
8.3	Exercises	216
8.4	The Surface Integral	221
8.5	Heat Flow	228
8.6	Exercises	230
9	Techniques of Differential Calculus	233
9.1	Implicit Differentiation	233
9.2	Invertibility	238
9.3	Exercises	244
9.4	Locating Extrema	248
9.5	Taylor's Formula in Several Variables	254
9.6	Exercises	262
9.7	Lagrange Multipliers	266
9.8	Exercises	277

10 The Fundamental Theorem of Calculus	279
10.1 Overview	279
10.2 Independence of Path	286
10.3 Exercises	294
10.4 The Divergence Theorems	297
10.5 Exercises	310
10.6 Stokes' Theorem	314
10.7 Summary for $\mathbf{R}^3$	321
10.8 Exercises	323
10.9 Potential Theory	326
11 $E = mc^2$	333
11.1 Prelude to Maxwell's <i>Dynamical Theory</i>	333
11.2 Flow in Space-Time	338
11.3 Electromagnetic Potential	345
11.4 Exercises	349
11.5 Special Relativity	352
11.6 Exercises	360
Appendices	
A An Opportunity Missed	361
B Bibliography	365
C Clues and Solutions	367
Index	382