

Contents

1	Philosophy and Mathematics for Physics	9
1.1	The Scientific Method	9
1.2	Special Notations	10
1.3	Units in Physics	11
1.4	Measurement	13
1.5	Integral Rational Equations	15
1.6	Systems of Equations	16
1.7	Proportionality	18
1.8	Trigonometry	18
1.9	Exponential Functions	20
1.10	Calculus for Physics	20
1.10.1	Differentiation	20
1.10.2	Integration	23
1.10.3	Partial Derivatives	24
1.11	Matrices	25
1.12	Series Representation of Functions	27
1.13	Important Formulas from Geometry	28
1.14	PROBLEMS	30
2	Motion in One Dimension	33
2.1	Displacement and Time	33
2.2	Speed and Velocity	34
2.3	Acceleration	37
2.4	Motion with Constant Acceleration	38
2.5	Air Resistance	43
2.6	PROBLEMS	47
3	Vectors	51
3.1	Scalar and Vector Quantities	51
3.2	Vectors in Polar Form	52
3.3	Vectors in Component Form	53
3.4	Addition and Subtraction of Vectors	55
3.5	Multiplication of Vectors: The Dot Product	58
3.6	Multiplication of Vectors: The Cross Product	60
3.7	Vector Identities	62

3.8	PROBLEMS	63
4	Motion in Two Dimensions	67
4.1	Parabolic Motion	67
4.2	The Range Equation	70
4.3	Velocity During Parabolic Motion	73
4.4	Uniform Circular Motion	76
4.5	Motion in Three Dimensions	78
4.6	Relative Velocity	80
4.7	PROBLEMS	82
5	Newton's Laws	87
5.1	Newton's Laws of Motion	87
5.2	Consequences of the laws of motion	89
5.3	Applications of Newton's First and Third Laws	91
5.4	Friction	96
5.5	Pulleys	101
5.6	Applications of Newton's Second Law	103
5.7	Newton's Law of Gravity	105
5.8	Satellite Motion	111
5.9	Hooke's Law	113
5.10	PROBLEMS	114
6	Energy	121
6.1	Work	121
6.2	The Work-Energy Theorem	125
6.3	Potential Energy	127
6.3.1	Gravitational Potential Energy	127
6.3.2	Hooke's Law Potential Energy	131
6.3.3	Relating Potential to Work	132
6.4	Non-Conservative Forces	134
6.5	Power	136
6.6	PROBLEMS	138
7	Momentum	141
7.1	Linear Momentum	141
7.2	Collision Types	145
7.3	Nuclear Decay	147
7.4	The Ballistic Pendulum	151
7.5	Rocket Propulsion	152
7.6	Momentum and Newton's Second Law	154
7.7	PROBLEMS	157

8	Rotational Motion	161
8.1	Center of Mass	161
8.2	The Rotational Analogues	165
8.2.1	Angular Position	165
8.2.2	Angular Velocity	166
8.2.3	Angular Acceleration	168
8.2.4	Moment of Inertia, Rotational Kinetic Energy	171
8.2.5	Torque	176
8.2.6	Angular Momentum	182
8.3	Composite Objects	184
8.4	The Parallel Axis Theorem	185
8.5	Torque and Statics	186
8.6	The Vector Nature of Rotational Quantities	191
8.7	PROBLEMS	193
9	Fluid Mechanics	197
9.1	Pressure	197
9.2	The Barometer	201
9.3	Pascal's Principle	202
9.4	Buoyancy	203
9.5	Fluid Dynamics	205
9.5.1	Bernoulli's Equation	205
9.5.2	Viscosity	209
9.5.3	Turbulence	210
9.6	PROBLEMS	212
10	Oscillations, Waves and Sound	217
10.1	Simple Harmonic Motion	217
10.2	Energy of the SHO	225
10.3	The Simple Pendulum	226
10.4	The Traveling Wave	228
10.5	Sound	233
10.5.1	Origin of Sound	233
10.5.2	Sound Intensity	234
10.5.3	Human Response to Sound	236
10.6	Musical Instruments	237
10.6.1	Vibrating Strings	237
10.6.2	Open and Closed Pipes	239
10.7	The Doppler Effect	240
10.8	The Wave Equation	242
10.9	PROBLEMS	243

11	Temperature and Heat	247
11.1	Temperature Scales	247
11.2	Thermal Expansion	249
11.3	Thermal Properties of Gases	252
11.4	The Kinetic Theory of Gases	255
11.5	Distribution of Speeds	259
11.6	The van der Waals Equation of State	261
11.7	Gaseous Diffusion	262
11.8	PROBLEMS	265
12	Thermodynamics	267
12.1	Terminology	267
12.2	The First Law of Thermodynamics	269
12.3	Heat Capacity	273
12.4	Calorimetry	277
12.5	Phase Transitions	279
12.6	Heat Engines	282
12.7	The Second Law of Thermodynamics	285
12.8	Heat Capacity Ratio	290
12.9	Refrigeration	292
12.10	Heat Transfer	293
12.11	PROBLEMS	296
13	Electricity	299
13.1	Electric Charge	299
13.2	The Electric Field	304
13.3	Source of Charge	310
13.4	Motion of Charged Particles in E fields	310
13.5	Potential Energy in Electric Fields	314
13.6	Potential Energy of a Charge Distribution	316
13.7	Gauss's Law	322
13.8	Energy of Electric Fields	326
13.9	Dielectrics	327
13.10	PROBLEMS	331
14	Current and Resistance	335
14.1	Charge Carriers in Conductors	335
14.2	Resistance	340
14.3	DC Circuits	344
14.3.1	Power in DC circuits	344
14.3.2	Resistors in Series	347
14.3.3	Resistors in Parallel	348
14.3.4	Lamps	353
14.3.5	Kirchhoff's Rules	355
14.4	A Model for Batteries	361

14.5	The RC Circuit	363
14.6	Capacitors in Series and Parallel	367
14.7	PROBLEMS	370
15	Magnetism	375
15.1	The Magnetic Field	375
15.2	Magnetic Force on a Line Current	379
15.3	The Velocity Selector	381
15.4	The Current Loop	384
15.5	Magnets	387
15.6	Ampère's Law	388
15.7	The Solenoid	391
15.8	The Biot-Savart Law	393
15.9	PROBLEMS	396
16	Electromagnetic Induction	401
16.1	Magnetic Flux	401
16.2	Faraday's Law	403
16.3	Induction in a Moving Conductor	406
16.4	Self Inductance	408
16.5	Lenz's Law	410
16.6	The RL Circuit	412
16.7	The LC Circuit	414
16.8	AC Circuits	417
16.8.1	Sources of Alternating Current	417
16.8.2	RMS Voltage and Current	419
16.8.3	The RLC Circuit	420
16.8.4	Phasor Diagrams	423
16.8.5	Power in an AC circuit	425
16.9	Mutual Inductance	427
16.10	PROBLEMS	431
17	Electromagnetic Radiation	437
17.1	Maxwell's Equations	437
17.2	Electromagnetic Waves	443
17.3	Energy in E & M Waves	446
17.4	E & M Radiation in Matter	448
17.4.1	The Ray Model	448
17.4.2	The Index of Refraction	449
17.4.3	Snell's Law	452
17.4.4	Total Internal Reflection	454
17.4.5	Dispersion	456
17.5	PROBLEMS	458

18 Optics I: Refraction and Reflection	461
18.1 Thin Lenses	461
18.1.1 Lens Types	461
18.1.2 The Converging Lens	462
18.1.3 The Diverging Lens	464
18.1.4 The Thin Lens Equation	465
18.1.5 The Lens Maker's Equation	469
18.1.6 Lens Aberrations	470
18.2 Mirrors	472
18.2.1 The Concave Mirror	474
18.2.2 The Convex Mirror	476
18.3 Optical Instruments	477
18.3.1 The Astronomical Refracting Telescope	478
18.3.2 The Terrestrial Refracting Telescope	480
18.3.3 The Reflecting Telescope	481
18.4 Corrective Lenses	483
18.5 PROBLEMS	486
19 Optics II: Interference and Diffraction	489
19.1 Wave Interference	489
19.2 Double-Slit Interference	493
19.3 Huygens' Principle	495
19.4 Single-Slit Diffraction	498
19.5 Intensity of Single and Double-Slit Patterns	500
19.5.1 Single-Slit Intensity	500
19.5.2 Double-Slit Intensity	503
19.6 The Diffraction Grating	508
19.7 Interference in Thin Films	510
19.7.1 The Soap Bubble	511
19.7.2 Thin Films on Glass	512
19.8 Resolution in Optical Instruments	513
19.9 PROBLEMS	516
Appendices	519
A Integral Formulas	519
B Trigonometric Identities	521
C Useful relations	522
D Physical Constants	523
E Relations Between Units	524
F Advanced Topics: Drag	525
F.1 Linear Drag in Two Dimensions	525
F.2 Quadratic Drag in Two Dimensions	526
G Advanced Topics: The Driven Oscillator	529
G.1 The Driven Mass-Spring System	529
G.2 The RLC Circuit	533

H	Advanced Topics: The Fourier Transform	535
I	Answers to problems	538
J	INDEX	541