

Contents: Unit C

Conservation Laws Constrain Interactions

About the Author	viii	Chapter C3	38
Preface	ix	Vectors	38
Introduction for Students	xvi	Chapter Overview	38
Chapter C1	2	C3.1 Introduction	40
The Art of Model Building	2	C3.2 Reference Frames	40
Chapter Overview	2	C3.3 Displacement Vectors	41
C1.1 The Nature of Science	4	C3.4 Arbitrary Vectors	44
C1.2 The Development and Structure of Physics	5	C3.5 Seven Rules to Remember	45
C1.3 A Model-Building Example	7	C3.6 Vectors in Two Dimensions	47
C1.4 Trick Bag: Unit Awareness	10	C3.7 Vectors in One Dimension	48
C1.5 Trick Bag: Unit Conversions	11	TWO-MINUTE PROBLEMS	49
C1.6 Trick Bag: Dimensional Analysis	12	HOMEWORK PROBLEMS	49
TWO-MINUTE PROBLEMS	14	ANSWERS TO EXERCISES	51
HOMEWORK PROBLEMS	14		
ANSWERS TO EXERCISES	17	Chapter C4	52
Chapter C2	18	Systems and Frames	52
Particles and Interactions	18	Chapter Overview	52
Chapter Overview	18	C4.1 Systems of Particles	54
C2.1 The Principles of Modern Mechanics	20	C4.2 A System's Center of Mass	54
C2.2 Describing an Object's Motion	21	C4.3 How the Center of Mass Moves	57
C2.3 Vector Operations	23	C4.4 Inertial Reference Frames	59
C2.4 Momentum and Impulse	24	C4.5 Freely Floating Frames	60
C2.5 Force and Weight	26	C4.6 Interactions with the Earth	62
C2.6 Interaction Categories	28	TWO-MINUTE PROBLEMS	64
C2.7 Momentum Transfer	30	HOMEWORK PROBLEMS	65
TWO-MINUTE PROBLEMS	32	ANSWERS TO EXERCISES	67
HOMEWORK PROBLEMS	33		
ANSWERS TO EXERCISES	37	Chapter C5	68
		Conservation of Momentum	68
		Chapter Overview	68
		C5.1 Degrees of Isolation	70
		C5.2 How to Solve Physics Problems	71
		C5.3 Conservation of Momentum Problems	75
		C5.4 Examples	76
		C5.5 Airplanes and Rockets	79
		TWO-MINUTE PROBLEMS	81
		HOMEWORK PROBLEMS	82
		ANSWERS TO EXERCISES	83

Chapter C6	84	C9.3	One-Dimensional Potential Energy Diagrams	139
Conservation of Angular Momentum	84	C9.4	Relaxing the Mass Limitation	144
Chapter Overview	84	C9.5	The Spring Approximation	145
C6.1 Introduction	86	C9.6	The Potential Energy “of an Object”	146
C6.2 Quantifying Orientation	86	C9.7	An Example	146
C6.3 Angular Velocity	87		TWO-MINUTE PROBLEMS	148
C6.4 The Angular Momentum of a Rigid Object	88		HOMEWORK PROBLEMS	149
C6.5 Twirl and Torque	91		ANSWERS TO EXERCISES	152
C6.6 Gyroscopic Precession	92			
C6.7 Conservation of Angular Momentum	93	Chapter C10		154
TWO-MINUTE PROBLEMS	96	Work		154
HOMEWORK PROBLEMS	97			
ANSWERS TO EXERCISES	99	Chapter Overview		154
Chapter C7	100	C10.1	The Momentum Requirement	156
More About Angular Momentum	100	C10.2	The Dot Product	157
Chapter Overview	100	C10.3	The Definition of Work	158
C7.1 First Steps	102	C10.4	Long-Range Interactions	161
C7.2 The Cross Product	103	C10.5	Contact Interactions	162
C7.3 The Angular Momentum of a Moving Particle	105		TWO-MINUTE PROBLEMS	165
C7.4 Rotating Objects	106		HOMEWORK PROBLEMS	166
C7.5 Rotating and Moving Objects	107		ANSWERS TO EXERCISES	169
C7.6 Torque and Force	108	Chapter C11		170
C7.7 Why Angular Momentum Is Conserved	110	Rotational Energy		170
TWO-MINUTE PROBLEMS	112			
HOMEWORK PROBLEMS	113	Chapter Overview		170
ANSWERS TO EXERCISES	117	C11.1	Introduction to Rotational Energy	172
Chapter C8	118	C11.2	Rotational Energy of an Object at Rest	172
Conservation of Energy	118	C11.3	Calculating Moments of Inertia	174
Chapter Overview	118	C11.4	When an Object Both Moves and Rotates	176
C8.1 Introduction to Energy	120	C11.5	Rolling Without Slipping	177
C8.2 Kinetic Energy	121		TWO-MINUTE PROBLEMS	182
C8.3 Potential Energy	122		HOMEWORK PROBLEMS	183
C8.4 Fundamental Potential Energy Formulas	124		ANSWERS TO EXERCISES	185
C8.5 Internal Energy and Power	126	Chapter C12		186
C8.6 Isolation	126	Thermal Energy		186
C8.7 Solving Conservation-of-Energy Problems	127			
TWO-MINUTE PROBLEMS	130	Chapter Overview		186
HOMEWORK PROBLEMS	131	C12.1	The Case of the Disappearing Energy	188
ANSWERS TO EXERCISES	134	C12.2	Caloric Is Energy	188
Chapter C9	136	C12.3	Thermal Energy as Microscopic Energy	190
Potential Energy Graphs	136	C12.4	Friction and Thermal Energy	192
Chapter Overview	136	C12.5	Heat, Work, and Energy Transfer	193
C9.1 Interactions Between Macroscopic Objects	138	C12.6	Specific “Heat”	194
C9.2 Interactions Between Two Atoms	138	C12.7	Problems Involving Thermal Energies	196
			TWO-MINUTE PROBLEMS	199
			HOMEWORK PROBLEMS	200
			ANSWERS TO EXERCISES	202

Chapter C13**Other Forms of Internal Energy**

	Chapter Overview	204
C13.1	Bonds	206
C13.2	Latent "Heat"	208
C13.3	Chemical Energy	211
C13.4	Nuclear Energy	212
C13.5	Modes of Energy Transfer	213
C13.6	Mechanisms of Heat Transfer	214
C13.7	A Comprehensive Energy Master Equation	216
	TWO-MINUTE PROBLEMS	218
	HOMEWORK PROBLEMS	219
	ANSWERS TO EXERCISES	221

Chapter C14**Collisions**

	Chapter Overview	222
C14.1	Types of Collisions	224
C14.2	One-Dimensional Collisions	224
C14.3	Two-Dimensional Collisions	227
C14.4	The Slingshot Effect	230
C14.5	Using All Three Conservation Laws	232
C14.6	Asteroid Impacts	234
	TWO-MINUTE PROBLEMS	236
	HOMEWORK PROBLEMS	237
	ANSWERS TO EXERCISES	239

204 Appendix CA**204 The Standard Model**

204	CA.1	Introduction	240
206	CA.2	Matter Particles	240
208	CA.3	Fundamental Interactions	240
211	CA.4	The Importance of Color-Neutrality	242
212	CA.5	Stability and the Weak Interaction	243
213	CA.6	Conclusion	245
214		TWO-MINUTE PROBLEMS	246
216		HOMEWORK PROBLEMS	246
218		ANSWERS TO EXERCISES	246
221		Index	247
		Periodic table	255
222		Short Answers to Selected Problems	256