

Contents

Preface	vii
Nomenclature	xvii

Chapter 1 Human Body Structure

Muscles, Tendons, Ligaments, and Bones	1
--	---

1.1 Introduction	1
1.2 Notation for Human Movement	3
1.3 Skeletal Tree	6
1.4 Bone, Cartilage, and Ligaments	10
1.5 Joints of the Human Body	14
1.6 Physical Properties of Skeletal Muscle	17
1.7 Muscle Groups and Movement	21
1.8 Summary	27
1.9 Problems	27

Chapter 2 Laws of Motion

Snowflakes, Airborne Balls, Pendulums	30
---	----

2.1 Laws of Motion: A Historical Perspective	30
2.2 Addition and Subtraction of Vectors	33
2.3 Time Derivatives of Vectors	39
2.4 Position, Velocity, and Acceleration	40
2.5 Newton's Laws of Motion and Their Applications	43
2.6 Summary	52
2.7 Problems	53

Chapter 3 Particles in Motion

Method of Lumped Masses and Jumping, Sit-Ups, Push-Ups	56
--	----

3.1 Introduction	56
3.2 Conservation of Linear Momentum	57
3.3 Center of Mass and Its Motion	58
3.4 Multiplication of Vectors	64
3.5 Moment of a Force	67
3.6 Moment of Momentum About a Stationary Point	70
3.7 Moment of Momentum About the Center of Mass	77
3.8 Summary	78
3.9 Problems	79

Chapter 4 Bodies in Planar Motion

Jumping, Diving, Push-Ups, Back Curls	84
---	----

4.1 Introduction	84
4.2 Planar Motion of a Slender Rod	85
4.3 Angular Velocity	88
4.4 Angular Acceleration	94
4.5 Angular Momentum	97
4.6 Conservation of Angular Momentum	100
4.7 Applications to Human Body Dynamics	103
4.8 Instantaneous Center of Rotation	109
4.9 Summary	111
4.10 Problems	112

Chapter 5 Statics

Tug-of-War, Weight Lifting, Trusses, Cables, Beams	117
--	-----

5.1 Introduction	117
5.2 Equations of Static Equilibrium	117
5.3 Contact Forces in Static Equilibrium	121
5.4 Structural Stability and Redundancy	127
5.5 Structures and Internal Forces	135
5.6 Distributed Forces	144
5.7 Summary	146
5.8 Problems	146

Chapter 6 Internal Forces and the Human Body	
Complexity of the Musculoskeletal System	150
6.1 Introduction	150
6.2 Muscle Force in Motion	152
6.3 Examples from Weight Lifting	157
6.4 Moment Arm and Joint Angle	161
6.5 Multiple Muscle Involvement in Flexion of the Elbow	164
6.6 Biarticular Muscles	165
6.7 Physical Stress	169
6.8 Musculoskeletal Tissues	172
6.9 Limb-Lengthening	178
6.10 Summary	182
6.11 Problems	183
Chapter 7 Impulse and Momentum	
Impulsive Forces and Crash Mechanics	194
7.1 Introduction	194
7.2 Principle of Impulse and Momentum	194
7.3 Angular Impulse and Angular Momentum	200
7.4 Elasticity of Collision: Coefficient of Restitution	207
7.5 Initial Motion	211
7.6 Summary	213
7.7 Problems	214
Chapter 8 Energy Transfers	
In Pole Vaulting, Running, and Abdominal Workout	220
8.1 Introduction	220
8.2 Kinetic Energy	221
8.3 Work	225
8.4 Potential Energy	227
8.5 Conservation of Mechanical Energy	230
8.6 Multibody Systems	232
8.7 Applications to Human Body Dynamics	235
8.8 Summary	246
8.9 Problems	247

Chapter 9	Three-Dimensional Motion	
Somersaults, Throwing, and Hitting Motions	256	
9.1 Introduction	256	
9.2 Time Derivatives of Vectors	257	
9.3 Angular Velocity and Angular Acceleration	258	
9.4 Conservation of Angular Momentum	264	
9.5 Dancing Holding on to a Pole	271	
9.6 Rolling of an Abdominal Wheel on a Horizontal Plane	275	
9.7 Biomechanics of Twisting Somersaults	280	
9.8 Throwing and Hitting Motions	283	
9.9 Summary	287	
9.10 Problems	289	
Appendix 1	Units and Conversion Factors	297
Appendix 2	Geometric Properties of the Human Body	299
Selected References	304	
Index	311	