

Contents

Preface	xi
Introduction Biomechanics Analysis Techniques: A Primer	1
<i>Gary Kamen</i>	
What Tools Are Needed in Biomechanics?	1
Applications of the Principles of Biomechanics: An Example	1
Numerical Accuracy and Significant Digits.	4
Summary.	5
List of Abbreviations	5
PART I KINEMATICS	7
Chapter 1 Planar Kinematics	9
<i>D. Gordon E. Robertson and Graham E. Caldwell</i>	
Description of Position	9
Degrees of Freedom	11
Kinematic Data Collection	12
Linear Kinematics	18
Angular Kinematics	24
Summary.	32
Suggested Readings	33
Chapter 2 Three-Dimensional Kinematics	35
<i>Joseph Hamill, W. Scott Selbie, and Thomas M. Kepple</i>	
Collection of Three-Dimensional Data	35
Coordinate Systems and Assumption of Rigid Segments	36
Transformations Between Coordinate Systems.	37
Defining the Segment LCS for the Lower Extremity	38
Pose Estimation: Tracking the Segment LCS.	45
Joint Angles	50
Joint Angular Velocity and Angular Acceleration of Cardan Joint Angles.	58
Summary.	59
Suggested Readings	59

PART II KINETICS **61**

Chapter 3	Body Segment Parameters	63
	<i>D. Gordon E. Robertson</i>	
	Methods for Measuring and Estimating Body Segment Parameters	63
	Two-Dimensional (Planar) Computational Methods	69
	Three-Dimensional (Spatial) Computational Methods	74
	Summary	78
	Suggested Readings	78
 Chapter 4	 Forces and Their Measurement	 79
	<i>Graham E. Caldwell, D. Gordon E. Robertson, and Saunders N. Whittlesey</i>	
	Force	79
	Newton's Laws	79
	Free-Body Diagrams	80
	Types of Forces	82
	Moment of Force, or Torque	84
	Linear Impulse and Momentum	85
	Angular Impulse and Momentum	89
	Measurement of Force	92
	Summary	108
	Suggested Readings	108
 Chapter 5	 Two-Dimensional Inverse Dynamics	 109
	<i>Saunders N. Whittlesey and D. Gordon E. Robertson</i>	
	Planar Motion Analysis	110
	Numerical Formulation	115
	Human Joint Kinetics	120
	Applications	123
	Summary	127
	Suggested Readings	129
 Chapter 6	 Energy, Work, and Power	 131
	<i>D. Gordon E. Robertson</i>	
	Energy, Work, and the Laws of Thermodynamics	131
	Conservation of Mechanical Energy	133
	Ergometry: Direct Methods	135
	Ergometry: Indirect Methods	136
	Mechanical Efficiency	147
	Summary	148
	Suggested Readings	149

Chapter 7	Three-Dimensional Kinetics	151
	<i>W. Scott Selbie, Joseph Hamill, and Thomas M. Kepple</i>	
	Segments and Link Models	151
	3-D Inverse Dynamics Analysis	152
	Presentation of the Net Moment Data	164
	Joint Power	168
	Interpretation of Net Joint Moments	169
	Sources of Error in Three-Dimensional Calculations	175
	Summary	175
	Suggested Readings	176
PART III MUSCLES, MODELS, AND MOVEMENT		177
Chapter 8	Electromyographic Kinesiology	179
	<i>Gary Kamen</i>	
	Physiological Origin of the Electromyographic Signal	179
	Recording and Acquiring the Electromyographic Signal	182
	Analyzing and Interpreting the Electromyographic Signal	188
	Applications for Electromyographic Techniques	193
	Summary	201
	Suggested Readings	201
Chapter 9	Muscle Modeling	203
	<i>Graham E. Caldwell</i>	
	The Hill Muscle Model	203
	Muscle-Specific Hill Models	216
	Beyond the Hill Model	223
	Summary	229
	Suggested Readings	229
Chapter 10	Computer Simulation of Human Movement	233
	<i>Saunders N. Whittlesey and Joseph Hamill</i>	
	Overview: Modeling as a Process	233
	Why Simulate Human Movement?	235
	General Procedure for Simulations	236
	Control Theory	242
	Limitations of Computer Models	243
	Summary	245
	Suggested Readings	246

Chapter 11	Musculoskeletal Modeling	247
	<i>Brian R. Umberger and Graham E. Caldwell</i>	
	Musculoskeletal Models	247
	Control Models	256
	Analysis Techniques	266
	Summary	273
	Suggested Readings	275
 PART IV FURTHER ANALYTICAL PROCEDURES		277
Chapter 12	Signal Processing	279
	<i>Timothy R. Derrick</i>	
	Characteristics of a Signal	279
	Fourier Transform	281
	Time-Dependent Fourier Transform	282
	Sampling Theorem	282
	Ensuring Circular Continuity	285
	Smoothing Data	285
	Summary	289
	Suggested Readings	290
Chapter 13	Dynamical Systems Analysis of Coordination	291
	<i>Richard E.A. van Emmerik, Ross H. Miller, and Joseph Hamill</i>	
	Movement Coordination	291
	Foundations for Coordination Analysis	296
	Quantifying Coordination: Relative Phase Methods	298
	Quantifying Coordination: Vector Coding	310
	Overview of Coordination Analysis Techniques	314
	Summary	315
	Suggested Readings	315
Chapter 14	Analysis of Biomechanical Waveform Data	317
	<i>Kevin J. Deluzio, Andrew J. Harrison, Norma Coffey, and Graham E. Caldwell</i>	
	Biomechanical Waveform Data	317
	Principal Component Analysis	319
	Functional Data Analysis	327
	Comparison of PCA and FDA	336
	Summary	336
	Suggested Readings	336

Appendix A: International System of Units (Système International, SI)	339
Appendix B: Selected Factors for Converting Between Units of Measure	343
Appendix C: Basic Electronics	345
Appendix D: Vectors and Scalars	355
Appendix E: Matrices and Matrix Operations	361
Appendix F: Numerical Integration of Double Pendulum Equations	365
Appendix G: Derivation of Double Pendulum Equations	369
Appendix H: Discrete Fourier Transform Subroutine	373
Appendix I: Shannon's Reconstruction Subroutine	375
Example Answers	377
Glossary	389
References	395
Index	415
About the Authors	427
Additional Contributors	428