

Contents

	<i>Preface</i>	<i>page vii</i>
1	Space and Time: Orientation and Euler Angles	1
	1.1 The Absolute Time of Newtonian Mechanics	2
	1.2 Space and Reference Frame	2
	1.3 Representation of Vectors and Operations Involving a Single Time Instant	5
	1.4 Geometric Time Derivative of Vectors	7
	1.5 Analytical Time Derivative of Vectors: Angular Velocity Vector	9
	1.6 Time Derivative of a Vector in Different Reference Frames	12
	1.7 Simple Rotation	13
	1.8 General Rotation: Euler Angles	15
	1.9 The Two Families of Euler Angles	20
	Appendix 1A Composition of Rotations around Fixed Axes	27
	Appendix 1B Alternatives to the Composition of Rotations	32
	Appendix 1C Integration of Vectors through Moving Bases	36
	Quiz Questions	38
	Puzzles	49
2	Point Kinematics	54
	2.1 The Mass Point: Position Vector	54
	2.2 The Velocity Vector and the Acceleration Vector	57
	2.3 Intrinsic Components of the Velocity and the Acceleration: Curvature Radius	59
	2.4 Composition of Velocities: Transportation Velocity	63
	2.5 Composition of Accelerations: Transportation and Coriolis Accelerations	66
	2.6 Additional Interesting Points regarding the Composition of Movements	70
	Appendix 2A Angular Velocity of the Intrinsic (or Frenet) Vector Basis	77
	Appendix 2B The Inertial Guidance	79
	Quiz Questions	82
	Problems	100
	Puzzles	109

vi	Contents	
3	Rigid Body Kinematics	114
	3.1 Position and Orientation of a Rigid Body	114
	3.2 Velocity and Acceleration Distributions in a Rigid Body	115
	3.3 Basic Constraint Conditions: Contact and No Sliding	122
	3.4 Geometry of the Velocity Distribution: The Screw Axis	124
	3.5 A Particular Case: Planar Motion, Instantaneous Center of Rotation	134
	Appendix 3A Perfect Rolling: The Geometric Contact Point: Acceleration of Contact Points	140
	Appendix 3B Maneuverability of Vehicles with Conventional Wheels	142
	Appendix 3C Maneuverability of Vehicles with Omnidirectional Wheels	158
	Quiz Questions	169
	Problems	190
	Puzzles	214
4	Introduction to Kinematics of Multibody Systems	224
	4.1 Mechanical Systems: Multibody Systems	225
	4.2 Generalized Coordinates: Configuration Space	225
	4.3 Geometric Constraints: Independent Coordinates	225
	4.4 Generalized Speeds: Phase Space	230
	4.5 Kinematic Constraints: Degrees of Freedom	231
	4.6 Holonomy	234
	4.7 Superposition of Partial Constraints: Full and Tangent Redundancy	240
	4.8 Systematic Analysis of Redundancy in Partial Constraints between Rigid Bodies	253
	Quiz Questions	258
	Puzzles	280
	<i>Index</i>	283