

3976

# Contents

<b>Series Preface</b>	v
<b>Preface</b>	vii
<b>1 Introduction</b>	1
1.1 Background . . . . .	1
1.2 Elements of a Robotic System . . . . .	3
1.3 Degrees-of-Freedom of a System . . . . .	6
1.4 Regional and Orientational Structures . . . . .	9
1.5 Coordinate Systems . . . . .	12
1.6 Displacements . . . . .	20
1.7 Problems . . . . .	39
<b>2 Kinematic Analysis</b>	45
2.1 Background . . . . .	45
2.2 Governing Equations . . . . .	46
2.3 Stanford Arm Manipulator . . . . .	52
2.4 Manipulator Case 2 . . . . .	58
2.5 Manipulator Case 3 . . . . .	62
2.6 PUMA by ZRP Method . . . . .	64
2.7 PUMA by Pieper-Roth Method . . . . .	68
2.8 Cincinnati Milacron T <sup>3</sup> . . . . .	72
2.9 Geared Wrists . . . . .	76
2.10 Velocity Relations . . . . .	80
2.11 Acceleration Relations . . . . .	93
2.12 Iterative Position Analysis . . . . .	93
2.13 Problems . . . . .	102

<b>3 Robot Workspace</b>	<b>109</b>
3.1 Background . . . . .	109
3.2 Workspace Classification . . . . .	109
3.3 Nature of Workspace . . . . .	113
3.4 Determination of Primary Workspace . . . . .	116
3.5 Determination of Workspace . . . . .	121
3.6 Free Spin of the Hand . . . . .	123
3.7 Problems . . . . .	127
<b>4 Dynamics and Control</b>	<b>129</b>
4.1 Background . . . . .	129
4.2 Kinematics . . . . .	129
4.3 Kinetics . . . . .	130
4.4 Recursion Relations . . . . .	139
4.5 Lagrangian Formulation . . . . .	145
4.6 Control . . . . .	147
4.7 Problems . . . . .	157
<b>References</b>	<b>161</b>
<b>Index</b>	<b>173</b>