

► Contents

Preface xi

■ 1	INTRODUCTION	1
1.1	Rationale	1
1.2	Analysis of Dynamic Systems	2
1.3	Classification of Variables	5
1.4	Classification of Systems	7
1.5	Scope and Objectives	14
■ 2	TRANSLATIONAL MECHANICAL SYSTEMS	16
2.1	Variables	16
2.2	Element Laws	19
2.3	Interconnection Laws	24
2.4	Obtaining the System Model	27
	Summary	46
	Problems	47
■ 3	STANDARD FORMS FOR SYSTEM MODELS	58
3.1	State-Variable Equations	58
3.2	Input-Output Equations	73
3.3	Matrix Formulation of State-Variable Equations	78
	Summary	85
	Problems	85

4	ROTATIONAL MECHANICAL SYSTEMS	a9
4.1	Variables	89
4.2	Element Laws	90
4.3	Interconnection Laws	99
4.4	Obtaining the System Model	100
	Summary	126
	Problems	126
5	ELECTRICAL SYSTEMS	138
5.1	Variables	138
5.2	Element Laws	141
5.3	Interconnection Laws	145
5.4	Obtaining the Input-Output Model	150
5.5	Resistive Circuits	158
5.6	Obtaining the State-Variable Model	163
5.7	Controlled Sources and Operational Amplifiers	171
	Summary	181
	Problems	182
6	ANALYTICAL SOLUTION OF LINEAR MODELS	191
6.1	The Complete Solution of Differential Equations	191
6.2	First-Order Systems	198
6.3	The Step Function and Impulse	208
6.4	Second-Order Systems	217
6.5	Systems of Order Three and Higher	230
6.6	Time-Domain Solution of Matrix State-Variable Equations	231
	Summary	242
	Problems	242
7	THE LAPLACE TRANSFORM	250
7.1	Transforms of Functions	251
7.2	Transform Properties	255
7.3	Transform Inversion	263
7.4	Solving for the Response	274
7.5	Additional Transform Properties	287
	Summary	294
	Problems	294

a	TRANSFER FUNCTION ANALYSIS	300
8.1	The Zero-Input Response	300
8.2	The Zero-State Response	309
8.3	The Complete Response	315
8.4	Step and Impulse Responses	318
8.5	Frequency Response	324
8.6	Impedances	331
8.7	Transform Solution of Matrix State-Variable Equations	336
	Summary	346
	Problems	347
9	DEVELOPING A LINEAR MODEL	353
9.1	Linearization of an Element Law	353
9.2	Linearization of the Model	360
9.3	Circuits with Nonlinear Resistors	368
	Summary	379
	Problems	379
10	ELECTROMECHANICAL SYSTEMS	388
10.1	Resistive Coupling	388
10.2	Coupling by a Magnetic Field	392
10.3	Devices Coupled by Magnetic Fields	396
10.4	A Device for Measuring Acceleration	409
	Summary	416
	Problems	416
11	THERMAL SYSTEMS	425
11.1	Variables	425
11.2	Element Laws	426
11.3	Dynamic Models of Thermal Systems	431
11.4	A Thermal System	443
	Summary	448
	Problems	448
12	HYDRAULIC SYSTEMS	454
12.1	Variables	455

12.2 Element Laws	455
12.3 Dynamic Models of Hydraulic Systems	464
Summary	471
Problems	472

■ 13 BLOCK DIAGRAMS _____ 478

13.1 Diagram Blocks	479
13.2 Diagrams for State-Variable Models	484
13.3 Diagrams for Input-Output Models	490
13.4 Models in Nonstandard Form	500
13.5 Block Diagrams of Feedback Systems	504
Summary	516
Problems	516

■ 14 FEEDBACK SYSTEM MODELING AND DESIGN TOOLS _____ 524

14.1 Application to a Control System	524
14.2 Root-Locus Diagrams	533
14.3 Bode Diagrams	552
14.4 Design Guidelines	564
14.5 Applications	578
Summary	592
Problems	593

■ 15 COMPUTER ANALYSIS _____ 602

15.1 Building Linear Models	603
15.2 Analysis with MATLAB	613
15.3 Building ACSL Models	622
15.4 Running ACSL Models	626
Summary	637
Problems	637
APPENDIX A Units	643
APPENDIX B Laplace Transforms	645
APPENDIX C Matrices	649
APPENDIX D Selected Reading	655
APPENDIX E Answers to Selected Problems	657
References	673
Index	677