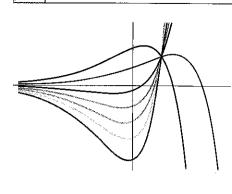


# CONTENTS

Preface ix

1 INTRODUCTION TO	D DIFFERENTIAL EQUATIONS	1
	<ul> <li>1.1 Definitions and Terminology 2</li> <li>1.2 Initial-Value Problems 13</li> <li>1.3 Differential Equations as Mathematical Models 19</li> <li>CHAPTER 1 IN REVIEW 32</li> </ul>	
2 FIRST-ORDER DIFFE	rential equations	34
	<ul> <li>2.1 Solution Curves Without a Solution 35</li> <li>2.1.1 Direction Fields 35</li> <li>2.1.2 Autonomous First-Order DEs 37</li> <li>2.2 Separable Variables 44</li> <li>2.3 Linear Equations 53</li> <li>2.4 Exact Equations 62</li> <li>2.5 Solutions by Substitutions 70</li> <li>2.6 A Numerical Method 75</li> <li>CHAPTER 2 IN REVIEW 80</li> </ul>	
3 MODELING WITH I	FIRST-ORDER DIFFERENTIAL EQUATIONS	8.
	<ul> <li>3.1 Linear Models 83</li> <li>3.2 Nonlinear Models 94</li> <li>3.3 Modeling with Systems of First-Order DEs 105</li> <li>CHAPTER 3 IN REVIEW 113</li> </ul>	



4.1	Preliminary '	Theory-	—Linear	Equations	118
	- I CAMILLIAN Y	THOOTY		Lyuauons	110

- **4.1.1** Initial-Value and Boundary-Value Problems 118
- **4.1.2** Homogeneous Equations 120
- **4.1.3** Nonhomogeneous Equations 125
- **4.2** Reduction of Order 130
- **4.3** Homogeneous Linear Equations with Constant Coefficients 133
- **4.4** Undetermined Coefficients—Superposition Approach 140
- 4.5 Undetermined Coefficients—Annihilator Approach 150
- **4.6** Variation of Parameters 157
- **4.7** Cauchy-Euler Equation 162
- **4.8** Solving Systems of Linear DEs by Elimination 169
- **4.9** Nonlinear Differential Equations 174

#### CHAPTER 4 IN REVIEW 178

# 5 MODELING WITH HIGHER-ORDER DIFFERENTIAL EQUATIONS

181

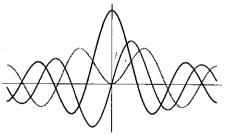


- **5.1** Linear Models: Initial-Value Problems 182
  - **5.1.1** Spring/Mass Systems: Free Undamped Motion 182
  - **5.1.2** Spring/Mass Systems: Free Damped Motion 186
  - **5.1.3** Spring/Mass Systems: Driven Motion 189
  - **5.1.4** Series Circuit Analogue 192
- **5.2** Linear Models: Boundary-Value Problems 199
- **5.3** Nonlinear Models 207

CHAPTER 5 IN REVIEW 216

### 6 | SERIES SOLUTIONS OF LINEAR EQUATIONS

219



- **6.1** Solutions About Ordinary Points 220
  - **6.1.1** Review of Power Series 220
  - **6.1.2** Power Series Solutions 223
- **6.2** Solutions About Singular Points 231
- **6.3** Special Functions 241
  - **6.3.1** Bessel's Equation 241
  - **6.3.2** Legendre's Equation 248

#### CHAPTER 6 IN REVIEW 253

/	/	1 /	1 /	<b>1</b> 
				/

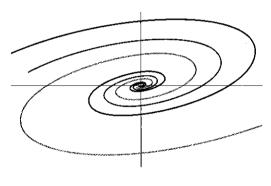
- **7.1** Definition of the Laplace Transform 256
- **7.2** Inverse Transforms and Transforms of Derivatives 262
  - **7.2.1** Inverse Transforms 262
  - **7.2.2** Transforms of Derivatives 265
- **7.3** Operational Properties I 270
  - **7.3.1** Translation on the s-Axis 271
  - **7.3.2** Translation on the t-Axis 274
- **7.4** Operational Properties II 282
  - **7.4.1** Derivatives of a Transform 282
  - **7.4.2** Transforms of Integrals 283
  - **7.4.3** Transform of a Periodic Function 287
- **7.5** The Dirac Delta Function 292
- **7.6** Systems of Linear Differential Equations 295

#### CHAPTER 7 IN REVIEW 300

## 8 SYSTEMS OF LINEAR FIRST-ORDER DIFFERENTIAL EQUATIONS

303

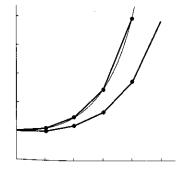
339



- **8.1** Preliminary Theory—Linear Systems 304
- **8.2** Homogeneous Linear Systems 311
  - **8.2.1** Distinct Real Eigenvalues 312
  - **8.2.2** Repeated Eigenvalues 315
  - **8.2.3** Complex Eigenvalues 320
- **3.3** Nonhomogeneous Linear Systems 326
  - 8.3.1 Undetermined Coefficients 326
  - **8.3.2** Variation of Parameters 329
- **8.4** Matrix Exponential 334

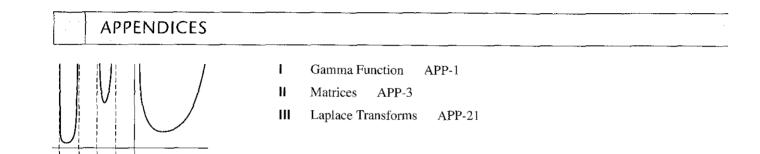
CHAPTER 8 IN REVIEW 337

### 9 NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS



- **9.1** Euler Methods and Error Analysis 340
- **9.2** Runge-Kutta Methods 345
- **9.3** Multistep Methods 350
- **9.4** Higher-Order Equations and Systems 353
- **9.5** Second-Order Boundary-Value Problems 358

CHAPTER 9 IN REVIEW 362



Index

I-1

Answers for Selected Odd-Numbered Problems

ANS-1