

INTRODUCTORY ENGINEERING MODELING

***Emphasizing
Differential Models
and Computer
Simulations***

***William G. Rieder and
Henry R. Busby***

CONTENTS

LIST OF SYMBOLS

xi

PART ONE MODEL SETUPS

Chapter 1	Some Engineering Approaches to Model Setups and Simulations	3
Chapter 2	Setups Involving Ordinary Derivatives	6
	Flow Systems	6
	Moving-Object Systems	20
	Structural Systems	33
	Problems	40
Chapter 3	Setups Involving Partial Derivatives	65
	Flow Systems	65
	Moving-Object Systems	70
	Structural Systems	73
	Problems	79

PART TWO SIMULATION METHODS

Chapter 4	Model Identifications and Choice of Simulation Method	87
	Models Containing Ordinary-Derivative Equations	88
	A Standard Form	88
	Features to Identify	90
	Models Containing Partial Derivative Equations	93
	A Standard Form	93
	Features to Identify	94

vii

	Classifications of Second-Order Models	95
	Picking the Simulation Method	96
	Ordinary-Derivative Models	96
	Partial-Derivative Models	97
	Problems	98
Chapter 5	Numerical Simulations from Ordinary-Derivative Models	101
	First-Order Models	101
	An Introduction—The Euler Method	101
	The Runge–Kutta Methods	107
	The Adams Predictor–Corrector Methods	112
	Higher-Order Models	117
	Initial Condition Problems	117
	Boundary Condition Problems	123
	The Shooting Method for Nonlinear Models	123
	Matrix Methods for Linear Models	128
	The Use of a Problem-Oriented Language (POL)	137
	Continuous System Modeling Program (CSMP)	137
	CSMP Statements	139
	Other POL Packages	145
	Developing Your Own Simulation Package	146
	Problems	148
Chapter 6	Numerical Simulations from Partial-Derivative Models	175
	Elliptic-Model Simulations with Finite-Difference Methods	175
	Parabolic-Model Simulations with Finite-Difference Methods	185
	The Fully Explicit Method	186
	The Fully Implicit Method	190
	The Crank–Nicolson Method	194
	Hyperbolic-Model Simulations with Finite-Difference Methods	198
	The Direct Explicit Method	198
	Problems	202
Chapter 7	Numerical Simulations Using Finite Elements	223
	An Introduction to Finite-Element Methods	223
	The Direct Approach for One-Dimensional Systems	226
	The Direct Approach for Some Simple Structural Systems	231
	Axial Bar-Element Systems	232
	Beam-Element Systems	238
	Plane Triangular-Element Systems	243

The Direct Approach for Some Simple, Steady Flow Systems	261
One-Dimensional Conduction Heat Transfer	261
One-Dimensional Fluid Flow	265
Two-Dimensional Conduction Heat Transfer	267
Two-Dimensional Fluid Flow	277
Problems	282
Chapter 8 Closure	291
The Problem of Stiff Models	291
Eigenvalue Problems	291
Verification Tasks	292
The Role of Exact Solutions and Transform Methods	292
Additional Sources of Modeling Information	293
Appendix A1 Some Classical Solution Methods	295
Appendix A2 Some General-Purpose Numerical Methods	313
Selected Answers	334
Index	341