

DET. 9  
TNT  
1973

---

# INTRODUCTION TO COMPUTER SIMULATION: THE SYSTEM DYNAMICS APPROACH

---

**NANCY ROBERTS**

*Lesley College*

**DAVID F. ANDERSEN**

*State University of  
New York at Albany*

**RALPH M. DEAL**

*Kalamazoo College*

**MICHAEL S. GARET**

*Stanford University*

**WILLIAM A. SHAFER**

*Data Resources, Inc.*

ĐẠI HỌC QUỐC GIA HÀ NỘI  
TRUNG TÂM THÔNG TIN THƯ VIỆN

A-DO/3938



Addison-Wesley Publishing Company

Reading, Massachusetts • Menlo Park, California  
London • Amsterdam • Don Mills, Ontario • Sydney

# CONTENTS

## Preface

<b>PART I</b>	<b>BASIC CONCEPTS OF SYSTEM SIMULATION</b>	<b>1</b>
<b>Chapter 1</b>	<b>Simulation, Models, and Systems</b>	<b>3</b>
	Simulation and Models	3
	The Systems Approach	5
	Rationale for the Content and Organization of This Book	7
<b>Chapter 2</b>	<b>Causation, Feedback, and System Boundary</b>	<b>11</b>
	Understanding Cause and Effect	11
	Example I: Newton's Laws	11
	Example II: Seatbelts	13
	Example III: Suicide	13
	Example IV: Inflation	14
	Feedback	16
	Example V: Dessert and Weight-Gain	18
	Example VI: Piano Practice	18
	Clarifying the Implications of Causal-Loop Diagrams	20
	“Walking Through” a Closed Loop	23
	System Boundary	25
	Example VII: Elements of a System	25
<b>PART II</b>	<b>STRUCTURE OF FEEDBACK SYSTEMS</b>	<b>29</b>
<b>Chapter 3</b>	<b>Reading Causal-Loop Diagrams</b>	<b>31</b>
	Structure and Behavior in Feedback Systems	31
	Single-Loop Positive Feedback Systems	33
	Example I: Student Performance	33
	Example II: Population Dynamics	34

## iv Contents

	Singly Loop Negative Feedback Systems	38
	Example III: Effect of Jobs on Migration	38
	Example IV: Negative Feedback in the Population system	38
	More Complicated Single Loops	39
	Example V: Multiple Items in One Loop	39
	Vertical Arrows: An Aid to Drawing Causal-Loop Diagrams	41
	Inferring the Behavior of Positive Feedback Loops	43
	Inferring the Behavior of Negative Feedback Loops	43
	Systems Involving More Than One Feedback Loop	43
	Loop Dominance	47
	Exogenous Items	48
	Inferring the Behavior of Multiple Loop Systems	49
<b>Chapter 4</b>	<b>Developing Causal-Loop Diagrams</b>	57
	Example I: The Pipeline Delay	57
	Example II: The Self-Regulating Biosphere	61
	Example III: The Tragedy of the Sailor	66
	Unstructured Material	76
<b>PART III</b>	<b>GRAPHING AND ANALYZING THE BEHAVIOR OF FEEDBACK SYSTEMS</b>	87
<b>Chapter 5</b>	<b>Graphing Data and Seeing Patterns</b>	89
	Example I: The Wrights' Daily Use of Electricity	89
	Patterns	92
	Example II: Midtown Parking Lot—Part I	99
	Example III: Midtown Parking Lot—Part II	99
	Summary	99
	Defining Rates and Levels	104
	Example IV: The Flu—Part I	105
	Example V: The Flu Epidemic—Part II	109
	More on Rates and Levels	116
<b>Chapter 6</b>	<b>Linking Causal Loops and Graphs</b>	119
	Example I: The Rabbit Population—Part I	119
	Example II: The Rabbit Population—Part II	121
	Example III: The Rabbit Population—Part III	126
	Rabbit-Lynx Levels and Rates	130
	Example IV: Population History of the Boston Area—Part I	131
	Example V: Population History of Boston—Part II	132
	Example VI: Population History of the Boston Area—Part III	135
	Developing Graphs from Causal Loops	137
	Supplemental Exercises	140

<b>Chapter 7</b>	<b>Graphs of Systems with Delayed Responses</b>	<b>147</b>
	Example I: Martan Chemical and the Sparkill River— Part I	147
	Example II: Martan Chemical—Part II	150
	Delays	152
	Example III: Tree Harvesting	154
<b>PART IV</b>	<b>ANALYZING LESS-STRUCTURED PROBLEMS</b>	<b>165</b>
<b>Chapter 8</b>	<b>Defining a Dynamic Problem</b>	<b>167</b>
	Perspective	168
	Example I: The “Oil Crisis”—Part I	168
	Time Horizon	168
	Example II: The “Oil Crisis”—Part II	169
	Reference Mode	169
	Example III: Eutrophication of a Lake	169
	Policy Choice	173
	Example IV: Rainfall	173
<b>Chapter 9</b>	<b>The Nuclear Power Controversy</b>	<b>175</b>
	Background Information	175
	Perspectives	177
	Time Horizon	177
	Problem Behavior	178
	Policy Choices	179
	Building a Causal-Loop Diagram of the Nuclear Power Controversy	179
	Alternative Issue: Build-Up of Radioactive Waste	185
	Alternative Problem Definition: Uranium Mine Owner	186
<b>Chapter 10</b>	<b>The Dilemma of Solid-Waste Disposal</b>	<b>189</b>
	Background Information	189
	Perspectives	190
	Time Frames	191
	Problem Behaviors	191
	Policy Choices	191
	Example I: Secretary of the Interior’s Viewpoint	192
<b>Chapter 11</b>	<b>Family Dynamics from a System Perspective</b>	<b>195</b>
	Perspectives	195
	Time Horizons	195
	Problem Behaviors	196
	Policy Choices	196
	Example I: Sibling Interaction	196
	Example II: Second Income	199
	Example III: A Commune	201
<b>Chapter 12</b>	<b>Descriptions of Unstructured Problems</b>	<b>207</b>