



# CONTENTS

## PART I. COMMUNICATION WITH DIGITAL COMPUTERS

### CHAPTER 1. Introduction

1.1 Characteristics of Digital Computers . . . . .	3
1.2 A Brief History and Survey of the Application of Digital Computers . . . . .	4

### CHAPTER 2. Main Computer Components

2.1 Functions of Computer Components . . . . .	6
2.2 Memory Units . . . . .	7
2.3 Central Processing Unit . . . . .	10
2.4 Bistate Elements . . . . .	11
2.5 Words . . . . .	13

### CHAPTER 3. Logical Flow Charting

3.1 The Solution of a Scientific or Engineering Problem on Computers . . . . .	15
3.2 Flow Chart . . . . .	15
3.3 Loop . . . . .	18
3.4 Loop Within a Loop . . . . .	19

### CHAPTER 4. Floating-Point Method

4.1 The Handling of Decimals . . . . .	25
4.2 Floating-Point Numbers . . . . .	26
4.3 Floating-Point Arithmetic . . . . .	28

### CHAPTER 5. Coding Systems for Digital Computers

5.1 Introduction . . . . .	31
5.2 Formula Translation Language—FORTRAN System . . . . .	32

5.3	Example in FORTRAN—Dart Problem . . . . .	37
5.4	Example in FORTRAN—Series Summation . . . . .	40
5.5	Output Statements for a Matrix Problem . . . . .	42
5.6	Input Statements for a Matrix Problem . . . . .	49
5.7	FORTRAN SUBROUTINE Subprograms . . . . .	50
5.8	Main Program . . . . .	54
5.9	FUNCTION Subprogram and FUNCTION Statement . . . . .	57
5.10	Summary of the FORTRAN Compiler Language . . . . .	59
5.11	Common Errors in FORTRAN . . . . .	69
5.12	Communication with a Computation Center . . . . .	73

## PART II. COMPUTER-ORIENTED NUMERICAL METHODS

### CHAPTER 6. Computer Solution of Polynomial and Transcendental Equations

6.1	Introduction . . . . .	83
6.2	Half-Interval Search . . . . .	83
6.3	Method of False Position ( <i>Regula Falsi</i> ) . . . . .	87
6.4	Newton-Raphson Method . . . . .	90
6.5	Bairstow's Method for Polynomial Equations with Real Coefficients . . . . .	95

### CHAPTER 7. Ordinary Differential Equations with Initial Conditions

7.1	Introduction . . . . .	107
7.2	Runge-Kutta Method with Runge's Coefficients . . . . .	108
7.3	Derivation of the Runge-Kutta Formula . . . . .	114
7.4	Runge-Kutta Method with Gill's Coefficients . . . . .	118
7.5	Higher-Order Ordinary Differential Equations; Bouncing Ball Problem . . . . .	124
7.6	Higher-Order Equations by Runge-Kutta Method . . . . .	131

### CHAPTER 8. Matrix Algebra and Simultaneous Equations

8.1	Introduction . . . . .	151
8.2	Elementary Operations of Matrices . . . . .	151
8.3	Gauss-Jordan Elimination Method—Direct Method . . . . .	154
8.4	Necessity of Normalization . . . . .	157
8.5	Zero Diagonal Element . . . . .	159
8.6	Determinants . . . . .	162
8.7	Matrix Inversion . . . . .	163
8.8	Matrix Inversion in Place . . . . .	167
8.9	FORTRAN Program for Matrix Inversion and Simultaneous Linear Equations . . . . .	169
8.10	Gauss-Seidel Iterative Method . . . . .	178

### CHAPTER 9. Eigenvalues and Eigenvectors of a Real Symmetric Matrix

9.1	Introduction . . . . .	185
9.2	Transformation of Coordinates . . . . .	186
9.3	Jacobi's Method for Eigenvalues . . . . .	189

9.4	Eigenvectors . . . . .	191
9.5	Machine Computation . . . . .	192
9.6	General Eigenvalue Problem . . . . .	199

**CHAPTER 10. Polynomial Interpolation**

10.1	Interpolation . . . . .	210
10.2	The Lagrange Polynomials . . . . .	212
10.3	Lagrange Interpolation Formula for Unequally Spaced Data . . . . .	214

**CHAPTER 11. Least-Squares Curve Fitting**

11.1	Introduction . . . . .	219
11.2	Normal Equations for Curve Fitting . . . . .	219
11.3	FORTRAN Program for Least-Squares Polynomial Fit . . . . .	224
11.4	Orthogonal Polynomials . . . . .	227
11.5	Chebyshev Polynomials . . . . .	228
11.6	Chebyshev Polynomials and Curve Fitting . . . . .	229
11.7	Chebyshev-Polynomial Curve Fitting with a Computer . . . . .	232

**CHAPTER 12. Numerical Integration**

12.1	Preliminary Remarks . . . . .	239
12.2	Legendre Polynomials . . . . .	240
12.3	Gaussian Quadrature . . . . .	240
12.4	Gaussian Quadrature in FORTRAN Language . . . . .	245

**CHAPTER 13. Errors**

13.1	Preliminary Remarks . . . . .	253
13.2	Round-off Errors . . . . .	253
13.3	Truncation Errors . . . . .	255

**PART III. MODERN METHODS****CHAPTER 14. Monte Carlo Method and Random Numbers**

14.1	Monte Carlo Method . . . . .	265
14.2	Buffon Needle Problem . . . . .	269
14.3	Generation of Random Numbers—Power Residue Method . . . . .	272

**CHAPTER 15. Linear Programming**

15.1	Constraint, Nonnegative Condition, and Objective Function . . . . .	278
15.2	Conversion to the Standard Minimization Form . . . . .	279
15.3	Two-Variable Problem—Graphical Solution . . . . .	280
15.4	Basic Feasible Solutions and Vertices . . . . .	282
15.5	Simplex Method for an Optimum Solution . . . . .	283
15.6	Gauss-Jordan Procedure and Simplex Tableau . . . . .	286
15.7	Computer Application in Linear Programming . . . . .	290
15.8	Artificial Variables . . . . .	299

**Appendix A. Operating Instructions for IBM 1620 and 1622**

A.1	For FORTRAN Programs . . . . .	311
A.2	For Symbolic Programming System Language (SPS) . . . . .	314
A.3	For Regular FORTRAN II Compilation . . . . .	317
A.4	FORGO Operating Instructions . . . . .	319

**Appendix B. Number Systems**

B.1	Introduction . . . . .	320
B.2	Binary System . . . . .	321
B.3	Octal System . . . . .	323
B.4	Number Conversions . . . . .	323

**Appendix C. Derivation of Bairstow's Iterative Equations . . . . .** 327

**Answers to Selected Problems . . . . .** 332

**Index . . . . .** 335

