

Contents

1	Solution of Equations	1
1.1	Introduction	1
1.2	Case Study 1: Finding Roots by Interval Halving	3
1.3	Finding Approximate Roots	17
1.4	Method of Successive Approximations	17
1.5	The Stopping Criterion	22
1.6	A Modified Method of Successive Approximations	23
1.7	The Newton-Raphson Method	25
1.8	Nearly Equal Roots	27
1.9	Comparison of the Methods	29
1.10	Roots of Polynomials	32
1.11	Effect of Uncertainty in the Coefficients	36
1.12	Complex Roots	38
1.13	Simultaneous Equations	39
1.14	Finding an Initial Approximation	41
1.15	Case Study 2: The Newton-Raphson Method in a Structures Problem	43
	Exercises	51

2	Errors	65
2.1	Introduction	65
2.2	Relative and Absolute Errors	67
2.3	Inherent Errors	67

2.4	Truncation Errors	69
2.5	Floating Point Arithmetic	69
2.6	Roundoff Errors	76
2.7	Error Propagation	80
2.8	Process Graphs	83
2.9	Examples	86
2.10	An Accuracy Checklist	94
	Exercises	94
<hr/>		
3	Numerical Instabilities and Their Cure	99
3.1	Introduction	99
3.2	Case Study 3: Errors in the Direct Evaluation of the Sine Series	100
3.3	Case Study 4: Subtractive Cancellation in a Calculation of π	106
3.4	Case Study 5: Errors in the Recursive Evaluation of a Definite Integral	120
3.5	Case Study 6: The Effect of Limited Precision in Calculating Means and Standard Deviations	129
	Exercises	145
<hr/>		
4	Simultaneous Linear Algebraic Equations	150
4.1	Introduction	150
4.2	Existence, Uniqueness, and Ill-Conditioning	151
4.3	Gaussian Elimination	155
4.4	Matrix Formulation	159
4.5	Flow Charts for Gaussian Elimination	162
4.6	Roundoff Errors	163
4.7	Case Study 7: Solving the Simultaneous Equations of a Chemical Process by Gaussian Elimination	169
4.8	Refinement of the Solution	175
4.9	Effect of Uncertainty in the Coefficients: Attainable Accuracy	177
4.10	Iterative Methods of Solution	182
4.11	Accelerating Convergence	191
4.12	Comparison of the Methods	195
4.13	Case Study 8: Solving the Simultaneous Equations of a Cost Accounting Problem by Gauss-Seidel Iteration	197
	Exercises	205
<hr/>		
5	Numerical Differentiation and Integration	219
5.1	Introduction	219
5.2	Numerical Differentiation	221
5.3	Truncation Errors	223
5.4	Total Error	224
5.5	Generalized Numerical Differentiation	226
5.6	Some Dangers in Differentiation	230

5.7	Numerical Integration	231
5.8	The Trapezoidal Rule	232
5.9	Truncation Error in the Trapezoidal Rule	233
5.10	Roundoff Errors in the Trapezoidal Rule	237
5.11	The Deferred Approach to the Limit	240
5.12	Simpson's Rule	241
5.13	Accuracy Checks	243
5.14	Gaussian Quadrature	244
5.15	Numerical Examples and Comparison of Methods	249
5.16	Case Study 9: Using Simpson's Rule in Computing Luminous Efficiency Exercises	251 256
<hr/>		
6	Interpolation	267
6.1	Introduction	267
6.2	Linear Interpolation	268
6.3	Truncation Error in Linear Interpolation	271
6.4	Roundoff Error in Linear Interpolation	274
6.5	Numerical Example	276
6.6	Quadratic Interpolation	278
6.7	Lagrangian Interpolation	281
6.8	Truncation Error in Lagrangian Interpolation	285
6.9	Roundoff Error in Lagrangian Interpolation	287
6.10	Repeated Linear Interpolation	292
6.11	Comparison of Lagrangian and Repeated Linear Interpolation	295
6.12	Extrapolation	296
6.13	Case Study 10: Two-Dimensional Interpolation in a Wind Chill Factor Table Exercises	297 304
<hr/>		
7	Least Squares Approximations	310
7.1	Introduction	310
7.2	The Principle of Least Squares	313
7.3	Linear Regression	314
7.4	Polynomial Regression	324
7.5	Case Study 11: Specific Heat of Water	326
7.6	Exponential, Geometric, and Trigonometric Regression	330
7.7	Multiple Regression	335
7.8	Numerical Problems	336
7.9	Case Study 12: Curve Fitting of a Stress-Strain Law Exercises	340 347
<hr/>		
8	Ordinary Differential Equations	360
8.1	Introduction	360
8.2	Taylor Series Solution	364

8.3	Runge-Kutta Methods	366
8.4	A Special Case: $f(x,y) = F(x)$	375
8.5	Truncation Error in Runge-Kutta Methods	376
8.6	Partial Instability	378
8.7	Predictor-Corrector Methods	379
8.8	A Special Case: $f(x,y) = F(x)$	383
8.9	Truncation Errors in Predictor-Corrector Methods	383
8.10	Stability of Predictor-Corrector Methods	386
8.11	Attainable Accuracy—Inherent Instability	389
8.12	Stability—A Summary	389
8.13	Comparison of Methods	390
8.14	Case Study 13: Solving the Differential Equation of Large Deflections of a Beam	391
	Exercises	403

Annotated Bibliography	415
Answers to Selected Exercises	421
Index	441

