

Contents

1. What can't be ignored	1
1.1 Real numbers	1
1.1.1 How do we represent them	2
1.1.2 How do we operate with floating-point numbers	4
1.2 Complex numbers	6
1.3 Matrices	8
1.3.1 Vectors	13
1.4 Real functions	14
1.4.1 The zeros	16
1.4.2 Polynomials	17
1.4.3 Integration and differentiation	19
1.5 To err is not only human	21
1.5.1 Talking about costs	24
1.6 A few more words about MATLAB	26
1.6.1 MATLAB statements	29
1.6.2 Programming in MATLAB	30
1.7 What we haven't told you	34
1.8 Exercises	34
2. Nonlinear equations	37
2.1 The bisection method	38
2.2 The Newton method	42

2.3	Fixed point iterations	47
2.3.1	How to terminate fixed point iterations	50
2.4	What we haven't told you	51
2.5	Exercises	53
3.	Approximation of functions and data	57
3.1	Interpolation	59
3.1.1	Lagrangian polynomial interpolation	60
3.1.2	Chebyshev interpolation	66
3.1.3	Trigonometric interpolation and FFT	67
3.2	Piecewise linear interpolation	72
3.3	Approximation by spline functions	74
3.4	The least squares method	76
3.5	What we haven't told you	80
3.6	Exercises	81
4.	Numerical differentiation and integration	83
4.1	Approximation of function derivatives	84
4.2	Numerical integration	87
4.2.1	Midpoint formula	87
4.2.2	Trapezoidal formula	89
4.2.3	Simpson formula	92
4.3	Simpson adaptive formula	95
4.4	What we haven't told you	99
4.5	Exercises	100
5.	Linear systems	103
5.1	The LU factorization method	106
5.2	The technique of pivoting	113
5.3	How accurate is the LU factorization?	115
5.4	How to solve a tridiagonal system	120
5.5	Iterative methods	122
5.5.1	How to construct an iterative method	123
5.6	When should an iterative method be stopped?	128
5.7	Richardson method	130
5.8	What we haven't told you	134
5.9	Exercises	134
6.	Eigenvalues and eigenvectors	137
6.1	The power method	140
6.1.1	Convergence analysis	142
6.2	Generalization of the power method	144
6.3	How to compute the shift	146

6.4	Computation of all the eigenvalues	148
6.5	What we haven't told you	149
6.6	Exercises	150
7.	Ordinary differential equations	153
7.1	The Cauchy problem	155
7.2	Euler methods	156
7.2.1	Convergence analysis	158
7.3	The Crank-Nicolson method	162
7.4	Zero-stability	163
7.5	Stability on unbounded intervals	165
7.5.1	Absolute stability controls perturbations	168
7.6	High order methods	174
7.7	The predictor-corrector methods	176
7.8	Systems of differential equations	179
7.9	What we haven't told you	182
7.10	Exercises	184
8.	Numerical methods for boundary-value problems	187
8.1	Approximation of boundary-value problems	190
8.1.1	Approximation by finite differences	190
8.1.2	Approximation by finite elements	192
8.2	Finite differences in 2 dimensions	195
8.2.1	Consistency and convergence	202
8.3	What we haven't told you	204
8.4	Exercises	205
9.	Solutions of the exercises	207
9.1	Chapter 1	207
9.2	Chapter 2	209
9.3	Chapter 3	215
9.4	Chapter 4	219
9.5	Chapter 5	223
9.6	Chapter 6	228
9.7	Chapter 7	232
9.8	Chapter 8	241
	Bibliography	245
	Index of MATLAB Programs	249
	Index	251