

Contents

Preface	vii
1 Introduction	1
1.1 A first example: computation of drag coefficient	2
1.2 The need for ‘goal-oriented’ mesh adaptation	4
1.3 Further examples of goal-oriented simulation	9
1.4 General concepts of error estimation	11
2 An ODE Model Case	15
2.1 Finite differences and finite elements	15
2.2 Efficiency comparison: FD versus FE method	19
2.3 Exercises	23
3 A PDE Model Case	25
3.1 Finite element approximation	26
3.2 Global a posteriori error estimates	29
3.3 A posteriori error estimates for output functionals	30
3.4 Higher-order finite elements	37
3.5 Exercises	39
4 Practical Aspects	41
4.1 Evaluation of the error identity and indicators	42
4.2 Mesh adaptation	46
4.3 Use of error estimators for post-processing	52
4.4 Towards anisotropic mesh adaptation	55
4.5 Exercises	60
5 The Limits of Theoretical Analysis	61
5.1 Convergence of residuals	64
5.2 Approximation of weights	65
5.3 Exercises	69

6	An Abstract Approach for Nonlinear Problems	71
6.1	Galerkin approximation of nonlinear equations	72
6.2	A nested solution approach	78
6.3	Exercises	79
7	Eigenvalue Problems	81
7.1	A posteriori error analysis	82
7.2	Error control for functionals of eigenfunctions	91
7.3	The stability eigenvalue problem	95
7.4	Exercises	99
8	Optimization Problems	101
8.1	A posteriori error analysis via Lagrange formalism	103
8.2	Application to a boundary control problem	105
8.3	Application to parameter estimation	110
8.4	Exercises	111
9	Time-Dependent Problems	113
9.1	Galerkin discretization	113
9.2	A parabolic model problem: the heat equation	115
9.3	A hyperbolic model problem: the wave equation	123
9.4	Exercises	128
10	Applications in Structural Mechanics	129
10.1	Approximation of the Lamé-Navier system	129
10.2	A model problem in elasto-plasticity theory	134
10.3	Exercises	142
11	Applications in Fluid Mechanics	143
11.1	Computation of drag and lift in a viscous flow	144
11.2	Minimization of drag by boundary control	152
11.3	Stability analysis for stationary flow	156
11.4	Exercises	160
12	Miscellaneous and Open Problems	161
12.1	Some historical remarks	161
12.2	Current developments	162
12.3	Open problems	164
A	Solutions of exercises	167
	Bibliography	191
	Index	203