Book Reviews

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BOOK REVIEWS

R. H. Enns: COMPUTER ALGEBRA RECIPES FOR MATHEMATICAL PHYSICS. Birkhauser-Verlag, Boston, 2005. ISBN 0-8176-3223-9, 390 pages, with CD-ROM, price EUR 68,–.

This book consists of over 200 carefully chosen and well motivated computer algebra worksheets. These worksheets cover many topics taught at universities during the first years of physics curriculum. These are e.g. linear ODEs of physics, series, vector and matrix calculus, examples of linear PDEs (wave equation, Laplace equation, Schrödinger equation etc.), integral transforms, calculus of variations, non-linear ODEs and PDEs and numerical methods. A CD-ROM with all worksheets discussed in the text is also included (worksheets are based on Maple 9.5 and are thus compatible with Maple 9 and later).

The book is self contained from the computer algebra point of view and thus it could serve as a good introductory guide for learning Maple for anybody familiar with above mentioned topics. It can also be used as an excellent companion for teaching introductory undergraduate physics classes or as a source of computer algebra or physics assignments.

Vojtěch Pravda

Q. Lin, J. Lin: FINITE ELEMENT METHODS: ACCURACY AND IMPROVEMENT. Science Press, Beijing, 2006. ISBN 7-03-016656-6, xiv + 320 pages, price yuan 85,–.

The finite element method is one of the most efficient numerical methods for solving partial differential equations and related problems. A special emphasize of the reviewed monograph is laid on higher order accuracy FE-techniques based on superconvergence, postprocessing, and extrapolation. These techniques make it possible to reduce substantially the number of arithmetic operations and computer memory in numerical solution. The monograph is divided into two parts and seven chapters. In the first chapter the main idea of the finite element method is introduced.

Chapter 2 is devoted to function spaces and norm equivalence lemmas. The authors show, e.g., how to prove Schwarz's inequality from the Cosine Theorem. They survey basic properties of interpolation operators and the Sobolev spaces. Several useful integral identities for standard finite element spaces are derived.

Chapter 3 recalls the classical Archimedes method for finding a lower and an upper bound for π by means of inscribed and circumscribed regular polygons to the unit circle. This method is then generalized to find lower and upper bounds of eigenvalues of elliptic operators. A higher order eigenvalue approximation is obtained by various extrapolation techniques.

The first part of the book ends up with four Appendices containing numerical experiments that illustrate high theoretical convergence orders. It also provides an interesting counterexample which demonstrates that coefficients of the asymptotic expansion of the finite element solution do not converge at almost all points, as the mesh size tends to zero.

The second part of the book starts with Chapter 4 containing formulae of integral expansions on rectangular elements. In particular, bilinear, biquadratic, Adini, Bernardi-Raguel, and Nédelec elements are investigated.

In Chapter 5 similar integral expansions are derived for triangular elements (e.g., linear, quadratic, Hood-Taylor, Raviart-Thomas elements) by means of the famous Bramble-Hilbert lemma.

Chapter 6 is devoted to quasi-superconvergence and quasi-expansion. The authors profit from the supercloseness between the finite element solution and an interpolation of the true solution. This makes it possible to obtain much higher approximation order than from a simple use of the Schwarz inequality commonly used in finite element analysis.

In the last Chapter 7, various postprocessing techniques are presented. Some of them use a higher order operator interpolation of finite element solution on a triangulation with a double mesh size. Real superconvergence is obtained by combining quasi-superconvergence and an appropriate postprocessing.

Throughout the monograph many exercises and pictures illustrating the proposed methods are given. Thus it can serve also as a text book for PhD students working in superconvergence of the finite element method. The monograph is provided with extensive literature on higher order finite element techniques.

Michal Křížek

W. M. McEneaney: MAX-PLUS METHODS FOR NONLINEAR CONTROL AND ESTIMATION. Birkhäuser-Verlag, Boston-Basel-Berlin, 2006. ISBN 0-8176-3534-3, xiv + 241 pages, price EUR 72,–.

One of the main contributions of this monograph concerns the application of the max-plus algebra to the solution of the Hamilton-Jacobi-Bellman partial differential equations. The max-plus algebra is a commutative semifield which has come under intense study in the last decade.

In the max-plus algebra, the addition operation is defined as $\max\{a, b\}$ and the multiplication operation is the standard addition $(a + b)$. There is a rich mathematics including probability theory, analysis and geometry that can be built on the max-plus algebra. It was successfully employed for the study of many problems in discrete event systems. More recently, the usefulness of the max-plus viewpoint for solution of nonlinear control problems in the continuous space was justified as well.

The author presents a thorough introduction to the concepts of max-plus analysis, such as spaces of semiconvex functions and countable bases for max-plus vector spaces. The convex duality can be extended to spaces of semiconvex functions and this forms one of the fundamental blocks for max-plus numerical methods.

The chapters deal, in turn, with: (i) basics of the max-plus eigenvector method for an infinite time-horizon control problem, (ii) errors induced by the truncation to a finite number of terms, (iii) a semigroup construction method, (iv) elimination of the curse-of-dimensionality via the Legendre/Fenchel duality transforms, (v) finite time-horizon application: nonlinear filtering, (vi) mixed L^∞/L^2 criteria.

The list of references contains 109 titles, 22 of which belong to the author.

The book will be useful to researches, applied mathematicians and engineers interested in the control of nonlinear systems by means of recently developed numerical methods. Basic knowledge of control theory for systems with dynamics governed by differential equations is required.

Ivan Hlaváček