p- and hp- Finite Element Methods: Theory and Applications to Solid and Fluid Mechanics (Numerical Mathematics and Scientific Computation)

By CH. Schwab

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This book is an introduction to the mathematical analysis of *p-* and *hp*-finite elements applied to elliptic problems in solid and fluid mechanics. In the last decade the *p-*, *hp-*, and spectral element methods have emerged as efficient and robust approximation methods for several classes of problems in this area. The aim of this book is to establish the exponential convergence of such methods for problems with the piecewise analytic solutions which typically arise in engineering. It looks at the variational formulation of boundary value problems with particular emphasis on the regularity of the solution. The books then studies the *p-* and *hp-* convergence of the finite element method (FEM) in one and two dimensions, supplying complete proofs. Also covered are *hp*-FEM for saddle point problems and the techniques for establishing the discrete infsup condition. Finally, *hp*-FEM in solid mechanics and the issue of locking is addressed in the context of these methods. It is suitable for graduate students and researchers who have had some prior exposure to FEM.

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Editorial Review

Review

"This is a volume in the series Numerical Mathematics and Scientific Computation. Finite element methods (FEM) are discretizations of boundary value problems in variational form. In the *h*-version FEM convergence is achieved by mesh refinement; in the *p*-version, it is achieved by increasing polynomial degree. This book resulted from a graduate course on FEM taught at the ETH, Zurich, to mathematicians and engineers who were interested in learning the mathematical basis for the recent higher-order, *hp* and spectral element methods. The investigation of the relative merits of higher-order methods over the classical *h*-version approach requires a careful look at the regularity of solutions of elliptic boundary value problems. . . . There are appendices on Sobolev and interpolation spaces, and orthogonal polynomials. The bibliography contains 152 items."--*Quarterly of Applied Mathematics*

"This book starts with a discussion of generalized solutions to time-independent partial differential equations and their relation to finite element methods. The author then gives a thorough discussion of the *hp*-finite element method for 1- and 2-dimensional problems, complete with theoretical results as well as algorithmic details. The treatment includes the question of robustness of methods for singularly perturbed convection-diffusion equations. The author then discusses saddle-point problems with application to the Stokes equation for incompressible flow. The final chapter is devoted to practical considerations for elasticity problems, including the various forms of 'locking' and how to avoid them. The requisite functional analysis for the book is included in an appendix. The writing is very clear, and it shows that the author has paid careful attention to detail, both in the theoretical development and in the programming details."--*Mathematical Reviews*

"Over the past half century, the finite element method has emerged as the method of choice for the numerical approximation of elliptic boundary value problems, particularly those arising in structural mechanics and particularly amongst the engineering community. ... The finite element method produces an approximation based on piecewise polynomial approximation on an underlying mesh. ... The book complements other texts in the area ... that are at a more elementary level and focus more on the practical implementation aspects. The manuscript is based on graduate lectures presented by the author to an audience of engineers and mathematicians at the ETH Zürich. ... [T]his is a detailed and authoritative account of the theory of *hp*-version finite element methods at the end of the 1990s, and provides a much needed reference source for theoreticians in this area."--*Mathematics of Computation*

About the Author
C. Schwab is at the Seminar fur Angewandte Mathematik, ETH, Zurich.

Users Review

From reader reviews:

Dan Gray:

Reading can called imagination hangout, why? Because while you are reading a book specifically book entitled p- and hp- Finite Element Methods: Theory and Applications to Solid and Fluid Mechanics (Numerical Mathematics and Scientific Computation) your brain will drift away trough every dimension, wandering in each aspect that maybe mysterious for but surely can become your mind friends. Imaging every single word written in a publication then become one form conclusion and explanation this maybe you never get previous to. The p- and hp- Finite Element Methods: Theory and Applications to Solid and Fluid Mechanics (Numerical Mathematics and Scientific Computation) giving you another experience more than blown away your thoughts but also giving you useful info for your better life on this era. So now let us teach you the relaxing pattern here is your body and mind will be pleased when you are finished looking at it, like winning an activity. Do you want to try this extraordinary wasting spare time activity?

Billy Anderson:

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Daniel Carter:

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Holly Sheehan:

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