Finite Element Methods for Computational Fluid Dynamics: A Practical Guide

Dmitri Kuzmin, Jari Hämäläinen

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This informal introduction to computational fluid dynamics and practical guide to numerical simulation of transport phenomena covers the derivation of the governing equations, construction of finite element approximations, and qualitative properties of numerical solutions, among other topics. To make the book accessible to readers with diverse interests and backgrounds, the authors begin at a basic level and advance to numerical tools for increasingly difficult flow problems, emphasizing practical implementation rather than mathematical theory.

Finite Element Methods for Computational Fluid Dynamics: A Practical Guide explains the basics of the finite element method (FEM) in the context of simple model problems, illustrated by numerical examples. It comprehensively reviews stabilization techniques for convection-dominated transport problems, introducing the reader to streamline diffusion methods, Petrov-Galerkin approximations, Taylor-Galerkin schemes, flux-corrected transport algorithms, and other nonlinear high-resolution schemes, and covers Petrov-Galerkin stabilization, classical projection schemes, Schur complement solvers, and the implementation of the k-epsilon turbulence model in its presentation of the FEM for incompressible flow problem. The book also describes the open-source finite element library ELMER, which is recommended as a software development kit for advanced applications in an online component.

Audience: The text is aimed at advanced undergraduate and graduate students in computational engineering. It may also be useful to physicists, computational scientists, and developers of numerical simulation software.

Contents: Chapter 1: Notation and Preliminaries; Chapter 2: Introduction to Numerical Methods for PDEs; Chapter 3: Equations of Fluid Dynamics and Heat Transfer; Chapter 4: The Basics of the Finite Element Method for the One-Dimensional Heat Equation; Chapter 5: The Galerkin Finite Element Method for Two-Dimensional Problems; Chapter 6: Stabilization Techniques in One Dimension; Chapter 7: Stabilization Techniques in Multidimensions; Chapter 8: Advanced Methods for Incompressible Flow Problems; Chapter 9: Further Reading

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