Preface

During the past 40 years numerical and experimental methods of fluid mechanics were substantially improved. Nowadays time-dependent three-dimensional flows can be simulated on high-performance computers, and velocity and pressure distributions and aerodynamic forces and moments can be measured in modern wind tunnels for flight regimes, until recently not accessible for research investigations. Despite of this impressive development during the recent past and even 100 years after Prandtl introduced the boundary-layer theory, the fundamentals are still the starting point for the solution of flow problems. In the present book the important branches of fluid mechanics of incompressible and compressible media and the basic laws describing their characteristic flow behavior will be introduced. Applications of these laws will be discussed in a way suitable for engineering requirements.
The book is divided into the six chapters: Fluid mechanics I and II, exercises in fluid mechanics, gas dynamics, exercises in gasdynamics, and aerodynamics laboratory. This arrangement follows the structure of the teaching material in the field, generally accepted and approved for a long time at German and foreign universities. In fluid mechanics I, after some introductory statements, incompressible fluid flow is described essentially with the aid of the momentum and the moment of momentum theorem. In fluid mechanics II the equations of motion of fluid mechanics, the Navier-Stokes equations, with some of their important asymptotic solutions are introduced. It is demonstrated, how flows can be classified with the aid of similarity parameters, and how specific problems can be identified, formulated and solved. In the chapter on gasdynamics the influence of variable density on the behavior of subsonic and supersonic flows is described.
In the exercises on fluid mechanics I and II and on gasdynamics the material described in the previous chapters is elaborated in over 200 problems, with the solutions presented separately. It is demonstrated how the fundamental equations of fluid mechanics and gasdynamics can be simplified for the various problem formulations and how solutions can be constructed. Numerical methods are not employed. It is intended here, to describe the fundamental relationships in closed form as far as possible, in order to elucidate the intimate connection between the engineering formulation of fluid-mechanical problems and their solution with the methods of applied mathematics. In the selection of the problems it was also intended, to exhibit the many different forms of flows, observed in nature and technical applications.
Because of the special importance of experiments in fluid mechanics, in the last chapter, aerodynamics laboratory, experimental techniques are introduced. It is not intended to give a comprehensive and complete description of experimental methods, but rather to explain with the description of experiments, how in wind tunnels and other test facilities experimental data can be obtained.
A course under the same title has been taught for a long time at the Aerodymisches Institut of the RWTH Aachen. In the various lectures and exercises the functioning of low-speed and supersonic wind tunnels and the measuring techniques are explained in experiments, carried out in the facilities of the laboratory. The experiments comprise measurements of pressure distributions on a half body and a wing section, of the drag of a sphere in incompressible and compressible flow, of the aerodynmic forces and their moments acting on a wing section, of velocity profiles in a flat-plate boundary layer, and of losses in compressible pipe flow. Another important aspect of the laboratory course is to explain flow analogies, as for example the

so-called water analogy, according to which a pressure disturbance in a pipe, filled with a compressible gas, propagates analogously to the pressure disturbance in supercritical shallow water flow.

This book was stimulated by the friendly encouragement of Dr. M. Feuchte of B.G. Teubner-Verlag. My thanks go also to Dr. D. Merkle of the Springer-Verlag, who agreed to publish the English translation of the German text. Grateful acknowledgement is due to my successor Professor Dr.-Ing. W. Schröder, who provided personal and material support by the Aerodynamisches Institut in the preparation of the manuscript. I am indebted to Dr.-Ing. O. Thomer who was responsible for the preparatory work during the initial phase of the project until he left the institute. The final manuscript was prepared by cand.-Ing. O. Yilmaz, whom I gratefully acknowledge. Dr.-Ing. M. Meinke offered valuable advice in the preparation of some of the diagrams.

Aachen, July 2004 E. Krause