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C. J. Chapman
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High Speed Flow

High Speed Flow is a textbook suitable for undergraduates, postgraduates, and research workers in fluid dynamics. It covers such topics as subsonic and supersonic flight, shock waves, high-speed aerofoils, and thermodynamics. Starting from first principles, the book gives complete and elementary derivations of all results and takes the reader to research level in the subject.

The book contains many exercises and an extensive bibliography, providing access to the entire literature of the subject from 1860 to the present day, and including over two hundred items published since 1990. It contains the most extensive set of formulae on oblique shock waves ever assembled.

Dr. Chapman is Reader in Mathematics and Mechanics at the University of Keele, England. He studied mathematics at the University of Cambridge and received his Ph.D. in fluid dynamics from the University of Bristol. He has held a Fellowship at the Woods Hole Oceanographic Institution and worked in the nuclear power industry, and he was a Fellow of Christ's College, Cambridge.

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CAMBRIDGE
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CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521661690

First published 2000

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication data

Chapman, C. J. (Christopher John), 1952–
High speed flow / C.J. Chapman
p. cm. – (Cambridge texts in applied mathematics)
Includes bibliographical references and index.
ISBN 0-521-66169-2 (hbk.). – ISBN 0-521-66647-3 (pbk.)
1. Fluid dynamics. I. Title. II. Series.
QA911.C43 2000
532′.0532 – dc21 99-37544
CIP

ISBN 978-0-521-66169-0 hardback
ISBN 978-0-521-66647-3 paperback

Transferred to digital printing 2009

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Preface

This book is based on a course of lectures I gave for several years to students reading Part III of the Mathematical Tripos at the University of Cambridge. The course was well received, and since giving the course I have had requests for copies of the lecture notes. The students on the course were familiar with the basics of fluid dynamics, but they had little prior knowledge of the effects of compressibility and required a course that, though elementary, would prepare them for the literature of high speed flow in the larger texts and in research journals, for example in the *Journal of Fluid Mechanics*.

In writing the book I have kept closely to the topics included in the original lecture course, which consisted of sixteen one-hour lectures. Accordingly, the book is suitable for undergraduate or beginning graduate students and could be studied subject-by-subject or in its entirety. The book derives most results from first principles, so that the only formal prerequisite from fluid dynamics is familiarity with the equations of motion (i.e., the equations of conservation of mass, momentum, and energy). All results from thermodynamics are derived from first principles. The emphasis is on topics that occur as simple components in the description of general flows; these topics include the Rankine–Hugoniot relation, Prandtl–Meyer expansion, Prandtl's relation, Riemann invariants, Mach reflection, von Neumann reflection, Maxwell's relations, Legendre transformations, the Laval nozzle, Hamilton's ray equations, the Monge cone, Crocco's equation, Ringleb's flow, Helmholtz free energy, and Gibbs free energy. The book contains a large number of exercises and problems for the reader, which would also be suitable for a lecturer in setting problem sheets or examinations.

After deliberation, I decided to include in the book a set of references large enough to provide an entry point to the entire literature of high speed flow, but to place all references in special sections at the end of each chapter and in a special chapter at the end of the book. In particular, I have included references to all the papers on high speed flow published in the *Journal of Fluid Mechanics* in the period 1990–1998. These papers, somewhat over two hundred in number, lend themselves readily to classification into four main groups, indicated by the tables in Section 13.6, and give a fair indication of the scope of current research in high speed flow. After studying this elementary book, the reader may be pleasantly surprised to find that an understanding of nearly all these papers is within his or her grasp.

I thank many colleagues, in the United Kingdom and throughout the world, for their generosity in providing comments on individual chapters of the book.