# **PREFACE**

# **Preface to the Fifth Edition (SIE)**

We would like to express our sincere gratitude to **Tapan K Sengupta** for his valuable contributions. The fifth edition (SIE) would not have been possible but for his support. He has comprehensively worked on the text and under his able guidance and dedicated efforts, the book has been brought to this level of perfection. It's not possible to completely express in words the instrumental role played by him. However, we endeavor to highlight some of his prime contributions which have enriched the text:

- Complete SI Metrication of the text
- Inclusion of Indian Research Activities pertaining to the field of Aerodynamics
- SI Metricated Solution Manual for Instructors

Dr Sengupta is a Professor in the Department of Aerospace Engineering in IIT Kanpur with over 18 years of teaching experience. His academic qualifications comprise a BTech from IIT Kharagpur, ME from IISc Bangalore, and a PhD from the Georgia Institute of Technology, Atlanta (USA). He is a senior Associate of International Centre of Theoretical Physics, Trieste, Italy. He was a Senior Research Associate, University Engineering Department, University of Cambridge, Cambridge (UK).

Dr Sengupta has written numerous papers for refereed journals, has participated in over 50 international conferences and has been invited for several discussions in international forums. He has authored two books on *Fundamentals of CFD* and *Instabilities of Flows: With and Without Heat Transfer and Chemical Reaction*.

The Web supplements are accessible at <u>http://www.mhhe.com/anderson/fa5e</u> containing

- SI Metricated Solution Manual, Chapterwise PPTs for Instructors
- Web Links and Professional Resources, Properties of Standard Atmosphere Tables, Fluent Animations *for Students*

Given below are the names of the reviewers who have enriched this edition with their comments and suggestions:

#### **Y S Chauhan**

Punjab Engineering College, Chandigarh, Punjab

Manas Kumar Laha IIT Kharagpur, West Bengal Preface

Avijit Chatterjee IIT Bombay, Mumbai, Maharashtra

**M R Patkar** Indian Institute for Aeronautical Engineering and Information Technology Pune, Maharashtra

**P K Mohanta** *Hindustan University, Chennai, Tamil Nadu* 

Raja Babu

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Tata McGraw-Hill welcomes new ideas, comments and views from all readers. If you have a suggestion, please send it to tmh.aerofeedback@gmail.com (kindly mention the title and author name in the subject line). Piracy-related issues may also be reported.

## **Publisher's Note**

## **Overview of the Fourth Edition**

The purpose of this edition is the same as the previous ones—to be read, understood, and enjoyed. Due to the extremely favorable comments from readers and users of the previous editions, virtually all of the features of those editions have been carried over intact to this edition.

It is consciously written in a clear, informal, and direct style designed to *talk* to the reader and to gain his or her immediate interest in the challenging and yet beautiful discipline of aerodynamics. The explanation of each topic is carefully constructed to make sense to the reader. Moreover, the structure of each chapter is highly organized in order to keep the reader aware of where we are, where we were, and where we are going. Too frequently the student of aerodynamics loses sight of what is trying to be accomplished; to avoid this, we attempt to keep the reader informed of our intent at all times. The fourth edition carries over the special educational tools introduced in the second and third editions, namely (1) the use of roadmaps at the beginning of each chapter to guide the reader safely and securely through the material of each chapter, and to highlight the important flow of ideas; and (2) the design boxes that are scattered throughout the book. These design boxes are special sections for the purpose of discussing design aspects associated with the fundamental material covered throughout the book. These sections are literally placed in boxes to set them apart from the mainline text.

Modern engineering education is placing more emphasis on design, and the design boxes in this book are in this spirit. They are a means of making the fundamental material more relevant, and making the whole process of learning aerodynamics more fun. Also, to help organize the reader's thoughts, there are special summary sections at the end of most chapters.

## **Target Audience**

The material in this book is at the level of college juniors and seniors in aerospace or mechanical engineering. It assumes no prior knowledge of fluid dynamics in general, or aerodynamics in particular. It does assume a familiarity with differential and integral calculus, as well as the usual physics background common to most students of science and engineering. Also, the language of vector analysis is used liberally; a compact review of the necessary elements of vector algebra and vector calculus is given in Chapter 2 in such a fashion that it can either educate or refresh the reader, whichever may be the case for each individual.

## **Roadmap for Various Courses**

This book is designed for a 1-year course in aerodynamics. Chapters 1 to 6 constitute a solid semester emphasizing inviscid, incompressible flow. Chapters 7 to 14 occupy a second semester dealing with inviscid, compressible flow. Finally, Chapters 15 to 18 introduce some basic elements of viscous flow, mainly to serve as a contrast to and comparison with the inviscid flows treated throughout the bulk of the text.

## **Salient Features**

- 1. The use of chapter roadmaps to help organize the material in the mind of the reader, as discussed earlier.
- 2. An introduction to computational fluid dynamics as an integral part of the beginning study of aerodynamics. Computational fluid dynamics (CFD) has recently become a third dimension in aerodynamics, complementing the previously existing dimensions of pure experiment and pure theory. It is absolutely necessary that the modern student of aerodynamics be introduced to some of the basic ideas of CFD—he or she will most certainly come face to face with either its "machinery" or its results after entering the professional ranks of practicing aerodynamicists. Hence, such subjects as the source and vortex panel techniques, the method of characteristics, and explicit finite-difference solutions are introduced and discussed as they naturally arise during the course of our discussions. In particular, Chapter 13 is devoted exclusively to numerical techniques, couched at a level suitable to an introductory aerodynamics text.
- **3.** A short chapter is devoted entirely to hypersonic flow. Although hypersonics is at one extreme end of the flight spectrum, it has current important applications to the design of the space shuttle, hypervelocity missiles, and planetary entry vehicles. Therefore, hypersonic flow deserves some attention in any modern presentation of aerodynamics. This is the purpose of Chapter 14.
- 4. Historical notes are placed at the end of many of the chapters. This follows in the tradition of the author's previous books, *Introduction to Flight: Its Engineering and History* (McGraw-Hill, 1978), and *Modern Compressible Flow: With Historical Perspective* (McGraw-Hill, 1982). Although aerodynamics is a rapidly evolving subject, its foundations are deeply rooted in the

history of science and technology. It is important for the modern student of aerodynamics to have an appreciation for the historical origin of the tools of the trade. Therefore, this book addresses such questions as who were Bernoulli, Euler, d'Alembert, Kutta, Joukowski, and Prandtl; how was the circulation theory of lift developed; and what excitement surrounded the early development of high-speed aerodynamics?

Much new material has been added in order to enhance, update, and expand that covered in the earlier editions. There are 51 new figures, and 50 inserts of new material.

In particular, the fourth edition has two important new features:

- 1. The classic organization has been preserved, namely, the presentation of the fundamental principles of aerodynamics in Part 1, inviscid incompressible flow in Part 2, inviscid compressible flow in Part 3, and viscous flow in Part 4. Specific sections on viscous flow, however, have been added much earlier in the book in order to give the reader some idea of how the inviscid results are tempered by the influence of friction. This is done by adding self-contained viscous flow sections at the end of various chapters, written and placed in such a way that they do not interfere with the flow of the inviscid flow discussion, but are there to complement the discussion. For example, at the end of Chapter 4 on incompressible, inviscid flow over airfoils, there is a viscous flow section that deals with the prediction of skin-friction drag on such airfoils. A similar viscous flow section at the end of the chapters on shock waves and nozzle flows, there are viscous flow sections on shock-wave/ boundary-layer interactions. And so forth.
- 2. Preview boxes have been introduced at the beginning of each chapter. These short sections, literally set in boxes, are to inform the reader in plain language what to expect from each chapter, and why the material is important and exciting. They are primarily motivational; they help to encourage the reader to actually enjoy reading the chapter, therefore enhancing the educational process.

The fourth edition also has many additional new worked examples. When learning new technical material, especially material of a fundamental nature as emphasized in this book, one can never have too many examples of how the fundamentals can be applied to the solution of problems.

In the same spirit, at the end of most chapters, new homework problems have been added to those carried over from the third edition.

Finally, as an aid with the worked examples and the new homework problems, tables of the Standard Atmosphere in both the SI and English Engineering units have been included as new Appendices.

All the new additional material not withstanding, the main thrust of this book remains the presentation of the fundamentals of aerodynamics; the new material is simply intended to enhance and support this thrust. We repeat that the book is organized along classical lines, dealing with inviscid incompressible flow, inviscid compressible flow, and viscous flow in sequence (and now with the new self-contained viscous flow sections presented earlier in the book). My experience in teaching this material to undergraduates finds that it nicely divides into a two - semester course with Parts 1 and 2 in the first semester, and Parts 3 and 4 in the second semester. Also, I have taught the entire book in a fast-paced, first-semester graduate course intended to introduce the fundamentals of aerodynamics to new graduate students who have not had this material as part of their undergraduate education. The book works well in such a mode.

The text has exhaustive web supplements containing

- Solution Manual, Chapterwise PPTs for Instructors
- Web Links and Professional Resources, Properties of Standard Atmosphere Tables, Fluent Animations *for Students*

#### Acknowledgements

I wish to thank various members of the staff of the National Air and Space Museum of the Smithsonian Institution for opening their extensive files for some of the historical research behind these history sections. Also, a constant biographical reference was the *Dictionary of Scientific Biography*, edited by C C Gillespie, Charles Schribner's Sons, New York, 1980. This is a 16-volume set of books which is a valuable source of biographic information on the leading scientists in history.

I also wish to thank my students for many stimulating discussions on the subject of aerodynamics—discussions which ultimately resulted in the present book. Special thanks go to two of my graduate students, Tae-Hwan Cho and Kevin Bowcutt, who provided illustrative results from the source and vortex panel techniques. Of course, all of my efforts would have gone for nought if it had not been for the excellent preparation of the typed manuscript of the first edition by Ms Sue Osborn.

I would like to thank the McGraw-Hill editorial and production staff for the excellent help in producing this book, especially Katie White in Boston, and April Southwood in Dubuque. Also, special thanks go to my long-time friend and associate, Sue Cunningham, whose expertise as a scientific typist is beyond comparison, and who has typed all my book manuscripts for me, including the fourth edition, with great care and precision.

I also thank the following reviewers for their valuable feedback: Roger L Simpson, Virginia Polytechnic Institute and State University; Narayanan Komerath, Georgia Institute of Technology; Ramkumar N Parthasarathy, University of Oklahoma; and Anastasios S. Lyrintzis, Purdue University.

Finally, special thanks go to two institutions: (1) the University of Maryland for providing a challenging intellectual atmosphere in which I have basked for the past 9 years, and (2) the Anderson household—Sarah-Allen, Katherine, and Elizabeth—who have been patient and understanding while their husband and father was in his ivory tower.

### Conclusion

This book has developed from my experience in teaching both incompressible and compressible flow to undergraduate students at the University of Maryland. Such courses require careful attention to the structure and sequence of the presentation of basic material, and to the manner in which sophisticated subjects are described to the uninitiated reader. This book meets my needs at Maryland; it is hoped that it will also meet the needs of others, both in the formal atmosphere of the classroom and in the informal pleasure of self-study.

Readers who are already familiar with my *Introduction to Flight* will find the present book to be a logical sequel. Many of the aerodynamic concepts first introduced in the most elementary sense in *Introduction to Flight* are revisited and greatly expanded in the present book. For example, at Maryland, *Introduction to Flight* is used in a sophomore-level introductory course, followed by the material of the present book in junior- and senior-level courses in incompressible and compressible flow. On the other hand, the present book is entirely self-contained; no prior familiarity with aerodynamics on the part of the reader is assumed. All basic principles and concepts are introduced and developed from their beginnings.

As a final comment, aerodynamics is a subject of intellectual beauty, composed and drawn by many great minds over the centuries. *Fundamentals of Aerodynamics* is intended to portray and convey this beauty. Do you feel challenged and interested by these thoughts? If so, then read on, and enjoy!

#### John D Anderson, Jr.