Elements of Acoustics
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Preface

This book is an outgrowth of a course in acoustics I have taught for a number of years at Rutgers University. The main reason for adding one more book to an already long list of books on this subject is the lack of modern introductory texts that treat acoustics as a branch of fluid mechanics. In my view, this is the most natural approach, at least for those areas of acoustics dealing with the most common media for sound propagation, namely, air and water. This approach is, of course, not new. It was used by the authors of many of the books now considered classical, including Rayleigh, Lamb, and others. In recent times, however, many of the acoustics texts that have appeared treat the subject as a branch of electrical engineering. There are indeed many instances in which acoustic oscillations are analogous to some phenomena discussed in electrical engineering courses and the analogies are clearly advantageous to those students whose background is in that discipline. For others, the analogies may be a drawback; to them, both the acoustic equations and their electrical analogues are new.

The main subjects discussed in this book are: propagation in uniform fluids at rest; transmission and reflection phenomena; attenuation and dispersion; and emission. These are only some of the main topics in acoustics. To have attempted to cover all of them would have been presumptuous on my part. Nevertheless, there are several topics that, by some, may be considered basic enough to warrant their inclusion in a text of this nature, but that have been omitted. These include aerodynamic sound, diffraction, and propagation in nonuniform media. Some of these are mentioned in the text, but all too briefly in relation to their importance. The reasons are that some of these topics are either outside my areas of competence or are too books that have appeared recently, so that their detailed discussion in this book is unnecessary. On the other hand, sound absorption is discussed in more detail than is usual in books on acoustics. To a certain extent, this reflects my personal

interest in that subject, but it is also intended to qualify the strongly held notion that dissipation effects in sound waves are unimportant. advanced compared to the general level of the book. In any event, most of them are fully treated in one or more specialized The material given here is intended primarily for a beginning graduate course in acoustics, but includes portions suitable for more advanced courses. In writing this book, I have assumed that the student's background includes the usual preparation in undergraduate physics and mathematics, as well as a course in advanced calculus and a course in basic thermodynamics. Prior acquaintance with fluid mechanics is desirable, but not required. The required material on that subject is developed in Chapter 1. Chapter 1 also includes a summary of basic thermodynamics. To make the book self-sufficient, both of these subjects are developed to a greater degree than is needed in an introductory course.
The book contains more material than is possible to cover in one semester. By deleting some of the more advanced material, it can be used in a one-semester course in basic acoustics for students in engineering or in the physical sciences. On the other hand, with some additional material, it may be used in a one-year sequence covering both basics and applications.

Because of the basic nature of the subject of this book, I have attempted to derive each result from basic principles. However, the emphasis throughout is on the physical meaning of the result's and not on the mathematics techniques that were used to derive them. On the other hand, in some of the derivations I have included more detail than customary, since all too often the student's main effort is spent in trying to fill in the mathematical steps missing between main results. Of course, this has some pedagogical value but, more often than not, it merely improves the ability of the student to manipulate equations. In my view, a better way of learning is by doing. To this end, a number of problems have been included in the text.

Each chapter contains a brief list of suggested references. A more complete list is given in the Bibliography at the end of the book. The lists are not exhaustive, their purpose is merely to direct the interested student to other general sources, or to recent articles touching on some of the material discussed in the text.

Although I have included the results of some of my own investigations, the bulk of the material presented may be considered classical. It is therefore difficult to acknowledge the sources of many of the results that are presented. I have, however, profited much from Chapter 8 of *Fluid Mechanics* by L.D. Landau and E.M. Lifshitz and from Chapters 1-3 of *An Introduction to Fluid Dynamics* by G.K. Batchelor. Other books that have influenced this work are *The Theory of Sound* by Lord Rayleigh, *Theoretical Acoustics* by P. Morse and U. Ingard, *Fundamentals of Acoustic* by L.E. Kinsler and A.R. Frey, and *The Foundations of Acoustics* by E. Skudrzyk.

A major portion of this book was written during 1974-1975 while I was on leave at the Technion-Israel Institute of Technology. I wish to thank Rutgers University and The Lady Davis Fellowship Trust for making this leave possible. I also owe much to the faculty of the Department of Mechanical Engineering at the Technion for their kind hospitality.
I would like to express my gratitude to Professor R.A. Dobbins of Brown University, who introduced me to the subject of this book; to my colleagues at Rutgers University for their continued encouragement; to many of my students for their valuable comments and observations; and to Mrs. Rosemarie Boysen, who typed an earlier version of this book. The final manuscript was typed by Mrs. Erma Sutton, to whom I am also indebted for improving the clarity of many passages.

To conclude, I wish to express my gratitude to my wife Judy and to my sons David and Michael, who patiently endured the writing of this book.

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