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Book review

Wright, M.C.M. (Ed.), Lecture Notes on the Mathematics of Acoustics, Imperial College Press, London, ISBN 1-86094-496-5, 2005 (pp. xvii+288, UK£48, US$78)

This graduate level text is the outcome of the first of a proposed biannual 1-week summer school held at Southampton University in 2003, with the praiseworthy objective of promoting the mathematical competence of research engineers, presumably principally those working in acoustics. In spite of the proliferating body of textbooks on 'engineering mathematics' the subject is all too frequently regarded as an optional extra by many engineering departments, where mathematics has become synonymous with *Matlab* and numerical computation.

The emphasis is on mathematical topics of particular relevance to acoustics, although many of the early chapters on basic mathematics are of broader application. With the exceptions of Chapters 5 and 7, each chapter forms an expanded development of lecture or seminar material, and most end with a list of problems for solution. The book is only practically useful as an adjunct to the summer school, the material of each chapter being discussed in insufficient detail to constitute a primary source. However, it is a valuable reference for the *type* of mathematics likely to be involved in the solution of a particular problem, and this alone could justify its purchase. It is not suitable for normal graduate level teaching.

The subjects treated are gathered together under the four headings:

I. *Mathematical Methods*; II. *Wave Motion*; III. *Aeroacoustics*; IV. *Signal Processing*.

My views on these sections are given in what follows; they largely reflect a personal bias and should not, therefore, be assumed to qualify my recommendation above regarding the overall value of this book.

I. Mathematical methods

The opening chapter is a short but useful survey of vector calculus; Chapter 2 is an introduction to complex variable theory. The latter starts with the definition of a complex number—only the most sophisticated will appreciate the subsequent all too rapid and necessarily brief developments leading to Cauchy's theorem and applications of the residue theorem, which can only be useful as a refresher of recently forgotten material.

Laplace and Fourier transforms are studied in Chapter 3 with the aid of complex variables, and applied to solve ordinary and partial differential equations (including 'pole-shifting' techniques to arrive at causal solutions). There is too much material in this chapter, at least for beginners. Far better to focus on the more generally useful Fourier transform than to risk confusion by discussion of 'non-acoustic' applications of the Laplace transform—any problem soluble by 'Laplace' can also be solved by 'Fourier', being different versions of the same thing. So much space is devoted to irrelevant applications of the Laplace transform that the derivation at the end of this chapter of the time-domain acoustic Green's function remains unfinished, with the embarrassing consequence that nowhere in this book is to be found a derivation of the retarded potential solution of the wave equation.

A useful but very brief outline of methods for the asymptotic evaluation of integrals is given in Chapter 4; the discussion of the very important 'method of stationary phase' would have benefitted from the inclusion of examples applied to acoustics.

II. Wave motion

The *Wiener-Hopf* method of solving the wave equation (Chapter 5) is unlikely to be the method of choice for many engineers, and indeed this chapter is an 'optional supplement' to the course lectures. The method

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requires some mastery of complex variable theory and Fourier transforms, and is illustrated by application to the Sommerfeld diffraction problem. The procedure follows Jones' method described in the classic text by Noble (1958). I have always found this approach too formal for beginners; a more natural and intuitive procedure (and therefore easily remembered by those making only occasional use of the technique) is the integral equation method propounded by Clemmow (Clemmow, P.C. 1966, *The plane wave spectrum representation of electromagnetic fields*. Oxford: Pergamon Press).

Further illustrations of these and related methods are given in a chapter (6) on waveguides; analytical solutions are derived, but there is no attempt to relate results to practical duct acoustics. Chapter 7 presents useful supplementary material on Fourier integral representations used in the solution of the acoustic wave equation. But the first glimpse of the 'real world' in mathematics applied to acoustics occurs in Chapter 8 (*Acoustics of rigid-porous materials*, p. 157), which discusses several valuable mathematical models applicable to fibrous, dissipative acoustic boundaries.

III. Aeroacoustics

The uninitiated will have no idea what is meant by 'aeroacoustics' until an indirect clue is given halfway through the first chapter of this section (9, *Generalised functions in aeroacoustics*). It is almost as if 'aeroacoustics' is a 'small by-product' of the theory of generalised functions. After a very clear and concise outline of generalised function theory we are led through an illustrative application to the derivation of the *Ffowcs Williams–Hawkings equation* of aeroacoustics. The particular form of this equation is discussed for turbulence near a shock wave, but the equation is not solved.

Thus far there has actually been no formal discussion of real flow acoustics, nor of *Lighthill's* theory of aerodynamic sound (presumably too well known to need elaboration), even though retarded potential solutions and the associated *Curle's equation* constitute ideal vehicles for illustrating applications of acoustic theory. It is not until the very useful Chapter 10 (*Monopoles*, *dipoles and quadrupoles*) that we meet for the first time the fundamental retarded potential solution—and then the absence of preparation in the previous chapters compels the author to refer elsewhere in the literature for the proof of the formula. Chapter 11 discusses resonant sound generation accompanying nominally steady mean flow through a corrugated pipe. It would have been nice to see this problem analysed from the fundamental equations of aeroacoustics.

IV. Signal processing

The last three chapters (12–14) provide a valuable overview of the 'practical mathematics' involved in acoustic measurements (of spectra, transfer functions, etc.), with application to adaptive processes used for noise cancellation. There is some overlap with the 'generalised function' theory discussed previously, but this is acceptable because the reader should be encouraged to accommodate changes in style and notation likely to accompany even quite small changes in engineering discipline.

M.S. Howe
College of Engineering, Boston University, 110 Cummington Street, Boston, MA 02215, USA;
Micheal Howe is Professor of Aerospace and Mechanical Engineering at Boston University and author of "Hydrodynamics and Sound", to be published by Cambridge University Press in 2006.
E-mail address: mshowe@bu.edu