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# Fundamentals of Hearing: An Introduction (4th edition) FREE

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## BOOK REVIEWS

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### Fundamentals of Hearing: An Introduction (4th edition)

**William A. Yost**

*Academic, San Diego, 2000.*

*349 pp. Price: \$44.95.*

*Fundamentals of Hearing: An Introduction* (4th edition) is a self-contained introductory textbook that covers basic acoustics as well as a wide range of topics in the fields of auditory anatomy, physiological acoustics and psychological acoustics. The organization of the text is nearly identical to the 3rd edition. The first 20% of the book is a primer on acoustics. Roughly 30% of the book is devoted to peripheral auditory anatomy and physiology, 20% to auditory perception of simple sounds, 20% to complex sounds, central auditory nervous system and auditory disorders, and the remaining 10% to the appendixes.

This 4th edition of the book is similar to the previous edition. This is not surprising given the previous edition's success as an introductory text, and that no scientific advances that would change the fundamental knowledge base for an introductory course in hearing occurred in the 6 years since the publication of the previous edition. Appropriately, references were updated to include a number of recently published books addressing special topics in hearing science. Many of these monographs and advanced textbooks are cited in a section at the end of each chapter titled "Supplement." These supplements are a significant contribution to the text. Each chapter is written at a very basic level and the supplements are used in a variety of ways to complement the content of chapters. These include the discussion of historical notes, the introduction of controversies, the discussion of topics at a higher level than found in the chapter, math proofs, and references for further study.

Another change to the text is the replacement of a chapter titled "Noise" with one called "Auditory Disorders." "Noise" described the deleterious effects of high-level sounds on hearing, including the physiological and perceptual consequences. "Auditory Disorders" covers this topic as well as ototoxicity, aging, diseases, infections, heredity, and the relationship between inner ear damage and hearing loss. This is an important change to the book given the large number of persons who are interested in hearing science who are also interested in impaired auditory systems. This chapter also includes a spectacular photograph of the basilar papilla from a bird shortly after damage to hair cells and 90 days later after the hair cells regenerated. This photo from a study by Ryals *et al.* (1999) is a nice complement to the spectacular photos representing damage to hair cells by intense sounds shown in earlier sections of the same chapter.

The most significant change since the publication of the 3rd edition is the simultaneous publication with the 4th edition of an instructor's workbook and compact disk (CD). The workbook has problem sets and tips for instructors. Examples of problems include the derivation of neural histograms from tabulated data and the plotting of psychometric functions. The workbook also suggests examples of appropriate auditory demonstrations on CD (Houstma *et al.*, 1987) that might be helpful for conveying concepts discussed in the book. The CD included with the workbook does not contain these auditory demonstrations, but it does contain executable programs for a signal generator, a two-alternative forced-choice (2AFC) task, and neural firing rate simulations. Also included are software functions (a "toolbox") for use with the program MatLab, a signal processing program, and all of

the figures in the book in two formats: files of each figure and PowerPoint presentations, organized by chapter, of the figures in each chapter. The signal generator and 2-AFC program work with Windows 95, 98 or NT operating systems. In less than 10 minutes, I was able to download the files for these programs, generate the sound files for a tone in noise, and set up a 2-AFC task for the detection of a tone in noise (fixed level). The neural firing rate simulator was just as easy to implement, and it simulated the synchronous firing of a single nerve fiber to tones of different frequencies and levels. This software would provide useful demonstrations for laboratory sections. Further, the files of the figures from the text on CD would aid in the development of lectures. The quality of the figures is outstanding for the most part and the use of this material would eliminate the time required to scan each figure from the book for the development of lectures presented using PowerPoint or similar presentation software. The MatLab "toolbox" provides a powerful tool for setting up auditory demonstrations/laboratory sections for a course, but the CD does not include the MatLab program that is required to run this software. Over the past few years MatLab has become a defacto standard for signal processing in auditory laboratories so this should not be a concern.

For those not familiar with this book (or its 3rd edition), the following is a summary and critical review of the major sections of the book.

Part I of the book titled "The auditory stimulus" introduces students to basic physics of sound. This section assumes knowledge of algebra and trigonometry (and not calculus). The four chapters in this section define terms used in the study of hearing such as modulation, envelope, fine structure, filters, and linear systems to name a few. In order to include all of the background material on acoustics necessary for understanding the rest of the text without having this section become an even larger proportion of the book, the presentation is quite dense. That is, there are not many examples to support newly learned knowledge in this area. This is not a problem though if instructors supplement the material in the book with some additional readings or exercises, such as those cited in the text or found in the recently released *Fundamentals of Hearing: An Instructors Workbook*. My only suggestion for improving this already excellent introduction to "The Auditory Stimulus" would be to follow the discussion of linear systems with a discussion of transfer functions. Given the importance of transfer functions to the study of hearing, their discussion here would be more effective than in the section of the text describing head-related transfer functions where this concept is currently introduced.

Part II and Part III represent the peripheral auditory system anatomy and physiology and the auditory perception of simple sounds. These eight chapters are logically presented in a clear manner, and there are many figures to support the text. In the chapters on physiology, there are many spectacular photos of the middle and inner ear. All of these chapters include figures representing data that are adapted from actual studies. Some of these adaptations aid the presentation of a particular idea more than the original figure would. For example, Fig. 9.13 was adapted from a study by Sachs and Young (1979) to show how neural firing rate represents adequately the peaks in the spectrum of a steady-state vowel for low presentation levels but not for moderate presentation levels. The adapted textbook figure combines two figures from Sachs and Young's original study to allow a direct comparison of the vowel stimulus with the neural firing pattern to that stimulus. Adaptations such as this one make the presentation of complex material easier for beginning students. The only disappointment with these sections was several significant errors in the figures or their legends that eluded the proofreaders. In one case, an erroneous figure in the book is presented correctly on the CD

that accompanies the workbook. The errors are relatively minor given all of the positive aspects of these chapters.

Part IV describes complex sounds processing, the central nervous system (CNS), and auditory disorders. Less is known about the processing of complex sounds and the CNS than is known about the auditory periphery and the processing of simple sounds, but the author's description of these areas is clear yet still able to represent the complexity of these topics. This section describes the possible link between the CNS and perception just as earlier chapters were able to show the link between the auditory periphery and the processing of simple sounds.

The appendices are an intrinsic part of the book. It is here where among other things "techniques and tools used to study hearing (Appendix F)" and "Psychophysics (Appendix D)" are discussed. Appendix F contains a brief introduction to microscopy, neural stains and markers, imaging, and genetics to provide the student with an appreciation of the difficulty with which measurements are obtained in physiological studies. Similarly, Appendix D provides a description of classical psychophysical procedures, direct scaling and matching procedures, and a brief introduction to the theory of signal detection (TSD), including receiver operating characteristic curves. The description of TSD is accurate but no references are cited. These appendices do not have supplements, as do the chapters of the book, so additional readings are not suggested as was done so well in the earlier chapters. Given the importance of TSD to hearing science and other fields, a reference to the classic book by Green and Swets (1974) or to the more recent book by MacMillan and Creelman (1991) about this topic would be nice as a supplemental reading for interested students.

Finally, the author points out in the preface that the massive amount of literature and vast number of topics in hearing science make it difficult for an author to write a textbook that represents a general survey of this field. Professor Yost meets this challenge by covering the important points and major controversies of prior research in a manner that inspires rather than intimidates. He avoids the more subtle controversies and as a consequence, does not get bogged down citing the entire history of publications about a particular topic. Although this is contrary to the approach often taken in scholarly journals, it is good fortune for the beginning student of hearing science who needs to master basic concepts and to understand how these concepts relate to each other and to the entire field of study. This approach also gives the instructor flexibility in emphasizing his or her specialty with supplemental readings or more detailed lectures.

Green, D. M., and Swets, J. A. (1974). *Signal Detection Theory and Psychophysics* (Krieger, New York).

Houtsma, A. J. A., Rossing, T. D., and Wagenaars, W. M. (1987). *Auditory Demonstrations* (Institute for Perception Research, Eindhoven, The Netherlands).

McMillan, N. A., and Creelman, C. D. (1991). *Detection Theory: A User's Guide* (Cambridge University Press, Cambridge, England).

Ryals, B. M., Dooling, R. J., Westbrook, E., Dent, M. L., MacKenzie, A., and Larsen, O. N. (1999). "Avian species differences in susceptibility to noise exposure," *Hear. Res.* **131**, 71–88.

Sachs, M. B., and Young, E. D. (1979). "Encoding of steady-state vowels in the auditory nerve: Representation in terms of discharge rate," *J. Acoust. Soc. Am.* **66**, 1381–1403.

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## Master Handbook of Acoustics, Fourth Edition

F. Alton Everest

*McGraw-Hill, New York, 2001.*

*xix+615 pp. Price: \$34.95 paperback.*

The application of science in the practice of acoustics can be a life-long endeavor. Mathematical analysis is necessary for a more complete understanding of what happens and most people do not have the technical and/or academic training to undertake a quantitative analysis of the physical principles involved with architectural room acoustics. There is a yearning on

the part of many people, who would describe themselves as audiophiles, as well as for people involved in audio production and post-production and for people for which sound is an avocation, for a nontechnical presentation of many of the aspects involved in acoustic room design. This book is a good introduction to acoustics for the layman. This lay guide provides an overview of and to the *lingua franca* of acoustics. The treatment is not rigorous—it provides the basic concepts involved in a qualitative descriptive way.

The fourth edition of F. Alton Everest's *Master Handbook of Acoustics* covers a lot of material in the 28 chapters, appendix, and glossary in the book. The review of the material is easy going with not much mathematics beyond logarithms and the physics is light and prosaic. The book appears to have grown since the first edition by the bulking up of some chapters, the revision of other chapters and the addition of some new chapters. The fourth edition has three new chapters.

While the book can provide a good introduction to many of the major concepts involved with studio and listening space design, a reader is left with the feeling that some areas are beaten to death while others are perfunctory in their coverage. A brief review of the contents follows.

The first portion of the book deals with the basics. Fundamentals of Sound, Chapter 1 (21 pages), talks about sinusoids, propagation of sound, wavelength and frequency and complex waves (harmonics, phase, partials, octaves, and the concept of spectrum) as well as the use of analogs (mechanical, electrical, and acoustical) for analysis. In Chapter 2, Sound Levels and the Decibel are covered in 17 pages while Chapter 3 (42 pages) deals with The Ear and the Perception of Sound (sensitivity, anatomy, loudness, audibility, pitch, timbre, localization, the ear as both analyzer and measurement instrument, perceptions of reflections, and occupational and recreational deafness). Sound Waves in the Free Field are described in a 6 page Chapter 4. Speech, Music and Noise, Chapter 5, deals with the voice system, music, speech and music power and frequency ranges, "future" dynamic range requirements, noise, signal distortion, harmonic distortion in 30 pages. The reviewer found that some chapters were overdone (in length) and some were a little too concise.

The next chapter delves into the realm of Analog and Digital Signal Processing where concepts such as filters, DSP and application of DSP to room equalization are developed. The placement of this chapter here is perplexing as some of the concepts discussed are not introduced until later in the book.

The next 11 chapters (7 to 17) present architectural acoustics issues. Reverberation, Control of Interfering Noise, Absorption of Sound, Reflection of Sound, Diffraction of Sound, Refraction of Sound, Diffusion of Sound, the Schroeder Diffuser, Modal Resonances in Enclosed Spaces, Reflections in Enclosed Spaces and Comb-Filter Effects are the Chapter titles. The coverage of these topics is uneven, with some areas receiving more attention and others, less. Some of the chapters here appear to remain unchanged from earlier editions with newer material presented in another area (e.g., number theory based diffusers). The author covers a lot of material, but the presentation is uneven from chapter to chapter—one travels from 1960s design to the present between chapters and sometimes within one.

Chapter 18, Quiet Air for the Studio, emphasizes the role of proper design in keeping an expensive proposition from becoming more so. Basic requirements and guidelines are described in a prosaic manner.

The next five chapters deal with Acoustics of the Listening Room, the Small Recording Studio, the Control Room, for Multitrack Recording and for Audio/Video Tech Room and Voice-Over Recording. Items such as small room acoustics, low frequency phenomena for rooms, echoes, flutters, modes, specular and other reflections, and others are described here. Some readers may wonder why there are separate chapters here—the answer may be due to the changing popularity of room design philosophies, separate chapters were developed to deal with these changes in fashion. However, one could also see that this is a good thing—as we get more proficient in the understanding of the phenomena involved for these facilities, and develop more and varied solutions, the art and science of room design benefits.

Chapter 24, Adjustable Acoustics, describes some commercially available products in more detail than in the previous chapters. Among these are products based upon number theory and limp mass (antinode mitigation).

Some of the nonlinear mechanisms of sound are covered in the next chapter, Acoustical Distortion. The descriptions are basic and cover well-known phenomena—comb filtering, resonances, and speaker boundaries.

Some are more theological in nature—and are dependent on your belief in a particular theory of room design.

Computer software for use in measurement and design of listening spaces are covered in the next two chapters. Chapter 26, reviews two of the commercially available software programs that are used to measure room acoustic metrics. Time domain spectroscopy and maximum length sequences are the two techniques used. The types and kinds of measurements that can be done are described.

Chapter 27 describes another commercially based program which is also the title of the chapter—Room Optimizer. This program is used to investigate modal properties of rooms under design and it then optimizes the room in regard to the placement of sound sources, such as loudspeakers, and the type and location of acoustic treatment of surfaces within the same.

The final chapter, Desktop Auralization, introduces what auralization is and how it can be used in the design phase of a room. Heretofore, the only way to get an idea of how a room sounded before it was built was to use

physical scale models of the room. Now, there are several programs that run on personal computers.

The appendix contains selected absorption coefficients in octave bands as well as reference to where the coefficients were found. A glossary of terms follows. A subject index is at the end of the book.

*Master Handbook of Acoustics* is a book that many in the Society may find uneven with some chapters containing many references and some none, some subjects detailed in lengthy prose and some in a very short manner, some photographs that are almost historic in nature while some graphics are modern. It is a comprehensive introductory guide for people who need to understand what designers and technicians are talking about.

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