FROM McGRAW-HILL

THE SECOND EDITION OF

INTRODUCTION TO RANDOM PROCESSES

With Applications to Signals and Systems

By William A. Gardner

An elegant and scholarly exposition—A comprehensive and penetrating introductory treatment for graduate students in engineering and science that narrows the gap between theory and practice

1990, 546 pages
(ISBN 0-07-022855-8)

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This book provides a unique and scholarly introduction to random processes for graduate-level engineering and science students and it is equally valuable as a reference book for professionals. It is a comprehensive and penetrating introductory treatment that emphasizes the correlation and spectrum theory of random processes, with applications to signals and systems. Professor Gardner devotes particular attention to the conceptual process of linking the real world of physical phenomena to the abstract mathematical models of the theory—a process crucial to achieving results in applications, but often ignored in other texts. He further narrows the gap between theory and practice by showing the reader how to take advantage of the duality between the theory based on ensemble averages and that based on time averages. Special attention is given to the often-neglected "why" in addition to the more common "how" of the theory.

FEATURES

- A unique treatment that bridges the gap between deep mathematical treatments and the more superficial applications-oriented approaches taken in most introductory texts for engineers and scientists.
- Emphasizes the important duality between the ensemble-average and time-average theories.
- Presents a wide variety of special topics and applications to signals and systems.
- Includes a thorough treatment of the geometrical theory of minimum-mean-squared-error estimation.
- Presents the first comprehensive treatment of the increasingly important cyclostationary processes.
- Includes a large assortment of exercises (over 350) ranging from applications and drill problems to verifications, extensions, and generalizations of theory (with procedural outlines provided).
- Detailed solutions to selected exercises are included at the back of the book, and a comprehensive solutions manual,The Random Processes Tutor, is available to all (see back page).
- Explains analogies and uses complementary theory, examples, and exercises for continuous-time and discrete-time processes to avoid unnecessary duplication.
- Provides nearly 150 important references to complementary treatments of theory and applications—some more applied, some more mathematical.

CHAPTER-BY-CHAPTER HIGHLIGHTS & CONTENTS

PART 1: REVIEW OF PROBABILITY, RANDOM VARIABLES, AND EXPECTATION

CHAPTER 1: Probability and Random Variables

Unity is given to the thorough yet concise review of probability and random variables given in this and the next chapter by repeated use of the same physical phenomenon—thermal noise—to illustrate and exemplify the concepts of sample space, event, probability and conditional probability, random variable, expectation and conditional expectation, variance, and correlation.

CONTENTS: The Notion of Probability. Sets. Sample Space. Probability Space. Conditional Probability. Independent Events. Random Variables. Probability Density, Functions of Random Variables. Exercises

CHAPTER 2: Expectation

CONTENTS: The Notion of Expectation. Expected Value. Moments and Correlation. Conditional Expectation. Convergence. Exercises.

PART 2: RANDOM PROCESSES

CHAPTER 3: Introduction to Random Processes

Substantial motivation for the study of random processes is provided by consideration of the various fundamental problems in signal processing and their solutions in terms of autocorrelation and spectral density. The duality of the time-average and ensemble-average theories is introduced at the outset.

CONTENTS: Introduction. Generalized Harmonic Analysis. Signal-Processing Applications. Types of Random Processes. Summary. Exercises.

CHAPTER 4: Mean and Autocorrelation

Important techniques for calculating the mean function and autocorrelation function are illustrated through application to various basic yet fundamental models of random processes.

CONTENTS: Definitions. Examples of Random Processes and Autocorrelations. Summary. Exercises.

CHAPTER 5: Classes of Random Processes

A broad overview of the most important classes of random processes is given to put the particular focus of this book in perspective.

CONTENTS: Specification of Random Processes. Gaussian Processes. Markov Processes. Stationary Processes. Summary. Exercises.

CHAPTER 6: The Wiener and Poisson Processes

Physically motivated derivations of the two fundamental random process models, the Wiener and Poisson processes, are given. Detailed expository discussions of the derivatives of these processes, such as thermal noise and shot noise, are included here and in subsequent chapters.

CONTENTS: Derivation of the Wiener Process. The Derivative of the Wiener Process. Derivation of the Poisson Process. The Derivative of the Poisson Counting Process. Marked and Filtered Poisson Processes. Summary. Exercises.

CHAPTER 7: Stochastic Calculus

A complete yet down-to-earth treatment of the important conditions under which operations of calculus can be interchanged with the expectation operation. Includes justification for formal manipulation of white noise.

CONTENTS: The Notion of a Calculus for Random Functions. Mean-Square Continuity. Mean-Square Differentiability. Mean-Square Integrability. Summary. Exercises.

CHAPTER 8: Ergodicity and Duality

Unusually comprehensive as well as physically motivated treatment of mean-square ergodicity, regularity, and duality between time-average and ensemble-average theories is given.

CONTENTS: The Notion of Ergodicity. Discrete and Continuous Time Averages. Mean-Square Ergodicity of the Mean. Mean-Square Ergodicity of the Autocorrelation. Regular Processes. Duality and the Role of Ergodicity. Summary. Exercises.

CHAPTER 9: Linear Transformations

Second order probabilistic analysis of both steady-state and transient responses of linear dynamical systems and filters is given. Both differential (state-variable) and integral (convolution) methods are introduced, including both continuous and discrete time.

CONTENTS: Linear Transformation of an N-tuple of Random Variables. Linear Discrete-Time Filtering. Linear Continuous-Time Filtering. Dynamical Systems. Summary. Exercises.

CHAPTER 10: Spectral Density

Unusually comprehensive treatment of spectral density, including both time-average and ensemble-average points of view, generalized Fourier transforms and spectral representations, and non-stationary and non-ergodic as well as stationary ergodic processes. Detailed discussion of various white-noise models.

CONTENTS: Input-Output Relations. Expected Spectral Density. Coherence. Time-Average Power Spectral Density and Duality. Spectral Density for Ergodic and Nonergodic Regular Stationary Processes. Spectral Density for Regular Nonstationary Processes. White Noise. Bandwidths. Spectral Lines. Summary. Exercises.

CHAPTER 11: Special Topics and Applications

A wide variety of special topics and applications that are particularly relevant to signal processing are given. Motivating problems treated within the time-average framework at the outset (Chapter 3) are reconsidered within the ensemble-average framework.

CONTENTS: Sampling and Pulse Modulation. Bandpass Processes. Frequency Modulation and Demodulation. PSD Measurement Analysis. Noise Modeling for Receiving Systems. Matched Filtering and Signal Detection. Wiener Filtering and Signal Extraction. Random-Signal Detection. Autoregressive Models and Linear Prediction. Summary. Exercises.

CHAPTER 12: Cyclostationary Processes

A comprehensive treatment of cyclostationary processes, which are especially important in signal processing applications, is presented.

CONTENTS: Introduction. Cyclic Autocorrelation and Cyclic Spectrum. Stationary and Cyclostationary Components. Linear Periodically Time-Variant Transformations. Examples of Cyclic Spectra for Modulated Signals. Stationary Representations. Cycloergodicity and Duality. Applications. Summary. Exercises.

CHAPTER 13: Minimum-Mean-Squared-Error Estimation

Complete introduction to geometrical vector space interpretation of random variables, with emphasis on analogy to familiar Euclidean space. Application to the fundamental problem of minimum-mean-squared-error estimation, and Wiener and Kalman filtering.

CONTENTS: The Notion of Minimum-Mean-Squared-Error Estimation. Geometric Foundations. Minimum-Mean-Squared-Error Estimation. Non-causal Wiener Filtering. Causal Wiener Filtering. Kalman Filtering. Optimum Periodically Time-Variant Filtering. Summary. Exercises.

REFERENCES.
SOLUTIONS.
AUTHOR INDEX.
SUBJECT INDEX.

TESTIMONIAL

"The choice of topics for the book is generally excellent and was a major reason for my selection of it as a course text...The organization of the material is excellent...The author's style is quite rigorous. The book is not "easy" to read; it requires effort and careful study on the part of the student. However, the serious reader is grateful for the precise, error-free, and logical exposition. The author's writing style sets a high standard to which students and potential authors can aspire...I have used the first edition of this book twice in the past and [will]definitely use the second edition in the future. My main reasons for using the book are the excellent selection of topics, the order of their presentation, the rigor of the writing, the clarity and succinctness of the explanations, and the almost total lack of errors. The author is to be congratulated on a fine book that has produced a timely increase in the level of presentation of an important subject."

Reviewer for McGraw-Hill

COMPANION MANUAL

THE RANDOM PROCESSES TUTOR:

A Comprehensive Solutions Manual for Independent Study

By William A. Gardner and Chih-Kang Chen

This manual provides unusually detailed and complete solutions to the over 350 exercises in the companion textbook. Because of its tutorial style, this manual makes independent study of this highly analytical subject practically feasible. This is the first solutions manual of this magnitude to be written on the subject of random processes

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