This book describes the stochastic method for ocean wave analysis. This method provides a route to predicting the characteristics of random ocean waves – information vital for the design and safe operation of ships and ocean structures.

Assuming a basic knowledge of probability theory, the book begins with a chapter describing the essential elements of wind-generated random seas from the stochastic point of view. The following three chapters introduce spectral analysis techniques, probabilistic predictions of wave amplitudes, wave height and periodicity. A further four chapters discuss sea severity, extreme sea state, directional wave energy spreading in random seas and special wave events such as wave breaking and group phenomena. Finally, the stochastic properties of non-Gaussian waves are presented. Useful appendices and an extensive reference list are included. Examples of practical applications of the theories presented can be found throughout the text.

This book will be suitable as a text for graduate students of naval, ocean and coastal engineering. It will also serve as a useful reference for research scientists and engineers working in this field.

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OCEAN WAVES

The Stochastic Approach

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PREFACE

This book is intended to provide uniform and concise information necessary to comprehend stochastic analyss and probabilistic prediction of wind-generated ocean waves.

Description and assessment of wind-generated ocean waves provide information vital for the design and operation of marine systems such as ships and ocean and coastal structures. Wind-generated seas continuously vary over a wide range of severity depending on geographical location, season, presence of tropical cyclones, etc. Furthermore, the wave profile in a given sea state is extremely irregular in time and space – any sense of regularity is totally absent, and thereby properties of waves cannot be readily defined on a wave-by-wave basis.

Characterization of the stochastic properties of ocean waves was first presented in the early 1950s; Neumann (1953), Pierson (1952, 1955), St Denis and Pierson (1953) introduced the stochastic approach for analysis of random seas, and Longuet-Higgins (1952) demonstrated the probabilistic estimation of random wave height. The four decades following the introduction of the stochastic prediction approach have seen phenomenal advances in the probabilistic analysis and prediction methodologies of random seas.

For the design of marine systems, information on the real world is required. Recent advances in technology permit the use of the probabilistic approach to estimate the responses of marine systems in a seaway, including extreme values, with reasonable accuracy. Such technology lends itself to application of the probabilistic approach as an integrated part of modern design technology in naval, ocean and coastal engineering.

In view of the growing need for more comprehensive advances in prediction methodologies and for application of the probabilistic approach in naval, ocean and coastal engineering, this book is designed as a text book at the graduate level and as a reference book for researchers and designers. The intent is to provide a thorough understanding of the modern concept of stochastic analysis and probabilistic prediction of wind-generated random seas. Specific efforts are made in this work to explain the basic principles supporting current prediction techniques and to provide practical applications of prediction methods.

Readers are expected to be familiar with basic probability theory and fundamental stochastic processes. For the readers' convenience, however, definitions, theorems and relevant formulae on probability and stochastic process theory used in the text are summarized in the appendixes without proof or derivation.

I am grateful to the College of Engineering, University of Florida, for granting me sabbatical leave to prepare this book. Significant progress was achieved toward its completion during this period of time. I would like to acknowledge the encouragement and support received from Professor Eatock Taylor of the University of Oxford during this undertaking. Thanks are also due to Professor Isobe of the Tokyo University who provided valuable suggestions on the section addressing directional wave spectra.

I am indebted to many learned scholars and researchers who directly or indirectly inspired me to study the stochastic analysis and probabilistic prediction of ocean waves. I thank those who sponsored my research which ultimately culminated in this book; in particular, Dr Silva, Office of Naval Research. Appreciation is extended to my graduate students; in particular, Drs C.H. Tsai, D.W.C. Wang, I.I. Sahinoglou, K. Ahn and Lieut. D.J. Robillard, US Navy, who through their dedicated project support had a significant influence on the final product. Finally, I would like to acknowledge the contribution of my wife, Margaret, who read the complete manuscript and provided valuable assistance with the editorial work.