Preface

The initial substantive interest in and contributions to water wave mechanics date from more than a century ago, beginning with the analysis of linear wave theory by Airy in 1845 and continuing with higher order theories by Stokes in 1847, long wave theories by Boussinesq in 1872, and limiting wave heights by Michell in 1893 and McCowan in 1894.

Following that half-century of pioneering developments, research continued at a relatively slow pace until the amphibious landings in the Second World War emphasized the need for a much better understanding of wave initiation and growth due to winds, the conservative and dissipative transformation mechanisms occurring from the source area to the shoaling, and the breaking processes at the shore. The largely unsuccessful attempt to utilize portable and floating breakwaters in the surprise amphibious landing at Normandy, France, stimulated interest in wave interaction with fixed and floating objects.

After the Second World War, the activity in water wave research probably would have subsided without the rather explosive growth in ocean-related engineering in scientific, industrial, and military activities. From the 1950s to the 1980s, offshore drilling and production of petroleum resources progressed from water depths of approximately 10 meters to over 300 meters, platforms for the latter being designed for wave heights on the order of 25 meters and costing in excess of $700,000,000 (U.S.). The financial incentives of well-planned and comprehensive studies of water wave phenomena became much greater. Laboratory studies as well as much more expensive field programs were required to validate design methodology and to provide a better basis for describing the complex and nonlinear directional seas. A second and substantial impetus to nearshore research on water waves has been the interest in coastal erosion, an area still only poorly understood. For example, although the momentum flux concepts were systematized by Longuet-Higgins and Stewart and applied to a number of relevant problems in the 1960s, the usual (spilling wave) assumption of the wave height inside the surf zone being proportional to the water depth avoids the important matter of the distribution of the applied longshore stress across the surf zone. This can only be reconciled through careful laboratory and field measurements of wave breaking. Wave energy provides another example. In the last two decades remote sensing has indicated the potential of defining synoptic measures of wave intensity over very wide areas, with the associated benefits to shipping efficiency. Simple calculations of the magnitudes of the "standing crop" of wave energy have stimulated many scientists and engineers to devise ingenious mechanisms to harvest this energy. Still, these mechanisms must operate in a harsh environment known for its long-term corrosive and fouling effects and the high-intensity forces during severe storms.

The problem of quantifying the wave climate, understanding the interaction of waves with structures and/or sediment, and predicting the associated responses of interest underlies almost every problem in coastal and ocean engineering. It is toward this goal that this book is directed. Although the book is intended for use primarily as a text at the advanced undergraduate or first-year graduate level, it is hoped that it will serve also as a reference and will assist one to learn the field through self-study. Toward these objectives, each chapter concludes with a number of problems developed to illustrate by application the material presented. The references included should aid the student and the practicing engineer to extend their knowledge further.

The book is comprised of twelve chapters. Chapter 1 presents a number of common examples illustrating the wide range of water wave phenomena, many of which can be commonly observed. Chapter 2 offers a review of potential flow hydrodynamics and vector analysis. This material is presented for the sake of completeness, even though it will be familiar to many readers. Chapter 3 formulates the linear water wave theory and develops the simplest two-dimensional solution for standing and progressive waves. Chapter 4 extends the solutions developed in Chapter 3 to many features of engineering relevance, including kinematics, pressure fields, energy, shoaling, refraction, and diffraction. Chapter 5 investigates long wave phenomena, such as kinematics, seiching, standing and progressive waves with friction, and long waves including geostrophic forces and storm surges. Chapter 6 explores various wavemaker problems, which are relevant to problems of wave tank and wave basin design and to problems of damping of floating bodies. The utility of spectral analysis to combine many elemental solutions is explored in Chapter 7. In this manner a complex sea comprising a spectrum of frequencies and, at each frequency, a continuum of directions can be represented. Chapter 8 examines the problem of wave forces on structures. A slight modification of the problem of two-dimensional idealized flow about a cylinder yields the well-known Morison equation. Both drag- and inertia-dominant systems are discussed, including methods for data analysis, and some field data are presented. This chapter concludes with a brief description of the Green's function representation for calculating the forces on large bodies. Chapter 9 considers the effects of waves propagating over seabeds which may be porous, viscous, and/or compressible and at which frictional effects may occur in the bottom boundary layer. Chapter 10 develops a number of nonlinear (to second order in wave height) results that, somewhat surprisingly, may be obtained from linear wave theory. These results, many of which are of engineering concern, include mass transport, momentum flux, set-down and set-up of the mean water level, mean pressure under a progressive wave, and the "microseisms," in-phase pressure fluctuations that occur under two-dimensional standing waves. Chaper 11 introduces the perturbation method to develop and solve various nonlinear wave theories, including the Stokes second order theory, and the solitary and cnoidal wave theories. The procedure for developing numerical wave theories to high order is described, as are the analytical and physical validities of theories. Finally, Chapter 12 presents a number of water wave experiments (requiring only simple instrumentation) that the authors have found useful for demonstrating the theory and introducing the student to wave experimentation, specifically methodology, instrumentation, and frustrations.

Each chapter is dedicated to a scientist who contributed importantly to this field. Brief biographies were gleaned from such sources as *The Dictionary of National Biography* (United Kindom scientists; Cambridge University Press), *Dictionary of Scientific Biography* (Charles Scribner's Sons, New York), *Neue Deutsche Biographie* (Helmholtz; Duncker and Humblot, Berlin) and *The London Times* (Havelock). These productive and influential individuals are but a few of those who have laid the foundations of our present-day knowledge; however, the biographies illustrate the level of effort and intensity of those people and their eras, through which great scientific strides were made.

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