Linear Water Waves A Mathematical Approach

Waves are a ubiquitous and important feature of the physical world, and throughout history it has been a major challenge to understand them. They can propagate on the surfaces of solids and of fluids; chemical waves control the beating of your heart; traffic jams move in waves down lanes crowded with vehicles. This introduction to the mathematics of wave phenomena is aimed at advanced undergraduate courses on waves for mathematicians, physicists or engineers. Some more advanced material on both linear and nonlinear waves is also included, thus making the book suitable for beginning graduate courses. The authors assume some familiarity with partial differential equations, integral transforms and asymptotic expansions as well as an acquaintance with fluid mechanics, elasticity and electromagnetism. The context and physics that underlie the mathematics is clearly explained at the beginning of each chapter. Worked examples and exercises are supplied throughout, with solutions available to teachers.

The mathematical techniques used to handle various water wave problems are varied and fascinating. This book highlights a number of these techniques in connection with investigations of some classes of water wave problems by leading researchers in this field. The first eight chapters discuss linearised theory while the last two cover nonlinear analysis. This book will be an invaluable source of reference for advanced mathematical work in water wave theory.

This is the first volume of a collection of articles dedicated to V.G Maz'ya on the occasion of his 60th birthday. It contains surveys on his work in different fields of mathematics or on areas to which he made essential contributions. Other articles of this book have their origin in the common work with Maz'ya. V.G Maz'ya is author or co-author of more than 300 scientific works on various fields of functional analysis, function theory, numerical analysis, partial differential equations and their application. The reviews in this book show his enormous productivity and the large variety of his work. The scond volume contains most of the invited lectures of the Conference on Functional Analysis, Partial Differential Equations and Applications held in Rostock in September 1998 in honor of V.G Maz'ya. Here different problems of functional analysis, potential theory, linear and nonlinear partial differential equations, theory of function spaces and numerical analysis are treated. The authors, who are outstanding experts in these fields, present surveys as well as new results.

Optical Remote Sensing is one of the main technologies used in sea surface monitoring. Optical Remote Sensing of Ocean Hydrodynamics investigates and demonstrates capabilities of optical remote sensing technology for enhanced observations and detection of ocean environments. It provides extensive knowledge of physical principles and capabilities of optical observations of the oceans at high spatial resolution, 1-4m, and on the observations of surface wave hydrodynamic processes. It also describes the implementation of spectral-statistical and fusion algorithms for analyses of multispectral optical databases and establishes physics-based criteria for detection of complex wave phenomena and hydrodynamic disturbances including assessment and management of optical databases. This book explains the physical principles of high-resolution optical imagery of the ocean surface, discusses for the first time the capabilities of observing hydrodynamic processes and events, and emphasizes the integration of optical measurements and enhanced data analysis. It also covers both the assessment and the interpretation of dynamic multispectral optical databases and includes applications for advanced studies and nonacoustic detection. This book is an invaluable resource for researches, industry professionals, engineers, and students working on cross-disciplinary problems in ocean hydrodynamics, optical remote sensing of the ocean and sea surface remote sensing. Readers in the fields of geosciences and remote sensing, applied physics, oceanography, satellite observation technology, and optical engineering will learn the theory and practice of optical interactions with the ocean.

In this book an introduction is given to aspects of water waves that play a role in ship hydrodynamics and offshore engineering. At first the equations and linearized boundary conditions are derived describing the non-viscous free surface water waves, with special attention to the combination of steady and non-steady flow fields. Then some simple kinds of free wave solutions are derived, such as plane waves and cylindrical waves. For several situations, steady and unsteady, the source singularity function is derived. These functions play a role in numerical codes used to describe the motion of ships and offshore structures. These codes are mostly based on a boundary integral formulation; therefore we give an introduction to these methods. It is shown how first order ship motions can be determined. In offshore engineering the second order wave drift motions play an important role. An introduction to this phenomenon is given and the effects which have to be taken into account are explained by means of a simple example where we can determine nearly all the aspects analytically. An interesting example that is worked out is the motion of very large floating flexible platforms with finite draft. Finally an introduction to the theory of shallow water non-linear dispersive waves is presented, and shallow water ship hydrodynamics, that plays a role in coastal areas and channels is treated. Here attention is paid to the interaction between passing ships in restricted water. In the appendix a short introduction to some of the mathematical tools is given.

For more than 200 years, the Fourier Transform has been one of the most important mathematical tools for understanding the dynamics of linear wave trains. Nonlinear Ocean Waves and the Inverse Scattering Transform presents the development of the nonlinear Fourier analysis of measured space and time series, which can be found in a wide variety of physical settings including surface water waves, internal waves, and equatorial Rossby waves. This revolutionary development will allow hyperfast numerical modelling of nonlinear waves, greatly advancing our understanding of oceanic surface and internal waves. Nonlinear Fourier analysis is based upon a generalization of linear Fourier analysis referred to as the inverse scattering transform, the fundamental building block of which is a generalized Fourier series called the Riemann theta function. Elucidating the art and science of implementing these functions in the context of physical and time series analysis is the goal of this book. Presents techniques and methods of the inverse scattering transform for data analysis Geared toward both the introductory and advanced reader venturing further into mathematical and numerical analysis Suitable for classroom teaching as well as research

A range of experts contribute introductory-level lectures on active topics in the theory of water waves.

This 2002 book examines the interaction between ocean waves and oscillating systems. With a focus on linear analysis of low-amplitude waves, the text is designed to convey a thorough understanding of wave interactions. Topics covered include the background mathematics of oscillations, gravity waves on water, the dynamics of wave-body interactions, and the absorption of wave energy by oscillating bodies. Linear algebra, complex numbers, differential equations, and Fourier transformation are utilized as bases for the analysis, and each chapter ends with problems. While the book's focus is on linear theory, the practical application of energy storage and transport is interwoven throughout. This book will be appropriate for those with backgrounds in elementary fluid dynamics or hydrodynamics and mathematical analysis. Graduate students and researchers will find it an excellent source of wave energy theory and application.

This book is intended as an introduction to classical water wave theory for the college senior or first year graduate student. The material is self-contained; almost all mathematical and engineering concepts are presented or derived in the text, thus making the book accessible to practicing engineers as well.The book commences with a review of fluid mechanics and basic vector concepts. The formulation and solution of the governing boundary value problem for small amplitude waves are developed and the kinematic and pressure fields for short and long waves are explored. The transformation of waves due to variations in depth and their interactions with structures are derived. Wavemaker theories and the statistics of ocean waves are reviewed. The application of the water particle motions and pressure fields are applied to the calculation of wave forces on small and large objects. Extension of the linear theory results to several nonlinear wave properties is presented. Each chapter concludes with a set of homework problems exercising and sometimes extending the material presented in the chapter. An appendix provides a description of nine experiments which can be performed, with little additional equipment, in most wave tank facilities.

This volume brings together four lecture courses on modern aspects of water waves. The intention, through the lectures, is to present quite a range of mathematical ideas, primarily to show what is possible and what, currently, is of particular interest. Water waves of large amplitude can only be fully understood in terms of nonlinear effects, linear theory being not adequate for their description. Taking advantage of insights from physical observation, experimental evidence and numerical simulations, classical and modern mathematical approaches can be used to gain insight into their dynamics. The book presents several avenues and offers a wide range of material of current interest. The lectures provide a useful source for those who want to begin to investigate how mathematics can be used to improve our understanding of water wave phenomena. In addition, some of the material can be used by those who are already familiar with one branch of the study of water waves, to learn more about other areas.

The outcome of a conference held in East Carolina University in June 1982, this book provides an account of developments in the theory and application of nonlinear waves in both fluids and plasmas. Twenty-two contributors from eight countries here cover all the main fields of research, including nonlinear water waves, K-dV equations, solitions and inverse scattering transforms, stability of solitary waves, resonant wave interactions, nonlinear evolution equations, nonlinear wave phenomena in plasmas, recurrence phenomena in nonlinear wave systems, and the structure and dynamics of envelope solitions in plasmas.

This volume includes articles on the mathematical modeling and numerical simulation of various wave phenomena. For many years Waves 2003 and its five prior conferences have been an important forum for discussions on wave propagation. The topic is equally important for fundamental sciences, engineering, mathematics and, in particular, for industrial applications. Areas of specific interest are acoustics, electromagnetics, elasticity and related inverse and optimization problems. This book gives an extensive overview of recent developments in a very active field of scientific computing.

This volume contains articles on analysis, theory of algebraic groups, partial differential equations, pseudodifferential operators, wavelets, and other areas of mathematics. This book is suitable for a broad group of graduate students and researchers interested in the topics presented here.

This text considers classical and modern problems in linear and non-linear water-wave theory.

This is the first book on explosion-generated water waves. It presents the theoretical foundations and experimental results of the generation and propagation of impulsively generated waves resulting from underwater explosions. Many of the theories and concepts presented herein are applicable to other types of water waves, in particular, tsunamis and waves generated by the fall of a meteorite. Linear and nonlinear theories, as well as experimental calibrations, are presented for cases of deep and shallow water explosions. Propagation of transient waves on dissipative, nonuniform bathymetries together with laboratory simulations are analyzed and discussed.

This book is a self-contained introduction to the theory of periodic, progressive, permanent waves on the surface of incompressible inviscid fluid. The problem of permanent water-waves has attracted a large number of physicists and mathematicians since Stokes' pioneering papers appeared in 1847 and 1880. Among many aspects of the problem, the authors focus on periodic progressive waves, which mean waves traveling at a constant speed with no change of shape. As a consequence, everything about standing waves are excluded and solitary waves are studied only partly. However, even for this restricted problem, quite a number of papers and books, in physics and mathematics, have appeared and more will continue to appear, showing the richness of the subject. In fact, there remain many open questions to be answered.The present book consists of two parts: numerical experiments and normal form analysis of the bifurcation equations. Prerequisite for reading it is an elementary knowledge of the Euler equations for incompressible inviscid fluid and of bifurcation theory. Readers are also expected to know functional analysis at an elementary level. Numerical experiments are reported so that any reader can re-examine the results with minimal labor: the methods used in this book are well-known and are described as clearly as possible. Thus, the reader with an elementary knowledge of numerical computation will have little difficulty in the re-examination.

This comprehensive text describes the science of waves in fluids.

Offers an integrated account of the mathematical hypothesis of wave motion in liquids with a free surface, subjected to gravitational and other forces. Uses both potential and linear wave equation theories, together with applications such as the Laplace and Fourier transform methods, conformal mapping and complex variable techniques in general or integral equations, methods employing a Green's function. Coverage

includes fundamental hydrodynamics, waves on sloping beaches, problems involving waves in shallow water, the motion of ships and much more.
Now in an accessible paperback edition, this classic work is just as relevant as when it first appeared in 1974, due to the increased use of nonlinear waves. It covers the behavior of waves in two parts, with the first part addressing hyperbolic waves and the second addressing dispersive waves. The mathematical principles are presented along with examples of specific cases in communications and specific physical fields, including flood waves in rivers, waves in glaciers, traffic flow, sonic booms, blast waves, and ocean waves from storms.
Wave motion in water is one of the most striking observable phenomena in nature. Throughout the twentieth century, development of the linearized theory of wave motion in fluids and hydrodynamic stability has been steady and significant. In the last three decades there have been remarkable developments in nonlinear dispersive waves in general, nonlinear water waves in particular, and nonlinear instability phenomena. New solutions are now available for waves modulatedin both space and time, which exhibit new phenomena as diverse as solitons, resonant interactions, side-band instability, and wave-breaking. Other achievements include the discovery of soliton interactions, and the Inverse Scattering Transform method forfinding the explicit exact solution for several canonical nonlinear partial differential equations. This monograph is the first to summarize the research on nonlinear wave phenomena over the past three decades, and it also presents numerous applications in physics, geophysics, and engineering.
This overview of some of the main results and recent developments in nonlinear water waves presents fundamental aspects of the field and discusses several important topics of current research interest. It contains selected information about water-wave motion for which advanced mathematical study can be pursued, enabling readers to derive conclusions that explain observed phenomena to the greatest extent possible. The author discusses the underlying physical factors of such waves and explores the physical relevance of the mathematical results that are presented. The book is intended for mathematicians, physicists and engineers interested in the interplay between physical concepts and insights and the mathematical ideas and methods that are relevant to specific water-wave phenomena. The material is an expanded version of the author's lectures delivered at the NSF-CBMS Regional Research Conference in the Mathematical Sciences organized by the Mathematics Department of the University of Texas-Pan American in 2010.
Classic monograph presents connected account of mathematical theory of wave motion in a liquid with a free surface and subjected to gravitational and other forces, together with applications to concrete physical problems. 1957 edition.
The theory of water waves is most varied and is a fascinating topic. It includes a wide range of natural phenomena in oceans, rivers, and lakes. It is mostly concerned with elucidation of some general aspects of wave motion including the prediction of behaviour of waves in the presence of obstacles of some special configurations that are of interest to ocean engineers. Unfortunately, even the apparently simple problems appear to be difficult to tackle mathematically unless some simplified assumptions are made. Fortunately, one can assume water to be an incompressible, in viscid and homogeneous fluid. The linearised theory of

water waves is based on the assumption that the amplitude of the motion is small compared to the wave length. If rotational motion is assumed, then the linearised theory of water waves is essentially concerned with solving the Laplace equation in the water region together with linearised boundary condition. There are varied classes of problems that have been/are being studied mathematically in the literature within the framework of linearised theory of water waves for last many years. Scattering by obstacles of various geometrical configurations is one such class of water wave problems. This book is devoted to advanced mathematical work related to water wave scattering. Emphasis is laid on the mathematical and computational techniques required to study these problems mathematically. The book contains nine chapters. The first chapter is introductory in nature. It includes the basic equations of linearised theory for a single layer fluid, a two-layer fluid, solution of dispersion equations, and a general idea on scattering problems and the energy identity in water with a free surface. Chapter 2 is concerned with wave scattering involving thin rigid plates of various geometrical configurations, namely, plane vertical barriers or curved barriers, inclined barriers, horizontal barrier, and also thin elastic vertical plate. For the horizontal case, the barrier is submerged below an ice-cover modelled as a thin elastic plate floating on water. Chapter 3 discusses wave scattering by a rectangular trench by using Galerkin technique. Chapter 4 involves wave scattering by a dock by using Carleman singular integral equation followed by reduction to Riemann-Hilbert problems. Chapter 5 involves several wave scattering problems involving discontinuities at the upper surface of water by using the Wiener-Hopf technique, by reduction to Carleman singular integral equations. Chapter 6 considers scattering by a long horizontal circular cylinder either half immersed or completely submerged. In chapter 7, some important energy identities are derived for scattering problems in a single-layer and also in a two-layer fluid. Chapter 8 is concerned with wave scattering in a two-layer fluid by a thin vertical plate and by a long horizontal circular cylinder submerged in either of the two layers. Chapter 9 is the final chapter which considers a number of wave scattering problems in a single-layer or a two-layer fluid with variable bottom topography by using a simplified perturbation analysis It is hoped that this book will be useful to researchers on water waves. The several wave scattering problems presented in the book are mostly based on the research work carried out by the authors and their associates.

Linear and nonlinear waves are a central part of the theory of PDEs. This book begins with a description of one-dimensional waves and their visualization through computer-aided techniques. Next, traveling waves are covered, such as solitary waves for the Klein-Gordon and KdV equations. Finally, the author gives a lucid discussion of waves arising from conservation laws, including shock and rarefaction waves. As an application, interesting models of traffic flow are used to illustrate conservation laws and wave phenomena. This book is based on a course given by the author at the IAS/Park City Mathematics Institute. It is suitable for independent study by undergraduate students in mathematics, engineering, and science programs. This book is published in cooperation with IAS/Park City Mathematics Institute.

In the summer of 2014 leading experts in the theory of water waves gathered at the Newton Institute for Mathematical Sciences in Cambridge for four weeks of research interaction. A cross-section of those experts was invited to give introductory-level talks on active topics. This book is a compilation of those talks and illustrates the diversity, intensity, and progress of current research in this area. The key themes that emerge are numerical methods for analysis, stability and simulation of water waves, transform methods, rigorous analysis of model equations, three-dimensionality of water waves, variational principles, shallow water hydrodynamics, the role of deterministic and random bottom topography, and modulation equations. This book is an ideal introduction for PhD students and researchers looking for a research project. It may also be used as a supplementary text for advanced courses in mathematics or fluid dynamics.

Mathematical Modelling of Waves in Multi-Scale Structured Media presents novel analytical and numerical models of waves in structured elastic media, with emphasis on the asymptotic analysis of phenomena such as dynamic anisotropy, localisation, filtering and polarisation as well as on the modelling of photonic, phononic, and platonic crystals.

This is an introductory book about nonlinear waves. It focuses on two properties that various different wave phenomena have in common, the "nonlinearity" and "dispersion", and explains them in a style that is easy to understand for first-time students. Both of these properties have important effects on wave phenomena. Nonlinearity, for example, makes the wave lean forward and leads to wave breaking, or enables waves with different wavenumber and frequency to interact with each other and exchange their energies. Dispersion, for example, sorts irregular waves containing various wavelengths into gentler wavetrains with almost uniform wavelengths as they propagate, or cause a difference between the propagation speeds of the wave waveform and the wave energy. Many phenomena are introduced and explained using water waves as an example, but this is just a tool to make it easier to draw physical images. Most of the phenomena introduced in this book are common to all nonlinear and dispersive waves. This book focuses on understanding the physical aspects of wave phenomena, and requires very little mathematical knowledge. The necessary minimum knowledges about Fourier analysis, perturbation method, dimensional analysis, the governing equations of water waves, etc. are provided in the text and appendices, so even second- or third-year undergraduate students will be able to fully understand the contents of the book and enjoy the fan of nonlinear wave phenomena without relying on other books.

The proceedings featured in this book grew out of a conference attended by 40 applied mathematicians and physicists which was held at the International Center for Research in Mathematics in Luminy, France, in May 1995. This volume reviews recent developments in the mathematical theory of water waves. The following aspects are considered: modeling of various wave systems, mathematical and numerical analysis of the full water wave problem (the Euler equations with a free surface) and of asymptotic models (Korteweg-de Vries, Boussinesq, Benjamin-Ono, Davey-Stewartson, Kadomtsev-Petviashvili, etc.), and existence and stability of solitary waves. It features: the latest developments in the theory of water waves; rigorous and formal results; and, papers from world-renowned experts in the field.

Waves in Oceanic and Coastal Waters describes the observation, analysis and prediction of wind-generated waves in the open ocean, in shelf seas, and in coastal regions with islands, channels, tidal flats and inlets, estuaries, fjords and lagoons. Most of this richly illustrated book is devoted to the physical aspects of waves. After introducing observation techniques for waves, both at sea and from space, the book defines the parameters that characterise waves. Using basic statistical and physical concepts, the author discusses the prediction of waves in oceanic and coastal waters, first in terms of generalised observations, and then in terms of the more theoretical framework of the spectral energy balance. He gives the results of established theories and also the direction in which research is developing. The book ends with a description of SWAN (Simulating Waves Nearshore), the preferred computer model of the engineering community for predicting waves in coastal waters.

This monograph provides a comprehensive and self-contained study on the theory of water waves equations, a research area that has been very active in recent years. The vast literature devoted to the study of water waves offers numerous asymptotic models.

This book gives a self-contained and up-to-date account of mathematical results in the linear theory of water waves. The study of waves has many applications, including the prediction of behavior of floating bodies (ships, submarines, tension-leg platforms etc.), the calculation of wave-making resistance in naval architecture, and the description of wave patterns over bottom topography in geophysical hydrodynamics. The first section deals with time-harmonic waves. Three linear boundary value problems serve as the approximate mathematical models for these types of water waves. The next section uses a plethora of mathematical techniques in the investigation of these three problems. The techniques used in the book include integral equations based on Green's functions, various inequalities between the kinetic and potential energy and integral identities which are indispensable for proving the uniqueness theorems. The so-called inverse procedure is applied to constructing examples of non-uniqueness, usually referred to as 'trapped nodes.'

This overview of some of the main results and recent developments in nonlinear water waves presents fundamental aspects of the field and discusses several important topics of current research interest. It contains selected information about water-wave motion for which advanced mathematical study can be pursued, enabling readers to derive conclusions that explain observed phenomena to the greatest extent possible. The author discusses the underlying physical factors of such waves and explores the physical relevance of the mathematical results that are presented. The material is an expanded version of the author's lectures delivered at the NSF-CBMS Regional Research Conference in the Mathematical Sciences organized by the Mathematics Department of the University of Texas-Pan American in 2010.

Nonlinear Waves in Integrable and Nonintegrable Systems presents cutting-edge developments in the theory and experiments of nonlinear waves. Its comprehensive coverage of analytical and numerical methods for nonintegrable systems is the first of its kind. This book is intended for researchers and graduate students working in applied mathematics and various physical subjects where nonlinear wave phenomena arise (such as nonlinear optics, Bose-Einstein condensates, and fluid dynamics).

Excerpt from Water Waves: The Mathematical Theory With Applications The subject of surface gravity waves has great variety whether regarded from the point of View of the types of physical problem which occur, or from the point of View of the mathematical ideas and methods needed to attack them. The physical problems range from discussion of wave motion over sloping beaches to flood waves in rivers, the motion of ships in a sea-way, free oscillations of enclosed bodies of water such as lakes and harbors, and the propagation of frontal discontinuities in the atmosphere, to mention just a few. The mathematical tools employed comprise just about the whole of the tools developed in the classical linear mathematical physics concerned with partial differential equations, as well as a good part of what has been learned about the nonlinear problems of mathe matical physics. Thus potential theory and the theory of the linear wave equation, together with such tools as conformal mapping and complex variable methods in general, the Laplace and Fourier transform techniques, methods employing a Green's function, integral equations, etc. Are used. The nonlinear problems are of both elliptic and hyperbolic type. In spite of the diversity of the material, the book, is not a collection of disconnected topics, written for specialists, and lacking unity and coherence. Instead, considerable pains have been taken to supply the fundamental background in hydrodynamics and also in some of the mathematics needed and to plan the book in order that it should be as much as possible a self - contained and readable whole. Though the contents of the book are outlined in detail below, it has some point to indicate briefly here its general plan. There are four main parts of the book. About the Publisher Forgotten Books publishes hundreds of thousands of rare and classic books. Find more at www.forgottenbooks.com This book is a reproduction of an important historical work. Forgotten Books uses state-of-the-art technology to digitally reconstruct the work, preserving the original format whilst repairing imperfections present in the aged copy. In rare cases, an imperfection in the original, such as a blemish or missing page, may be replicated in our edition. We do, however, repair the vast majority of imperfections successfully; any imperfections that remain are intentionally left to preserve the state of such historical works.