Non Linear Waves In Dispersive Media International Series Of Monographs In Natural Philosophy Volume 71

This self-contained set of lectures addresses a gap in the literature by providing a systematic link between the theoretical foundations of the subject matter and cutting-edge applications in both geophysical fluid dynamics and nonlinear optics. Rogue and shock waves are phenomena that may occur in the propagation of waves in any nonlinear dispersive medium. Accordingly, they have been observed in disparate settings – as ocean waves, in nonlinear optics, in Bose-Einstein condensates, and in plasmas. Rogue and dispersive shock waves are both characterized by the development of extremes: for the former, the wave amplitude becomes unusually large, while for the latter, gradients reach extreme values. Both aspects strongly influence the statistical properties of the wave propagation and are thus considered together here in terms of their underlying theoretical treatment. This book offers a self-contained graduate-level text intended as both an introduction and reference guide for a new generation of scientists working on rogue and shock wave phenomena across a broad range of fields in applied physics and geophysics.

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.

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.

This book is devoted to one of the most interesting and rapidly developing areas of modern nonlinear physics and mathematics - the theoretical, analytical and advanced numerical, study of the structure and dynamics of one-dimensional as well as two- and three-dimensional solitons and nonlinear waves described by Korteweg-de Vries (KdV), Kadomtsev-Petviashvili (KP), nonlinear Schrödinger (NLS) and derivative NLS (DNLS) classes of equations. Special attention is paid to generalizations (relevant to various complex physical media) of these equations, accounting for higher-order dispersion corrections, influence of dissipation, instabilities, and stochastic fluctuations of the wave fields. The book addresses researchers working in the theory and numerical simulations of dispersive complex media in such fields as hydrodynamics, plasma physics, and aerodynamics. It will also be useful as a reference work for graduate students in physics and mathematics.

This book is the first to concentrate on the theory of nonlinear nonlocal equations. The authors solve a number of problems concerning the asymptotic behavior of solutions of nonlinear evolution equations, the blow-up of solutions, and the global in time existence of solutions. In addition, a new classification of nonlinear nonlocal equations is introduced. A large class of these equations is treated by a single method, the main features of which are apriori estimates in different integral norms and use of the Fourier transform. This book will interest specialists in partial differential equations, as well as physicists and engineers.

This IMA Volume in Mathematics and its Applications MICROLOCAL ANALYSIS AND NONLINEAR WAVES is based on the proceedings of a workshop which was an integral part of the 1988- 1989 IMA program on "Nonlinear Waves". We thank Michael Beals, Richard Melrose and Jeffrey Rauch for organizing the meeting and editing this proceedings volume. We also take this opportunity to thank the National Science Foundation whose financial support made the workshop possible. A vner Friedman Willard Miller, Jr. PREFACE Microlocal analysis is natural and very successful in the study of the propagation of linear hyperbolic waves. For example consider the initial value problem Pu = f E e'(RHd), supp f C {t ;::: O} u = 0 for t

This volume contains the proceedings of the AMS Special Session on Spectral Calculus and Quasilinear Partial Differential Equations and the AMS Special Session on PDE Analysis on Fluid Flows, which were held in January 2017 in Atlanta, Georgia. These two sessions shared the underlying theme of the analysis aspect of evolutionary PDEs and mathematical physics. The articles address the latest trends and perspectives in the area of nonlinear dispersive equations and fluid flows. The topics mainly focus on using state-of-the-art methods and techniques to investigate problems of depth and richness arising in quantum mechanics, general relativity, and fluid dynamics.

The first part of the book provides an introduction to key tools and techniques in dispersive equations: Strichartz estimates, bilinear estimates, modulation and adapted function spaces, with an application to the generalized Korteweg-de Vries equation and the Kadomtsev-Petviashvili equation. The energy-critical nonlinear Schrödinger equation, global solutions to the defocusing problem, and scattering are the focus of the second part. Using this concrete example, it walks the reader through the induction on energy technique, which has become the essential methodology for tackling large data critical problems. This includes refined/inverse Strichartz estimates, the existence and almost periodicity of minimal blow up solutions, and the development of long-time Strichartz inequalities. The third part describes wave and Schrödinger maps. Starting by building heuristics about multilinear estimates, it provides a detailed outline of this very active area of geometric/dispersive PDE. It focuses on concepts and ideas and should provide graduate students with a stepping stone to this exciting direction of research.?

Based in part on a lecture course, this book gives an authoritative and up-to-date overview of recent research on the behaviour of waves in crystalline solids. It covers aspects of plasticity, fracture, and nonlinear wave propagation.

This self-contained treatment covers all aspects of nonlinear dynamics, from fundamentals to recent developments, in a unified and comprehensive way. Numerous examples and exercises will help the student to assimilate and apply the techniques presented.

This book is mainly devoted to the dynamics of the one-dimensional nonlinear stochastic waves. It contains a description of the basic mathematical tools as well as the latest results in the following fields: exactly integrable nonlinear stochastic equations, dynamics of the nonlinear waves in random media, evolution of the random waves in nonlinear media and the basic concepts of the numerical simulations in nonlinear random wave dynamics. A brief outline of the localization phenomenon in the nonlinear medium is also given. The approach is interdisciplinary describing the general methods with application to specific examples. The results presented may be useful for those who work in the areas of solid state physics, hydrodynamics, nonlinear optics, plasma physics, mathematical models of micromolecules and biological structures, …etc. Since many results are based on the inverse scattering technique, perturbation theory for solitons and the methods of the statistical radiophysics, the terminology of the respective fields is used. Contents: IntroductionLinear Random Waves. Some Basic ResultsExactly Solvable ModelsDirect Perturbation MethodsFrom Inverse Scattering to Perturbative ApproachDynamical Solitons under Random PerturbationsSine-Gordon Kinks under Random PerturbationsRandom Wave Packets in Nonlinear MediaDynamics of Randomly Modulated SolitonsWaves in Nonlinear Stationary Inhomogeneous MediaNumerical Study of the Single-Particle MotionNumerical Studies: A Panoramic ViewNonlinear Klein-Gordon ModelsSimulations with Dynamical and Envelope Solitons Readership: Researchers, postgraduate and undergraduate students of theoretical physics, applied mathematics and mathematical physics. keywords:Solitons;Perturbation Methods;Random Perturbations;Numerical Methods;Stochastic Simulations;Linear Random Waves;Sine-Gordon Kinks;Korteweg-de Vries Solitons;Nonlinear Schrodinger Solitons;Inverse Scattering

Non-Linear Waves in Dispersive Media introduces the theory behind such topic as the gravitational waves on water surfaces. Some limiting cases of the theory, wherein proof of an asymptotic class is necessary and generated, are also provided. The first section of the book discusses the notion of linear approximation. This discussion is followed by some samples of dispersive media. Examples of stationary waves are also examined. The book proceeds with a discussion of waves of envelopes. The concept behind this subject is from the application of the methods of geometrical optics to non-linear theory. A section on non-linear waves with slowly varying parameters is given at the end of the book, along with a discussion of the evolution of electro-acoustic waves in plasma with negative dielectric permittivity. The gravitational waves on fluid surfaces are presented completely. The text will provide valuable information for physicists, mechanical engineers, students, and researchers in the field of optics, acoustics, and hydrodynamics.

Although the mathematical theory of nonlinear waves and solitons has made great progress, its applications to concrete physical problems are rather poor, especially when compared with the classical theory of linear dispersive waves and nonlinear fluid motion. The Whitham method, which describes the combining action of the dispersive and nonlinear effects as modulations of periodic waves, is not widely used by applied mathematicians and physicists, though it provides a direct and natural way to treat various problems in nonlinear wave theory. Therefore it is topical to describe recent developments of the Whitham theory in a clear and simple form suitable for applications in various branches of physics.This book develops the techniques of the theory of nonlinear periodic waves at elementary level and in great pedagogical detail. It provides an introduction to a Whitham's theory of modulation in a form suitable for applications. The exposition is based on a thorough analysis of representative examples taken from fluid mechanics, nonlinear optics and plasma physics rather than on the formulation and study of a mathematical theory. Much attention is paid to physical motivations of the mathematical methods developed in the book. The main applications considered include the theory of collisionless shock waves in dispersive systems and the nonlinear theory of soliton formation in modulationally unstable systems. Exercises are provided to amplify the discussion of important topics such as singular perturbation theory, Riemann invariants, the finite gap integration method, and Whitham equations and their solutions.

Most of the Earth''s surface is covered by water. Our everyday lives and activities are affected by water waves in oceans, such as the tsunami that occurred in the Indian Ocean on 26 December 2004. This indicates how important it is for us to fully understand water waves, in particular the very large ones. One way to do so is to perform numerical simulation based on the nonlinear theory. Considerable research advances have been made in this area over the past decade by developing various numerical methods and applying them to emerging problems; however, until now there has been no comprehensive book to reflect these advances. This unique volume aims to bridge this gap. This book contains 18 self-contained chapters written by more than 50 authors from 12 different countries, many of whom are world-leading experts in the field. Each chapter is based mainly on the pioneering work of the authors and their research teams over the past decades.The chapters altogether deal with almost all numerical methods that have so far been employed to simulate nonlinear water waves and cover many important and very interesting applications, such as overturning waves, breaking waves, waves generated by landslides, freak waves, solitary waves, tsunamis, sloshing waves, interaction of extreme waves with beaches, interaction with fixed structures, and interaction with free-response floating structures. Therefore, this book provides a comprehensive overview of the state-of-the-art research and key achievements in numerical modeling of nonlinear water waves, and serves as a unique reference for postgraduates, researchers and senior engineers working in industry.

A non-linear wave is one of the fundamental objects of nature. They are inherent to aerodynamics and hydrodynamics, solid state physics and plasma physics, optics and field theory, chemistry reaction kinetics and population dynamics, nuclear physics and gravity. All non-linear waves can be divided into two parts: dispersive waves and dissipative ones. The history of investigation of these waves has been lasting about two centuries. In 1834 J. S. Russell discovered the extraordinary type of waves without the dispersive broadening. In 1965 N. J. Zabusky and M. D. Kruskal found that the Korteweg-de Vries equation has solutions of the solitary wave form. This solitary wave demonstrates the particle-like properties, i. e. , stability under propagation and the elastic interaction under collision of the solitary waves. These waves were named solitons. In succeeding years there has been a great deal of progress in understanding of soliton nature. Now solitons have become the primary components in many important problems of nonlinear wave dynamics. It should be noted that non-linear optics is the field, where all soliton features are exhibited to a great extent. This book had been designed as the tutorial to the theory of non-linear waves in optics. The first version was projected as the book covering all the problems in this field, both analytical and numerical methods, and results as well. However, it became evident in the process of work that this was not a real task.

This book provides a self-contained presentation of classical and new methods for studying wave phenomena that are related to the existence and stability of solitary and periodic travelling wave solutions for nonlinear dispersive evolution equations. Simplicity, concrete examples, and applications are emphasized throughout in order to make the material easily accessible. The list of classical nonlinear dispersive equations studied includes Korteweg-de Vries, Benjamin-Ono, and Schrodinger equations. Many special Jacobian elliptic functions play a role in these examples. The author brings the reader to the forefront of knowledge about some aspects of the theory and motivates future developments in this fascinating and rapidly growing field. The book can be used as an instructive study guide as well as a reference by students and mature scientists interested in nonlinear wave phenomena.

This book addresses the fascinating phenomena associated with nonlinear waves and spatio-temporal patterns. These appear almost everywhere in nature from sand bed forms to brain patterns, and yet their understanding still presents fundamental scientific challenges. The reader will learn here, in particular, about the current state-of-the art and new results in: Nonlinear water waves: resonance, solitons, focusing, Bose-Einstein condensation, as well as and their relevance for the sea environment (sea-wind interaction, sand bed forms, fiber clustering) Pattern formation in non-equilibrium media: soap films, chimera patterns in oscillating media, viscoelastic Couette-Taylor flow, flow in the wake behind a heated cylinder, other pattern formation. The editors and authors dedicate this book to the memory of Alexander Ezersky, Professor of Fluid Mechanics at the University of Caen

Normandie (France) from September 2007 to July 2016. Before 2007, he had served as a Senior Scientist at the Institute of Applied Physics of the Russian Academy of Sciences in Nizhny Novgorod (Russia). The chapters have been written by leading scientists in Nonlinear Physics, and the topics chosen so as to cover all the fields to which Prof. Ezersky himself contributed, by means of experimental, theoretical and numerical approaches. The volume will appeal to advanced students and researchers studying nonlinear waves and pattern dynamics, as well as other scientists interested in their applications in various natural media.
This volume contains lectures and invited papers from the Focus Program on "Nonlinear Dispersive Partial Differential Equations and Inverse Scattering" held at the Fields Institute from July 31-August 18, 2017. The conference brought together researchers in completely integrable systems and PDE with the goal of advancing the understanding of qualitative and long-time behavior in dispersive nonlinear equations. The program included Percy Deift's Coxeter lectures, which appear in this volume together with tutorial lectures given during the first week of the focus program. The research papers collected here include new results on the focusing ?nonlinear Schrödinger (NLS) equation, the massive Thirring model, and the Benjamin-Bona-Mahoney equation as dispersive PDE in one space dimension, as well as the Kadomtsev-Petviashvili II equation, the Zakharov-Kuznetsov equation, and the Gross-Pitaevskii equation as dispersive PDE in two space dimensions. The Focus Program coincided with the fiftieth anniversary of the discovery by Gardner, Greene, Kruskal and Miura that the Korteweg-de Vries (KdV) equation could be integrated by exploiting a remarkable connection between KdV and the spectral theory of Schrodinger's equation in one space dimension. This led to the discovery of a number of completely integrable models of dispersive wave propagation, including the cubic NLS equation, and the derivative NLS equation in one space dimension and the Davey-Stewartson, Kadomtsev-Petviashvili and Novikov-Veselov equations in two space dimensions. These models have been extensively studied and, in some cases, the inverse scattering theory has been put on rigorous footing. It has been used as a powerful analytical tool to study global well-posedness and elucidate asymptotic behavior of the solutions, including dispersion, soliton resolution, and semiclassical limits.
The book includes all the subject matter covered in a typical undergraduate course in engineering thermodynamics. It includes a series of worked examples in each chapter, carefully chosen to expose students to diverse applications of engineering thermodynamics. Each worked example is designed to be representative of a class of physical problems. At the end of each chapter, there are an additional 10 to 15 problems for which numerical answers are provided.
Although the mathematical theory of nonlinear waves and solitons has made great progress, its applications to concrete physical problems are rather poor, especially when compared with the classical theory of linear dispersive waves and nonlinear fluid motion. The Whitham method, which describes the combining action of the dispersive and nonlinear effects as modulations of periodic waves, is not widely used by applied mathematicians and physicists, though it provides a direct and natural way to treat various problems in nonlinear wave theory. Therefore it is topical to describe recent developments of the Whitham theory in a clear and simple form suitable for applications in various branches of physics. This book develops the techniques of the theory of nonlinear periodic waves at elementary level and in great pedagogical detail. It provides an introduction to a Whitham's theory of modulation in a form suitable for applications. The exposition is based on a thorough analysis of representative examples taken from fluid mechanics, nonlinear optics and plasma physics rather than on the formulation and study of a mathematical theory. Much attention is paid to physical motivations of the mathematical methods developed in the book. The main applications considered include the theory of collisionless shock waves in dispersive systems and the nonlinear theory of soliton formation in modulationally unstable systems. Exercises are provided to amplify the discussion of important topics such as singular perturbation theory, Riemann invariants, the finite gap integration method, and Whitham equations and their solutions. Contents:Introduction and Basic ConceptsNonlinear Wave Equations in PhysicsWhitham Theory of ModulationsComplete Integrability of Nonlinear Wave EquationsPeriodic SolutionsDissipationless Shock WaveNonlinear Theory of Modulational InstabilityAppendices:Some Formulas from the Theory of Elliptic FunctionsAlgebraic Resolvents of Fourth Degree PolynomialsSolutions to Exercises Readership: Advanced graduate students and young researchers in nonlinear wave theory. Keywords:Nonlinear Waves;Solitons;Integrable Equations;Inverse Scattering Transform;Periodic Solutions;Whitham Theory;Modulation;Hodograph Transform;Dissipationless Shock Waves;Modulational Instability
Non-Linear Waves in Dispersive MediaInternational Series of Monographs in Natural PhilosophyElsevier
The Boussinesq equation is the first model of surface waves in shallow water that considers the nonlinearity and the dispersion and their interaction as a reason for wave stability known as the Boussinesq paradigm. This balance bears solitary waves that behave like quasi-particles. At present, there are some Boussinesq-like equations. The prevalent part of the known analytical and numerical solutions, however, relates to the 1d case while for multidimensional cases, almost nothing is known so far. An exclusion is the solutions of the Kadomtsev-Petviashvili equation. The difficulties originate from the lack of known analytic initial conditions and the nonintegrability in the multidimensional case. Another problem is which kind of nonlinearity will keep the temporal stability of localized solutions. The system of coupled nonlinear Schroedinger equations known as well as the vector Schroedinger equation is a soliton supporting dynamical system. It is considered as a model of light propagation in Kerr isotropic media. Along with that, the phenomenology of the equation opens a prospect of investigating the quasi-particle behavior of the interacting solitons. The initial polarization of the vector Schroedinger equation and its evolution evolves from the vector nature of the model. The existence of exact (analytical) solutions usually is rendered to simpler models, while for the vector Schroedinger equation such solutions are not known. This determines the role of the numerical schemes and approaches. The vector Schroedinger equation is a spring-board for combining the reduced integrability and conservation laws in a discrete level. The experimental observation and measurement of ultrashort pulses in waveguides is a hard job and this is the reason and stimulus to create mathematical models for computer simulations, as well as reliable algorithms for treating the governing equations. Along with the nonintegrability, one more problem appears here - the multidimensionality and necessity to split and linearize the operators in the appropriate way.
Presents in a systematic and unified manner the ray method, in its various forms, for studying nonlinear wave propagation in situations of physical interest, essentially fluid dynamics and plasma physics.
This book gives an overview ofthe current state of nonlinear wave mechanics with emphasis on strong discontinuities (shock waves) and localized self preserving shapes (solitons) in both elastic and fluid media. The exposition is intentionallyat a detailed mathematical and physical level, our expectation being that the reader will enjoy coming to grips in a concrete manner with advances in this fascinating subject. Historically, modern research in nonlinear wave mechanics began with the famous 1858 piston problem paper of Riemann on shock waves and con tinued into the early part of the last century with the work of Hadamard,

Rankine, and Hugoniot. After WWII, research into nonlinear propagation of dispersive waves rapidly accelerated with the advent of computers. Works of particular importance in the immediate post-war years include those of von Neumann, Fermi, and Lax. Later, additional contributions were made by Lighthill, Glimm, Strauss, Wendroff, and Bishop. Dispersion alone leads to shock fronts of the propagating waves. That the nonlinearity can com pensate for the dispersion, leading to propagation with a stable wave having constant velocity and shape (solitons) came as a surprise. A solitary wave was first discussed by J. Scott Russell in 1845 in "Report of British Asso ciations for the Advancement of Science. " He had, while horseback riding, observed a solitary wave travelling along a water channel and followed its unbroken progress for over a mile.

Dynamical systems and Nonlinear Waves in Plasmas is written in a clear and comprehensible style to serve as a compact volume for advanced postgraduate students and researchers working in the areas of Applied Physics, Applied Mathematics, Dynamical Systems, Nonlinear waves in Plasmas or other nonlinear media. It provides an introduction to the background of dynamical systems, waves, oscillations and plasmas. Basic concepts of dynamical systems and phase plane analysis for the study of dynamical properties of nonlinear waves in plasmas are presented. Different kinds of waves in plasmas are introduced. Reductive perturbative technique and its applications to derive different kinds of nonlinear evolution equations in plasmas are discussed. Analytical wave solutions of these nonlinear evolution equations are presented using the concept of bifurcation theory of planar dynamical systems in a very simple way. Bifurcations of both small and arbitrary amplitudes of various nonlinear acoustic waves in plasmas are presented using phase plots and time-series plots. Super nonlinear waves and its bifurcation behaviour are discussed for various plasma systems. Multiperiodic, quasiperiodic and chaotic motions of nonlinear plasma waves are discussed in presence of external periodic force. Multistability of plasma waves is investigated. Stable oscillation of plasma waves is also presented in dissipative plasmas. The book is meant for undergraduate and postgraduate students studying plasma physics. It will also serve a reference to the researchers, scientists and faculties to pursue the dynamics of nonlinear waves and its properties in plasmas. It describes the concept of dynamical systems and is useful in understanding exciting features, such as solitary wave, periodic wave, supernonlinear wave, chaotic, quasiperiodic and coexisting structures of nonlinear waves in plasmas. The concepts and approaches, discussed in the book, will also help the students and professionals to study such features in other nonlinear media.

This text considers models of different "acoustic" media as well as equations and behavior of finite-amplitude waves. It also considers the effects of nonlinearity, dissipation, dispersion, and for two- and three-dimensional problems, reflection and diffraction on the evolution and interaction of acoustic beams.

This book covers interaction between wind and ocean waves, for ocean wave modellers, physicists, applied mathematicians, engineers.

This book is an introduction to the perturbation theory for linear and nonlinear waves in dispersive and dissipative media. The main focus is on the direct asymptotic method which is based on the asymptotic expansion of the solution in series of one or more small parameters and demanding finiteness of the perturbations; this results in slow variation of the main-order solution. The method, which does not depend on integrability of basic equations, is applied to quasi-harmonic and non-harmonic periodic waves, as well as to localized waves such as solitons, kinks, and autowaves. The basic theoretical ideas are illustrated by many physical examples throughout the book.

Travelling wave processes and wave motion are of great importance in many areas of mechanics, and nonlinearity also plays a decisive role there. The basic mathematical models in this area involve nonlinear partial differential equations, and predictability of behaviour of wave phenomena is of great importance. Beside fluid dynamics and gas dynamics, which have long been the traditional nonlinear scienes, solid mechanics is now taking an ever increasing account of nonlinear effects. Apart from plasticity and fracture mechanics, nonlinear elastic waves have been shown to be of great importance in many areas, such as the study of impact, nondestructive testing and seismology. These lectures offer a thorough account of the fundamental theory of nonlinear deformation waves, and in the process offer an up to date account of the current state of research in the theory and practice of nonlinear waves in solids.

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 book uses asymptotic methods to obtain simple approximate analytic solutions to various problems within mechanics, notably wave processes in heterogeneous materials. Presenting original solutions to common issues within mechanics, this book builds upon years of research to demonstrate the benefits of implementing asymptotic techniques within mechanical engineering and material science. Focusing on linear and nonlinear wave phenomena in complex micro-structured solids, the book determines their global characteristics through analysis of their internal structure, using homogenization and asymptotic procedures, in line with the latest thinking within the field. The book’s cutting-edge methodology can be applied to optimal design, non-destructive control and in deep seismic sounding, providing a valuable alternative to widely used numerical methods. Using case studies, the book covers topics such as elastic waves in nonhomogeneous materials, regular and chaotic dynamics based on continualisation and discretization and vibration localization in 1D Linear and Nonlinear lattices. The book will be of interest to students, research engineers, and professionals specialising in mathematics and physics as well as mechanical and civil engineering.

This book gathers contributions on various aspects of the theory and applications of linear and nonlinear waves and associated phenomena, as well as approaches developed in a global partnership of researchers with the national Centre of Excellence in Nonlinear Studies (CENS) at the Department of Cybernetics of Tallinn University of Technology in Estonia. The papers chiefly focus on the role of mathematics in the analysis of wave phenomena. They highlight the complexity of related topics concerning wave generation, propagation, transformation and impact in solids, gases, fluids and human tissues, while also sharing insights into selected mathematical methods for the analytical and numerical treatment of complex phenomena. In addition, the contributions derive advanced mathematical models, share innovative ideas on computing, and present novel applications for a number of research fields where both linear and nonlinear wave problems play an important role. The papers are written in a tutorial style, intended for non-specialist researchers and students. The authors first describe the basics of a problem that is currently of interest in the scientific community, discuss the state of the art in related research, and then share their own experiences in tackling the problem. Each chapter highlights the importance of applied mathematics for central issues in the study of waves and associated complex phenomena in different media. The topics range from basic principles of wave mechanics up to the mathematics of Planet Earth in the broadest sense, including contemporary challenges in the mathematics of society. In turn, the areas of application range from classic ocean wave mathematics to material science, and to human nerves and tissues. All contributions describe the approaches in a straightforward manner, making them ideal material for educational purposes, e.g. for courses, master class lectures, or seminar presentations.

The field of nonlinear dispersive waves has developed enormously since the work of Stokes, Boussinesq and

Korteweg–de Vries (KdV) in the nineteenth century. In the 1960s, researchers developed effective asymptotic methods for deriving nonlinear wave equations, such as the KdV equation, governing a broad class of physical phenomena that admit special solutions including those commonly known as solitons. This book describes the underlying approximation techniques and methods for finding solutions to these and other equations. The concepts and methods covered include wave dispersion, asymptotic analysis, perturbation theory, the method of multiple scales, deep and shallow water waves, nonlinear optics including fiber optic communications, mode-locked lasers and dispersion-managed wave phenomena. Most chapters feature exercise sets, making the book suitable for advanced courses or for self-directed learning. Graduate students and researchers will find this an excellent entry to a thriving area at the intersection of applied mathematics, engineering and physical science.

Waves are essential phenomena in most scientific and engineering disciplines, such as electromagnetism and optics, and different mechanics including fluid, solid, structural, quantum, etc. They appear in linear and nonlinear systems. Some can be observed directly and others are not. The features of the waves are usually described by solutions to either linear or nonlinear partial differential equations, which are fundamental to the students and researchers.Generic equations, describing wave and pulse propagation in linear and nonlinear systems, are introduced and analyzed as initial/boundary value problems. These systems cover the general properties of non-dispersive and dispersive, uniform and non-uniform, with/without dissipations. Methods of analyses are introduced and illustrated with analytical solutions. Wave-wave and wave-particle interactions ascribed to the nonlinearity of media (such as plasma) are discussed in the final chapter.This interdisciplinary textbook is essential reading for anyone in above mentioned disciplines. It was prepared to provide students with an understanding of waves and methods of solving wave propagation problems. The presentation is self-contained and should be read without difficulty by those who have adequate preparation in classic mechanics. The selection of topics and the focus given to each provide essential materials for a lecturer to cover the bases in a linear/nonlinear wave course.

A variety of nonlinear effects occur in a plasma. First, there are the wave steepening effects which can occur in any fluid in which the propagation speed depends upon the wave-amplitude. In a dispersive medium this can lead to classes of nonlinear waves which may have stationary solutions like solitons and shocks. Because the plasma also acts like an inherently nonlinear dielectric resonant interactions among waves lead to exchange of energy among them. Further, an electromagnetic wave interacting with a plasma may parametrically excite other waves in the plasma. A large-amplitude Langmuir wave undergoes a modulational instability which arises through local depressions in plasma density and the corresponding increases in the energy density of the wave electric field. Whereas a field collapse occurs in two and three dimensions, in a one-dimensional case, spatially localized stationary field structures called Langmuir solitons can result. Many other plasma waves like upper-hybrid waves, lower-hybrid waves etc. can also undergo a modulational instability and produce localized field structures. A new type of nonlinear effect comes into play when an electromagnetic wave propagating through a plasma is strong enough to drive the electrons to relativistic speeds. This leads to a propagation of an electromagnetic wave in a normally overdense plasma, and the coupling of the electromagnetic wave to a Langmuir wave in the plasma. The relativistic mass variation of the electrons moving in an intense electromagnetic wave can also lead to a modulational instability of the latter.

The book details a few of the novel methods developed in the last few years for studying various aspects of nonlinear wave systems. The introductory chapter provides a general overview, thematically linking the objects described in the book. Two chapters are devoted to wave systems possessing resonances with linear frequencies (Chapter 2) and with nonlinear frequencies (Chapter 3). In the next two chapters modulation instability in the KdV-type of equations is studied using rigorous mathematical methods (Chapter 4) and its possible connection to freak waves is investigated (Chapter 5). The book goes on to demonstrate how the choice of the Hamiltonian (Chapter 6) or the Lagrangian (Chapter 7) framework allows us to gain a deeper insight into the properties of a specific wave system. The final chapter discusses problems encountered when attempting to verify the theoretical predictions using numerical or laboratory experiments. All the chapters are illustrated by ample constructive examples demonstrating the applicability of these novel methods and approaches to a wide class of evolutionary dispersive PDEs, e.g. equations from Benjamin-Oro, Boussinesq, Hasegawa-Mima, KdV-type, Klein-Gordon, NLS-type, Serre, Shamel , Whitham and Zakharov. This makes the book interesting for professionals in the fields of nonlinear physics, applied mathematics and fluid mechanics as well as students who are studying these subjects. The book can also be used as a basis for a one-semester lecture course in applied mathematics or mathematical physics.

This book treats two problems simultaneously: sequential analytical consideration of nonlinear strain wave amplification and selection in wave guides and in a medium; demonstration of the use of even particular analytical solutions to nonintegrable equations in a design of numerical simulation of unsteady nonlinear wave processes. The text includes numerous detailed examples of the strain wave amplification and selection caused by the influence of an external medium, microstructure, moving point defects, and thermal phenomena. The main features of the book are: (1) nonlinear models of the strain wave evolution in a rod subjected by various dissipative/active factors; (2) an analytico-numerical approach for solutions to the governing nonlinear partial differential equations with dispersion and dissipation. This book is essential for introducing readers in mechanics, mechanical engineering, and applied mathematics to the concept of long nonlinear strain wave in one-dimensional wave guides. It is also suitable for self-study by professionals in all areas of nonlinear physics.