Geophysical Fluid Dynamics Pedlosky

This is the most comprehensive introductory graduate or advanced undergraduate text in fluid mechanics available. It builds from the fundamentals, often in a very general way, to widespread applications to technology and geophysics. In most areas, an understanding of this book can be followed up by specialized monographs and the research literature. The material added to this new edition will provide insights gathered over 45 years of studying fluid mechanics. Many of these insights, such as universal dimensionless similarity scaling for the laminar boundary layer equations, are available nowhere else. Likewise for the generalized vector field derivatives. Other material, such as the generalized stream function treatment, shows how stream functions may be used in three-dimensional flows. The CFD chapter enables computations of some simple flows and provides entrée to more advanced literature. *New and generalized treatment of similar laminar boundary layers. *Generalized treatment of streamfunctions for three-dimensional flow . *Generalized treatment of vector field derivatives. *Expanded coverage of gas dynamics. *New introduction to computational fluid dynamics. *New generalized treatment of boundary conditions in fluid mechanics. *Expanded treatment of viscous flow with more examples.

This book provides an introductory-level exploration of geophysical fluid dynamics (GFD), the principles governing air and water flows on large terrestrial scales. Physical principles are illustrated with the aid of the simplest existing models, and the computer methods are shown in juxtaposition with the equations to which they apply. It explores contemporary topics of climate dynamics and equatorial dynamics, including the Greenhouse Effect, global warming, and the El Nino Southern Oscillation. Combines both physical and numerical aspects of geophysical fluid dynamics into a single affordable volume Explores contemporary topics such as the Greenhouse Effect, global warming and the El Nino Southern Oscillation Biographical and historical notes at the ends of chapters trace the intellectual development of the field Recipient of the 2010 Wernaers Prize, awarded each year by the National Fund for Scientific Research of Belgium (FNR-FNRS).

This textbook for senior undergraduate and graduate students outlines and provides links between classical mechanics and geophysical fluid dynamics. It is particularly suitable for the mechanics and fluids dynamics courses of geophysics, meteorology, or oceanography students as well as serving as a general textbook for a course on geophysical fluid dynamics. It describes the motions of rigid bodies and shows how classical mechanics has important applications to geophysics, as in the precession of the earth, oceanic tide, and the retreat of the moon from the earth owing to the tidal friction. Unlike the more general mechanics textbooks this gives a unique presentation of these applications

This book develops a fundamental understanding of geophysical fluid dynamics based on a mathematical description of the flows of inhomogeneous fluids. It covers these topics: 1. development of the equations of motion for an inhomogeneous fluid 2. review of thermodynamics 3. thermodynamic and kinetic energy equations 4. equations of state for the atmosphere and the ocean, salt, and moisture effects 5. concepts of potential temperature and potential density 6. Boussinesq and quasi-geostrophic approximations 7. conservation equations for vorticity, mechanical and thermal energy instability theories, internal waves, mixing, convection, double-diffusion, stratified turbulence, fronts, intrusions, gravity currents Graduate students will be able to learn and apply the basic theory of geophysical fluid dynamics of inhomogeneous fluids on a rotating earth, including: 1. derivation of the governing equations for a stratified fluid starting from basic principles of physics 2. review of thermodynamics, equations of state, isothermal, adiabatic, isentropic changes 3. scaling of the equations, Boussinesq approximation, applied to the ocean and the atmosphere 4. examples of stratified flows at geophysical scales, steady and unsteady motions, inertia-gravity internal waves, quasi-geostrophic theory 5. vorticity and energy conservation in stratified fluids 6.boundary layer convection in stratified containers and basins.

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.

This book presents important recent applied mathematics research on environmental problems and impacts due to climate change. Although there are inherent difficulties in addressing phenomena that are part of such a complex system, exploration of the subject using mathematical modelling is especially suited to tackling poorly understood issues in the field. It is in this spirit that the book was conceived. It is an outcome of the International INDAM Workshop “Mathematical Approach to Climate Change Impacts – MAC2I”, held in Rome in March 2017. The workshop comprised four sessions, on Ecosystems, Hydrology, Glaciology, and Monitoring. The book includes peer-reviewed contributions on research issues discussed during each of these sessions or generated by collaborations among the specialists involved. Accurate parameter determination techniques are explained and innovative mathematical modelling approaches, presented. The book also provides useful material and mathematical problem-solving tools for doctoral programs dealing with the complexities of climate change.

Fluid dynamics is fundamental to our understanding of the atmosphere and oceans. Although many of the same principles of fluid dynamics apply to both the atmosphere and oceans, textbooks tend to concentrate on the atmosphere, the ocean, or the theory of geophysical fluid dynamics (GFD). This textbook provides a comprehensive unified treatment of atmospheric and oceanic fluid dynamics. The book introduces the fundamentals of geophysical fluid dynamics, including rotation and stratification, vorticity and potential vorticity, and scaling and approximations. It discusses baroclinic and barotropic instabilities, wave-mean flow interactions and turbulence, and the general circulation of the atmosphere and ocean. Student problems and exercises are included at the end of each chapter. Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large-Scale Circulation will be an invaluable graduate textbook on advanced courses in GFD, meteorology, atmospheric science and oceanography, and an excellent review volume for researchers. Additional resources are available at www.cambridge.org/9780521849692.

The vigorous stirring of a cup of tea gives rise, as we all know, to interesting fluid dynamical phenomena, some of which are very hard to explain. In this book our "cup of tea" contains the currents of the Earth's atmosphere, oceans, mantle, and fluid core. Our goal is to under stand the basic physical processes which are most important in describing what we observe, directly or indirectly, in these complex systems. While in many respects our understanding is measured by the ability to predict, the focus here will be on relatively simple models which can aid our physical intuition by suggesting useful mathematical methods of investiga tion. These elementary models can be viewed as part of a hierarchy of models of increasing complexity, moving toward those which might be use fully predictive. The discussion in this book will deal primarily with the Earth. Interplanetary probes of Venus, Mars, Jupiter and Saturn have revealed many exciting phenomena which bear on geophysical fluid dynamics. They have also enabled us to see the effect of changing the values of certain parameters, such as gravity and rotation rate, on geophysical flows. On the other hand, satellite observations of our own planet on a daily and hourly basis have turned it into a unique laboratory for the study of fluid motions on a scale never dreamt of before: the motion of cyclones can be observed via satellite just as wing tip vortices are studied in a wind tunnel.

This book is an introduction to a comprehensive and unified dynamic transition theory for dissipative systems and to applications of the theory to a range of problems in the nonlinear sciences. The main objectives of this book are to introduce a general principle of dynamic transitions for dissipative systems, to establish a systematic dynamic transition theory, and to explore the physical implications of applications of the theory to a range of problems in the nonlinear sciences. The basic philosophy of the theory is to search for a complete set of transition states, and the general principle states that dynamic transitions of all dissipative systems can be classified into three categories: continuous, catastrophic and random. The audience for this book includes advanced graduate students and researchers in mathematics and physics as well as in other related fields.

Intermediate/advanced textbook which provides concise and accessible introduction to GFD for broad range of students.

Helioseismology has enabled us to probe the internal structure and dynamics of the Sun, including how its rotation varies in the solar interior. The unexpected discovery of an abrupt transition - the tachocline - between the differentially rotating convection zone and the uniformly rotating radiative interior has generated considerable interest and raised many fundamental issues. This volume contains invited reviews from distinguished speakers at the first meeting devoted to the tachocline, held at the Isaac Newton Institute. It provides a comprehensive account of the understanding of the properties and dynamics of the tachocline, including both observational results and major theoretical issues, involving both hydrodynamic and magnetohydrodynamic behaviour. The Solar Tachocline is a valuable reference for researchers and graduate students in astrophysics, heliospheric physics and geophysics, and the dynamics of fluids and plasmas.

An Introduction to the Mathematical Theory of Geophysical Fluid Dynamics

Buoyancy is one of the main forces driving flows on our planet, especially in the oceans and atmosphere. These flows range from buoyant coastal currents to dense overflows in the ocean, and from avalanches to volcanic pyroclastic flows on the Earth's surface. This book brings together contributions by leading world scientists to summarize our present theoretical, observational, experimental and modeling understanding of buoyancy-driven flows. Buoyancy-driven currents play a key role in the global ocean circulation and in climate variability through their impact on deep-water formation. Buoyancy-driven currents are also primarily responsible for the redistribution of fresh water throughout the world's oceans. This book is an invaluable resource for advanced students and researchers in oceanography, geophysical fluid dynamics, atmospheric science and the wider Earth sciences who need a state-of-the-art reference on buoyancy-driven flows.

A Tribute to the Scientific Work of Pedro Ripa

This book sets forth the physical, mathematical, and numerical foundations of computer models used to understand and predict the global ocean climate system. Aimed at students and researchers of ocean and climate science who seek to understand the physical content of ocean model equations and numerical methods for their solution, it is largely general in formulation and employs modern mathematical techniques. It also highlights certain areas of cutting-edge research. Stephen Griffies presents material that spans a broad spectrum of issues critical for modern ocean climate models. Topics are organized into parts consisting of related chapters, with each part largely self-contained. Early chapters focus on the basic equations arising from classical mechanics and thermodynamics used to rationalize ocean fluid dynamics. These equations are then cast into a form appropriate for numerical models of finite grid resolution. Basic discretization methods are described for commonly used classes of ocean climate models. The book proceeds to focus on the parameterization of phenomena occurring at scales unresolved by the ocean model, which represents a large part of modern oceanographic research. The final part provides a tutorial on the tensor methods that are used throughout the book, in a general and elegant fashion, to formulate the equations.

For some time there has existed an extensive theoretical literature relating to tides on continental shelves and also to the behavior of estuaries. Much less attention was traditionally paid to the dynamics of longer term, larger scale motions (those which are usually described as circulation') over continental shelves or in enclosed shallow seas such as the North American Great Lakes. This is no longer the case: spurred on by other disciplines, notably biological oceanography, and by public concern with the environment, the physical science of the coastal ocean has made giant strides during the last two decades or so. Today, it is probably fair to say that coastal ocean physics has come of age as a deduc tive quantitative science. A well developed body of theoretical models exist, based on the equations of fluid motion, which have been related to observed currents, sea level variations, water properties, etc. Quantitative parameters required in using the models to predict e.g. the effects of wind or of freshwater influx on coastal currents can be estimated within reasonable bounds of error. While much remains to be learned, and many exciting discoveries presumably await us in the future, the time seems appropriate to summarize those aspects of coastal ocean dynamics relevant to 'circulation' or long term motion.

Bottom Turbulence

This book presents a geometric theory for incompressible flow and its applications to fluid dynamics. The main objective is to study the stability and transitions of the structure of incompressible flows, and applications to fluid dynamics and geophysical fluid dynamics. The development of the theory and its applications has gone well beyond the original motivation, which was the study of oceanic dynamics. One such development is a rigorous theory for boundary layer separation of incompressible fluid flows. This study of incompressible flows has two major parts, which are interconnected. The first is the development of a global geometric theory of divergence-free fields on general two-dimensional compact manifolds. The second is the study of the structure of velocity fields for two-dimensional incompressible fluid flows governed by the Navier-Stokes equations or the Euler equations. Motivated by the study of problems in geophysical fluid dynamics, the program of research in this book seeks to develop a new mathematical theory, maintaining close links to physics along the way. In return, the theory is applied to physical problems, with more problems yet to be explored.

This scholarly text provides an introduction to the numerical methods used to model partial differential equations, with focus on atmospheric and oceanic flows. The book covers both the essentials of building a numerical model and the more sophisticated techniques that are now available. Finite difference methods, spectral methods, finite element method, flux-corrected methods and TVC schemes are all discussed. Throughout, the author keeps to a middle ground between the theorem-proof formalism of a mathematical text and the highly empirical approach found in some engineering publications. The book establishes a concrete link between theory and practice using an extensive range of test problems to illustrate the theoretically derived properties of various methods. From the reviews: "...the books unquestionable advantage is the clarity and simplicity in presenting virtually all basic ideas and methods of numerical analysis currently actively used in geophysical fluid dynamics." Physics of Atmosphere and Ocean

This book is a collection of selected lectures presented at the ‘Intensive Course on Mesoscale Meteorology and Forecasting’ in Boulder, USA, in 1984. It includes mesoscale classifications, observing techniques and systems, internally generated circulations, mesoscale convective systems, externally forced circulations, modeling and short-range forecasting techniques. This is a highly illustrated book and comprehensive work, including extensive bibliographic references. It is aimed at graduates in meteorology and for professionals working in the field.

An overview of the advances made in the last decade and a half in this field. Based on an advanced graduate level course, the book represents fundamental insights into the structure of the physical theory of the large-scale dynamics of the oceans. The author has maintained throughout a blend of analytical and numerical results so as to achieve as deep a physical understanding of the dynamics of the large-scale circulations as possible. The results of the theories are compared with observations and the success or inadequacies of the theories are highlighted. Topics of particular interest are: theory of the wind-driven circulation, the thermocline, the equatorial circulation and the abyssal circulation. Much of the material - previously scattered throughout the literature - has been collated here for the first time.

Part of the excitement in boundary-layer meteorology is the challenge associated with turbulent flow - one of the unsolved problems in classical physics. An additional attraction of the filed is the rich diversity of topics and research methods that are collected under the umbrella-term of boundary-layer meteorology. The flavor of the challenges and the excitement associated with the study of the atmospheric boundary layer are captured in this textbook. Fundamental concepts and mathematics are presented prior to their use, physical interpretations of the terms in equations are given, sample data are shown, examples are solved, and exercises are included. The work should also be considered as a major reference and as a review of the literature, since it includes tables of parameterizatlons, procedures, filed experiments, useful constants, and graphs of various phenomena under a variety of conditions. It is assumed that the work will be used at the beginning graduate level for students with an undergraduate background in meteorology, but the author envisions, and has catered for, a heterogeneity in the background and experience of his readers.

The goals ofthe Symposium were to highlight advances in modelling ofatmosphere and ocean dynamics, to provide a forum where atmosphere and ocean scientists could present their latest research results and learn ofprogress and promising ideas in these allied disciplines; to facilitate interaction between theory and applications in atmosphere/ocean dynamics. These goals were seen to be especially important in view ofcurrent efforts to model climate requiring models which include interaction between atmosphere, ocean and land influences. Participants were delighted with the diversity ofthe scientific programme; the opportunity to meet fellow scientists from the other discipline (either atmosphere or ocean) with whom they do not normally interact through their own discipline; the opportunity to meet scientists from many countries other than their own; the opportunity to hear significant presentations (50 minutes) from the keynote speakers on a range ofrelevant topics. Certainly the goal ofcreating a forum for exchange between atmosphere and ocean scientists who need to input to create realistic models for climate prediction was achieved by the Symposium and this goal will hopefully be further advanced by the publication ofthese Proceedings.

For advanced undergraduate and beginning graduate students in atmospheric, oceanic, and climate science, Atmosphere, Ocean and Climate Dynamics is an introductory textbook on the circulations of the atmosphere and ocean and their interaction, with an emphasis on global scales. It will give students a good grasp of what the atmosphere and oceans look like on the large-scale and why they look that way. The role of the oceans in climate and paleoclimate is also discussed. The combination of observations, theory and accompanying illustrative laboratory experiments sets this text apart by making it accessible to students with no prior training in meteorology or oceanography. * Written at a mathematical level that is appealing for undergraduates and beginning graduate students * Provides a useful educational tool through a combination of observations and laboratory demonstrations which can be viewed over the web * Contains instructions on how to reproduce the simple but informative laboratory experiments * Includes copious problems (with sample answers) to help students learn the material.

For decades, previous editions of John Knauss’s seminal work have struck a balance between purely descriptive texts and mathematically rigorous ones, giving a wide range of marine scientists access to the fundamental principles of physical oceanography. Newell Garfield continues this tradition, delivering valuable updates that highlight the book’s resourceful presentation and concise effectiveness. The authors include historical and current research, along with a 12-page color insert, to illuminate their perspective that the world ocean is tumultuous and continually helps to shape global environmental processes. The Third Edition builds a solid foundation that readers will find straightforward and lucid. It presents valuable insight into our understanding of the world ocean by: • Encompassing essential oceanic processes such as the transfer of heat across the ocean surface, the distribution of temperature and salinity, and the effect of the earth's rotation on the ocean. • Providing sensible and well-defined explanations of the roles played by a stratified ocean, global balances, and equations of motion. • Discussing cogent topics such as major currents, tides, waves, coastal oceans, semienclosed seas, and sound and optics.

This book leads readers from a basic foundation to an advanced-level understanding of fluid and solid mechanics. Perfect for graduate or PhD mathematical-science students looking for help in understanding the fundamentals of the topic, it also explores more specific areas such as multi-deck theory, time-mean turbulent shear flows, non-linear free surface flows, and internal fluid dynamics. "Fluid and Solid Mechanics" is the second volume of the LTCC Advanced Mathematics Series. This series is the first to provide advanced introductions to mathematical science topics to advanced students of mathematics. Edited by the three joint heads of the London Taught Course Centre for PhD Students in the Mathematical Sciences (LTCC), each book supports readers in broadening their mathematical knowledge outside of their immediate research disciplines while also covering specialized key areas.Contents: Introductory Geophysical Fluid Dynamics "(Michael Davey)"Multiple Deck Theory "(S N Timoshin)"Time-Mean Turbulent Shear Flows: Classical Modelling — Asymptotic Analysis — New Perspectives "(Bernhard Scheichl)"Nonlinear Free Surface Flows with Gravity and Surface Tension "(J-M Vanden-Broeck)"Internal Fluid Dynamics "(Frank T Smith)"Fundamentals of Physiological Solid Mechanics "(N C Ovenden and C L Walsh)" Readership: Researchers, graduate or PhD mathematical-science students who require a reference book that covers fluid dynamics and solid mechanics. Pure Mathematics;Applied Mathematics;Mathematical Sciences;Techniques;Algebra;Logic;Combinatorics;Fluid Dynamics;Solid MechanicsKey Features: Each chapter is written by a leading lecturer in the fieldConcise and versatileCan be used as a masters level teaching support or a reference handbook for researchers

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The content of this book is based, largely, on the core curriculum in geophys ical fluid dynamics which I and my colleagues in the Department of Geophysical Sciences at The University of Chicago have taught for the past decade. Our purpose in developing a core curriculum was to provide to advanced undergraduates and entering graduate students a coherent and systematic introduction to the theory of geophysical fluid dynamics. The curriculum and the outline of this book were devised to form a sequence of courses of roughly one and a half academic years (five academic quarters) in length. The goal of the sequence is to help the student rapidly advance to the point where independent study and research are practical expectations. It quickly became apparent that several topics (e. g. , some aspects of potential theory) usually thought of as forming the foundations of a fluid-dynamics curriculum were merely classical rather than essential and could be, however sadly, dispensed with for our purposes. At the same time, the diversity of interests of our students is so great that no curriculum can truly be exhaust ive in such a curriculum period. It seems to me that the best that can be achieved as a compromise is a systematic introduction to some important segment of the total scope of geophysical fluid dynamics which is illustrative of its most fruitful methods.

This book presents selected mathematical problems involving the dynamics of a two-dimensional viscous and ideal incompressible fluid on a rotating sphere. In this case, the fluid motion is completely governed by the barotropic vorticity equation (BVE), and the viscosity term in the vorticity equation is taken in its general form, which contains the derivative of real degree of the spherical Laplace operator. This work builds a bridge between basic concepts and concrete outcomes by pursuing a rich combination of theoretical, analytical and numerical approaches, and is recommended for specialists developing mathematical methods for application to problems in physics, hydrodynamics, meteorology and geophysics, as well for upper undergraduate or graduate students in the areas of dynamics of incompressible fluid on a rotating sphere, theory of functions on a sphere, and flow stability.

This revised text presents a cogent explanation of the fundamentals of meteorology, and explains storm dynamics for weather-oriented meteorologists. It discusses climate dynamics and the implications posed for global change. The Fourth Edition features a CD-ROM with MATLABÂ® exercises and updated treatments of several key topics. Much of the material is based on a two-term course for seniors majoring in atmospheric sciences. * Provides clear physical explanations of key dynamical principles * Contains a wealth of illustrations to elucidate text and equations, plus end-of-chapter problems * Holton is one of the leading authorities in contemporary meteorology, and well known for his clear writing style * Instructor's Manual available to adopters NEW IN THIS EDITION * A CD-ROM with MATLABÂ® exercises and demonstrations * Updated treatments on climate dynamics, tropical meteorology, middle atmosphere dynamics, and numerical prediction

This second edition of the widely acclaimed Geophysical Fluid Dynamics by Joseph Pedlosky offers the reader a high-level, unified treatment of the theory of the dynamics of large-scale motions of the oceans and atmosphere. Revised and updated, it includes expanded discussions of * the fundamentals of geostrophic turbulence * the theory of wave-mean flow interaction * thermocline theory * finite amplitude barocline instability.

For over twenty years, the Joint Program in Physical Oceanography of MIT and the Woods Hole Oceanographic Institution has based its education program on a series of core courses in Geophysical Fluid Dynamics and Physical Oceanography. One of the central courses in the Core is one on wave theory, tailored to meet the needs of both physical oceanography and meteorology students. I have had the pleasure of teaching of years, and I have particularly enjoyed the response of the the course for a number students to their exposure to the fascination of wave phenomena and theory. This book is a reworking of course notes that I have prepared for the students, and I was encouraged by their enthusiastic response to the notes to reach a larger audience with this material. The emphasis, both in the course and in this text, is twofold: the de velopment of the basic ideas of wave theory and the description of specific types of waves of special interest to oceanographers and meteorologists. Throughout the course, each wave type is introduced both for its own intrinsic interest and importance and as a ve hicle for illustrating some general concept in the theory of waves. Topics covered range from small-scale surface gravity waves to large-scale planetary vorticity waves.

Lectures on Geophysical Fluid Dynamics offers an introduction to several topics in geophysical fluid dynamics, including the theory of large-scale ocean circulation, geostrophic turbulence, and Hamiltonian fluid dynamics. Since each chapter is a self-contained introduction to its particular topic, the book will be useful to students and researchers in diverse scientific fields.

Geophysical Fluid DynamicsSpringer Science & Business Media

This book gives a coherent development of the current understanding of the fluid dynamics of the middle latitude atmosphere. It is primarily aimed at post-graduate and advanced undergraduate level students and does not assume any previous knowledge of fluid mechanics, meteorology or atmospheric science. The book will be an invaluable resource for any quantitative atmospheric scientist who wishes to increase their understanding of the subject. The importance of the rotation of the Earth and the stable stratification of its atmosphere, with their implications for the balance of larger-scale flows, is highlighted throughout. Clearly structured throughout, the first of three themes deals with the development of the basic equations for an atmosphere on a rotating, spherical planet and discusses scale analyses of these equations. The second theme explores the importance of rotation and introduces vorticity and potential vorticity, as well as turbulence. In the third theme, the concepts developed in the first two themes are used to give an understanding of balanced motion in real atmospheric phenomena. It starts with quasi-geostrophic theory and moves on to linear and nonlinear theories for mid-latitude weather systems and their fronts. The potential vorticity perspective on weather systems is highlighted with a discussion of the Rossby wave propagation and potential vorticity mixing covered in the final chapter.

A concise introduction to atmosphere-ocean dynamics at the intermediate-advanced undergraduate level, taking the reader from basic dynamics to cutting-edge topics.

In recent decades, great progress has been made in our understanding of zonal jets across many subjects - atmospheric science, oceanography, planetary science, geophysical fluid dynamics, plasma physics, magnetohydrodynamics, turbulence theory - but communication between researchers from different fields has been weak or non-existent. Even the terminology in different fields may be so disparate that researchers working on similar problems do not understand each other. This comprehensive, multidisciplinary volume will break cross-disciplinary barriers and aid the advancement of the subject. It presents a state-of-the-art summary of all relevant branches of the physics of zonal jets, from the leading experts. The phenomena and concepts are introduced at a level accessible to beginning graduate students and researchers from different fields. The book also includes a very extensive bibliography.